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Original article

Effect of physical education stretching programme on sit-and-reach score in schoolchildren

Effet d'un programme d'étirement musculaire sur le test *sit-and-reach* chez des écoliers

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Abstract

Aims of the study. – Limited hamstring flexibility has been proposed as a possible cause of low-back pain. Different hamstring stretching programmes have showed improvement, but few studies have been conducted in physical education classes. Thus, this study aims to test whether an improvement in sit-and-reach score could be achieved in schoolchildren and adolescents performing hamstring-stretching exercises in physical education classes.

Materials and methods. – Forty-six elementary schoolchildren (mean age of 10.27 ± 0.31 years) and 44 secondary school adolescents (13.46 ± 0.68 years) were assigned to control ($n = 41$) or experimental groups ($n = 49$). The experimental group (elementary and secondary groups) performed 5 min of hamstrings stretching during the two weekly physical education classes for a period of 32 weeks. The control group (elementary and secondary groups) followed the standard class programme and did not participate in any hamstring-stretching programme. Hamstring flexibility was evaluated through the sit-and-reach test, performed both before and after the 32-week hamstring-stretching programme.

Results. – The score increased in both secondary (+7.22 cm; $p < 0.001$) and elementary (+1.95 cm; $p > 0.05$) experimental groups, whereas the score decreased in the control groups (−4.38 cm; $p < 0.001$ in the elementary group and −2.31 cm; $p > 0.05$ in the secondary group).

Conclusion. – A hamstring flexibility programme should be incorporated to physical activities at school to prevent decrease of hamstring muscle extensibility.

Résumé

Objectifs. – La diminution de l'extensibilité des muscles ischiojambiers a été associée à la douleur lombaire. Différents programmes dïétirement de ces muscles ischiojambiers ont montré des améliorations de celle-ci, mais peu d'études ont été réalisées lors des cours d'éducation physique et sportive.

Méthodes. – Quarante-six écoliers du primaire (moyenne d'âge de $10{,}27 \pm 0{,}31$ ans) et 44 collégiens du secondaire ($13{,}46 \pm 0{,}68$ ans) ont été assignés au groupe témoin ou expérimental. Le groupe expérimental (groupes du primaire et secondaire) a réalisé cinq minutes d'étirement des muscles ischiojambiers lors des deux séances hebdomadaires d'éducation physique et sportive pendant 32 semaines. Le groupe témoin (groupes du primaire et du secondaire) a suivi les cours normaux, sans participer au programme d'étirement. La souplesse a été évaluée avant et après les 32 semaines avec le test *sit-and-reach*.

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Résultats

Le score au test *sit-and-reach* a été amélioré pour le groupe expérimental du primaire (+ 1,95 cm ; $p > 0,05$) et du secondaire (+ 7,22 cm ; $p < 0,001$) tandis que les groupes témoins ont montré une réduction du score (−4,38 cm ; $p < 0,001$, en primaire et −2,31 cm ; $p > 0,05$ en secondaire).

Conclusion. – Un programme d'étirement des muscles ischiojambiers devrait être incorporé dans les activités physiques scolaires pour prévenir la diminution de l'extensibilité de ce groupe musculaire.

Keywords: Schoolchildren; Adolescent; Stretching programme; Hamstring flexibility

Mots clés : Écoliers ; Collégiens ; Programme d'étirement ; Flexibilité des muscles ischiojambiers

1. Introduction

Measurement of flexibility is an important component of fitness testing. Hamstring flexibility is recognised as an important component of physical fitness and plays a substantial role in protecting the spine from possible risk [1]. The reported incidence of reduced hamstring muscle length is frequent in children and adolescents [2,14,22] and has been associated with low-back pain [8,17,20,31], spinal deformity [9,17], herniated disk [31,35], and changes in lumbopelvic rhythm [6].

It has been suggested that hamstring flexibility significantly improves when hamstring-stretching exercises are performed systematically. Many studies in young adults have examined different hamstring stretching programmes (from 2 to 12 weeks, 2–7 times per week, holding each stretch for 9–30 s) in an attempt to determine the most effective methods for increasing hamstring flexibility [3,5,11,12,21,26,27,32].

Several studies have examined the effects of a hamstring-stretching programme on hamstring flexibility of children and adolescents. Nelson and Bandy [23] measured hamstring flexibility in high-school — aged 15–17 years old — after a six-week programme of static stretching for 30 s at three days per week and found a significant improvement. Reid and McNair [25] found that six weeks of static stretches for the hamstring muscles resulted in an increase on knee extension range of movement for adolescent school males. Zakas et al. [34] found a significant improvement in hamstring extensibility in prepubertal, pubertal and adolescent boys after a school physical programme that incorporated static stretching as part of strength training, while no significant differences were revealed for the control group that participated only in the school physical activities.

Other studies investigated the effect of strength training on the lower and upper extremities range of motion. These studies incorporated stretching exercises during strength training and found significant improvement in the hamstring flexibility of the children and adolescent subjects [28,29,33].

However, the effects of hamstring stretching programme in physical education classes have not yet been examined in children and adolescents. The aim of the present study was to test whether an improvement in sit-and-reach score could be achieved in school children and adolescents performing some minutes of hamstring stretching exercises in physical education classes.

2. Material and methods

2.1. Participants

Forty-six elementary schoolchildren (20 boys and 26 girls, in their fifth year) and 44 secondary adolescent students (21 boys and 23 girls, in their second year) from public schools in Murcia, Spain, were randomly assigned to control and experimental groups for each of the two school grade levels. Table 1 presents the physical characteristics of the individuals in the experimental and control groups. Prior to beginning this study, written informed consent was obtained from the school, parents, and participants. The study protocol was approved by the ethic committee of the university of Murcia. No prior information was given as to the allocation of the subjects in the experimental or control groups. All subjects were free of musculoskeletal disorders and had no current history of low-back pain.

2.2. Procedures

The experimental groups participated in a programme of hamstring stretching exercises two times a week during the physical education sessions for the entire school term (32 weeks). If a subject missed a session, he/she made up the session on next day during the same week. Any subject who missed more than two days of stretching was eliminated from the study. The subjects were instructed not to participate in any other physical activity programmes, and not to alter their daily habits during the study. None of these subjects were involved in an organized sports programme during the previous year.

The stretching exercises were performed at the end of the warming-up (3 min of hamstring stretching) and cooling-down period (2 min of hamstring stretching) of each physical education class. The stretching programme was conducted and supervised by some physical education teachers. The stretching exercises were done seated with knees remaining fully extended. The subjects flexed forward at the hip, maintaining the spine in a neutral position until a gentle stretch was felt in the posterior thigh (Fig. 1). In all the stretching exercises, the stretched positions were assumed gently and slowly until the end-point of range. Once this position was achieved, the subjects held it for 20 s. The physical education teacher instructed them to feel a strain of the hamstring muscles without feeling pain.

The control group was composed of individuals who participated only in the usual school physical education classes, and did not participate in the hamstring-stretching programme. The

Table 1
Physical characteristics of the subjects

	n	Age (years)		Mass (kg)		Height (cm)	
		M	S.D.	M	S.D.	M	S.D.
Control group							
Elementary students	21	10.27	0.30	43.61	11.81	140.91	5.90
Secondary students	20	13.46	0.67	50.43	7.82	155.23	8.21
Experimental group							
Elementary students	25	10.28	0.32	44.01	12.03	140.39	4.96
Secondary students	24	13.45	0.70	51.11	8.02	157.45	7.86

M: mean; S.D.: standard deviation.

subjects in the control group were unaware of the purpose of the study.

2.3. Hamstring flexibility evaluation

Sit-and-reach score was measured before and after the programme. The sit-and-reach test is an indirect measure of hamstring flexibility. The subjects sat with their heels firmly against the testing box (Acuflex I Flexibility tester). Subjects kept their knees extended and placed their right hand over the left, with the long fingers even, and reached forward as far as they could by sliding their hands along the measuring board. A tape measure on top of the measuring board indicated how far beyond the toes each individual reached. The distance from the toes (zero point) was measured in centimetres; positive values were awarded if subjects could reach beyond their toes, and negative values were awarded if subjects could not reach beyond their toes. The score was the greatest distance contacted by the fingertips and was registered an accuracy of up to 0.5 cm. Three trials were performed with 10 min separating measurements. The average of the three trials was used for data analysis. Environmental influences were standardized by measuring each subject at the same time of the day and in the same temperature conditions (25 °C). Moreover, no warm-up and stretching exercises were performed by the subjects prior to measurements. A licensed physical therapist who was one of the main investigators collected all the data.

Fig. 1. Example of proposed hamstring-muscle-stretching exercise.

2.4. Statistical analysis

Pre- and post-test means and standard deviations (S.D.) for the experimental and control groups were calculated. In addition, the mean difference between pretest and post-test measurements was calculated for each group. Internal consistency reliability for SR score was determined using intraclass correlation coefficients. A *t* test for dependent samples was used to examine differences between pre- and post-test scores for each group. A one-way Anova was used to assess whether any significant differences existed in the pretest or post-test scores among the groups. Also, a one-way Anova was conducted on difference scores between pre- and post-test among the groups. The effect of stretching programme on score across time was tested by a 2×4 (test × group) Anova with repeated measures on test (pre- and post-test). If an interaction was found, Tukey post hoc comparisons were used to identify significant pair group differences. The level of significance was set at $p < 0.05$.

3. Results

The reliability of the SR scores from intraclass correlation technique was 0.98 in the pretest and 0.97 in the post-test. Table 2 presents the mean, S.D., and significance values of the sit-and-reach score in the pre- and post-test and difference score between pre- and post-test measurements for both experimental and control groups.

The one-way Anova of pretest measurements demonstrated no difference among groups before initiation of any stretching interventions. The two-way Anova demonstrated a significant difference for the main effect of time between pretest and post-test score measurements. Because of significant interaction of time and group factors, a one-way Anova was applied to group pretest to post-test change scores, revealing a significant difference among groups. The elementary experimental group showed a low and no significant improvement in score (+1.95 cm), while the secondary experimental group showed improved score significantly (+7.22 cm). Both elementary and secondary control groups showed a reduction in the score (−4.38 cm and −2.31 cm, respectively), although no significant differences were found for the secondary group (Table 2). Differences in the SR gain scores between the post-test and pretest averages showed greater improvements for experimental groups ($p < 0.001$) in both elementary (difference score: 6.33 cm;

Table 2
Results of the sit-and-reach test score in the pre- and post-test

	Pretest score (cm)		Post-test score (cm)		Difference score (cm)	*t* value
	M	S.D.	M	S.D.	M	
Control group						
Elementary students	+0.44	8.47	−3.94	9.89	−4.38	4.53*
Secondary students	−0.38	6.17	−2.69	7.34	−2.31	2.06 NS
Experimental group						
Elementary students	−0.65	6.11	+1.30	7.78	+1.95	1.87 NS
Secondary students	−4.00	7.72	+3.22	7.75	+7.22	6.21*

M : mean; S.D. : standard deviation; + : indicates improvement; − : indicates not improvement; NS: not significant.
* $p < 0.001$ between pre- and post-test.

$p < 0.001$) and secondary groups (difference score: 9.53 cm; $p < 0.001$).

A one-way Anova was calculated to assess the post-test scores of the four groups, revealing some significant differences. The *t* tests indicated increases in score in both secondary ($p < 0.001$) and elementary ($p > 0.05$) experimental groups, and decreases in score in both elementary ($p < 0.001$) and secondary ($p > 0.05$) control groups (Table 2).

4. Discussion

The purpose of this study was to examine the effects of passive hamstring stretching on sit-and-reach score when incorporated into a physical education programme. The results indicated that incorporating hamstring stretching as a part of physical education classes produces an improvement in the sit-and-reach score for the experimental groups, but not for control groups. The sit-and-reach test was chosen for being the most frequently used flexibility test in school setting and because the procedure is simple, easy to administer, and require minimal skills training. The SR test as measure of hamstring flexibility is particularly useful in large-scale flexibility evaluation in the field setting, such us physical education classes. Also, some studies reported that this test has moderate criterion-related validity as a test of hamstring flexibility in children and adolescents [4,15,24].

The findings of this study are consistent with Zakas et al. [34] who investigated the effect of a 12-week passive stretching exercises programme on lower extremity range of motion in prepubertal (10 years old) and pubertal boys (13 years old). Experimental groups participated in school physical activities and in an interval strength training programme alternating with several minutes of passive stretching exercises (holding stretches for 30 s). Their control group participated only in the school physical activities, 2–3 times per week, consisting of ball game and some general exercises without following any organized stretching programme. Significant improvements in passive straight leg raise were shown in experimental groups ($p < 0.01$), while the control group showed no significant differences.

In a study of 43 children from two secondary schools, Reid and McNair [25] found a significant improvement after a six-week hamstring stretching programme using the stance phase stretch method performed once a day on five consecutive days of the week, held for 30 s and for three repetitions. No significant differences were observed in the control group that did not stretch. In males, ages 15–17 years old, Nelson and Bandy [23] found that static stretching programme (three days per week for six weeks, holding for 30 s) increased hamstring flexibility significantly more (+12.05°) than a control group that did not stretch.

The reported incidence of reduced hamstring muscle length is high in children and adolescents. In a study on 459 children and adolescents from third, sixth and ninth classes in seven schools in Funen, Denmark, 75% of the boys and 35% of the girls over 10 years old had limited hamstring extensibility [2]. In another study on adolescents between 13 and 16 years old, using the passive knee extension test, Harreby et al. [14] found that tightness of the hamstring muscles is common in growing adolescents. Milne and Mierau [22] observed a reduction in flexibility coinciding with the pubertal stage of rapid growth. However, Feldman et al. [7] registered no relation between growth and changes in hamstring muscle flexibility during the peripubertal period. The loss of hamstring muscle flexibility begins to manifest itself during the prepubertal period and reaches major significance in later growth stages. This fact is apparent in the control groups because no hamstring-stretching programme was done and SR score decreased in both elementary and secondary groups. However, Zakas et al. [34] did not find a significant decrease in the straight leg raise for the 10- and 13-year-old groups. Nelson and Bandy [23] found no significant improvement (+1.67°) in hamstring flexibility in the control group measured by passive knee extension test.

Because the reported incidence of reduced hamstring flexibility is high and has been associated to low-back troubles [8,16,17,30,35], several studies on the effect of stretching programme on hamstring extensibility have been done. In most studies, the difference between straight leg raise and passive or active knee extension tests after a training programme showed considerable improvement in hamstring flexibility. A stretching protocol, which included three sets of exercises similar to our study done three days a week and held the stretching between 10 and 30 s for 10 weeks, revealed significant improvement on back-saver sit-and-reach test and active-knee-extension test in young adults [21]. Also, supervision of a stretching programme provided additional benefits for improving hamstring flexibility [21].

Other studies have revealed significant improvements in flexibility when stretching exercises were included during strength training programme [28,29,33]. Sewall and Micheli [28] found a slight increase in flexibility of the experimental group (4,5%) and the control group (3,6%) of prepubertal children that participated in progressive resistive strength training on machines done three times per week. Weltman et al. [33] in a 14-week strength-training programme incorporated stretching into the warming-up and cooling-down phases on prepubertal boys, and found a significant improvement in the hamstring muscle extensibility (measured by a sit-and-reach test) of subjects that participated in sport activities and activities of daily living.

In this study, the SR score demonstrated the improvement registered in the secondary education experimental group following the stretching programme relative to its corresponding control group. The differences between pre- and postgain scores between both secondary experimental and secondary control groups showed a significantly greater score for experimental group (+ 9.53 cm). Also, the differences between pre- and postgain scores between both elementary experimental and elementary control groups showed a greater improvement in score for experimental group (+ 6.33 cm). These improvements observed in the experimental groups cannot be attributed to an increase in the mobility of the thoracic spine because the stretching exercises were performed with the neutral spine. However, a limitation of this study was that spine posture (thoracic and lumbar spinal curvatures) in the sit-and-reach test was not measured.

After the stretching programme, the SR score increased in the experimental groups, probably because the hip flexion range of motion (anterior pelvic rotation) was improved. The SR score was improved because stretching exercises were performed systematically. Long-term stretching induced increases in muscle extensibility. The increased SR scores could result from increased stretch tolerance [10,12,13] and/or structural/mechanical changes in the viscoelastic characteristics of the hamstring muscles [18,25]. Previous studies indicated that during the school years, flexibility decreases until the onset of puberty [19]. This decline could be related to increased musculotendinous stiffness around the joint, due to the faster bone development and growth compared to the muscles [19]. It also seems that this decline in the hamstring muscles could be related to the prolonged sitting position during school classes and daily activities or to a less physically lifestyle of the population that prefers watching television, playing computer games, etc.

It should be highlighted that a slight deterioration in SR score was detected in the control groups. This could be due to the fact that the control groups were immersed in physical education classes, in which articular amplitude movements form part of a wide range of exercises, something, which should afford a certain level of improvement in schoolchildren.

School centres should promote correct posture habits, considering that physical education programme seeks to obtain the adequate musculoskeletal development of schoolchildren. The school is an ideal setting for hamstring shortness prevention since it has the potential of optimizing environmental conditions and giving prolonged feedback that reaches a large percentage of the population. Brodersen et al. [2] recommended that schoolchildren be involved in a daily stretching programme. Considering that an improvement in hamstring flexibility, based only on two 5-min sessions a week over the 32 weeks of the school term, has been detected in the school environment, it is extremely likely that the progress registered in the field of rehabilitation or more stretching volume would be even more evident.

5. Conclusion

The sit-and-reach score improved following 5 min of stretching exercises performed in the warming-up and cooling-down periods of the physical education sessions done twice a week of the school term. The improvement was even more evident in the secondary level. However, control groups showed a reduced score. For this reason, a hamstring flexibility programme should be incorporated to physical activities at school to prevent decrease of hamstring muscle extensibility.

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