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Universidad Nacional de La Plata.
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Departamento de Educación Física

How do students' hamstring extensibility levels change through an academic year? A longitudinal study

¿Cómo cambian los niveles de extensibilidad isquiosural de los estudiantes durante un año académico? Un estudio longitudinal

Carlos A. Becerra-Fernández *; Daniel Mayorga-Vega **; Rafael Merino-Marban***

*Instituto de Educación Secundaria les Sagrado Corazón, Málaga, Spain; **Department of Physical Education and Sport, University of Granada, Spain; ***Facultad de Ciencias de la Educación, Universidad de Málaga (UMA), España | cabeccerrafernandez@sinmal.com ; dmayorgavega@gmail.com ; rmerino@uma.es

**Although the study was design and performed while Daniel Mayorga-Vega was working at the University of Granada, currently he works as a Full-time Professor at the University of Jaen.

KEYWORDS

Flexibility

Shortened hamstring extensibility

Classic sit-and-reach test

Decrease

Adolescents

ABSTRACT

The main purpose of the present study was to examine the students' hamstring extensibility levels through an academic year. A sample of 128 11th-grade students from a high school center was assessed by the classic sit-and-reach test in pre-, mid- and post-academic year. The results showed that students' hamstring extensibility level statistically significantly decreased from pre-academic year (22.1 ± 8.5 cm) to mid- (19.9 ± 8.6 cm; d = -0.26) and post-academic year (18.6 ± 9.3 cm; d = -0.41) ($p < 0.001$) and from mid-academic year to post-academic year (d = -0.16) ($p < 0.001$). The results of the McNemar's test indicated that there was a statistically significant decrease on the proportion of students with normal hamstring extensibility level from pre-academic year to post-academic year ($p < 0.05$). In conclusion, high-school students lost hamstring extensibility levels during an academic year. As a result of this decrease, the number of students with hamstring extensibility shortening increased by 10.9%. Physical education teachers should implement stretching programs to avoid students' hamstring extensibility shortening.

PALABRAS CLAVES

Flexibilidad

Acortamiento isquiosural

Prueba *classic sit-and-reach*

Disminución

Adolescentes

RESUMEN

El objetivo principal del presente estudio fue examinar los niveles de extensibilidad isquiosural de los estudiantes durante un curso académico. Una muestra de 128 estudiantes de 1º de bachillerato de un centro de educación secundaria se evaluó mediante la prueba de *classic sit-and-reach* al comienzo, mediados y final del curso académico. Los resultados mostraron que el nivel de extensibilidad de isquiosural de los estudiantes disminuyó estadísticamente significativamente desde el comienzo (22,1 ± 8,5 cm) a mediados (19,9 ± 8,6 cm, d = -0,26) y final del año académico (18,6 ± 9,3 cm; d = -0,41) ($p <$ 0,001), y desde mediados al final (d = -0.16) ($p < 0,001$). Los resultados de la prueba de McNemar indicaron que hubo una disminución estadísticamente significativa en la proporción de estudiantes con un nivel de extensibilidad isquiosural normal desde el comienzo al final del curso académico ($p < 0,05$). En conclusión, los estudiantes de educación secundaria perdieron niveles de extensibilidad isquiosural durante un curso académico. Como resultado de esta disminución, el número de estudiantes con acortamiento de los músculos isquiosurales aumentó un 10,9%. Los profesores de educación física deberían implementar programas de estiramiento para prevenir el acortamiento de extensibilidad isquiosural de los estudiantes.

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Introduction

Hamstring extensibility is characterized to be in a permanent involution process along age (Chodzko-Zajko et al., 2009). Because of the high prevalence of physical inactivity, sedentary behaviours and bad postures, cases of muscle tension and shortenings increase considerably in children (Kanásová, 2008; Penha & Amado Joäo, 2008) and adolescents (Vidal, Vidal, Almela, & Vidal, 2011; Huang & Malina, 2007).

Currently low hamstring extensibility affects a large number of school population (Santonja & Pastor, 2003). For instance, in Spain over one in five adolescents have limited hamstring extensibility (Castro-Piñero et al., 2013; Ortega et al., 2005). Therefore, health promotion policies should also be designed to identify adolescents with low hamstring extensibility, as well as to encourage them to achieve health-related flexibility levels (Ortega et al., 2008).

The subject of school physical education (PE) might play an important role in this public health issue. Particularly, hamstring muscle shortening is the locomotors pathology more likely to be addressed proactively by a systematical performance of stretching exercises during PE sessions (Santonja Medina, Sainz de Baranda Andújar, Rodríguez García, López Miñarro, & Canteras Jordana, 2007; Thacker, Gilchrist, Stroup, & Kimsey, 2004).

Kanasova (2008) observed the hamstring extensibility levels of 10-12 year-old boys from elementary schools through two academic years. The results showed a high prevalence of shortened hamstrings, increasing to 89% after the 5th year of elementary school. Unfortunately, to our knowledge there are no previous longitudinal studies examining high-school students' hamstring extensibility levels through an academic year. Consequently, the main purpose of the present study was to examine the students' hamstring extensibility levels through an academic year. A secondary purpose of this study was to compare the changes on students' hamstring extensibility levels after the academic year according to their flexibility baseline.

Methodology

Participants

A sample of 128 students, 50 boys and 78 girls, from four different 11th-grade of a public-private high school center (i.e., 16-17 years old) participated in the present study. All the participants were free of orthopedic disorders such as episodes of hamstring and/or lumbar injuries, fractures, surgery or pain in the spine or hamstring and/or lumbar muscles over the previous six months (López-Miñarro, Sainz de Baranda, & Rodríguez-Garcia, 2009).

Procedure

Students' hamstring extensibility was assessed by the standardized protocol of the classic sit-and-reach (CSR) test in pre-, mid- and post-academic year. A detailed description of the CSR protocol has been published elsewhere (Mayorga-Vega, Merino-Marban, & Garcia-Romero, 2015). Briefly, at the beginning of the test, the students in sportswear and barefoot stood in front of the box, sat with their hips flexed, knees extended and both hands on the top of the ruler. From this position, the students had to bend the trunk forward slowly and progressively (no swings) in order to reach the furthest possible distance and to remain still for at least two seconds. Two trials were performed one minute apart, and the average was retained (Mayorga-Vega et al., 2015).

The CSR test was applied by the same tester, instrument and environmental conditions. The instrument consisted of a wooden box with a ruler at the top where the tangent of the feet corresponded to the score 23 cm (accuracy 0.1 cm). The measurements were performed in an indoor sports facility under similar environmental conditions (e.g., temperature equal to 21-23ºC), on the same day of the week and at the same

time for each student. Because of practical reasons, no warming up exercises was performed prior to the flexibility measurements. Students' hamstring extensibility was categorized as follows: < 21.0 cm low and ≥ 21.0 normal hamstring extensibility (Ferrer, 1998). The CSR test has demonstrated high reliability (ICC = 0.99) (Ayala et al., 2012) and adequate criterion-related validity (r_p = 0.67, 0.55-0.79) among adolescents (Mayorga-Vega, Merino-Marban, & Viciana, 2014).

Statistical analysis

Descriptive statistics (means ± standard deviations/ frequency) for general characteristics and CSR scores were calculated. The reliability of the CSR scores was estimated using the intraclass correlation coefficient from the two-way ANOVA (Shrout & Fleiss, 1979), as well as the 95% confidence interval. Afterward, the changes on students' hamstring extensibility levels through the academic year were examined using the repeated measures ANOVA applied over the CSR scores (pre-academic year, mid-academic year, post-academic year). Subsequently, the *post hoc* analyses with the Bonferroni adjustment were used for the within-groups pairwise comparisons. Moreover, the Cohen's *d* effect size was used to examine the magnitude of the changes (Cohen, 1988). The minimal detectable change was also calculated in order to examine if the change score was true and reliable rather than the measurement error (Haley & Fragala-Pinkham, 2006). On the other hand, the McNemar's test was calculated to examine the changes on the proportion of students with normal hamstring extensibility level after the academic year. Finally, the two-way ANOVA, Cohen's *d*, and minimal detectable change were calculated in order to examine the changes on students' hamstring extensibility levels after the academic year according to their flexibility baseline. Since interaction effects between boys and girls were not found, all statistical analyses were performed with the whole sample. All statistical analyses were performed using the SPSS version 21.0 for Windows (IBMR SPSS® Statistics 21). The statistical significance level was set at $p < 0.05$.

Results and discussion

The general characteristics of the participants studied are the following: body mass = 63.3 ± 9.9 kg, body height = 171.9 ± 9.8 cm and body mass index = 21.4 ± 2.4 kg/m ^{2}. The reliability of the SR scores was 0.98 (0.97- 0.99). Figure 1 shows the changes on students' hamstring extensibility levels through the academic year. The results of the repeated measures ANOVA on the average obtained in the CSR test showed statistically significant changes [$F(2, 254) = 70.734$; $p < 0.001$; $\eta^2_p = 0.358$]. Subsequently, the within-group pairwise comparisons with the Bonferroni adjustment showed that students' hamstring extensibility level statistically significantly decreased from pre-academic year (22.1 ± 8.5 cm) to mid- (19.9 ± 8.6 cm; d = -0.26) and post-academic year (18.6 ± 9.3 cm; d = -0.41) ($p < 0.001$) and from mid-academic year to post-academic year (d = -0.16) ($p < 0.001$). The minimal detectable change value of the CSR score was 3.2 cm, when the absolute average decrease from pre- to post-academic year was 3.5 cm. However, the absolute average changes from pre- to mid-academic year (2.2 cm) and from mid- to post-academic year (1.3 cm) were below this threshold.

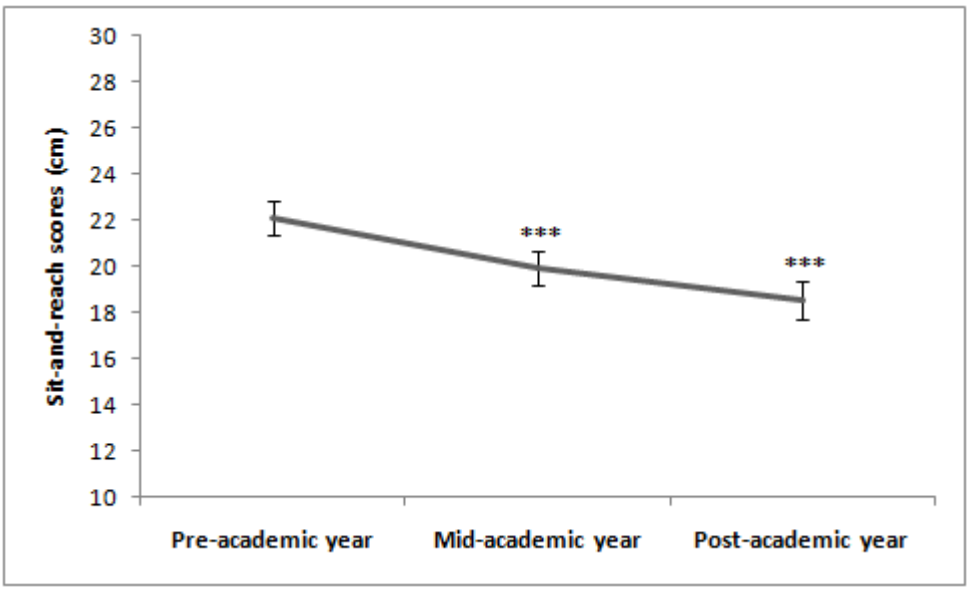

Figure 1. Changes on students' hamstring extensibility levels through the academic year (classic sit-and-reach scores, cm). The values represent the mean and the error bars the standard error. Repeated measures ANOVA ($p < 0.001$) followed by the within-groups pairwise comparisons (*** $p < 0.001$ for all comparisons).

Table 1 shows the changes on the proportion of students with normal hamstring extensibility level after the academic year. The results of the McNemar's test showed that there was a statistically significant decrease on the proportion of students with normal hamstring extensibility level from pre-academic year to post-academic year ($p < 0.05$).

Table 1. Changes on the share of students with normal hamstring extensibility level after the academic year. **Data are reported as frequency (% total).**

		Post-academic year			McNemar's test
		Low	Normal	Total	*p*
Pre-academic year	Low	54 (42.2%)	4 (3.1%)	58 (45.3%)	0.031
	Normal	14 (10.9%)	56 (43.8%)	70 (54.7%)	
	Total	68 (53.1%)	60 (46.9%)	128 (100%)	

Figure 2 shows the changes on students' hamstring extensibility levels after the academic year according to their flexibility baseline. The results of the two-way ANOVA on the average obtained in the CSR test did not show statistically significant interaction effect between the *group* and *time* variables [$F(2, 252) = 1.388$; $p = 0.250$; $\eta^2_p = 0.011$]. Subsequently, the within-group pairwise comparisons with the Bonferroni adjustment showed that both low and normal groups had a statistically significant decrease in hamstring extensibility from pre-academic year (14.4 ± 5.0 and 28.5 ± 4.6 cm, respectively) to post-academic year (10.9 ± 6.0 cm, $d = -0.41$, and 24.9 ± 6.1 cm, $d = -0.42$, respectively) ($p < 0.001$). The absolute average change in the students with low and normal hamstring extensibility (3.5 and 3.6 cm, respectively) was above the minimal detectable change value (i.e., 3.2 cm).

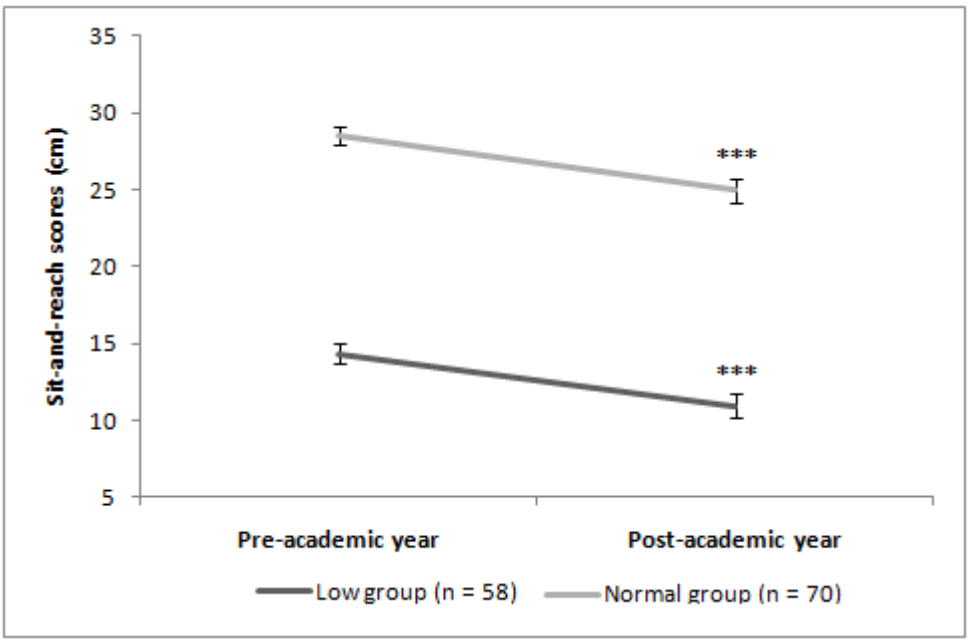

Figure 2. Changes on students' hamstring extensibility levels through the academic year according to their flexibility baseline (classic sit-and-reach scores, cm). The values represent the mean and the error bars the standard error. Two-way ANOVA ($p > 0.05$) followed by the within-groups pairwise comparisons (*** $p < 0.001$).

The main purpose of the present study was to examine the students' hamstring extensibility levels through an academic year. The results of this study indicated that high-school students lost flexibility hamstring levels during an academic year. Additionally, as a result of this decrease, the number of students with hamstring shortness increased by 10.9%. Therefore, it may be essential to perform specific hamstring stretching programs as a part of PE classes in order to avoid a decrease in hamstring extensibility levels during an academic year.

Several previous studies have shown that a PE-based stretching program improves students' hamstring extensibility in experimental groups of secondary schoolchildren, while all control groups showed a statistically significant decrease throughout time (Becerra-Fernandez, Merino-Marban, & Mayorga-Vega, 2016; Mayorga-Vega, Merino-Marban, Real, & Viciana, 2015; Sainz de Baranda, 2009; Van Resbourg & Coetzee, 2014; Rodríguez, Santonja, López-Miñarro, Sáinz de Baranda, & Yuste, 2008). For instance, these previous studies found a reduction in the control groups score of 0.7-2.3 cm after 4-32 weeks of an academic year. Similar results were found in the present study, where the absolute average decrease from pre- to post-academic year was 3.5 cm.

Regarding the number of students with shortened hamstring extensibility, Castro-Piñero et al. (2013) administrated the sit-and-reach test to girls and boys of different ages in a cross sectional study and they observed that 17.8% of boys and 25% of girls were under normal limits of hamstring extensibility. On the other hand, Vidal et al. (2011) compared the levels of flexibility in adolescents from different generations in a cross sectional study. The results showed that there was a significant increase in cases of hamstring shortness, from 5.13% in 1986 to 20% in 2008.

The decrease in students' hamstring extensibility levels also appears to be significantly through the same academic year. For instance, Kanásová (2008) found a high prevalence (up to 89%) of shortened hamstring muscles in 10-to-12-year-old students. In the study by Rodríguez et al. (1999), the data obtained in the previous test indicated that 77% of adolescents were within normal limits, while 23% suffered from

shortness. In the subsequent test, however, subjects with hamstring shortness amounted to 38.4%. In the present study, the data obtained in the post-academic year showed that 53.1% of students were under normal limits, having increased in 7.8% according to the cases of students with hamstring shortness in the pre-academic year.

A secondary purpose of the present study was to compare the changes on students' hamstring extensibility levels after the academic year according to their flexibility baseline. The results of this study showed that there was not an influence of students' flexibility baseline on the changes on their hamstring extensibility levels through the academic year. The results also indicated that students with both low and normal flexibility had a decrease in hamstring extensibility from pre-academic year to post-academic year (3.5 and 3.6 cm, respectively). Unfortunately, to our knowledge there are no studies examining the influence of the high-school students' flexibility baseline on the changes on their hamstring extensibility levels through an academic year. However, Mayorga-Vega, Merino-Marban, Manzano-Lagunas, Blanco and Viciana (2016) examined the influence of children's hamstring extensibility baseline on the effect of a PE-based stretching intervention program. In contrast to the results of the present study regarding the "natural" evolution, these authors found that meanwhile the improvement was high among the children with low hamstring extensibility, for the classmates with normal flexibility baseline levels the improvement was low.

According to Vidal et al. (2011), one of the reasons for this significant increase in cases of hamstring shortness could be due to the change of lifestyle that has been imposed in recent years, in which there is an abuse of new technologies and sedentary behaviours, factors that also reduce the time of physical activity. The results of the present study may be interesting for PE teachers in order to know the changes that occur naturally in the adolescents' flexibility during an academic year. Traditional PE lessons are not sufficient to prevent this loss of flexibility along the course, unless specific stretching programs and tests are integrated in them. Many studies have defended the implementation of these programs because they *improved the students' flexibility during the PE classes.* Moreover, it prevented an increase of shortened cases at medium and long term, by maintaining the high school student values above the common decline of flexibility levels at this age (Becerra-Fernandez, Merino-Marban, & Mayorga-Vega, 2016; Mayorga-Vega, Merino-Marban, Real, & Viciana, 2015; Sainz de Baranda, 2009; Van Resbourg & Coetzee, 2014).

Conclusions

During an academic year not only the students' average hamstring extensibility level decreased, but also the number of students with normal hamstring extensibility. It seems that there is not an influence of students' flexibility baseline on the changes on their hamstring extensibility levels through the academic year.

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