Comparison between warm-up and cool-down stretching programs on hamstring extensibility gains in primary schoolchildren

Authors' Contribution:

A – Study Design
B – Data Collection
C – Statistical Analysis
D – Manuscript Preparation
E – Funds Collection

Daniel Mayorga-Vega[1ACDE], **Rafael Merino-Marban**[2ABD], **Francisco Javier Garrido**[3AB], **Jesús Viciana**[1AD]

1. Department of Physical Education and Sport, University of Granada, Spain
2. Facultad de Ciencias de la Educación, Universidad de Málaga (UMA), Campus de Teatinos, s/n, 29071, Málaga, España
3. Department of Physical Education, Elementary Education School of Gibraljaire, Spain

Abstracts.
The purpose of this study was to compare the effects of a physical education-based stretching program performed during warm-up and cool-down periods on hamstring extensibility in schoolchildren aged 9-10 years. A sample of 73 schoolchildren, 36 boys and 37 girls, aged 9-10 years old from three classes were clustered randomly assigned to a no-training group (n = 24), warm-up group (n = 25), or cool-down group (n = 24). During physical education classes, the students of the warm-up and cool-down groups performed a four-minute stretching program twice a week for ten weeks during the warm-up and the cool-down periods, respectively. Hamstring extensibility was estimated by the classic sit-and-reach test at the beginning and at the end of the stretching intervention program. The results of the ANOVA showed that both the warm-up and cool-down students had statistically significant higher values on the hamstring extensibility than the no-training students ($p < 0.05$). The warm-up and cool-down groups did not show statistically significant differences. Nevertheless, the cool-down students obtained a slightly higher magnitude effect when compared with the warm-up group ($g = 0.67$ and $g = 0.56$, respectively). In addition to the slight higher improvement during the cool-down, due to the negative effect of static stretching on performance as previously found in the literature, it seems that physical education teachers should improve students´ flexibility during the cool-down period of the sessions.

Keywords: *Flexibility program, classic sit-and-reach test, elementary school, physical education setting, physical fitness.*

INTRODUCTION

Physical fitness has been considered a powerful marker of health in childhood [1,2], and flexibility is an important component of physical fitness [3]. Particularly, the lack of hamstring extensibility has been associated with several spinal disorders such as thoracic hyperkyphosis [4], spondylolysis [5], disc herniation [6], changes in lumbopelvic rhythm [7,8] and low back pain [9-11]. In young people, for instance, poor hamstring extensibility has been related with low-back pain [11-13] and neck tension [14], as well as with a higher risk of low-back pain later

in life [15-17].

Reduced hamstring extensibility has been found to affect a large number of schoolchildren [18-20]. For example, in Spain about the 18-38% of schoolchildren show insufficient hamstring extensibility [19,21]. Fortunately, it has been demonstrated that hamstring extensibility significantly improves when stretching exercises are performed systematically [22, 23]. In this line, previous studies found that PE-based stretching programs improve hamstring extensibility in schoolchildren [22-27]. Therefore, several authors advocate the implementation of stretching programs in a physical education (PE) classes [22-27].

Aiming to improve hamstring extensibility, up to date research studies with schoolchildren have compared the effectiveness of diverse stretching protocols such as flexibility methods [28] or frequency [23]. Unfortunately, to our knowledge there are no studies comparing the effect of performing the stretching program in the warm-up or the cool-down period of the session. This knowledge could help PE teachers to design programs that guarantee the correct improvement of students´ flexibility. Currently, as there is a lack of scientific information about this aspect among schoolchildren, research in this area is required. Consequently, the purpose of this study was to compare the effects of a PE-based stretching program performed during the warm-up and the cool-down phases on hamstring extensibility in schoolchildren aged 9-10 years.

METHODS

Participants

A sample of 73 schoolchildren, 36 boys and 37 girls, aged 9-10 years old from three different third grade PE classes of a primary school participated in this study. For practical reasons and the nature of the present study (the intervention was focused on natural groups in a school context) a cluster randomized controlled trial was used [29]. Natural classes were assigned randomly to form one of the following study groups: no-training group (NTG), warm-up group (WUG), or cool-down group (CDG).

All the participants were free of orthopedic disorders such as episodes of hamstring injuries, fractures, surgery or pain in the spine or hamstring muscles over the past six months [30]. 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 (25-01-2010).

Measures

Hamstring extensibility was estimated using the classic sit-and-reach (SR) test to show the best current science-based field test option [31]. The SR test was applied at the beginning and at the end of the stretching intervention program (pre-intervention and post-intervention, respectively) in order to examine the possible changes produced. Additionally, a week before, a familiarization session was carried out by the children in order to learn about the protocol of the tests, and then children performed two attempts. Hamstring extensibility was assessed by the same tester and using the same equipment. The test was administered by a trained evaluator using a wooden box with a ruler on the top (the score 16 cm corresponded to the tangent of the feet; accuracy 1 cm). The measures were performed 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 warming up exercises were performed prior to the flexibility measurements.

At the beginning of the test, each child stood in front of the box, sat with his/ her 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 child had to bend the trunk forward slowly and progressively (no rebounds) in order to reach the furthest possible distance and to remain still for at least two seconds. The average of two trials was retained [32].

Procedures

A stretching intervention program was applied to the WUG and CDG during the PE classes. These groups performed a stretching intervention program twice a week on nonconsecutive days for 10 weeks. The stretching program was conducted and supervised by the same PE teacher of the groups. Based on previous studies carried out in the PE setting [23, 27], the WUG and CDG students performed hamstring stretches utilizing the static passive technique for four minutes during the warm-up and cool-down period, respectively.

Six different stretching exercises were performed during the intervention program (Figure 1). A unipodal and two bidopals exercises were performed in each session. Standing and sitting stretching exercises were also alternated between sessions. Each intervention session included three sets of three stretching exercises. For 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). Once this position was achieved, the children held it for 20 seconds.

Fig.1: The six stretching exercises performed during the intervention program: (a) standing with feet together; (b) sitting with feet together; (c) standing with feet shoulders width apart; (d) sitting with feet shoulders 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 of the supervised setting during the intervention period. During the stretching program period all the students participated in their standard PE lessons. However, the NTG followed the standard PE program without performing hamstring stretches. Furthermore, the participants in the NTG were unaware of the purpose of the study.

Statistical analysis

Descriptive statistics (means and standard deviations) for age, body mass, height, body mass index, and SR scores were calculated. A one-way analysis of variance (ANOVA) was used to study the differences of the general characteristics and pre-intervention SR scores between groups, except for the age variable where the Kruskal-Wallis test was used. Additionally, chi-squared analyses were carried out to test the ratio differences of gender and extra-curricular sport practitioners between the groups. Subsequently, the effect of the stretching program on hamstring extensibility was examined using analysis of variance (ANOVA) applied to one factor, including group as a fixed factor (NTG, WUG, CDG) and change on SR scores as a dependent variable (post-intervention values - pre-intervention values). Then, the *post-hoc* pairwise comparisons were carried out with the Bonferroni adjustment. Furthermore, the Hedges´ *g* effect size defined as the difference between the post-pre score means of two groups divided by the standard deviation of the pooled variances of both groups was used to estimate the magnitude of treatment effects [33]. The test-retest reliability of SR test was estimated using the intraclass correlation coefficient from two-way ANOVA [34], 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 $p < 0.05$.

RESULTS

The general characteristics of the participants studied are shown in Table 1. Statistically significant differences in the age, body mass, height, body mass index, and SR pre-intervention values between the three groups were not found ($p > 0.05$). Additionally, the chi-square analyses showed that the three groups had a balanced representation of boys and girls ($\chi^2_2 = 0.026$; $p = 0.987$) and extra-curricular sport practitioners and non-practitioners ($\chi^2_2 = 1.415$; $p = 0.493$).

Table 2 shows the effect of the stretching intervention program on hamstring extensibility. The results of the ANOVA on the SR values showed interaction effects between the three group [$F(2) = 7.366$; $p = 0.001$; $\eta^2_p = 0.174$; $P = 0.930$]. Subsequently, the *post-hoc* pairwise comparisons with the Bonferroni adjustment showed that the scores of the NTG participants were statistically significant lower than the WUG and CDG ($p = 0.017$ and $p = 0.001$, respectively). However, between the WUG and CDG statistically significant differences were not found ($p = 1.000$). Finally, the test-retest reliability for SR was 0.92 (0.88-0.95).

Table 1. General characteristics (mean ± standard deviation) of the participants.

	All sample (*n* = 73)	**No-training (*n* = 24)**	**Warm-up (*n* = 25)**	**Cool-down (*n* = 24)**	***p*[a]**
Age (year)	9.0 ± 0.2	9.0 ± 0.2	9.0 ± 0.2	9.0 ± 0.2	0.999
Body mass (kg)	32.7 ± 6.9	32.6 ± 8.4	32.8 ± 5.9	32.7 ± 6.4	0.996
Height (cm)	132.7 ± 6.1	133.7 ± 8.0	131.9 ± 5.5	132.4 ± 4.3	0.594
Body mass index (kg/m^2)	18.4 ± 2.9	18.0 ± 3.2	18.7 ± 2.6	18.6 ± 3.1	0.662
Gender (boys/ girls)	36/ 37	12/ 12	12/ 13	12/ 12	0.987
Physical activity (yes/ no)[b]	31/ 42	9/ 15	13/ 12	9/ 15	0.493

Note. [a] Significance level from the Kruskal-Wallis test for the age, from the analysis of variance for the body mass, height and body mass index, and from the chi squared test for the gender and physical activity; [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 stretching intervention program on sit-and-reach scores (cm).

Group	Pre-intervention (*M* ± *SD*)	Post-intervention (*M* ± *SD*)	Pre-post difference (*M* ± *SD*)	*p*[a]	Effect size[b]	
Warm-up (*n* = 25)	10.2 ± 3.7	9.9 ± 3.2	- 0.3 ± 2.4*	0.001	0.56	(WUG vs NTG)
Cool-down (*n* = 24)	11.8 ± 4.3	12.3 ± 5.0	0.5 ± 3.3††		0.67	(CDG vs NTG)
No-training (*n* = 24)	12.6 ± 5.2	9.9 ± 4.2	- 2.8 ± 3.4		0.19	(CDG vs WUG)

Note. *M* = mean; *SD* = standard deviation; WUG = Warm-up group; CDG = Cool-down group; NTG = No-training group; [a] Significance level from analysis of variance with the *post hoc* pairwaise comparison with the Bonferroni adjustment; difference statistically significant between WUG and NTG (* $p < 0.05$), and between CDG and NTG (†† $p < 0.01$). [b] Hedges´ *g* effect size.

DISCUSSION

The purpose of the present study was to compare the effects of a PE-based stretching program performed during the warm-up and the cool-down phases on hamstring extensibility in schoolchildren. The results of this study show that both WUG and CDG students significantly have higher scores on the hamstring extensibility than the NTG after performing the stretching program in the PE setting. However, the WUG and CDG did not show post- pre-intervention differences on hamstring extensibility. In this line, previous studies in which schoolchildren performed a PE-based stretching program during the warm-up [24] or cool-down [22, 23, 26, 27] found a significant improvement in hamstring extensibility. However, in the preceding studies the students carried out the stretching intervention program separately

during the warm-up [24] or the cool-down phase [22, 23, 26, 27], and to our knowledge there are no studies comparing the effect of performing the stretching program during the warm-up or the cool-down phase of the session.

Regarding the magnitude effects of the intervention, the effect size of the present study was moderate for both WUG (g = 0.56) and CDG (g = 0.67) indicating that the stretching program was effective to improve SR scores compared to the NTG. In contrast with the current results, all the previous studies carried out with primary schoolchildren obtained large effect sizes (g = 0.85-2.06) [22-24, 26, 27]. Several training factors such as duration of the program or time of stretching per session might clearly influence the magnitude effect of the intervention. In this line, the intervention program of all the above mentioned studies had a significant longer duration, lasting from 16 weeks [24] to a whole academic year (31-32 weeks) [22, 23, 26, 27]. Regarding the time per session allocated to stretching, in comparison with the three minutes of improving hamstring extensibility in the current study (i.e., although the program lasted four minutes, each hamstring muscle was stretched for three minutes), all the preceding studies were carried out for five to seven minutes [22-24, 26, 27].

Although the WUG and CDG did not show statistically significant post- pre-intervention differences on hamstring extensibility, CDG students obtained a slightly higher magnitude effect when compared with the WUG (g = 0.19). Despite the fact that a magnitude effect lower than 0.20 is considered insignificant [35], according to Valentine and Cooper [36], we have to be aware that in an education context even low values of effect size could be considered as a practical relevance. This result could be due to the fact that performing the stretching exercises in the cool-down period might relax the muscles worked during the session, returning them to their previous length and even improving it. However, when stretching exercises are performed during the warm-up (i.e., before the main part of the session) this could not happen. Additionally, previous studies have shown that the inclusion of static stretching exercises during the warm-up negatively affects the posterior performance in important parameters such as explosive strength [37-40], speed [41] or sports skills [42]. Hence, for all the above mentioned reasons, it seems to be more reasonable for PE teacher to improve the students flexibility during the cool-down period.

In conclusion, to our knowledge this study is the first one that compares the effect of a PE-based stretching program performed during warm-up and cool-down among schoolchildren. The results of the present study suggest that it is possible to develop schoolchildren´s hamstring extensibility through a PE-based stretching program performed during both warm-up and cool-down. However, although both groups did not show statistically significant differences, it seems that PE teachers should improve students´ flexibility during the cool-down period of the sessions because of the slight higher improvement during the cool-down and the negative effect of static stretching on performance previously found in the literature [37-42]. Future research interventions should deeply examine (e.g., different durations, intensities or flexibility techniques) the effect of PE-based stretching programs performed during the warm-up and the cool-down periods. All this knowledge could help PE teachers to design programs that guarantee the correct improvement of students´ flexibility.

ACKNOWLEDGMENTS

We thank Aliisa Hatten for the English revision. The first author is supported by research grant from the Spanish Ministry of Education, Culture and Sport (AP2010-5905)

REFERENCES

1. Ortega FB, Ruiz JR, Castillo MJ, Sjöström M: Physical fitness in childhood and adolescence: A powerful marker of health. International Journal of Obesity, 2008; 32: 1-11.
2. Ruiz JR, Castro-Pinero J, Artero EG, Ortega FB, Sjöström M, Suni J, Castillo MJ: Predictive validity of health-related fitness in youth: A systematic review. British Journal of Sports Medicine, 2009; 43: 909-23.
3. Bouchard C, Sheppard RJ: Physical activity, fitness, and health: The model and key concepts. In: Bouchard C, Shephard RJ, Stephens T (eds.), Physical Activity, Fitness, and Health, Human Kinetics, 1994; 77-88.
4. Fisk JW, Baigent ML, Hill PD: Scheuermann´s disease. Clinical and radiological survey of 17 and 18 year olds. American Journal of Physical Medicine, 1984; 63: 18-30.
5. Standaert CJ, Herring SA: Spondylolysis: A critical review. British Journal of Sports Medicine, 2000; 34: 415-22.
6. Harvey J, Tanner S: Low back pain in young athletes: A practical approach. Sports Medicine, 1991; 12: 394-406.
7. Esola MA, McClure PW, Fitzgerald GK, Siegler S: Analysis of lumbar spine and hip motion during forward bending in subjects with and without a history of low back pain. Spine, 1996; 21: 71-8.
8. López-Miñarro PA, Alacid F: Influence of hamstring muscle extensibility on spinal curvatures in young athletes. Science & Sports, 2009; 25: 188-93.
9. Biering-Sorensen F: Physical measurements as risk indicator for low-back trouble over a one year period. Spine, 1984; 9: 106-19.
10. Mierau D, Cassidy JD, Yong-Hing K: Low-back pain and straight in children and adolescents. Spine, 1989; 14: 526-8.
11. Sjolie AN: Low-back pain in adolescents is associated with poor hip mobility and high body mass index. Scandinavian Journal of Medicine & Science in Sports, 2004; 14: 168-75.
12. Feldman DE, Shrier I, Rossignol M, Abenhaim L: Risk factors for the development of low back pain in adolescence. American Journal of Epidemiology, 2001; 154: 30-36.
13. Jones MA, Stratton G, Reilly T, Unnithan VB: Biological risk indicators for recurrent non-specific low back pain in adolescents. British Journal of Sports Medicine, 2005; 39: 137-40.
14. Mikkelsson LO, Nupponen H, Kaprio J, Kautiainen H, Mikkelsspn M, Kujala U: Adolescent flexibility, endurance strength, and physical activity as predictors of adult tension neck, low back pain, and knee injury: A 25 year follow up study. British Journal of Sports Medicine, 2006; 40: 107-13.
15. Hestbaek L, Leboeuf-Yde C, Kyvik KO, Manniche C: The course of low back pain from adolescence to adulthood. Eight year follow up of 9600 twins. Spine, 2006; 31: 468-72.
16. Kujala UM, Salminen JJ, Taimela S, Oksanen A, Jaakkola L: Subject characteristics and low-back-pain in young athletes and nonathletes. Medicine and Science in Sports and Exercise, 1992; 24: 627–32.
17. Kujala UM, Taimela S, Salminen JJ, Oksanen A: Baseline anthropometry, flexibility and strength characteristics and future low-back pain in adolescent athletes and nonathletes. Scandinavian Journal of Medicine and Science in Sports, 1994; 4: 200-5.
18. Brodersen A, Pedersen B, Reimers J: Incidence of complaints about heel, knee and back related discomfort among Danish children, possible relation to short muscles. Ugeskrift fot Laeger, 1994; 156: 2243-5.
19. Ferrer V: Repercusiones de la cortedad isquiosural sobre la pelvis y el raquis lumbar. Doctoral dissertation. University of Murcia, 1998 [in Spanish].
20. Harreby M, Neergaard K, Jessen T, Larsen E, Storr-Paulsen A, Lindahl A, Fisker I, Laegaard E: Risk factors for low back pain in a cohort of 1389 Danish school children an epidemiologic study. European Spine Journal, 1999; 8: 444-50.
21. Castro-Piñero J, Girela-Rejón MJ, González-Montesinos JL, Mora J, Conde-Caveda J, Sjöström M, Ruiz JR: Percentile values for flexibility tests in youths aged 6 to 17 years: Influence of weight status. European Journal of Sport Science, 2013; 13: 139-48.

22. Rodríguez PL, Santonja FM, López-Miñarro PA, Sáinz de Baranda JL: Effect of physical education stretching program on sit-and-reach score in schoolchildren. Science & Sports, 2008; 23: 170-5.
23. Santonja Medina FM, Sainz de Baranda P, Rodríguez García PL, López Miñarro PA, Canteras Jordana M: Effects of frequency of static stretching on straight-leg raise in elementary school children. Journal of Sports Medicine and Physical Fitness, 2007; 47: 304-8.
24. Coledam DHC, Arruda GA, Ramos de Oliveira A: Chronic effect of static stretching performed during warm-up on flexibility in children. Revista Brasileira de Cineantropometria e Desempenho Humano, 2012; 14: 296-304.
25. Kanásová J: Reducing shortened muscles in 10-12-year-old boys through a physical exercise program. Medicina Sportiva, 2008; 12: 115-23.
26. Rodríguez García PL, Santonja Medina F, Canteras Jornada M, Delgado Fernández M, Fernández Piñera J, Balsalobre Marín J: Mejora de la extensibilidad isquiosural tras un programa escolar de estiramientos. Selección, 1999; 8: 157-64 [in Spanish].
27. Sainz de Baranda P, Rodríguez PL, Santonja FM, López-Miñarro PA, Andujar P, Ferrer V, Pastor A: Effects of hamstring stretching exercises on the toe-touch test in elementary schoolchildren. Journal of Human Movement Studies, 2006; 51: 277-89.
28. Vidal Barbier M: Valoración de siete métodos de desarrollo de la flexibilidad. Apunts. Medicina de l´Esport, 1995; 32: 195-201 [in Spanish].
29. Mayorga-Vega D, Viciana J, Cocca A: Effects of a circuit training program on muscular and cardiovascular endurance and their maintenance in schoolchildren. Journal of Human Kinetics, 2013; 37: 153-60.
30. López-Miñarro PA, Sainz de Baranda P, Rodríguez-Garcia PL: A comparison of the sit-and-reach test and the back-saver sit-and-reach test in university students. Journal of Sports Science & Medicine, 2009; 8: 116-22.
31. Mayorga-Vega D, Merino-Marban R, Viciana J: Criterion-related validity of sit-and-reach tests for estimating hamstring and lumbar extensibility: A meta-analysis. Journal of Sports Science and Medicine, in press.
32. Mayorga-Vega D, Merino-Marban R, Garcia-Romero JC: Validity of sit-and-reach with plantar flexion test in children aged 10-12 years. Revista Internacional de Medicina y Ciencias de la Actividad Física y del Deporte, in press.
33. Hedges LV: Effect sizes in cluster-randomized designs. Journal of Educational and Behavioral Statistics, 2007; 32: 341-70.
34. Shrout PE, Fleiss JL: Intraclass correlations: Uses in assessing rater reliability. Psychological Bulletin, 1979; 86: 420-8.
35. Cohen JA: Power primer. Psychological Bulletin, 1992; 112: 155-9.
36. Valentine J, Cooper H: Effect size substantive interpretation guidelines: Issues in the interpretation of effect sizes. Washington, What Works Clearing House, 2000.
37. Faigenbaum AD, Belluci M, Bernieri A, Bakker B, Hoorens K: Acute effects of different warm-up protocols on fitness performance in children. Journal of Strength and Conditioning Research, 2005; 19: 376-81.
38. Faigenbaum AD, McFarland JE, Kelly NA, Ratamess NA, Kang J, Hoffman JR: Influence of recovery time on warm-up effects in male adolescent athletes. Pediatric Exercise Science, 2010; 22: 266-77.
39. Gelen E: Acute effects of different warm-up methods on jump performance in children. Biology of Sport, 2011; 28: 133-8.
40. Duncan MJ, Woodfield LA: Acute effects of warm up protocol on flexibility and vertical jump in children. Journal of Exercise Physiology online, 2006; 9: 9-16.
41. Needham RA, Morse CI, Degens H: The acute effect of different warm-up protocols on anaerobic performance in elite youth soccer players. Journal of Strength and Conditioning Research, 2009; 23: 2614-20.
42. Di Cagno A, Baldari C, Battaglia C, Gallotta MC, Videira M, Piazza M, Guidetti L: Pre-exercise static stretching effect on leaping performance in elite rhythmic gymnasts. Journal of Strength and Conditioning Research, 2010; 24: 1995-2000.

Address for correspondence:

Daniel Mayorga-Vega - Faculty of Science of Physical Activity and Sport, Department of Physical Education and Sport, University of Granada, Alfacar street, 18011, Granada (Spain). email: dmayorgavega@gmail.com

Recevied: 30.10.2013; Accepted: 4.01.2014; Published online: 2.02.2014