Semi-longitudinal analysis of physical status in madrilenian adolescents

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Summary

Physical fitness is very important for health, but is also essential to adjust the training load and adapt it to the age of individuals. The Physical Education teachers can assess the fitness of their students, from seven tests that are part of the curricular contents of that subject. The aim of the present work was to determine the physical aptitude of Madrilenian students of both sexes aged 13 to 18, and to develop an updated reference patterns that could serving to assess the physical fitness in High Schools students.

Longitudinal study was performed, since each individual was evaluated among two and eight times. The sample consisted of 4271 records (2333 boys and 1938 girls) from more than 500 individuals between 13 and 18 years old. The tested exercises determine the physical capabilities of students, strength, endurance, speed and flexibility. These tests are the following: Sit-Ups in 30 seconds, 4 x 9 meter Shuttle Run test, 50 m shuttle-run test, Standing Broad Jump, medicine ball explosive power test and trunk flexion test. Results allow characterizing the physical fitness of the Madrilenian students. Ontogenic and sexual variability were examined and the corresponding tables are provided with mean, standard deviation and percentile distribution for each test, according to sex and age. The statistical analysis, made using the SPSS v.20.0, shows a significant sexual dimorphism ($p < 0.001$) for all the studied tests.

The obtained values in this research also prove that boys outperform girls in all the physical test, except in those that measure flexibility.

Key words:
Physical fitness. Physical activity. Adolescents. Spain. Standards.

Análisis semilongitudinal de la condición física en adolescentes madrileños

Resumen

La condición física tiene gran importancia sobre la salud de los sujetos, pero también es primordial ajustar la carga del entrenamiento y adecuarla a la edad de los individuos. El profesorado de Educación Física puede evaluar la condición física de su alumnado a partir de siete pruebas que forman parte de los contenidos curriculares de la mencionada asignatura. Los objetivos de este trabajo son, por un lado, conocer la condición física de los estudiantes madrileños de ambos sexos de 13 a 18 años y, por otro, elaborar unos patrones actualizados que sirvan de referencia al profesorado de Educación Física para su alumnado de ESO y Bachillerato. Se ha efectuado un análisis semilongitudinal, ya que cada sujeto ha sido evaluado entre dos y ocho ocasiones. La muestra se compone de 4.271 registros (2.333 de chicos y 1.938 de chicas) de más de 500 escolares de 13 a 18 años. Los ejercicios examinados determinan las capacidades físicas de los estudiantes, fuerza, resistencia, velocidad y flexibilidad. Estas pruebas son: abdominales en 30 segundos, carrera de 9 m x 4, salto horizontal, carrera de 50 m lisos, lanzamiento del balón medicinal de 3 kg, flexión del tronco y carrera de 1.000 m. Los resultados presentados permiten caracterizar la aptitud física de los escolares madrileños. Se ha examinado la variabilidad ontogénica y sexual y se aportan las correspondientes tablas con la media, desviación estándar y la distribución percentilar para cada una de las pruebas, según sexo y edad en años cumplidos. En el análisis efectuado con el paquete estadístico SPSS (versión 20.0) se manifiesta un dimorfismo sexual significativo ($p < 0,001$) para todos los ejercicios estudiados. Asimismo los valores aportados por esta investigación muestran que los varones obtienen mejores resultados que las mujeres en todas las pruebas físicas, excepto en aquellas que miden la flexibilidad.

Palabras clave:
Aptitud física. Actividad física. Adolescentes. España. Estándares.

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Introduction

Physical capabilities are unique to each individual, are genetically influenced, and develop with exercise. There is controversy among authors regarding their title; as such, Álvarez Villar[1] calls them basic physical qualities and describes them as the factors that determine the physical condition of the subject, guiding them to performing a specific activity and enabling them to develop their physical potential via training. The majority of specialists in this field establish that these capacities are strength, resistance, speed and flexibility.

Meanwhile, physical activity is defined by the World Health Organisation (WHO) as any bodily movement produced by the skeletal muscles that requires an expenditure of energy[2]. This should not be confused with exercise, which is a variety of the aforementioned, but that requires planning, structure and repetition. In other words, physical activity encompasses exercise and other activities that imply movement of the body. If we bring together and assess the physical capacities of an individual with activity or exercise, we reach the idea of physical condition.

The definition of this concept has evolved and has significantly transformed over time, but the importance of physical condition in personal well-being and health[3] was established in the early 21st century. A sedentary lifestyle is a risk associated with the propagation of excess weight and other metabolopathies in childhood and adolescence[4-6]. The AVENA study (Feeding and Assessment of the Nutritional Status of Spanish Adolescents)[7] estimates that 1 out of every 5 Spanish young people face future cardiovascular risks, due to their low level of physical shape, but as well as this it has been proven that exercise should form part of the treatment for diverse pathologies, such as type 1 diabetes[8]. There are also very recent studies, such as the MOCA study[9], which reveal a significant relationship between practising sports, self-esteem and adequate perception of their Body Mass Index (BMI).

Exercise presents additional advantages, as it also constitutes a practice that socialises the individual, allowing participants to interact with their surroundings and other people[10]. Unfortunately, the majority of western populations do not perform the recommended amount of physical exercise to lead a healthy life[11]. As highlighted in the research carried out by the WHO[12] on 11,230 students aged between 11 and 18 years, the percentage of Spanish students that perform 1 hour of exercise each day is very low. Furthermore, this proportion is lower in girls, and gets lower as the age increases. Therefore, at 11 years the figures stand at 21% for females, and 41% for males, whilst by 15 years they stand at 8% for females and 25% in males. Similar results were obtained in a study performed on Catalan students from 5 to 17 years, in which the recommendation was to increase the number of Physical Education teaching hours at school[13], the advantage of which is proven in the EDUFIT intervention programme (Physical Education and Education for Fitness)[14].

In short, it is essential to raise awareness among families, teaching staff, school centres and governments, that promoting physical exercise ensures a healthier future for young people[15]. In this respect, educational institutions could play an important role, for example, by providing students with sporting materials during break times, or by designating sporting spaces on playgrounds in schools[16]. The guidelines of the PERSEO Programme (Pilot Programme in Schools for Health, Physical Exercise and against Obesity) assign an important role to Physical Education teaching staff[17]. These teachers must strive to increase the time spent on motor activities in classes, and to encourage exercise habits. But first, to increase the quality of their subject, they should update their knowledge regarding the importance of physical condition on health and its age appropriateness for students. Regarding this point, the majority of teachers consider that it is key to resort to aptitude tests to assess the physical condition of students and in turn adjust the training load[18].

The aims of this work are, firstly, to discover the physical condition of Madrilenian students in the second cycle of Compulsory Secondary Education (ESO) and Baccalaureate. Secondly, to check if there is sexual dimorphism in the results of the different tests analysed, as signalled by multiple research studies. Finally, to create some current reference values that can be used by Physical Education teaching staff to assess the capacity and physical activity of Madrilenian students at the aforementioned educational stages.

Material and methods

The population studied includes 4,271 records (2,333 from males and 1,938 from females) from over 500 students aged between 13 and 18 years from the Santa Eugenia de Madrid Secondary Education Institute (IES). The data was obtained between the 2000/01 and 2011/12 academic years, and was collected by two Physical Education teachers from the cited centre, adhering to the Helsinki regulations dictated by the *World Medical Association* (WMA)[19].

The teaching staff involved did not carry out a specific course to ensure the reliability of the measurements, nor did they design a pilot sample because the tests analysed here had to be performed by all ESO and Baccalaureate students, and each of the tests followed the corresponding protocol in the programmes established by the Ministry of Education of the Autonomous Community of Madrid, in Physical Education.

As the methodology for a semi-longitudinal study dictates, each subject was assessed on at least two separate occasions, i.e. at the start and finish of the course and on a maximum of eight occasions, as the students repeated the same tests on each of the four academic years (3rd and 4th of ESO and 1st and 2nd of Baccalaureate) that stayed on at the IES.

The sample is heterogeneous because it covers all the IES students from previously mentioned educational stages during the cited time period, apart from those students that were excluded from the Physical Education subject by means of an official medical certificate. The series was classified by sex and age in completed years. To assess the physical condition, a series of tests was selected to establish the basic physical capacities of the student: strength, resistance, speed and flexibility. A warm-up is recommended before each of the exercises. The protocols followed have already been described and standardised[20-22].

Abdominals for 30 seconds are used to determine the strength and resistance of the abdominal muscles. To perform this test, subjects had to adopt the supine position, with legs flexed at 90º, feet supported, hip distance apart and with hands interlocked behind the neck. At the same time, another person held their feet to the floor. Students must touch both knees with their elbows and count the number of times this movement is performed in 30 seconds. Students must touch the mat with their backs, their knees with their elbows and the floor with their forearms. Only one attempt is made for this exercise.

The 9 m x 4 run measures agility and speed of movement. To perform this exercise, a flat, non-slip floor is required, upon which two parallel lines are marked 9 m apart. Subjects are positioned behind one of the lines and on the starting signal, must run and touch the other line with their hand. Next, they must return to the first line and bend down to touch it. Again, the same pattern is repeated returning to the opposite point and returning to the starting point. The time taken is measured in seconds and split seconds. Two attempts are made, with the best result noted down.

The horizontal jump with feet together is used to assess the explosive strength of the leg muscles. Students stand behind the line with feet in line, slightly separated with the knees lightly flexed. Students must jump forward as far as possible over the starting line and fall without touching the ground with their hands. The distance is measured in m and cm from the starting line and the back heel mark. Two attempts are made with the best result noted down.

The 50 m flat run checks movement and reaction speed. Students stand behind the starting line. Upon hearing the signal, they must cover the distance as quickly as possible. The time is measured in seconds and split seconds, from the moment the back foot is lifted to the moment the finishing line is crossed. Two attempts are made and the best result is noted.

Throwing the medicine ball measures the explosive strength of the arm and shoulder. Subjects stand with legs hip distance apart next to the starting line, and must throw a 3 kg ball as far as possible. The ball's trajectory should be as perpendicular as possible to the starting line and upwards with an angle of around 45º. The distance is measured in m and cm from the starting point to the nearest landing point. It is worth practising the throw, indicating the most suitable launch angle. Two attempts are made, with the best result noted down.

The sitting trunk flex assess the flexibility of the thorax, hip and legs. A bench is needed upon which a 55-cm long millimetre ruler is positioned with a sliding bar. Students sit on the floor with no shoes on, with legs parallel and stretched out, so that the feet rest completely on the front wall of the bench. With arms completely extended, they flex their trunk forward, push the bar as far down as possible with the fingertips and hold the position for at least 2 seconds. The bar movement along the scale is measured in cm but if the student does not reach 0, the numeration is negative and if it is passed it is positive. Knees should not bend, nor should the sliding bar be pushed forward hard. Two attempts are made, with the best length noted down.

The 1,000 m run determines their mid-distance aerobic resistance. Students must cover the set distance in as short a time as possible. Students stand behind the starting line and start running upon hearing the signal. The time is measured in minutes and seconds, from the moment the back foot is lifted to the moment the finishing line is crossed. Only one attempt is made for this exercise.

Analysis has been carried out using the SPSS statistics package (20.0 version). The normality of the distributions has been verified and the average, standard deviation and percentile value have been calculated for each of the trials, by sex and age in completed years. The Student T test has been used to analyse the sexual dimorphism and the ANOVA test to check the variation experienced with age in each of the exercises.

Results

Tables 1 to 7 display the averages, standard deviations and percentiles 3, 10, 25, 50, 75, 90 and 97 by age (in completed years) and sex, which correspond to each of the physical tests analysed. Likewise, in all the figures (Figures 1 to 7), sexual dimorphism is represented based on the average values obtained in each of the tests.

Table 1 presents the results of the abdominals in 30 seconds; in both sexes it can be seen that the number of repetitions varies significantly with age (males $F = 15.36$ $p < 0.001$, females $F = 7.26$ $p < 0.001$). There is a first stage (from 13 to 16 years) in which performance increases, then later there is a relative stabilisation, with a slight fall in values in the 17 year-old female series. Likewise, Figure 1 displays the sexual differences, which are significant ($p < 0.001$) across all age intervals analysed.

Table 2, corresponding to the 9 m x 4 run, clearly shows that in the male series the average time is reduced as age increases ($F = 33.84$ $p < 0.001$). However, in the female tests this reduction is not as clear, though it is significant ($F = 2.05$ $p < 0.05$). For this reason, the difference between the age extremes is 0.839 s for males and 0.076 for females. Equally, Figure 2 reveals that there is significant sexual dimorphism ($p < 0.001$) from 13 to 18 years. Effectively, the time taken in the test is higher for females than for males and this divergence increases with age.

Table 3 reflects the results obtained in the horizontal jump test. It seems obvious that for males, the average distance increases with age ($F = 47.81$ $p < 0.05$). For females, despite the variation being less, it is still significant ($F = 2.45$ $p < 0.05$). The average differences between the age extremes is greater for males (171.41 cm at 13 years and 219.61 cm at 18 years) than for females, with the respective figures of 155.84 and 157.13 cm. Figure 3 reveals the disparity between both sexes ($p < 0.001$), which is easily explainable because the power of the jump is directly related to muscle strength.

In the 50 m run, the strength of the lower limb muscles comes into play, which is why the results are better in males than in females (Table 4). It can be observed that for females, time increases with age ($F = 8.19$ $p < 0.001$) and varies by 2.92 seconds from 13 to 18 years. For males, this increase is less, though the variation of just 0.5 seconds between the age extremes is significant ($F = 4.38$ $p < 0.05$). Figure 4 reveals the marked sexual differences across all ages ($p < 0.001$) except for in the 13-year old set which reveals no significant differences ($p < 0.140$).

Table 1. Abdominals in 30 seconds (number of repetitions).

Males									
Age (years)	Average	S.T.	P3	P10	P25	P50	P75	P90	P97
13 (N=104)	26.66	3.70	19.00	22.00	24.00	27.00	29.00	32.00	33.00
14 (N=454)	28.33	4.73	20.00	22.00	25.00	28.00	31.00	34.00	38.00
15 (N=700)	29.64	4.26	22.00	25.00	27.00	30.00	32.00	35.00	38.00
16 (N=677)	30.32	4.31	22.00	25.00	28.00	30.00	33.00	36.00	38.00
17 (N=304)	30.81	4.39	22.00	25.00	28.00	31.00	34.00	36.00	38.00
18 (N=70)	30.59	4.61	22.13	24.00	27.00	31.00	34.00	37.00	40.74
Females									
Age (years)	Average	S.D.	P3	P10	P25	P50	P75	P90	P97
13 (N=108)	23.47	3.77	16.27	18.00	21.00	24.00	26.00	29.00	30.00
14 (N=423)	23.67	3.65	17.00	19.00	21.00	24.00	26.00	28.00	31.00
15 (N=438)	24.37	4.14	16.00	19.00	22.00	24.00	27.00	29.00	32.83
16 (N=615)	25.34	4.46	16.00	19.60	23.00	26.00	28.00	31.00	33.00
17 (N=228)	24.68	4.64	14.74	19.00	22.00	25.00	28.00	30.00	33.00
18 (N=38)	25.71	4.55	16.17	19.70	22.75	26.00	29.00	31.00	34.49

S.T.: Standard deviation.

Table 2. Running 9 m x 4 (seconds and split seconds).

Males									
Age (years)	Average	S.D.	P3	P10	P25	P50	P75	P90	P97
13 (N=104)	9.862	0.705	8.800	9.000	9.400	9.700	10.300	10.900	11.485
14 (N=455)	9.482	0.649	8.500	8.760	9.000	9.400	9.800	10.400	11.000
15 (N=696)	9.235	0.545	8.500	8.700	8.900	9.100	9.500	9.900	10.500
16 (N=672)	9.130	0.499	8.400	8.600	8.800	9.000	9.400	9.800	10.281
17 (N=305)	9.026	0.474	8.218	8.500	8.700	9.000	9.300	9.600	10.182
18 (N=70)	9.023	0.476	8.300	8.400	8.700	9.000	9.300	9.500	10.074
Females									
Age (years)	Average	S.D.	P3	P10	P25	P50	P75	P90	P97
13 (N=109)	10.457	0.595	9.430	9.800	10.000	10.400	10.900	11.300	11.600
14 (N=439)	10.551	0.626	9.520	9.800	10.200	10.500	10.900	11.300	11.900
15 (N=437)	10.396	0.635	9.200	9.700	10.000	10.300	10.800	11.200	11.800
16 (N=615)	10.409	0.708	9.200	9.700	10.000	10.300	10.800	11.200	11.800
17 (N=230)	10.435	0.645	9.300	9.700	10.100	10.400	10.700	11.190	11.900
18 (N=37)	10.381	0.559	9.142	9.660	10.000	10.400	10.700	10.960	11.700

S.T.: Standard deviation.

In the medicine ball throw, it can be observed (Table 5) that the averages are significantly higher for males than for females ($p < 0.001$). Males improve appreciably with age ($F = 81.70$ $p < 0.001$) with the distance increasing by 2.82 m in the age range analysed. However, there was barely any variation among females. Figure 5 displays the discrepancies between males and females ($p < 0.001$).

Females had better physical performance than their male classmates in terms of flexibility (Table 6). This is the only test of those described

Table 3. Horizontal jump (centimetres).

Male									
Age (years)	Average	S.D.	P3	P10	P25	P50	P75	P90	P97
13 (N=104)	171.41	0.23	123.20	141.50	154.25	170.00	188.00	204.50	214.55
14 (N=457)	195.59	0.26	140.00	160.00	180.00	198.00	213.00	227.20	242.00
15 (N=697)	205.91	0.24	152.94	174.80	192.00	208.00	222.00	237.00	245.00
16 (N=677)	211.77	0.23	161.02	181.60	200.00	213.00	228.00	240.00	252.00
17 (N=304)	216.16	0.22	170.00	182.50	203.50	220.00	232.00	243.00	255.00
18 (N=70)	219.61	0.21	170.00	190.00	210.00	220.00	235.00	246.60	261.96
Female									
Age (years)	Average	S.D.	P3	P10	P25	P50	P75	P90	P97
13 (N=109)	155.84	0.21	110.10	123.00	141.50	156.00	173.00	182.00	196.70
14 (N=442)	153.06	0.21	110.00	127.00	140.00	152.00	167.00	180.00	195.00
15 (N=443)	158.11	0.26	107.00	123.00	143.00	160.00	175.00	187.60	209.76
16 (N=618)	158.55	0.23	115.00	130.00	143.00	160.00	173.00	185.00	210.00
17 (N=226)	157.04	0.24	120.00	129.40	141.50	154.50	173.00	182.30	203.38
18 (N=38)	157.13	0.31	55.34	129.00	145.00	162.00	176.00	181.40	209.96

S.D.: Standard deviation

Table 4. Running 50 m (seconds and split seconds).

Male									
Age (years)	Average	S.D.	P3	P10	P25	P50	P75	P90	P97
13 (N=46)	4.32	0.34	3.70	3.80	4.10	4.30	4.62	4.80	4.90
14 (N=146)	4.72	1.41	3.40	3.60	3.80	4.10	4.90	7.23	8.04
15 (N=239)	5.19	1.65	3.50	3.60	3.80	4.20	6.90	7.30	8.18
16 (N=216)	5.34	1.81	3.40	3.50	3.70	4.20	7.00	7.80	8.49
17 (N=108)	4.71	1.54	3.30	3.40	3.60	3.80	6.60	7.00	7.50
18 (N=34)	4.85	1.60	3.40	3.50	3.67	3.85	6.82	7.05	7.59
Female									
Age (years)	Average	S.D.	P3	P10	P25	P50	P75	P90	P97
13 (N=60)	4.41	0.27	3.87	4.10	4.30	4.40	4.60	4.70	5.00
14 (N=144)	6.10	2.05	3.90	4.20	4.40	4.80	8.37	8.95	9.56
15 (N=126)	6.16	2.12	3.88	4.00	4.30	4.70	8.20	8.73	9.91
16 (N=165)	6.48	2.05	3.99	4.20	4.50	7.40	8.30	8.90	9.70
17 (N=56)	6.31	2.02	3.57	4.27	4.60	4.90	8.20	8.83	9.73
18 (N=20)	7.33	1.73	4.20	4.34	5.45	8.10	8.60	8.98	9.70

S.D.: Standard deviation

in which they achieved better results ($p < 0.001$). It can be observed that the males increased trunk flex over the period analysed ($F = 8.25$ $p < 0.001$) yet their female classmates maintained more stable average values, which even reduced after 17 years. Figure 6 reveals the disparity between both sexes, which is significant in all ages ($p < 0.001$) except for in the 18-year old set ($p = 0.805$).

Table 7 reveals how the time taken for males in the 1,000 run reduces with age ($F = 8.49$ $p < 0.001$), whilst in the female series the values are

Table 5. Throwing medicine ball (metres).

Male									
Age (years)	Average	S.D.	P3	P10	P25	P50	P75	P90	P97
13 (N=103)	5.26	1.07	3.41	3.74	4.50	5.30	6.00	6.70	7.39
14 (N=465)	6.31	1.17	4.20	4.80	5.45	6.20	7.20	7.80	8.50
15 (N=702)	7.19	1.17	5.20	.70	6.30	7.20	8.00	8.77	9.50
16 (N=682)	7.62	1.29	5.25	6.10	6.70	7.60	8.50	9.40	10.10
17 (N=312)	7.95	1.43	5.20	6.30	7.10	7.90	9.00	9.80	10.60
18 (N=69)	8.08	1.47	5.14	6.40	7.00	8.20	9.15	10.00	10.80
Female									
Age (years)	Average	S.D.	P3	P10	P25	P50	P75	P90	P97
13 (N=109)	4.71	0.77	3.70	3.80	4.20	4.60	5.00	6.00	6.60
14 (N=440)	4.65	0.79	3.40	3.70	4.20	4.50	5.00	5.80	6.50
15 (N=448)	4.93	0.89	3.60	4.00	4.30	4.80	5.50	6.00	6.80
16 (N=637)	4.95	0.85	3.60	4.00	4.40	4.80	5.40	6.00	6.80
17 (N=240)	5.06	0.96	3.70	4.10	4.30	4.95	5.50	6.00	7.38
18 (N=38)	4.81	0.72	3.28	4.09	4.27	4.65	5.40	6.00	6.00

S.D.: Standard deviation

Table 6. Trunk flex (centimetres).

Male									
Age (years)	Average	S.D.	P3	P10	P25	P50	P75	P90	P97
13 (N=104)	5.327	7.213	-11.550	-1.500	1.000	4.500	9.000	15.500	21.850
14 (N=462)	5.619	7.580	-9.000	-4.000	1.000	6.000	10.000	15.000	20.000
15 (N=700)	7.579	6.853	-7.000	-2.000	3.000	8.000	12.000	15.900	21.000
16 (N=674)	8.798	7.578	-7.000	-1.000	4.000	9.000	14.000	18.000	21.750
17 (N=304)	7.954	8.095	-9.850	-3.000	2.000	9.000	14.000	18.000	21.000
18 (N=69)	9.377	8.048	-6.900	-4.000	5.000	11.000	15.000	17.000	23.000
Female									
Age (years)	Average	S.D.	P3	P10	P25	P50	P75	P90	P97
13 (N=110)	12.005	6.928	-2.670	4.100	7.000	11.500	17.000	20.000	24.670
14 (N=444)	12.689	6.369	0.000	4.000	9.000	13.000	17.000	21.000	24.000
15 (N=455)	12.545	7.229	-2.320	4.000	8.000	12.000	17.000	22.000	26.000
16 (N=652)	12.948	7.441	-1.410	4.000	8.000	13.000	18.000	23.000	26.000
17 (N=238)	11.483	7.137	-5.490	3.000	7.000	11.500	16.000	21.000	25.000
18 (N=39)	9.795	8.600	-13.800	0.000	5.000	9.000	16.000	22.000	26.400

S.D.: Standard deviation

more stable. This is confirmed upon checking that the result between the age extremes is four times less for females (0.35 min), than for males (1.57 min). There are significant discrepancies (Figure 7) between the markers of both sexes ($p < 0.001$ in all ages apart from 13 years in which $p < 0.05$), again higher for males than for females.

Discussion

The *Eurydice network,* adopted by 40 European countries including Spain and coordinated by the European Union Education, Audiovisual and Culture Executive Agency, has produced a report entitled *Physical*

Table 7. Running 1,000 m (minutes and tenths of a minute).

Male									
Age (years)	Average	S.D.	P3	P10	P25	P50	P75	P90	P97
13 (N=25)	5.66	1.84	3.44	3.57	4.36	5.12	6.27	8.79	10.02
14 (N=285)	4.46	0.97	3.33	3.41	3.58	4.28	5.04	5.52	7.07
15 (N=491)	4.34	0.99	3.25	3.37	3.55	4.20	4.52	5.37	6.45
16 (N=454)	4.24	0.99	3.20	3.35	3.49	4.15	4.45	5.28	6.66
17 (N=188)	4.22	0.90	3.23	3.38	3.53	4.14	4.40	5.29	6.43
18 (N=40)	4.09	0.61	3.29	3.40	3.54	4.10	4.34	4.49	6.18
Female									
Age (years)	Average	S.D.	P3	P10	P25	P50	P75	P90	P97
13 (N=29)	6.63	1.39	4.25	5.19	5.58	6.36	7.43	9.42	10.02
14 (N=299)	6.13	1.18	4.35	5.05	5.33	6.03	6.55	7.50	9.04
15 (N=315)	5.96	1.14	4.26	5.00	5.26	5.58	6.45	7.31	8.42
16 (N=418)	5.98	1.22	4.15	4.52	5.20	5.57	6.50	7.49	8.92
17 (N=153)	6.24	1.35	4.38	5.09	5.35	6.12	6.57	8.36	9.79
18 (N=26)	6.28	1.05	4.27	5.04	5.39	6.32	7.08	8.15	8.33

S.D.: Standard deviation

Figure 1. Comparison between sexes in abdominals in 30 seconds.

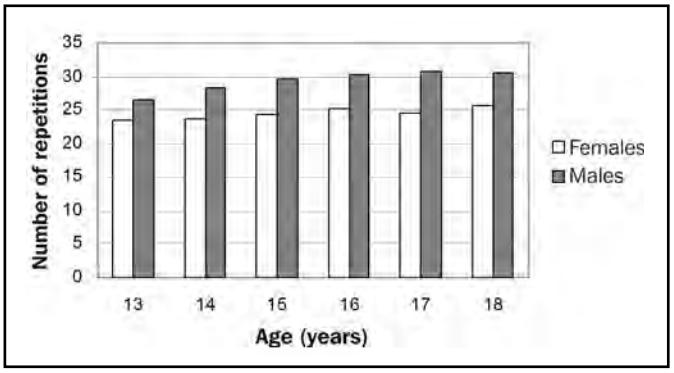


Figure 2. Comparison between sexes in running 9 m x 4.

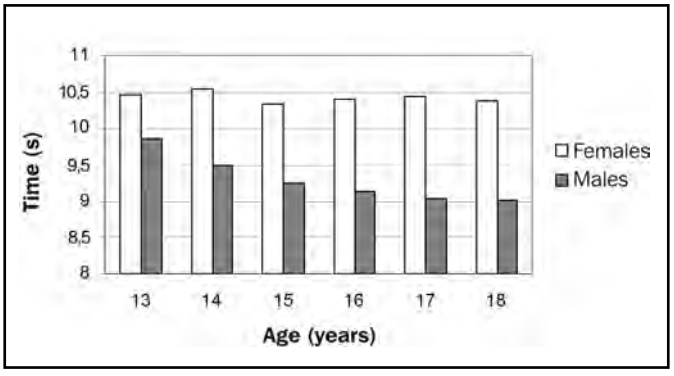


Figure 3. Comparison between sexes in horizontal jump.

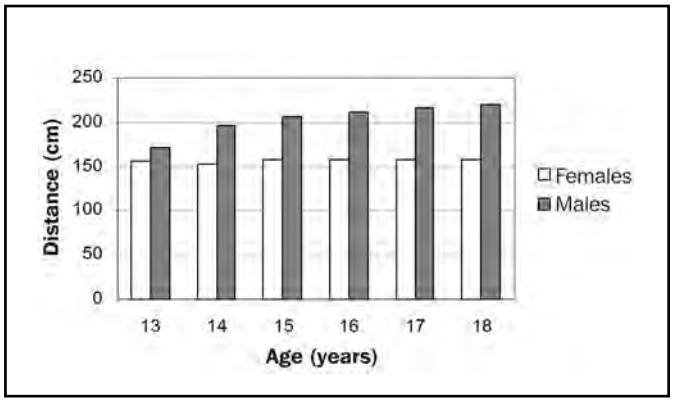


Figure 4. Comparison between sexes in running 50 m.

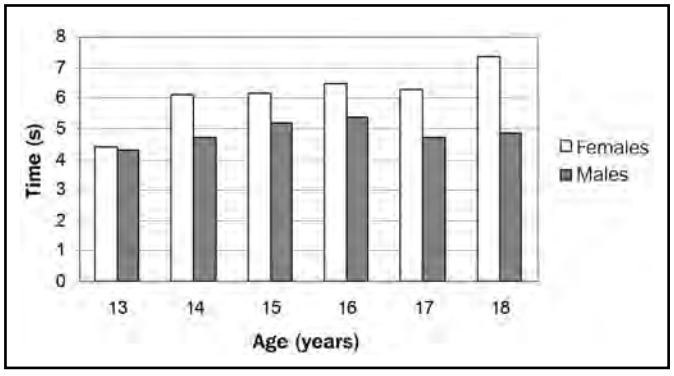


Figure 5. Comparison between sexes in throwing medicine ball.

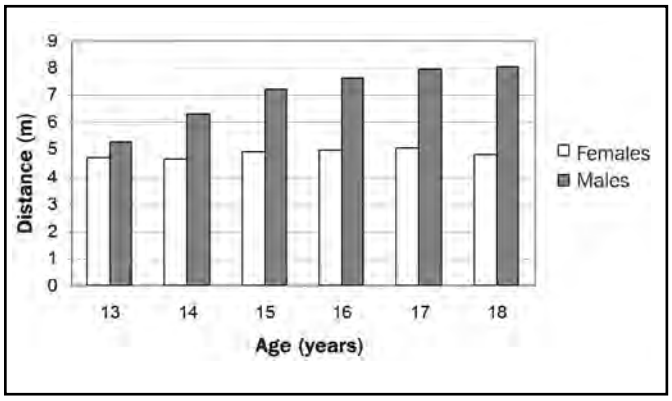


Figure 6. Comparison between sexes in trunk flex.

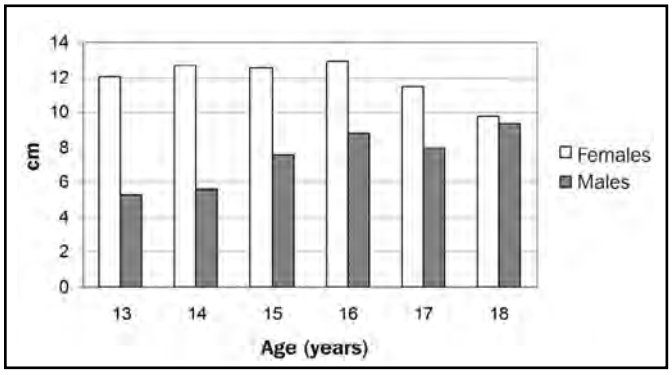
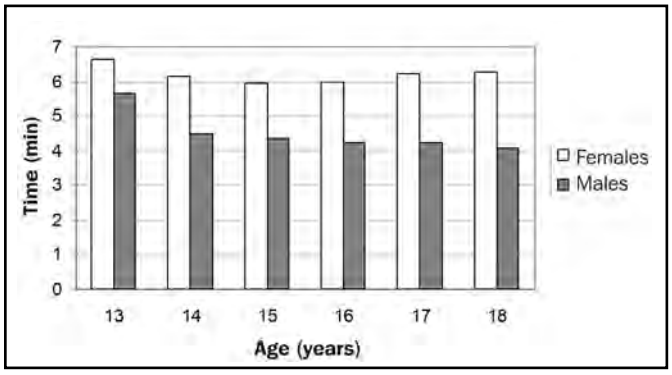


Figure 7. Comparison between sexes in running 1,000 m



Education and sports at school in Europe[23]. This report examines the current state of Physical Education and sporting activity in the schools of participating countries. For both primary and secondary schools, aspects such as the position of the subject, number of recommended teaching hours per stage, teacher qualification, etc. are analysed. It is important not to reduce the time dedicated to this regulated activity in the school curriculum, as for a high percentage of children, particularly girls, this is the only exercise they do[24].

In the cited *Eurydice* dossier, there is also an analysis of the way assessment processes are carried out, and it highlights the need to include the assessment of the physical condition of students in curricular contents. Some authors even indicate that it would be recommendable to do this for each educational stage in the different itineraries corresponding to a course[25]. To perform this assessment, updated reference models are needed, adapted to the demographic to be analysed, given that, as in many anthropometric values, physical condition also reveals secular and demographic variations.

In this respect, in research carried out on school children from North America, Australia, Denmark, the Baltic States and Venezuela[26-30] significant generational changes that affect the average marks obtained in specific aerobic-type tests, or included in the *Eurofit* test battery have been detected. Equally, a meta-analysis[31] that covers 77 studies from 23 European countries with a sample size of over a million students aged between 7 and 18 years notes the considerable variability between the performance of subjects from different nationalities, which could be a reflection of socio-cultural type issues, or the importance that each society grants the teaching and practice of exercise.

The need for suitable reference models has driven the development of different research studies in Latin America and Europe. As such, in Montería (Colombia), the physical capacities of aerobic resistance, strength, speed and flexibility were assessed among 612 students aged between 12 and 18 years, and the percentile ranges were established by age and by sex[32] for each of these functional capacities. Using similar methodology, but on a larger scale, a transverse study was carried out on 48,738 students from Bogota aged 7 to 18 years[33], with the aim of classifying the physical aptitudes of Colombian adolescents. Along this same line is another study[34], which examined 7,843 students of both sexes from the central region of Peru, from 6 to 17 years.

In terms of Europe, in Latvia, Sauka *et al.*[35], based on a transverse study on 10,464 students aged 6 to 17 years, have established *Eurofit* test battery reference values to be used, on the one hand, to evaluate the school population, and on the other hand, to eventually establish comparisons with other Nordic countries. In the same continent, the HELENA study has been undertaken *(Healthy Lifestyle in Europe by Nutrition in Adolescence)*[36] on a sample group of 3,428 adolescents aged between 12.5 and 17.5 years, recruited between 2006 and 2008 from 10 cities in Austria, Germany, Belgium, Spain, France, Greece, Hungary, Italy and Sweden.

However, all the aforementioned studies are based on transverse-type research, in which the subject is measured just once at a specific time. Furthermore, the majority include *Eurofit* test batteries that do not completely coincide with the normal protocol applied to Physical Education curricula in the different educational stages in Spain. Instead, the tests presented in this work are those habitually carried out in Spanish schools, they meet the methodology applied by Physical Education teaching staff and the results adhere to a semi-longitudinal study. As such, the exercises analysed are easily applied and do not require a large infrastructure or technology, meaning they could be performed in any educational institution. Consequently, the values reflected here can be used as a reference to assess the nutritional condition of students. To

some extent, these models complement those already published by researchers in our group, regarding the dynamometric hand strength of Spanish students[37].

Likewise, in all the tests analysed there is a clear sexual dimorphism, which coincides with the majority of the studies that assess these or other physical activities, both in adolescents and adults. In the field of young people, the values contributed by this research demonstrate that males obtain better results in all the tests that measure functional capacity, except for those that determine flexibility. In the male series, the physical condition assessed in different tests clearly increases with age, whilst for females, capacity levels tend to be more stable over the ontogenetic period studied; this fact coincides with that observed in preceding research studies38-41 that also analyse some of the tests shown here.

Conclusions

This investigation firstly enables the establishment of the physical aptitudes of Madrilenian students in the final two years of the ESO (3rd and 4th) and the two educational levels of the Baccalaureate (1st and 2nd). Likewise, all the values presented here can be used by the Physical Education teaching staff at the Madrid teaching centres, to assess the physical condition of their students.

At the same time, as the measurements are expressed in the form of averages, standard deviations and percentile value by age and sex, they can be used as reference model to characterise the physical condition (using strength, resistance, speed and flexibility tests) of young Madrilenians of both sexes, aged between 13 and 18 years.

Finally, it should be highlighted that in all the exercises analysed there is a clear difference between both sexes; males obtained better markers in all the tests, apart from the trunk flex in which females were better. Furthermore, for males there was a noticeable improvement in performance with age, whilst for females the values remained more similar over the period studied.

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PREMIOS FEMEDE A LA INVESTIGACION 2015

Los trabajos que han logrado los premios FEMEDE a la investigación en el año 2015, consistentes en la **publicación en la revista Archivos de Medicina del Deporte, junto con una dotación de 600 euros y el certificado acreditativo** son los que se relacionan a continuación con sus correspondientes autores:

- **María Perales**, por el trabajo titulado *"Fetal and maternal heart rate responses to exercise in pregnant women. A randomized Control Trial"*, con coautoría de Silvia Mateos, Marina Vargas, Isabel Sanz, Alejandro Lucia y Ruben Barakat.
- **Oriol Abellán-Aynés**, por el trabajo titulado "*Anthropometric profile, physical fitness and differences between performance level of Parkour practitioners",* con coautoría de Fernando Alacid.
- **Eliane Aparecida de Castro**, por el trabajo titulado *"Peak oxygen uptake prediction in overweight and obese adults"* con coautoría de Rocio Cupeiro, Pedro J. Benito, Javier Calderón, Isabel R. Fernández y Ana B. Peinado.

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