EFFECT OF A PHYSICAL EDUCATION-BASED DYNAMIC STRETCHING PROGRAM ON HAMSTRING EXTENSIBILITY IN FEMALE HIGH-SCHOOL STUDENTS

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Abstract:

The aim of the present study was to examine the effects of a dynamic stretching development program followed by a four-week detraining period and maintenance program on hamstring extensibility in a physical education setting. A sample of 108 female high-school students aged 16-17 years from four classes were clustered randomly and assigned to either an experimental or a control group. During physical education sessions, the experimental group students performed a dynamic stretching program twice a week for eight weeks. Subsequently, after a four-week period of detraining, the experimental group students completed a maintenance program twice a week during four weeks. The results of the two-way analysis of variance showed that the physical education-based development program significantly improved students' hamstring extensibility ($p<.001$). Although after four weeks of detraining students' flexibility reverted to its baseline levels ($p>.05$), the gains obtained previously were recovered after a four-week maintenance program ($p<.001$). Hence, a physical education-based dynamic stretching intervention is effective in improving and maintaining hamstring extensibility among female high-school students. However, after four weeks of detraining, students' flexibility reverts to its baseline levels. These findings could help and guide teachers to design programs that guarantee a feasible and an effective development of flexibility in a physical education setting.

Key words: *flexibility program, bouncing technique, detraining, classical sit-and-reach test, adolescents, physical education setting*

Introduction

Nowadays physical fitness is considered to be one of the most important health markers in childhood and adolescence (Ortega, Ruiz, Castillo, & Sjöström, 2008), with flexibility as an essential component of health-related physical fitness (National Association for Sports and Physical Education, 2005). Particularly, low hamstring extensibility has been 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). Moreover, adolescents with an inadequate hamstring extensibility seem to have a higher risk of 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 a higher risk of low back pain later during adulthood (Hestbaek, Leboeuf-Yde, Kyvik, & Manniche, 2006; Kujala, Taimela, Salminen, & Oksanen, 1994).

Unfortunately, hamstring extensibility appears to be in a permanent involution process (Chodzko-Zajko, et al., 2009). Currently, low hamstring extensibility affects a large number of adolescents. 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 and to encourage them to achieve health-enhancing levels (Ortega, et al., 2008). For instance, the subject of physical education (PE) might play an important role in this public health issue. Shortened hamstring muscles could 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).

In most countries PE teachers are required to achieve and maintain students' health-enhancing flexibility levels (e.g. Ministerio de Educación y Ciencia, 2007; National Association for Sport and Physical Education, 2004). Since static stretching exercises seem to contribute to greater control of the spine aligned arrangement and, therefore, a lower potential risk of muscle injury, this technique has been mainly recommended for schoolchildren (Behm, Faigenbaum, Falk, & Klentrou, 2008; Faigenbaum, et al., 2009). Nevertheless, dynamic stretching exercise may not be harmful when practiced in a soft way. It may also increase the sensitivity of muscle spindles thus improving its performance within the muscle; synergy like it occurs in most sport movements (Behm, et al., 2011; Turki-Belkhiria, et al., 2014). Unfortunately, although several previous studies have shown that a PE-based static stretching program improves students' hamstring extensibility (e.g. Mayorga-Vega, Merino-Marban, Vera-Estrada, & Viciana, 2014b; Merino-Marban, Mayorga-Vega, Fernandez-Rodriguez, Vera Estrada, & Viciana, 2015; Sanchez Rivas, Mayorga-Vega, Fernández Rodríguez, & Merino-Marban, 2014), to our knowledge there are no studies examining effectiveness and safety of a dynamic stretching program.

Despite the fact that hamstring extensibility improvements are expected to decrease after a period of detraining (Kenney, Wilmore, & Costill, 2011), the PE-based stretching programs are frequently interrupted by several holiday periods (Viciana, Mayorga-Vega, & Cocca, 2014a; Viciana, Mayorga-Vega, & Merino-Marban, 2014b). Therefore, PE teachers usually have to cease doing stretching exercises in their sessions and they do not know how long the effect will last. Regrettably, as far as we know research studies examining the effect of flexibility detraining are really scarce and contradictory (Cipriani, Terry, Haines, Tabibnia, & Lyssanova, 2012; Rancour, Holmes, & Cipriani, 2009; Willy, Kyle, Moore, & Chleboun, 2001), especially among school-age children (Mayorga-Vega, et al., 2014b; Merino-Marban, et al., 2015). While several previous studies showed that, after a short-term stretching program, individuals' flexibility levels reverted to their baseline after 4-5 weeks of detraining (Merino-Marban, et al., 2015; Willy, et al., 2001), other research studies found that individuals retained significant gains (Cipriani, et al., 2012; Mayorga-Vega, et al., 2014b; Rancour, et al., 2009).

PE teachers must also face other planning-related problems when intending to develop students' flexibility levels (Viciana, et al., 2014a, 2014b). For instance, apart from the fact that many curricular contents must be developed each academic year (e.g. Ministerio de Educación y Ciencia, 2007), PE is usually restricted by its limited curriculum time allocation (European Commission/EACEA/Eurydice, 2013). Therefore, previous authors have suggested that, after a stretching development program, PE teachers should include a maintenance program in order to retain students' flexibility levels throughout the whole academic year (Viciana, et al., 2014a, 2014b). Apart from maintaining the flexibility levels previously obtained, these programs should not interfere with normal development of other curricular contents. Unfortunately, to our knowledge there are no previous studies examining the effect of a stretching maintenance program in a PE setting.

Consequently, the aims of this study were: (a) to evaluate the effects of a dynamic stretching development program on hamstring extensibility in female high-school students; (b) to examine the effects of a four-week period of flexibility detraining on hamstring extensibility in female high-school students; and (c) to observe the effects of a dynamic stretching maintenance program on hamstring extensibility in female high-school students.

Methods

Participants

A sample of 108 apparently healthy female adolescents, aged 16-17 years, from four different PE classes of a high school took part in this study. For practical reasons and the nature of the present study (the intervention focused on natural groups in a school context), a cluster randomized controlled trial was used (Mayorga-Vega, et al., 2014b; Merino-Marban, et al., 2015). Natural classes were assigned randomly to either a control (CG) or experimental group (EG).

All 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 past six months (López-Miñarro, Sainz de Baranda, & Rodríguez-Garcia, 2009). The exclusion criteria were: (a) not satisfying an attendance rate of 90% or more for PE classes during the intervention period, and (b) missing some flexibility evaluation session. Adolescents and their legal guardians were fully informed about the research and were required to sign an informed-consent document. The study protocol was approved by the Ethical Committee of the University of Malaga.

Measures

Students' flexibility was assessed by the classical sit-and-reach (SR) test (Mayorga-Vega, Merino-Marban, & Viciana, 2014c). The SR test was used before (pre-intervention, week 0) and after (post-development, week 9) the stretching development program in order to identify possible changes. Subsequently, after four weeks of detraining that coincided with Christmas holidays, a reassessment was performed in order to examine levels of retention (post-detraining, week 13). Finally, after the stretching maintenance program, the SR test was carried out again (post-maintenance, week 18).

The SR test was applied by the same examiner and instrument. 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). Additionally, the measurements were performed in an indoor sports facility under the same environmental conditions (e.g. temperature equal to 21-23ºC), on the same day of the week and at the same time of a day for each student. Because of practical reasons, no warming up was performed prior to flexibility measurements.

Students, in their sportswear and bearfoot, were assessed by a standardized protocol of the SR test. A detailed description of the SR protocol has been published elsewhere (Mayorga-Vega, Merino-Marban, & Garcia-Romero, 2015). Briefly, at the beginning of the test, the adolescents stood in front of the box, then sat down 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).

Procedures

Figure 1 shows a summary of the procedure carried out in the present study. A stretching intervention program was applied to the EG during PE sessions. Firstly, the EG students performed a stretching development program twice a week for eight weeks. Then, coinciding with the Christmas holidays, the EG students underwent a four-week period of flexibility detraining. Subsequently, the EG students performed a stretching maintenance program twice a week for four weeks. During the development program, the stretching exercises were performed at the end of the warm-up (two sets) and cool-down periods (two sets) of each PE session. However, during the maintenance program stretching exercises were performed only at the end of the cool-down period (two sets) of each PE session. In the PE planning, this kind of intervention implementation is called an "intermittent teaching unit" (Viciana & Mayorga-Vega, 2016).

During each intervention session, the EG participants performed hamstring stretches using a dynamic technique. The students sat down with their hips flexed and knees fully extended. The feet were placed together and toes pointed to the ceiling with no hip rotation. From this position, the adolescents flexed forward at the hip, trying to maintain the spine in a neutral position as much as possible until a gentle stretch was felt in the hamstrings. The stretched position was held gently until the end point of the range was reached (i.e. stretch to the point of feeling the tightness, but no pain). Once this position was achieved, the students performed soft repetitive bounces for 60 seconds (each set). During the development and maintenance programs the total stretching time per session was 240 and 120 seconds at the warm-up and cool-down, respectively.

All adolescents were urged to maintain their normal levels of physical activity outside the supervised setting during the research period. During the

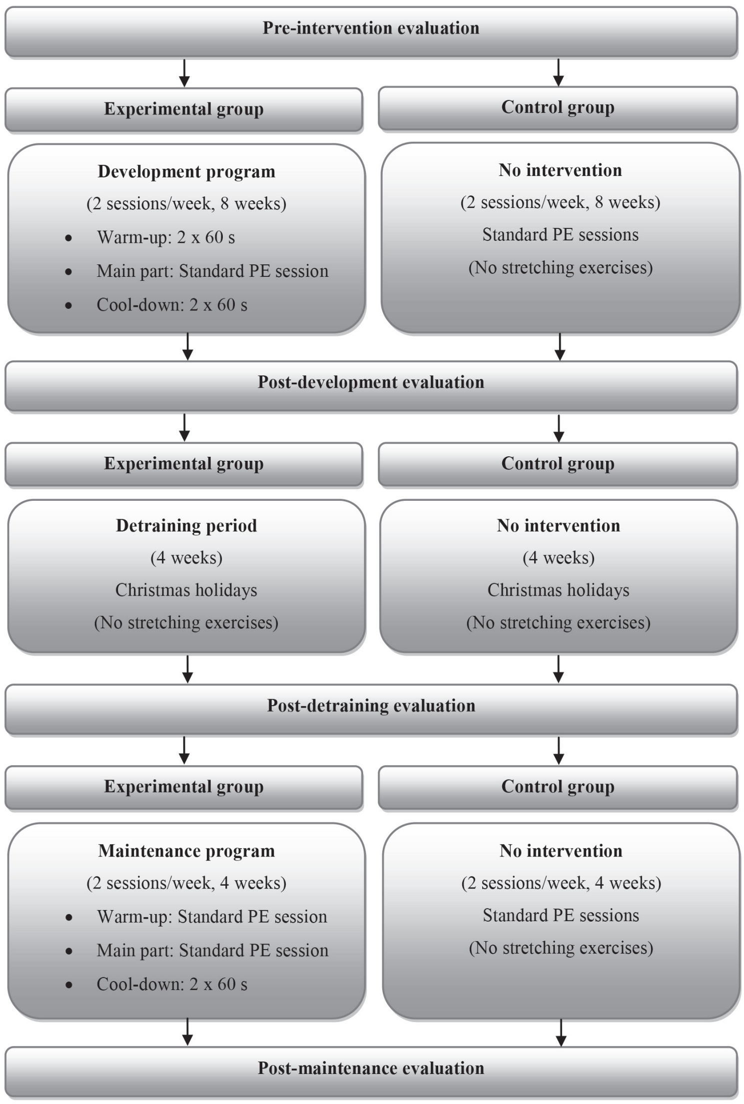

Figure 1. Flow chart representing the procedure in the present study.

flexibility program period all the students took part in their standard PE sessions. Additionally, both the standard PE sessions and the stretching intervention programs were conducted and supervised by the same PE teacher for both groups. However, the CG students did not perform stretching exercises and were not aware of the purpose of the study. On the other hand, the EG students were constantly urged to report any musculoskeletal discomfort or injury during the intervention program, as well as during the rest of the academic year.

Statistical analyses

Descriptive statistics (means and standard deviations) for body mass, body height, body mass index, and SR scores were calculated. Several common exploratory analyses for detecting potential data errors such as the extreme cases, statistical tests assumptions (i.e. normality, homogeneity of variance, etc.) were examined. Data met the set criteria for all the tests conducted. 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 the experimental and control groups. Afterwards, the effect of the stretching intervention program on the SR scores was examined using a two-way ANOVA, including *group* as an independent variable (CG, EG) and *time* as a dependent variable (pre-intervention, post-development, post-detraining, post-maintenance). Subsequently, 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 intervention effects (Hedges, 2007). The test-retest reliability of the pre-intervention and post-development SR scores of the CG was estimated using the intra-class correlation coefficient from a two-way ANOVA (ICC) (Shrout & Fleiss, 1979), as well as the 95% interval of confidence (95%IC). 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

Figure 2 is a flow chart that corresponds with the participants included in the present study. Although all the 108 invited students agreed to participate, six EG students did not meet the attendance rate criterion and, therefore, their data were not analyzed. The EG students analyzed had an average attendance rate of over 95%. General characteristics of the 102 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, or SR pre-intervention values between the experimental and control group ($p>.05$). The test-retest reliability for the SR score was high [ICC(95%IC)=.95 (.91-.97)].

Table 2 shows the effect of the stretching intervention program on the SR scores. The results of the two-way ANOVA showed interaction effects between the *group* and *time* variables [$F(3, 300)=17.696$; $p<.001$; $\eta^2_p=0.150$; P=1.000]. Subsequently, for *post hoc* analyses, ANOVA with the

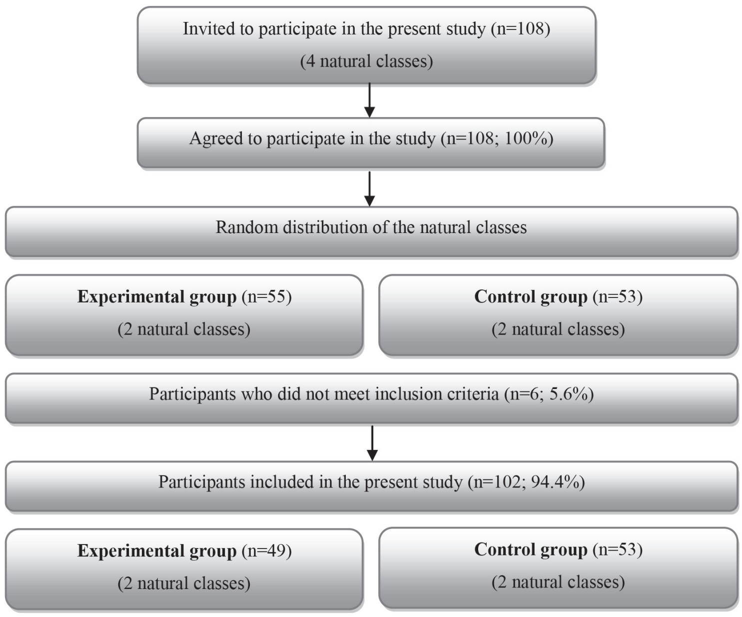

Figure 2. Flow chart corresponding to the participants included in the present study.

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

	Sample (N=102)	Experimental (n=49)	Control (n=53)	ANOVA[a]	
				F	p
Body mass (kg)	55.1±6.8	55.5±7.4	54.8±6.3	.265	.608
Body height (cm)	165.0±5.7	165.0±5.8	165.0±5.7	.003	.958
Body mass index (kg/m²)	20.2±2.2	20.4±2.3	20.1±2.0	.277	.600
Pre-intervention score (cm)	31.5±6.4	31.4±5.8	31.5±6.9	.018	.893

Note. [a] Significance level from the one-way analysis of variance between the experimental and control group.

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

Group	Pre-inter (1)	Post-dev (2)	Post-detr (3)	Post-mant (4)	ANOVA[a]	Pairwise comparisons[b]				
	(M±SD)	(M±SD)	(M±SD)	(M±SD)	p	(1-2)	(2-3)	(3-4)	(1-3)	(1-4)
Experimental (n=49)	31.4±5.8	34.0±5.3	30.8±5.5	32.6±5.5	<.001	<.001	<.001	<.001	1.000	.614
Control (n=53)	31.5±6.9	29.6±7.3	28.0±8.0	27.3±8.0		<.001	.012	.496	<.001	<.001
Effect size[c]	-	-	-	-	-	.70	-.24	.38	.46	.84

Note. M=mean; SD=standard deviation; [a] Significance level from the two-way analysis of variance (interaction effects); [b] Within-group pairwise comparisons with the Bonferroni adjustment (*post hoc* analyses); [c] Hedges' *g* effect size.

Bonferroni adjustment showed that the EG participants improved significantly hamstring extensibility from pre-intervention to post-development (p<.001). They also presented significantly higher values in post-maintenance than in post-detraining (p<.001). However, flexibility levels decreased significantly from post-development to post-detraining for the EG (p<.001), and statistically significant differences between the pre-intervention and post-detraining were not found (p>.05). Additionally, the EG did not show statistically significant differences from pre-intervention to post-maintenance (p>.05). On the other hand, the CG participants showed a statistically significant decrease throughout the time (p<.05), except from post-detraining to post-maintenance where statistically significant differences were not found (p>.05). Finally, no adolescent reported any musculoskeletal discomfort or injury either during the dynamic-based (bouncing) stretching intervention program or during the rest of the academic year.

Discussion and conclusions

Development program

The first aim of the present study was to evaluate the effects of a dynamic stretching development program on hamstring extensibility in female high-school students. Since static stretching technique has been mainly recommended for schoolchildren, up-to-date studies carried out with schoolchildren have used static stretching techniques to improve children's flexibility (e.g. Mayorga-Vega, et al., 2014b; Merino-Marban, et al., 2015; Sanchez Rivas, et al., 2014). The practice of dynamic stretching techniques has been avoided in work with young people because of a greater potential risk of muscle injury (Behm, et al., 2008; Faigenbaum, et al., 2009). Nevertheless, as several authors suggest (e.g. Behm, et al., 2011; Turki-Belkhiria, et al., 2014), dynamic stretching exercises may not be harmful when practiced in a soft way. The results of the present study revealed that a dynamic stretching program, carried out only twice a week, improves hamstring extensibility in female high-school students. Additionally, no musculoskeletal discomfort or injury was found either during the bouncing-based stretching intervention program or during the rest of the academic year.

Detraining period

The second aim of the present study was to examine the effects of a four-week period of flexibility detraining on hamstring extensibility in female high-school students. Hamstring extensibility improvements are expected to decrease after a period of detraining. Regrettably, an important limitation of PE planning is that an academic year is frequently interrupted by several holiday periods such as Christmas holidays. Therefore, after a short-term program during a semester, PE teachers have to cease doing stretching exercises in their classes and they do not know how long the effect will last. In this sense, the results of the present study showed that after four weeks of flexibility detraining, coinciding with Christmas holidays, adolescents' flexibility reverts to the baseline level.

Current scientific information about flexibility detraining is really scarce and contradictory (Cipriani, et al., 2012; Rancour, et al., 2009; Willy, et al., 2001), especially in school-age children (Mayorga-Vega, et al., 2014b; Merino-Marban, et al., 2015). Similarly to the present study, previous studies, in which a PE-based stretching program was carried out, also observed statistically significant loss of hamstring extensibility after five weeks of detraining (e.g. Mayorga-Vega, et al., 2014b; Merino-Marban, et al., 2015). Although Mayorga-Vega et al. (2014b) observed that schoolchildren retained significant gains, other previous studies found that children's flexibility levels decreased to baseline (Merino-Marban, et al., 2015). Considering research studies with adults, Willy et al. (2001) also observed that, after a short-term stretching program, adults' flexibility levels reverted to baseline after four weeks of detraining. In contrast, Cipriani et al. (2012) and Rancour et al. (2009) found that after four weeks of flexibility detraining adults retained significant gains.

The CG, the CG students showed a statistically significant decrease in the SR scores measured at the time points corresponding to the post-development, post-detraining and post-maintenance measurements, compared to their baseline levels. These findings might be mainly due to the well-described factor of age (Alter, 2004). In particular, during youth one of the main explanations for hamstring extensibility decrease is linked to the pubertal changes that occur in the musculoskeletal system, a fact that has shown to reach a major significance at the end of the adolescent period (Delgado, Martín, Zurita, Antequera, & Fernández, 2009; Ramos, González, & Mora, 2007). In line with the present study, previous studies about the effect of PE-based stretching programs also found statistically significant decreases in the CG students' scores (e.g. Rodríguez, Santonja, López-Miñarro, Sáinz de Baranda, & Yuste, 2008).

Therefore, since the effect of the stretching program has completely vanished after four weeks of flexibility detraining, PE teachers should continue training students' flexibility after a shorter detraining period in order to maintain the gains obtained in the previous semesters. In this sense, the increase of active time for learning in extra-curricular periods would represent an excellent strategy for PE teachers to pursue important objectives such as flexibility improvement (Merino-Marban, et al., 2015). Using, this strategy can help to avoid impairments of the flexibility improvements previously obtained. However, as Merino-Marban et al. (2015) indicated, this strategy mainly depends on students' autonomy. Therefore, apart from teaching their students how to properly perform stretching exercises, PE teachers should take appropriate didactic measures to ensure that their students really follow the indicated exercises.

Maintenance program

The third aim of the present study was to observe the effects of a dynamic stretching maintenance program on hamstring extensibility in female high-school students. Given that many PE curricular contents must be developed each academic year (e.g. Ministerio de Educación y Ciencia, 2007) and the curriculum time allocation of the subject is very restricted (European Commission/EACEA/Eurydice, 2013), the application of a stretching development program (i.e. with a relatively high volume) during the whole academic year could not be suitable. Therefore, since stretching programs cannot be allocated a large part of PE time, several authors have suggested that PE teachers should include a maintenance program with reduced volume in order to retain students' flexibility levels already gained during previous semesters (Viciana, et al., 2014a, 2014b). In this way, apart from maintaining the flexibility levels previously obtained, such programs would allow teachers to address other PE curricular contents at the same time (Mayorga-Vega, Viciana, & Cocca, 2013).

Unfortunately, to our knowledge there are no previous studies examining the effect of a stretching maintenance program in a PE setting, and the number of related studies with adults is scarce. As for the studies with adults, Rancour et al. (2009) found that, after a daily development stretching program with 2-3 sessions per week, the adults maintained the flexibility levels previously gained. Regrettably, since in most countries PE sessions occur only twice a week, the application of this program is not suitable. Additionally, Rancour et al. (2009) applied the maintenance program just after the development program, that is, without a period of inactivity between development and maintenance. 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 and academic periods (Viciana, et al., 2014a, 2014b).

On the other hand, as it was mentioned before, in order to apply this program in a PE setting, for instance, efficacy of a maintenance program of half a volume of stretching development program in each session should be tested. In this line, the results of the present study showed that a stretching maintenance program carried out for only two minutes per PE session (i.e. half a volume) improved students' hamstring extensibility. Unfortunately, it must be highlighted that the measured flexibility values before the *maintenance* program were at the baseline levels, therefore, strictly speaking it should be called *resumption* or *re-development* instead of *maintenance*. However, since the CG students showed a significant decrease in flexibility throughout the time of research, it seems that this program would allow to avoid the apparently normal decline of flexibility at this age.

Intervention magnitude effects

Regarding the magnitude effects of the intervention, the effect size of the 8-week development program was moderate-to-high. In contrast with these results, all previous studies carrying out short-term PE-based stretching programs (5-10 weeks) obtained lower effect sizes, with a low-to-moderate median value (g=.43) (Kamandulis, Emeljanovas, & Skurvydas, 2013; Mayorga-Vega, Merino-Marban, Garrido, & Viciana, 2014a; Mayorga-Vega, et al., 2014b; Merino-Marban, et al., 2015; Sánchez Rivas, et al., 2014). On the other hand, the effect size of the two-minute-per-session maintenance program carried out for four weeks was moderate. Similarly to the current study, Kamandulis et al. (2013) found that, after a five-week development stretching program carried out twice a week, adolescents obtained a moderate improvement of hamstring extensibility, but small when the volume of stretching was reduced (80 s vs. 320 s of total stretching time).

Finally, we would like to mention that at the end of the intervention the effect size in the present study was high, being similar to previous studies with mid-term programs (median g=.86) (Coledam, Arruda, & Ramos de Oliveira, 2012) and even to those with longer term programs (median g=.94) (Rodríguez, et al., 2008; Sainz de Baranda, 2009; Sainz de Baranda, et al., 2006; Santonja Medina, et al., 2007). Therefore, it seems that a stretching program using a dynamic technique is effective for improving hamstring extensibility in a PE setting.

Limitations and future research studies

The main limitations of the present study were related to the validity of the test used. Flexibility is typically characterized by the maximum range of motion in a joint or series of joints (McHugh, Kremenic, Fox, & Gleim, 1998). Particularly, the angular test that specifically measures hip flexion (i.e. straight leg raise test) has been widely considered the criterion measure of hamstring extensibility (Mayorga-Vega, et al., 2014c). However, as in the present study, when the use of this angular test is limited due to practical issues such as the time constraints, the classical SR test has shown to be a useful alternative for estimating hamstring extensibility (Mayorga-Vega, et al., 2014c).

A potential factor that could affect the validity of the SR test is the difference in length between the participants' upper and lower limbs (Hoeger, Hopkins, Button, & Palmer, 1990). However, since in the present study the pre-intervention values were assessed, any change in the participants' flexibility was compared with their baseline level. Additionally, another potential limitation of using a lineal test might be due to the change in the proportion of anthropometric parameters and/or in the position of the spine between the pre-intervention and the subsequent measurements. Nevertheless, it must be highlighted that the study design included an equivalent CG (i.e. characteristics such as age, body height, body mass, gender ratio, extra-curricular sport practitioners ratio, or pre-intervention values were equivalent between the groups). Therefore, we could reasonably assume that any change in the proportion of anthropometric parameters and/or in the position of the spine was similar in both the experimental and control group.

Future research interventions should compare effectiveness of different stretching techniques on flexibility improvements in school-age children. In this way, while controlling other potential moderator factors, we may identify the most appropriate technique to be used in a PE setting. Future research studies should also examine in depth the effects of different periods of flexibility detraining in schoolchildren, as well as the application of maintenance stretching programs in order to maintain the flexibility gains obtained previously. This knowledge could help PE teachers to design programs that guarantee a feasible and effective development of students' flexibility in a PE setting.

In conclusion, a PE-based dynamic stretching program, performed twice a week for eight weeks, improves hamstring extensibility in female high-school students. After four weeks of flexibility detraining, students' hamstring extensibility reverts to its baseline levels. A dynamic stretching program carried out for only two minutes per session improves hamstring extensibility in female high-school students, also maintaining their flexibility values above the common decline of flexibility levels at this age. Apart from being an effective way to improve hamstring extensibility, the dynamic (bouncing) technique seems to be completely safe to be used by female high-school students in a PE setting.

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