EFFECT OF A SHORT-TERM PHYSICAL EDUCATION-BASED FLEXIBILITY PROGRAM ON HAMSTRING AND LUMBAR EXTENSIBILITY AND ITS POSTERIOR REDUCTION IN PRIMARY SCHOOLCHILDREN

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Abstract:

The purpose of this study was to examine the effects of a short-term flexibility program on hamstring and lumbar extensibility and its posterior reduction among primary schoolchildren in a physical education (PE) setting. Forty-five 10-to-11-year-old schoolchildren from two classes were clustered randomly to an experimental group (EG) (n=22) or a control group (CG) (n=23). During the PE classes, the students in EG performed a six-minute flexibility program twice a week for eight weeks. Subsequently, these students underwent a five-week detraining period. The results of the two-way ANOVA showed that the intervention program significantly increased the students' hamstring and lumbar extensibility (pretest=15.7±7.0 cm; posttest=18.2±7.7 cm; p<.001). Although after the detraining period flexibility levels decreased statistically significantly (retest=17.1±7.9 cm; p<.001), the students from EG presented statistically higher values than in the baseline flexibility level (p=.006). For the CG no significant differences were found (pretest=13.4±8.5 cm; posttest=13.1±8.5 cm; retest=13.2±8.4 cm; p=1.000). Although children lose a significant part of the obtained flexibility gains over a five-week detraining period, they do not revert to their baseline flexibility level. Hence, the students might continue working on their flexibility within the next five weeks in order to maintain the gains obtained previously. These findings could help teachers to design programs that guarantee feasible improvement and maintenance of children's flexibility in a physical education setting.

Key words: *stretching program, detraining, elementary schoolchildren, physical education setting, classical sit-and-reach test, health-related physical fitness*

Introduction

Hamstring and lumbar extensibility is a recognized health-related physical fitness component that plays an important role in protecting the spine from possible risks and, therefore, allowing people to execute the normal daily living activities and social functioning (Roth-Isigkeit, Thyen, Stöven, Schwarzenberger, & Schmucker, 2005; Sato, et al., 2008). For instance, poor hamstring extensibility is associated with several spinal disorders such as thoracic hyperkyphosis (Fisk, Baigent, & Hill, 1984), spondylolysis (Standaert & Herring, 2000), disc herniation (Harvey & Tanner, 1991), changes in lumbopelvic rhythm (López-Miñarro & Alacid, 2009) and low back pain (Sjölie, 2004). Specifically in children, poor hamstring and lumbar extensibility has been associated with current low back pain (Feldman, Shrier, Rossignol, & Abenhaim, 2001; Jones, Stratton, Reilly, & Unnithan, 2005; Sjölie, 2004) and neck tension (Mikkelsson, et al., 2006), as well as with a higher risk of low-back pain during adulthood (Hestbaek, Leboeuf-Yde, Kyvik, & Manniche, 2006; Kujala, Taimela, Salminen, & Oksanen, 1994).

Limited hamstring and lumbar extensibility affects a large number of schoolchildren (Brodersen, Pedersen, & Reimers, 1994; Harreby, et al., 1999). For instance, in Spain about 18-38% of schoolchildren show reduced hamstring and lumbar extensibility (Ferrer, 1998; Castro-Piñero, et al., 2013). Shortened hamstring and lumbar muscles are the locomotor pathology more likely to be addressed proactively in physical education (PE) because their treatment is based on the execution of stretching exercises and postural correction (Santonja, Rodríguez, Sainz de Baranda, & López, 2004; Santonja, Sainz de Baranda, Rodríguez, López, & Canteras, 2007; Thacker, Gilchrist, Stroup, & Kimsey, 2004). Therefore, it seems that PE teachers should include stretching exercises within their classes (Kanásová, 2008; Rodríguez, Santonja, López-Miñarro, Sáinz de Baranda, & Yuste, 2008; Sainz de Baranda, et al., 2006; Santonja, et al., 2007).

Previous studies found that PE-based flexibility programs performed twice a week for 16-32 weeks improve hamstring and lumbar extensibility in primary schoolchildren (Coledam, Arruda, & Ramos de Oliveira, 2012; Rodríguez, et al., 2008; Rodríguez, et al., 1999; Sainz de Baranda, et al., 2006). However, a planning-related problem in PE is that the teachers must "deliver" a large volume of curricular contents during each academic course (Hardman, 2008; Ministerio de Educación y Ciencia, 2006). Hence, the application of a short-term flexibility development program seems to be more suitable (Viciana, Mayorga-Vega, & Cocca, 2013, 2014). Furthermore, since the academic year is frequently interrupted by several holiday periods, another problem related to the PE planning is that after a period of detraining the obtained flexibility gains are expected to decrease (Cipriano, Terry, Haines, Tabibnia, & Lyssanova, 2012; Rancour, Holmes, & Cipriani, 2009; Willy, Kyle, Moore, & Chleboun, 2001). Unfortunately, all of the previous studies about flexibility detraining were carried out with adults, and were limited and contradictory (Cipriano, et al., 2012; Rancour, et al., 2009; Willy, et al., 2001). A flexibility maintenance program should be applied in order to maintain the flexibility levels previously gained during the remainder of the academic year (Viciana, et al., 2013, 2014). However, the current scientific information about the efficacy of this kind of programs is still limited (Rancour, et al., 2001), especially in a PE setting.

Hence, PE teachers include stretching exercises in their classes only for a few weeks, without knowing how long the effects of these exercises will last. Unfortunately, to our knowledge there are no studies examining the effect of a short-term flexibility program and its posterior detraining among schoolchildren. Consequently, the purposes of this study were: (a) to examine the effects of a short-term PE-based flexibility program on hamstring and lumbar extensibility in schoolchildren aged 10-11 years; and (b) to evaluate the effects of a five-week period of flexibility detraining on hamstring and lumbar extensibility in schoolchildren aged 10-11 years. It was hypothesized that an eight-week PE-based flexibility program would develop hamstring and lumbar extensibility in schoolchildren, as well as that after a five-week period of detraining schoolchildren's flexibility levels would, at least partially, be lost. Regrettably, because of the lack of previous studies regarding the flexibility detraining in children together with the limited related information among adults, a more certain hypothesis cannot be postulated.

Methods

Participants

A sample of 45 schoolchildren, 26 boys and 19 girls, aged 10-11 years, from two different sixth grade PE classes of a public primary school participated in the present study. For practical reasons and the nature of the present study (the intervention was focused on natural groups in a school setting) a cluster randomized controlled trial was used (Viciana, et al., 2013). Natural classes were assigned randomly to form one of the following study groups: control group (CG) or experimental group (EG).

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/lumbar muscles over the past six months (López-Miñarro, Sainz de Baranda, & Rodríguez-Garcia, 2009). The inclusion criterion was to have an attendance rate of 90% or higher for PE classes during the intervention period. Children and their parents or legal guardians were fully informed about all the features of the study, and were required to sign an informed-consent document. The Ethical Committee of the University of Malaga approved the study protocol.

Measures

Hamstring and lumbar extensibility was estimated using the classical sit-and-reach (SR) test (Mayorga-Vega, Merino-Marban, & Viciana, 2014). The SR test was applied at the beginning and at the end of the flexibility intervention program (pretest and, after eight weeks, posttest, respectively) in order to examine the possible changes produced. Then, after five weeks of flexibility detraining a reassessment was performed in order to observe the levels of retention (retest).

Hamstring and lumbar extensibility was assessed by the same tester, instruments and under the same conditions. The SR test was administered using a wooden box with a ruler on the top (the score of 15 cm corresponded to the tangent of the feet; accuracy 0.1 cm). The measures were taken in an indoor sports facility under the same environmental conditions, on the same day of the week and at the same time for each student. No warm-up exercises were performed prior to the flexibility measurements.

At the beginning of the test the children stood in front of the box, sat with their hips flexed, knees extended and both hands on the top of the ruler. The feet were placed to the width of the hips and ankles at 90º. The knees were fixed in extension with the help of the tester. The hands with the fingers extended were placed parallel. From this position, the children 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. The average of two attempts was retained (Mayorga-Vega, Merino-Marban, & Garcia-Romero, in press).

Procedures

The EG participants performed a flexibility intervention program during their regular PE classes. The flexibility program was conducted and supervised by the same PE teacher in both groups. Firstly, the EG students performed a flexibility development intervention program twice a week on non-consecutive days for eight weeks. Subsequently, coinciding with the Christmas holidays, the EG participants underwent a five-week period of flexibility detraining. Similarly to previous studies carried out in a PE setting (Coledam, et al., 2012; Rodríguez, et al., 2008; Sainz de Baranda, et al., 2006; Santonja, et al., 2007), the EG students performed hamstring/lumbar stretches using the static technique for six minutes during the cool-down period of their regular PE classes.

Each intervention session included three 20-second sets of five stretching exercises. Six different stretching exercises were designed and alternated during the intervention program (Figure 1). Four bidopal exercises and one unipodal exercise were performed in each session. In all the stretching exercises, the children flexed forward at the hip, maintaining the spine in a neutral position until a gentle stretch was felt in the hamstrings. The knees were fully extended and toes pointed to the ceiling with no hip rotation. The stretched positions were held gently until the end point of the range was reached (i.e. stretch to the point of feeling the tightness of the hamstring muscles, but no pain).

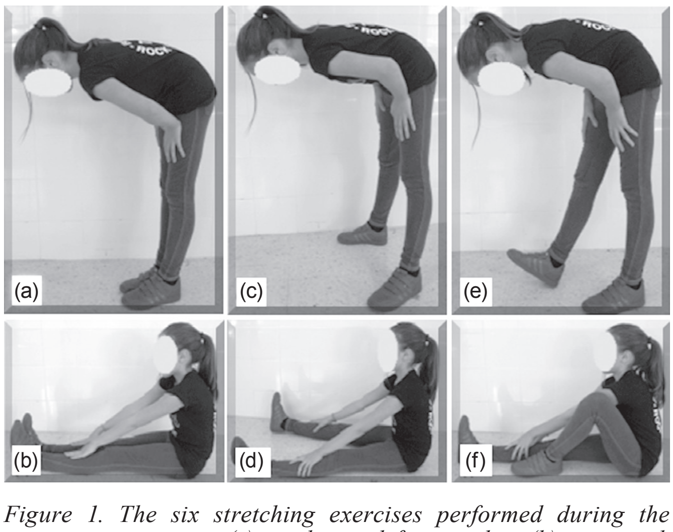

Figure 1. The six stretching exercises performed during the intervention program: (a) standing with feet together; (b) sitting with feet together; (c) standing with feet shoulder-width apart; (d) sitting with feet shoulder-width apart; (e) standing with only one leg extended, and (f) sitting with only one leg extended.

All the participants were urged to maintain their normal levels of physical activity outside the supervised setting during the research period. Twelve students in the EG (55%) and seven students in the CG (30%) regularly participated (at least twice per week) in organized extra-curricular sport programs. During the flexibility program period all the students participated in their standard PE classes. However, the CG participants followed the standard PE program without performing stretching exercises and were not aware of the purpose of the study.

Statistical analyses

Descriptive statistics (means and standard deviations) for age, body mass, body height, body mass index, and SR scores were calculated. A one-way analysis of variance (ANOVA) was used to study the differences in body mass, body height, body mass index, and baseline SR scores between EG and CG. Additionally, chi-squared analyses were carried out to test the ratio differences of gender and extra-curricular sport practitioners between the two groups. Subsequently, the effect of the eight-week flexibility intervention program followed by five weeks of detraining on hamstring and lumbar extensibility was examined using a two-way ANOVA applied over the SR scores, including *group* as an independent variable (CG, EG) and *time* as a dependent variable (pretest, posttest, retest). For the *post-hoc* analyses, α values were corrected using the Bonferroni adjustment. Moreover, the Hedges' g effect size was used to examine the magnitude of treatment effects (Hedges, 2007). The test-retest reliability of the SR test was estimated using the intra-class correlation coefficient from one-way ANOVA ($ICC_{1,2}$) (Shrout & Fleiss, 1979), as well as the 95% interval of confidence. All statistical analyses were performed using the SPSS version 20.0 for Windows (IBM® SPSS® Statistics 20). The statistical significance level was set at $p<.05$.

Results

All the participants completed the intervention program according to previously established attendance norms, the EG students obtaining an average attendance over 95%. The general characteristics of the participants studied are shown in Table 1. The one-way ANOVA results did not show statistically significant differences in body mass, body height, body mass index, and SR baseline values between EG and CG ($p>.05$). Additionally, the chi-square analyses showed that the two groups had a balanced representation of boys and girls and extra-curricular sport practitioners and non-practitioners ($p>.05$).

Table 2 shows the effect of the flexibility intervention program on hamstring and lumbar extensibility. The results of the two-

Table 1. General characteristics (mean±standard deviation/frequency) of the participants and differences between experimental and control groups

	Sample (N=45)	Experimental (n=22)	Control (n=23)	Differences[a]	
				F	p
Age (year)	10.9±0.3	10.9±0.3	10.9±0.3	-	-
Body mass (kg)	40.4±6.7	41.3±8.3	39.6±4.8	.685	.412
Body height (cm)	145.9±6.5	147.1±6.5	144.8±6.4	1.489	.229
Body mass index (kg/m^2)	19.0±2.9	19.0±3.4	18.9±2.4	.009	.924
Gender (boys/girls)	26/19	14/8	12/11	.606	.436
Extra-curricular sport (yes/no)[b]	19/26	12/10	7/16	2.680	.102

Note. [a]Significance level from the analysis of variance for the body mass, body height and body mass index, and from the chi-square test for the gender and extra-curricular sport ratios. [b]Children that regularly participated (yes) or not (no) at least twice per week in organized extra-curricular sport activities.

Table 2. Effect of the flexibility intervention program on the classical sit-and-reach scores (cm)

Group	Pretest (1) (M±SD)	Posttest (2) (M±SD)	Retest (3) (M±SD)	p[a]	Effect size[b]		
					1-2	2-3	1-3
Experimental (n=22)	15.7±7.0	18.2±7.7***	17.1±7.9***††	<.001	.35	-.15	.20
Control (n=23)	13.4±8.5	13.1±8.5	13.2±8.4				

Note. M=mean; SD=standard deviation; [a] Significance level from two-way analysis of variance with the *post-hoc* analysis with Bonferroni adjustment: change statistically significant from pretest to posttest (***p<.001), from posttest to retest (***p<.001), and from pretest to retest (††p<.01). [b] Hedges' *g* effect size.

way ANOVA on the average obtained in the SR showed interaction effects between the *group* and *time* variables [F(2, 86)=15.657; p<.001; η^2_p=.267; P=.997]. Subsequently, for *post-hoc* analyses, the ANOVA with the Bonferroni adjustment showed that EG improved flexibility statistically significantly from pretest to posttest (p<.001). In addition, although the flexibility levels from posttest to retest decreased statistically significantly (p<.001), EG presented statistically higher values in retest than in the baseline flexibility levels (p=.006). For CG no significant differences were found (p=1.000). The test-retest reliability for SR was .997 (.994-.999).

Discussion and conclusions

The first purpose of the present study was to examine the effects of a short-term PE-based flexibility program on hamstring and lumbar extensibility in primary schoolchildren. The results of this study showed that a six-minute PE-based flexibility development program, performed twice a week for only eight weeks, improved hamstring and lumbar extensibility in schoolchildren. In this line, previous studies in which primary schoolchildren performed a PE-based flexibility program found a significant improvement in hamstring and lumbar extensibility (Coledam, et al., 2012; Rodríguez, et al., 2008; Rodríguez, et al., 1999; Sainz de Baranda, et al., 2006).

However, despite the fact that in a PE setting the application of short flexibility development programs seems to be more feasible, in all the above mentioned studies the EG students carried out the flexibility intervention programs with a considerably longer duration, lasting from 16 (Coledam, et al., 2012) to 31-32 weeks (Rodríguez, et al., 2008; Rodríguez, et al., 1999; Sainz de Baranda, et al., 2006). On the other hand, similarly to the present research, in previous short-term stretching programs carried out with adults, improvements in flexibility were found (Cipriano, et al., 2012; Rancour, et al., 2009; Willy, et al., 2001). Although in these studies the flexibility gains were found after only 4-6 weeks, the participants performed stretching exercises from 3-4 to 14 times a week. Nevertheless, as in many other countries (European Commission/ EACEA/ Eurydice, 2013), PE in Spain is limited to two sessions a week and, therefore, stretching programs with higher frequencies are not feasible in this setting.

The second purpose of the present study was to evaluate the effect of a five-week period of flexibility detraining on hamstring and lumbar extensibility in schoolchildren. In PE planning another common limitation is the fact that an academic year is frequently interrupted by several holiday periods. Therefore, although after a period of detraining the flexibility gains obtained are expected to decrease (Cipriano, et al., 2012; Rancour, et al., 2009; Willy, et al., 2001), PE teachers include stretching exercises in their classes only for a few weeks, and then they cease doing them because of the holiday periods or the necessity to teach other curricular contents. Unfortunately, the current scientific information about the flexibility detraining is limited and contradictory (Cipriano, et al., 2012; Rancour, et al., 2009; Willy, et al., 2001). Similarly to the present study, Cipriano et al. (2012) and Rancour et al. (2009) found that after four weeks of flexibility detraining adults retained significant gains. However, on the contrary, Willy et al. (2001) observed that adults' flexibility levels decreased to baseline after four weeks of detraining. Additionally, to our knowledge there are no previous studies examining the flexibility loss effects during detraining periods among schoolchildren.

Although most previous studies examined the effects of a flexibility program over the whole academic year (Rodríguez, et al., 2008; Rodríguez, et al., 1999; Sainz de Baranda, et al., 2006), they only examined the global effects ignoring the changes in flexibility during relatively long detraining periods such as the Christmas holidays. Therefore, one of the most important outcomes of the current study was to show that, although in a five-week detraining period children lost a significant portion of their flexibility gains previously obtained, they did not revert to their baseline flexibility level. Hence, as the effect of an eight-week flexibility program performed for six minutes twice a week is not completely worn off, PE teachers should continue to develop students' flexibility within the next five weeks in order to maintain the gains obtained in the previous semester.

Unfortunately, scientific information about the efficacy of flexibility maintenance programs among schoolchildren has not been found and the studies among adults are limited. In this line, Rancour et al. (2009) found out that, after a daily development stretching program, with 2-3 sessions a week, the adults maintained the flexibility levels previously gained. Regrettably, as it was pointed out before, since in the most countries PE is performed only twice a week, the application of this program is not suitable. In order to apply this program in a PE setting, for instance, the efficacy of a maintenance program of one session a week or the half volume of stretching in each session should be tested instead. Additionally, Rancour et al. (2009) applied the maintenance program just after the development program, that is, without a period of inactivity between the development and maintenance. However, in most countries, the efficacy of a maintenance program should be examined after a period of detraining because it is the most common situation in normal PE planning (due to the typical alternation of holidays, academic periods and the need to teach other curricular contents in the PE classes) (Viciana, et al., 2013, 2014). Regrettably, previous studies evaluating the effects of the flexibility maintenance program in a PE setting have not been found.

Regarding the physiological explanation of the increase in hamstring and lumbar extensibility observed after the development stretching program, a few theories have been proposed (Weppler & Magnusson, 2010). Traditionally, most of these theories suggest that increases in muscle extensibility observed after a flexibility program might be due to a mechanical increase in length of the stretched muscle (e.g. due to the viscoelastic deformation, plastic deformation, increased sarcomeres in series, and/or neuromuscular relaxation). However, a new theory has been proposed recently suggesting that increases in muscle extensibility could be due to a modification of sensation. In this line, increases in muscle extensibility observed especially after a short-term flexibility program could be, at least predominantly, due to modifications in individuals' sensation. Likewise, all these theories may explain the reduction in hamstring and lumbar extensibility during the detraining stretching period. A more extensive explanation of physiological mechanisms of improvements in muscle extensibility due to a stretching program can be found in several published review articles (e.g. Gajdosik, 2001; Magnusson, 1998; Weppler & Magnusson, 2010).

In conclusion, to our knowledge this is the first study that examines the effect of a short-term flexibility developmental program lasting eight weeks followed by five weeks of detraining on hamstring and lumbar extensibility among schoolchildren. The results of the current study suggest that it is possible to improve students' hamstring and lumbar extensibility performing a PE-based flexibility program for only eight weeks. Additionally, another contribution of the present study is it has demonstrated that although children lose a significant portion of the flexibility gains previously obtained in a 5-wk detraining period, they do not revert to their baseline flexibility level. Hence, PE teachers should continue working on students' flexibility within the next five weeks in order to maintain their gains obtained previously.

For all the previously mentioned reasons, it would be beneficial for PE teachers to know the minimum duration of a flexibility program that would provide authentic outcomes, then how long it takes to lose the improvements achieved after such a development program, and how a maintenance flexibility program for students should be applied (Viciana, et al., 2014). Consequently, future research interventions should examine the effect of different detraining periods among schoolchildren, as well as the application of different maintenance training programs in order to maintain the flexibility gains obtained previously (Viciana, et al., 2013, 2014). Additionally, since PE teachers must also "deliver" a large volume of curricular contents so that flexibility cannot be allocated a large part of PE time, the effectiveness of flexibility programs consisting of sessions with shorter duration should also be examined. This knowledge could help PE teachers to design programs that guarantee feasible development and maintenance of flexibility in a PE setting.

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