Changes in flexibility according to gender and educational stage

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ABSTRACT

Flexibility is one of the basic physical qualities that are worked on both in elementary and secondary education but not at the university stage. Of the four basic physical qualities, flexibility is the only quality that progressively diminishes with age.

We selected a sample of 410 subjects (42% males vs. 58% females) aged 6 to 30 years old from Granada and Almería. To collect data, the deep trunk flexion test was used, establishing that the mean flexibility among the sample was 22.25 cm. By gender, females (X = 22.82 cm) were more flexible than males (X = 21.46 cm). The highest flexor capacity values were achieved between the ages of 10 and 11 years, with these values steadily decreasing with age. Consequently, the highest peaks of flexibility were found in primary education (24.98 cm) while the lowest values were found in university education (19.50 cm).

Finally, as reported in the literature consulted, the results of this study found that average flexibility decreases with age.

KEY WORDS: Flexibility. Deep trunk flexion. University. College. School.

RESUMEN

La flexibilidad es una de las cualidades físicas básicas que se trabaja tanto en los ciclos de primaria como de secundaria, pero no en la etapa universitaria. De las cuatro cualidades físicas básicas, la flexibilidad es la única que disminuye conforme aumenta la edad.

Para realizar el estudio se ha contado con una muestra de 410 sujetos (42% varones frente al 58% de mujeres) de 6 a 30 años de Granada y Almería. Se empleó el test de flexión profunda de tronco para la recogida y toma de datos, estableciendo que la flexibilidad media de la población era de 22,25 cm. De igual forma, por sexos, las chicas (X = 22,82 cm) eran más flexibles que los varones (X = 21,46 cm). En cuanto a la evolutividad, es en el rango de 10 a 11 años cuando se alcanzan los valores más altos de capacidad flexora, produciéndose una disminución constante conforme aumenta la edad cronológica de los individuos, por lo que el nivel de enseñanza de primaria (24,98 cm) es el que mayores picos de flexibilidad presenta frente a los universitarios, que son los que obtienen los valores más inferiores (19,50 cm).

Finalmente, se ha determinado que al igual que toda la bibliografía consultada, la flexibilidad media disminuye conforme aumenta el rango de edad.

PALABRAS CLAVE: Flexibilidad. Flexión profunda de tronco. Universidad. Colegio. Escolares.

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Introduction

The concept of "physical fitness" (PF) has traditionally been sports-oriented with the objective of achieving external goals. From the seventies onwards, a new approach to this concept emerged that was centred on general health and improving the well-being of individuals.

Torres[1] and Bajo[2] define the basic physical qualities (motor skills or physical fitness qualities) as physiological predispositions that are innate in the individual and that can be measured and improved and facilitate movement and muscle tone. Therefore training and education have a significant impact on these qualities and can develop the potential of the physiological qualities inherited.

There are four basic physical qualities: stamina, strength, speed and flexibility. Flexibility was defined by Arregui[3] as the physical ability to perform a range of movements using one joint or a series of joints. He further developed Villar's[4] concept of flexibility as a quality associated with joint mobility and muscular elasticity and that facilitated the maximum range of motion of the joints in different positions and allowed the subject to perform actions that required an great deal of agility and skill, completed by Martínez[5] by using the elasticity of muscular fibres.

Araújo[6] maintains that this quality can be understood as the maximum passive physiological range of movement of a given joint movement. According to this approach, this range is specific to each joint and movement; in this way, in order to achieve a good level of flexibility, the muscular fibres should be able to relax and extend themselves depending on the different external conditions and the state of the body.

A number of problems emerge when studying flexor muscle performance and factors like sex, age, stage of growth and exercise will have some kind of impact. According to González[7] and Leiva De Antonio,[8] childhood and adolescence are the most important stages in life for acquiring behaviour patterns and life habits.

According to Torres[1] and Bajo[2], the main factors that affect flexibility are:

- Anatomical and biomechanical aspects; the joints and the movements they perform.
- Muscular and neurophysiological characteristics (elasticity, muscle tone, intramuscular and intermuscular coordination.)
- Age.
- Psychological status; activity level, motivation etc., favours or hinders movement.
- Environment; temperature, time of day, etc. influence the degree of mobility that can develop.
- Training and the level of exercise.
- Fatigue.
- Warm up.

According to Grosser,[9] greater flexibility is evident in children during the stages of development up until the age of 12. After this age, flexibility becomes more limited as the child gets older and consequently any changes in flexibility that occur are negative. The cause of this lies in the release of androgens and oestrogens in the body. According to Sánchez,[10] the greatest mobility can be identified in children aged 10 – 14. At this age, any work done to develop flexibility is twice as effective as that done by adults. Zurita[11] indicates specifically that flexibility decreases most significantly at the age of 12, which coincides with the onset of puberty.

Achour-Junior[12] highlights that assessing flexibility in individuals is important in order to understand their level of fitness and be able to develop exercise programmes with the aim of reaching the optimum fitness levels in different contexts, like a sporting environment or within the general context of maintaining good health and well-being. Flexibility is a quality that is developed as part of the curriculum in primary and secondary schools as shown in table I.

Working on flexor muscle performance is a crucial part of the curriculum in primary and secondary schools but not at university.

Some authors like Ramos,[13] Bale,[14] García,[15] Garcías[16] and Mc Dougall[17] have referenced the few studies that exist about the relationship between changes during the growth stages and exercise, physical qualities and the results achieved in sport and affirm that this subject should be studied in more detail in order to reach more specific conclusions about changes in flexor muscle performance. This is the reason behind this study and the objectives are as follows:

- Establish the mean flexibility of the study population.
- Show the relationship between deep trunk flexion and gender in the study population.
- Establish the changes in flexor muscle performance according to the age and level of education of the study population.

Materials and methods

This was a cross-sectional, descriptive study. The dependent variable was flexor muscle performance which was

Table I Flexibility as part of the curriculum at different educational levels

Level of education	Year	Physical quality	Content block	Contents
Primary	Year 1	Flexibility	Health	Physical conditioning (game play)
	Year 2		Health	Physical conditioning (game play)
	Year 3		Health	Physical conditioning (specific activities)
Secondary	Year 7		Physical conditioning and Health	Physical qualities
	Year 8		Physical conditioning and Health	Physical qualities
University			None	

measured using the deep trunk flexion test. The main problem in this study lay in obtaining reliable measurements for this variable. The expert teachers and scientists chosen presented a highly standardised protocol for intervention in this study. The corresponding reliability tests for the deep trunk flexion test were carried out in the same way and 60 male and female pupils aged between 8 and 12 were assessed. The first sessions which involved about 10 pupils were filmed. The footage was later analysed and discussed in a group session and the methodological aspects that could produce differences and/or mistakes during the data collection process were highlighted. The remaining 50 students were assessed in blocks of 10 and, after collecting the data in each group, the relationship between the data series of the different observers was established. The 6th block was considered the most reliable after the relationship between the collaborators' results in any of the given tests was over 95%, thereby establishing the corresponding test (r = 0.92) that produced low variability between assessors. The statistical analysis was carried out in SPSS version 13.0, which used contingency tables for the data analysis and the frequency analysis. The Student's t-test was used to compare means and Pearson's chi-square test was used to identify any links.

Sample selection

The selection process was based on the criteria established in the studies carried out by Casajús,[18] Ureña[19] and Zurita[11] with regard to the pedagogical objectives in the field of school children's health. The selection of the school and university study population was carried out using a combination of stratified, proportional and randomised sample selection techniques to include the following variables:

- Level of education: primary, secondary and university.
- Age groups: 6 to 30.
- Sex: male and female.

Our sample was made up of school children and university students from the provinces of Granada and Almeria. The study was based in the city of Almeria and in two schools in Granada's metropolitan area.

A total of six centres were selected (two primary schools, two secondary schools and two universities) from different areas, according to their characteristics (number of classes per year group, type of school and pupil characteristics), with the aim of obtaining a representative population sample. "Main" centres and "reserve" centres were chosen, which would be used in case any of the main centres declined to participate. Afterwards, a meeting between the person responsible for the programme and the head of the selected primary school, secondary school or university was arranged, during which they were given a letter/application addressed to the school board or university directors, explaining the whole process and requesting the centre's collaboration, following the approval of all the different bodies involved (school council, teachers, parents, medical staff, etc.) A standard modified letter template was requested in order to inform parents of the study and request authorisation to participate. In the case of the universities, the individuals themselves had to provide consent.

Once the proposal had been accepted, an agreement was reached regarding when and where the study would be carried out (in the gym or multipurpose classroom with an adjoining room), the rules to be followed (mainly in relation to the sports clothing to be worn) and the collaboration of the members of the centre (teachers, psychologists, etc.) In order to ensure anonymity, all subjects were identified using the number in their registration file which enabled us to send out personalised reports to the centres and to the parents of the school children

detailing the results obtained. Registration took place during February and March 2008.

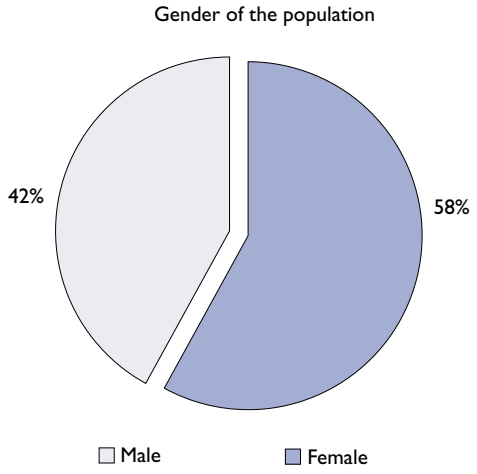
A sample of the population was taken and the natural composition of the groups in the chosen centres was taken into consideration. There were no other inclusion or exclusion criteria apart from consent to participate in the study which was 100%. The final sample used in this study was made up of 410 subjects aged 6 to 30 from the provinces of Granada and Almeria. The composition of the final sample reflected the natural composition of the groups in which 42% were male (n = 172) and 58% were female (n = 238), (fig. 1.)

The distribution of the subjects aged between 6 and 30 across the different centres was reasonably homogenous, as shown in table II, taking into consideration that the sample was made up of primary school children from Reception to Year 6 (n = 177), 116 (28.3%) secondary school pupils (Year 7 to Year 10) and 1st, 2nd and 3rd year Physiotherapy students (n = 117.) However, the age ranges in this last group are hardly representative although they were still included so that the groups would be 100% complete.

The ages of the individuals in this study (6 to 30) were grouped together in ranges that spanned 2 calendar years in order to show a greater proportion of individuals in each of the groups (table III.)

As table III shows, range 3 (10-11 years) has the best representation (n = 87). In contrast ranges 10, 11 and 12 have around 1% and were the least well represented.

Figure 1 Percentage of each sex in the sample.



Study variable

With regard to the study variable, a consistent test was carried out to assess flexor muscle performance, determined by the modifications in the vertebral column during anterior trunk flexion and the measurements obtained using the deep trunk flexion test, used by a number of authors such as Arregui,[3] Martínez,[5] Bajo[2] and Zurita.[11]

The test is carried out while the subject is standing barefoot with his/her heels positioned where zero is marked on the metre-stick. The subject begins the deep trunk flexion test by bending the knees and stretching as far back as possible with the hands (through the legs) in order to reach the metre-stick.

Table II Population distribution according to level of education

Level of education	n	Percentage
Primary	177	43.2
Secondary	116	28.3
University	117	28.5
Total	410	100.0

Table III Number of subjects and percentages per age range

Range	Age	n	Percentage
1	6-7 years old	44	10.57
2	8-9 years old	46	11.17
3	10-11 years old	87	21.50
4	12-13 years old	53	13.12
5	14-15 years old	63	15.51
6	16-17 years old	35	8.53
7	18-19 years old	39	9.51
8	20-21 years old	19	4.44
9	22-23 years old	8	2.00
10	24-25 years old	6	1.35
11	26-27 years old	5	1.15
12	28-29 years old	5	1.15

Certain rules must be followed when doing the test: the feet must stay on the floor or board at all times, the subject must keep his/her balance, leave the test from the front and not move until the distance has been measured. Two attempts were made and the best result was recorded, fractions of a centimetre were not taken into account and results were rounded to the nearest whole number. The equipment used was a wooden platform (0.76 by 0.88m) with a movable yardstick, as shown in figure 2.

Results

The analysis results established the mean flexibility by gender, age range and level of education in order to identify any possible relationships between the level of education and sex according to age, using the aforementioned software package SPSS version 13.0.

The mean flexibility of our population from Granada and Almeria was 22.25cm. Table IV shows that there were no statistically significant differences between the sexes (p = 0.06.)

Slightly better flexor muscle performance was identified in women (X = 22.82cm) compared to men (X = 21.46cm)

Figure 3 shows the mean flexibility of each range that spanned 3 calendar years.

This figure indicates that range 3 (10-11 years) obtained the highest mean flexibility (X = 25.71cm), and the subjects of range 12 (X = 14.40cm) obtained the lowest mean flexibility. These differences in the age ranges were reflected statistically (p = 0.00.)

In table V the mean flexibility of 24.98cm obtained by primary school children (n = 177) contrasted with a mean flexibility of 19.50cm obtained by university students in Almeria (n = 117.)

There are significant differences (p = 0.00) between the subjects from the three levels of education included in the study.

Figure 4 shows the mean flexibility results obtained by subjects according to age range and sex.

It is possible to deduce from figure 4 that female subjects from range 3 were the most flexible (X = 29.02cm), compared with a mean of 17.27cm which was obtained by the girls in range 8. Similarly, the mean of 29cm obtained by the males in range 10 cannot be considered reliable given that only one subject was tested and that the mean flexibility of range 12 was 10.50cm by comparison.

Finally, table VI shows the mean flexibility of the subjects from the different levels of education according to gender.

The mean flexibility of 27.38cm was obtained by primary school girls and was the highest result, compared to 19.23cm which was the lowest mean flexibility result obtained by female university students.

Figura 2 How a deep trunk flexion is performed.

Table IV Distribution of flexor muscle performance according to sex

Gender	Mean	N	Standard deviation	Variance
Male	21.46	172	7.253	52.612
Female	22.82	238	7.163	51.307
Total	22.25	410	7.223	52.176

Figure 3 Flexibility according to age range.

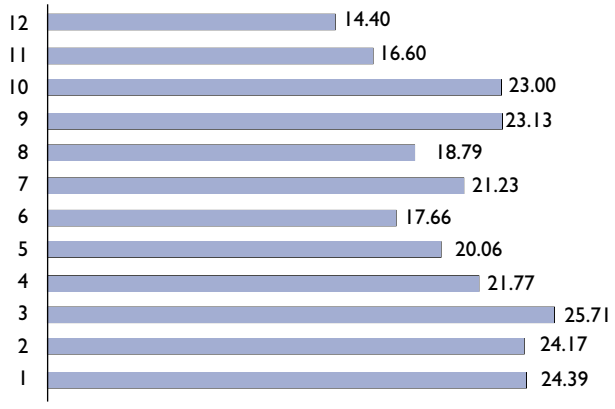


Table V Distribution of flexor muscle performance according to level of education

Level of education	Mean	N	Standard deviation	Variance
Primary	24.98	177	6.821	46.528
Secondary	20.84	116	6.210	38.567
University	19.50	117	7.356	54.114
Total	22.25	410	7.223	52.176

Discussion

The mean flexibility in our study (22.25cm), established using the anterior trunk flexion test, could not be checked against any figures in the literature consulted, since this data is not available. Similarly, there were no statistically significant differences with regard to sex (p = 0.06), although the trend is slightly higher among females, a finding which coincides with that of authors like Navarro,[20] Weineck[21] and Porta,[22] who mention greater flexor muscle performance among women compared to men, stating that one of reasons behind the differences between the sexes fundamentally lies in hormonal variations, given that oestrogen levels are higher in women and this produces water retention and a higher percentage of adipose tissue and lower muscle mass, making women anatomically more adept at executing a wider range of joint movements. Authors like Bale[14] and Maffuli[23] also support this view by adding that flexor muscle performance was more characteristic in females.

The changes in flexibility analysed in this study involving 410 subjects identified the greatest peak in flexor muscle performance in range 3 (10-11 years old), and a gradual decrease in flexibility as the age ranges increased, until reaching the minimum flexibility at level 12 (29-30 years old), as shown in figure 3. This data is similar to that produced by Docherty [24] and Grosser,[9] who established that decreasing flexibility began at the age of 12, and Sánchez,[10] who set the range at between 10 and 14 years of age. It appears that this data may be linked to the start of adolescent development, as established by Garagorri,[25] who stated that the growth spurt during puberty affects females at the age of 11, whereas in males it takes place 3 years later (aged 14.)

Figure 3, which shows the way flexibility changes with age, indicates increases in certain age ranges that do not concur with the literature consulted. This increase in mean flexibility

Figura 4 Comparative analysis of mean flexibility by sex in each of the age ranges.

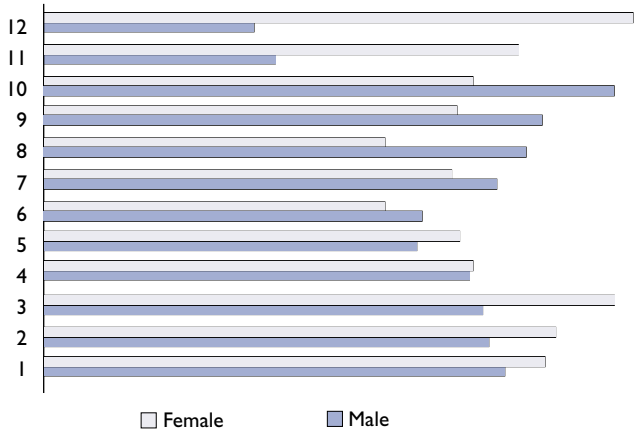


Table VI Distribution of flexor muscle performance of each sex according to level of education

Level	Male		Female	
	Mean	N	Mean	N
Primary	22.67	90	27.38	87
Secondary	20.08	51	21.95	65
University	20.23	31	19.23	86
Total	21.46	172	22.82	238

is caused by specific individuals from the university group who practiced sport at a semi-professional level and, in line with the findings of authors like Draper[26] and Grobbe,[27] who confirmed that this quality could be developed through training. This explains why considerable increases were identified in this age range when compared to similar age ranges with subjects who did not do any training.

Primary school children obtained the greatest mean flexibility (table IV), and university students demonstrated the worst flexor muscle performance. Zaragoza[28] in 2004 stated that flexibility decreased with age in his study on subjects aged between 20 and 64. Secondary school pupils presented very similar results to university students, which indicates that deep trunk flexion increases until the age of 12 or Year 6 in primary school (the final year of Spanish primary schools), and is followed by a sharp decrease until secondary school. The

downward trend continues more steadily after this, confirming the findings of Brent[29] and Sánchez.[10]

With regard to age range and sex, the data from our study only confirms what has already been established by Mafulli[23] (1994) and Arregui[3] (2001), who stated that females demonstrate greater mean flexibility and that this decreases with age. These findings correspond with the results in figure 4 that show the same trend in relation to the level of education and sex.

Conclusions

The conclusions of this study are as follows:

- The maximum mean flexibility of our study was obtained in range 3 (10-11 years) which coincides with the onset of puberty.
- Women have greater mean flexibility than men across most of the age ranges and different levels of education although there are no significant differences between the sexes.
- Flexor muscle performance increases until the age of 12 which coincides with primary level education. It progressively decreases from this age onwards. Older university students were the least flexible, which indicates that flexibility decreases with age, with the exception of the age ranges that included sportsmen or women who were responsible for peaks in flexibility in the results.

References

1. Torres J. Teoría y práctica del entrenamiento deportivo. Consideraciones didácticas. Granada: Torres Guerrero; 1996.
2. Bajo S. La flexibilidad y la educación física escolar: evolución y aplicación en la escuela. En: Guillén del Castillo M, editor. Medicina deportiva y educación física en edad escolar. Córdoba: Universidad de Córdoba, Servicio de Publicaciones; 2003. p. 421-40.
3. Arregui Eraña JA, Martínez de Haro V. Estado actual de las investigaciones sobre la flexibilidad en la adolescencia. Revista internacional médica de las ciencias de la actividad física y el deporte. 2001;1:127-135.
4. Álvarez del Villar C. La preparación física del fútbol basada en el atletismo. Madrid: Gymnos; 1987.
5. Martínez López EJ. La flexibilidad: pruebas aplicables en educación secundaria-grado de utilización del profesorado. Revista Digital, Educación Física y Deportes. 2003;8:58.
6. Araujo C. Flexitest: an innovative flexibility asseessment method. Champaing: Human Kinetics; 2003.
7. González Montesinos JL, Martínez González J, Mora Vicente J, Salto Chamorro G, Álvarez Fernández E. El dolor de espalda y los desequilibrios musculares. Revista internacional médica de las ciencias de la actividad física y el deporte. 2004;4:18-34.
8. Leiva de Antonio JH. Capacidades físicas de trabajos de la población en edad escolar, matriculada en instituciones educativas de la ciudad de Cali. Colombia: Revista Corpus; 2000.
9. Grosser M, Müller H. Desarrollo muscular: un nuevo concepto de musculación (power-stretch). Barcelona: Hispano-Europea; 1992.
10. Sánchez EG, Águila MQ, Rojas JY. Consideraciones generales acerca del uso de la flexibilidad en el béisbol. Revista Digital, Educación Física y Deportes. 2001;7:2001.
11. Zurita F. Screening de las alteraciones raquídeas (escoliosis e hipercifosis) en la población escolar de 8 a 12 años de Granada y provincia. Tesis doctoral. Granada: Universidad de Granada. 2007.
12. Achour-Junior A. Bases para exercícios de alongamento, relacionando com a saúde e no desempenho atlético. 2.ª edicao. Sao Paulo: Phorte Editora; 1999.
13. Ramos D, González J, Mora J. Diferencias en las amplitudes articulares entre varones y mujeres en edad escolar. Apunts. 2007;42: 153.
14. Bale P, Mayhew J, Ball TE, Williman MK. Biological and performance variables in to age in male and female adolescent athletes. J Sports Med Phys Fitness. 1992;32:142-8.
15. García JM. Bases teóricas del entrenamiento deportivo. Principios y aplicaciones. Madrid: Gymnos; 1996.
16. Garcías D, Capablo M. Valoración y estudio de las deformaciones ortopédicas en personas con parálisis cerebral. Revista Fisioterapia. 1999;21.
17. Mac Dougall JD, Wenger HA, Green HJ. Evaluación fisiológica del deportista. Badalona: Paidotribo; 1995.
18. Casajús J. Actividades físicas en el niño en edad escolar; características antropométricas, composición corporal y madurez. Tesis doctoral. Zaragoza: Universidad de Zaragoza; 1990.
19. Ureña F. Valoración y baremación de la aptitud física en el alumnado de 2.º ciclo de Educación Secundaria obligatoria de la comunidad autónoma de Murcia. Su utilización según los postulados de la reforma. Tesis doctoral. Murcia: Universidad de Murcia; 1996.
20. Navarro M. La condición física en la población adulta de la isla de Gran Canaria y su relación con determinadas actitudes y hábi-

tos de vida. Tesis doctoral. Las Palmas: Universidad de las Palmas de Gran Canaria; 1998.
21. Weineck J. Entrenamiento óptimo. Barcelona: Hispano-Europea; 1988.
22. Porta J, Martín R. Metodología del entrenamiento para el desarrollo de la velocidad y la flexibilidad. Módulo 2.2.3. Madrid: Centro Olímpico de Estudios Superiores; 1993.
23. Maffulli N, King JB, Helms P. Training in elite young athletes (the Training of Young Athletes TOYA): injuries, flexibility and isometric strengt. Br J Sports Med. 1994;28:123-36.
24. Docherty D, Bell RD. The relationship between flexibility and linearity measures in boys and girls 6-15 year of age. Journal of Human Movement Studies. 1995;11:279-88.
25. Garagorri JM. Hipercrecimientos: Sistema diagnóstico. An Esp Pediatr. 2004;60 Supl 4:291-5.
26. Draper O. The carry-over effects of diathermy and stretching in developing hamstring flexibility. J Athletic Training. 2002;37:37-42.
27. Grobbe B. Reliability of common coger extremity muculoskeletal screening tests. Physical Therapy in Sport. 2004;5:90-7.
28. Zaragoza J. La medición de la educación física saludable: aplicación de la batería de Eurofit para adultos. Revista digital de Buenos Aires. 2004;10:68.
29. Brent JW, Myrer W, Merrill RM. Acute changes in hamstring flexibility: PNF versus Static Stretch in senior athletes. Physical Therapy in Sport. 2001;2:183-93.