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original article

Chronic effect of static stretching performed during warm-up on flexibility in children

Efeito crônico do alongamento estático realizado durante o aquecimento sobre a flexibilidade de crianças

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Abstract – The purpose of this study was to assess the chronic effect of static stretching performed during warm-up on flexibility in children. The study sample comprised 29 boys (mean age 8.58±0.63 years, height 1.27±0.07 m, weight 28.94±6.03 kg) and 29 girls (mean age 8.60±0.92 years, height 1.31±0.09 m, weight 31.30±8.56 kg). Participants were allocated into four groups: male control group (MCG, n=15); male intervention group (MIG, n=14); female control group (FCG, n=15); and female intervention group (FIG, n=14). The FIG and MIG took part in a 16-week intervention program that consisted of six stretching exercises performed during the warm-up period of physical education classes. Flexibility was assessed by the sit-and-reach test, which was performed at baseline and after 16 weeks of the intervention program. Factorial ANOVA for repeated measures was used with group, sex, and point in time (pre- or post-intervention) as the independent variables, followed by Tukey's post-hoc test. Sit-and-reach test performance improved significantly in both intervention groups (MIG, 24.89±5.01 cm at baseline vs. 29.07±4.51 cm post-intervention; FIG, 27.25±4.43 cm at baseline vs. 32.14±3.24 cm post-intervention; P<0.0001). There were no significant changes in either control group (MCG, 24.17±5.14 cm at baseline vs. 23,87±4,35 cm post-intervention; FCG, 28,60±6,07 cm at baseline vs. 28,97±6,38 cm post-intervention; P>0.05). Furthermore, the results revealed a significant group × time interaction (F=1.54, P<0.0001). The performance of stretching exercises during warm-up can increase flexibility in children.

Key words: Physical exercises; Physical fitness; Schoolchildren.

Resumo – *O objetivo desse estudo foi verificar o efeito crônico do alongamento estático realizado durante o aquecimento sobre a flexibilidade de crianças. Participaram do estudo 29 meninos 8,58 (0,63) anos, 1,27 (0,07) m e 28,94 (6,03) kg e 29 meninas 8,60 (0,92) anos, 1,31 (0,09) m e 31,30 (8,56) kg que foram divididos em quatro grupos: Grupo Controle Masculino (GCM) n=15, Grupo Intervenção Masculino (GIM) n=14, Grupo Controle Feminino (GCF) n= 15 e Grupo Intervenção Feminino (GIF) n=14. O GIF e GIM foram submetidos a um programa de atividade com duração de 16 semanas que consistiu na realização de aquecimento por meio de seis exercícios de alongamento durante as aulas de Educação Física escolar. A flexibilidade foi avaliada pelo Teste de "Sentar-e-Alcançar", realizado anteriormente às 16 semanas do programa de intervenção e após o seu término. ANOVA Fatorial com medidas repetidas foi utilizada tendo com variáveis independentes o grupo, sexo e momento, seguido do teste Post-Hoc de Tukey. O GIM 24,89 (5,01) vs 29,07 (4,51) cm e GIF 27,25 (4,43) vs 32,14 (3,24) cm aumentaram significativamente o desempenho no Teste de "Sentar-e-Alcançar" após 16 semanas de intervenção utilizando aquecimento por meio de alongamento (P<0,0001). Nos grupos GCM 24,17 (5,14) vs 23,87 (4,35) cm e GCF 28,60 (6,07) vs 28,97 (6,38) cm não foram verificadas alterações significativas (P>0,05). Além disso, os resultados apresentaram interação significativa para os fatores grupo x tempo (F=1,54, P<0,0001). É possível aumentar a flexibilidade de crianças por meio de exercícios de alongamento utilizados durante o aquecimento em crianças.*

Palavras-chave: *Aptidão física; Escolares; Exercício físico.*

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INTRODUCTION

Flexibility is an important, health-related component of physical fitness. Inadequate flexibility of the hamstrings and lumbar region is associated with low back pain[1] and neck pain[2].

Low back pain affects approximately 40% of children in the UK[3], 37% in the U.S.[4] and 49% in Brazil[5]. In addition to this high prevalence of low back pain, children and adolescents in Brazil also have a high prevalence of failure to meet the established criteria for flexibility on the sit-and-reach test: 40 to 70% in children aged 7-11 years in different regions of Brazil[6,7].

Physical inactivity is associated with increased risk of low back pain and neck pain in adults[8]. Therefore, one of the interventions for treatment and prevention of low back pain is the prescription of specific postural stabilization exercises and general exercises for the abdominal and lumbar region[9]. Furthermore, due to the significant association between impaired flexibility and lumbar pain[10], stretching exercises have been used for the prevention of low back pain in adults and children[12]. Exercise-based intervention decreases the perception of low back pain and the number of missed training sessions, as well as improves performance on the sit-and-reach test, hip flexibility, and core strength in adolescents[13].

Traditionally, stretching exercises are performed during physical education (PE) classes in school, usually at the start of classes, during the warm-up period[14]. Evidence as to the effect of warm-up on performance has shown that the inclusion of active static stretching exercises hinders later performance on parameters such as vertical jump and long jump[15,16], speed[17], agility[15],and specific rhythmic gymnastics elements[18] in children and adolescents. Therefore, it has been recommended that static stretching be replaced with other exercises during the warm-up routines of children and adolescents[6,19].

The available evidence on the chronic effects of stretching concerning the efficacy of stretching in preventing injury and adolescent athletes after performance of preventive exercises meant to improve strength, power, coordination and balance[20,21]. However, there is little information about the chronic effect of the stretching-based warm-ups commonly performed in PE classes on flexibility in children. Therefore, the objective of this study was to analyze the chronic effect of stretching-based warm-ups on flexibility in children.

METHODS

Sample

The study sample comprised 58 volunteer fourth-graders (29 boys and 29 girls) enrolled in the municipal school system of the municipality of Nova Europa, state of São Paulo, Brazil. An intentional sampling strategy was used. The inclusion criteria were: absence of any characteristics that might prevent involvement in physical exercise; no involvement in any form of systematic physical training; and an attendance rate of 85% or higher for PE classes. Pursuant to National Health Council Resolution no. 196/96, the parents or guardians of study participants signed an informed consent form that specified all study procedures. This study project was approved by the Universidade Estadual Paulista at Bauru Research Ethics Committee with protocol number 11017/46/01/10.

Experimental procedures

Data collection took place at the start the school year (first semester) so that results would not be influenced by exercises performed during previous classes. During the two months preceding the study (summer vacation), participants were not involved in PE classes or any other form of systematized physical training. Participants were allocated into four groups: male control group (MCG), n=15; male intervention group (MIG), n=14; female control group (FCG), n=15; and female intervention group (FIG), n=14. All participants were instructed to maintain their habitual activities throughout the course of the study.

Body mass was measured with digital scales (resolution 100 g), and height, with a portable wall-mounted stadiometer (resolution 0.1 cm). A standardized sit-and-reach test was performed, as previously described in the literature[21], before the start of intervention. (pre) and after the end of the intervention period (post), which had a duration of 16 weeks. Participants were given information on how the test should be performed, observed the demonstration of the test, and only then performed the test themselves.

All experimental procedures were carried out with the same investigator, the same site, and using the same equipment. Throughout the two-day periods during which the sit-and-reach tests were performed, room temperature was measured with a portable digital thermometer (Incoterm®, resolution 0.1°C) (pre=22.8 ºC, post=21.2 ºC; 5% variation).

Stretching-based intervention program

The study intervention was performed during PE classes, which took place twice a week and had a duration of 50 minutes each. In the male and female control groups, the warm-up routine consisted solely of a 3-minute jog followed by a 5-minute walk, for a total duration of 8 minutes.

Participants in the male and female intervention groups also performed a 3-minute jog, but this was then followed by a 5-minute stretching routine, which was the subject of analysis.

Stretching exercises were performed by means of the static active stretching method; participants performed each stretching motion unaided and held each position (which corresponded to a certain range of joint motion) statically. The stretching intervention consisted of a series of six exercises. Participants were instructed to hold each position for 20 seconds counted from the onset of muscle or joint discomfort[16], with a 10-second rest period between each exercise. The overall duration of the warm-up intervention was 8 minutes per class. All stretching exercises are described in Box 1 and portrayed in Figure 1. The duration and content of the warm-up routine remained constant throughout the 16-week intervention period. Warm-up routines were supervised by the same investigator on all 32 classes that took place during the intervention period.

Box 1. Description of stretching exercises performed during the warm-up routine.

Muscle group	Description
Triceps surae	While standing, with the legs spread along the anterior-posterior axis, the participant keeps the sole of the trailing foot firmly on the floor while pushing up against a wall. This exercise was performed for both sides of the body (Figure 1A).
Hamstrings 1	While standing, knees extended, the participant bends at the waist and reaches as far as possible toward the toes (Figure 1B).
Thigh adductors	While standing, after spreading the legs laterally, the participant flexes one knee without letting it cross the toe line while keeping the opposite knee extended. This exercise was performed for both sides of the body (Figure 1C).
Hamstrings 2	While standing, with one knee extended and the other flexed, the participant flexes the trunk, arms extended, towards the foot of the stretched leg. This exercise was performed for both sides of the body (Figure 1D).
Quadriceps femoris	While standing, the participant flexes the right knee, keeping it close to the body, and holds the ankle of the ipsilateral foot. This exercise was performed for both sides of the body (Figure 1E).

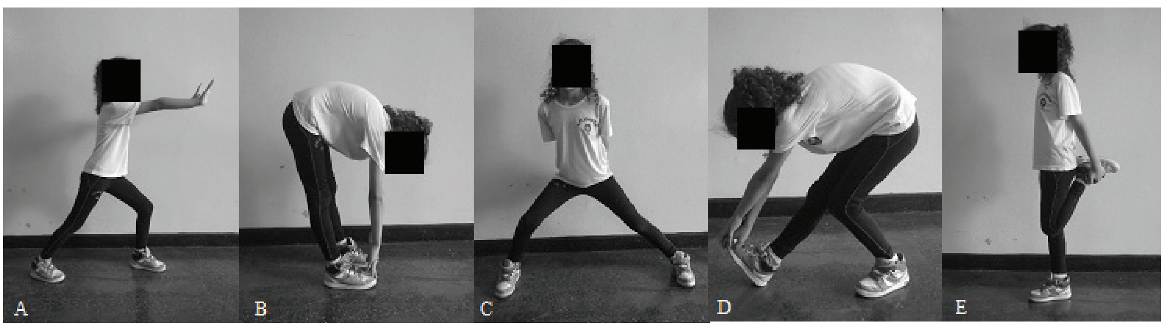

Figure 1. Stretching exercises performed in the present study for the (A) triceps surae, (B) and (D) hamstrings, (C) thigh adductors, and (E) quadriceps femoris.

Statistical analysis

Sample size calculation was based on the results of a pilot study, for a mean difference of 3.0, a standard deviation of 2.90 cm, and an effect size of 1.03. According to this calculation, the minimum sample size required for detection of potential differences between the pre- and post-intervention periods was 12 participants per group. The Shapiro–Wilk test was used for analysis of normality, and Levene's test to test for homogeneity of variance (homoscedasticity). Results were expressed as means and standard deviations. Factorial repeated-measures ANOVA (2 x 2 x 2 design) was used, with group (intervention vs. control), gender (male vs. female), and point in time (pre- vs. post-intervention) as the independent variables, followed by Tukey's post-hoc test for unequal sample sizes (Tukey–Kramer method). Sit-and-reach test performance was the dependent variable. One-way ANOVA was used for between-group comparison of age and anthropometric parameters at baseline. The level of significance was set at 5%.

RESULTS

There were no significant between-group differences in age, height, weight, or BMI (Table 1).

Table 1. Mean (SD) age, height, body mass and BMI of participants.

	Male		Female	
	MCG (n=15)	MIG (n=14)	FCG (n=15)	FIG (n=14)
Age (years)	8.53 (0.52)	8.64 (0.74)	8.60 (0.74)	8.36 (0.50)
Height (m)	1.28 (0.06)	1.26 (0.08)	1.33 (0.09)	1.29 (0.09)
Body mass (kg)	29.29 (7.18)	28.58 (4.88)	33.33 (9.84)	29.26 (7.29)
BMI (kg/m^2)	17.63 (3.32)	17.79 (1.63)	18.69 (4.80)	17.59 (3.07)

* *P*<0.05; MCG, male control group; MIG, male intervention group; FCG, female control group; FIG, female intervention group.

Sit-and-reach test results are shown in Table 2. The male and female intervention groups exhibited significant improvements in sit-and-reach test performance after 16 weeks of the study intervention (*P*<0.0001), with a percent difference of 16.79% for boys and 17.94% for girls as compared to the pre-intervention period. In the control groups, there were no significant differences between the pre- and post-intervention periods (*P*>0.05), with a percent change of -1.24% among boys and 1.29% among girls. Furthermore, the results showed a significant interaction between the group and time factors (F=1.54, *P*<0.0001).

Table 2. Sit-and-reach test results of girls (FIG and FCG) and boys (MIG and MCG) before (Pre) and after (Post) 16 weeks of the study intervention.

Group	MIG (n=14)			MCG (n=15)		
	Pre	Post	Δ%	Pre	Post	Δ%
SA (cm)	24.89 (5.01)	29.07 (4.51)^{a}	16.79	24.17 (5.14)	23.87 (4.35)	-1.24
	FIG (n=14)			FCG (n=15)		
	Pre	Post	Δ%	Pre	Post	Δ%
SA (cm)	27.25 (4.43)	32.14(3.24)^{abcd}	17.94	28.60 (6.07)	28.97 (6.38)	1.29

Results expressed as mean (standard deviation). Δ% denotes percent change.
[a] *P*<0.0001 vs. Pre; [b] *P*<0.01 vs. MIG Pre; [c] *P*<0.002 vs. MCG Pre; [d] *P*<0.05 vs. MCG Post. MCG, male control group; MIG, male intervention group; FCG, female control group; FIG, female intervention group.

DISCUSSION

The main finding of this study was that the addition of a stretching-based warm-up routine to PE classes produced a significant increase in flexibility among boys and girls in the intervention groups after 16 weeks, with no such improvement occurring in the control groups. The positive effect of stretching-based warm-up routines on flexibility in children was proved by the significant group vs. time interaction detected in this study.

Warm-up routines are very widely practiced prior to physical effort, with the objective of preparing the body's systems for effort, preventing injury, and improving performance. Several warm-up models[15-19] are known to have a positive effect on the performance of children and adolescents on several motor tasks. Conversely, when static stretching is used as a warm-up technique, there is a decline in motor performance, particularly for tasks that rely on strength[16].

Although the acute effect of stretching-based warm-up is to decrease subsequent performance, this decline in performance occurs immediately after warm-up exercises, and is negated when other dynamic exercises are carried out[23]. Hence, static stretching can hinder performance for brief, competitive athletic activities, which is not the case with physical education classes in a school environment. Therefore, the warm-up model proposed herein could be implemented in PE classes, in view of its beneficial effect of producing significant improvements in flexibility in boys and girls alike.

A warm-up program of exercises designed to improve neuromuscular control, strength, power, balance, and stretching had the chronic effect of reducing the incidence of lower extremity injuries in a sample of young handball players[20], and decreases the risk of severe and repetitive strain injuries in female soccer players[21]. Therefore, in addition to improving the flexibility of children exposed to the intervention, as shown in this study, systematized warm-up routines that include stretching exercises can be used to prevent injury in young athletes.

With the objective of improving flexibility in children, several studies have assessed the effect of intervention programs carried out during PE classes and extramurally. Significant improvements in flexibility after implementation of a program based on twice-weekly hamstring stretching exercises during PE classes have been described elsewhere[24,25]. Although the results of our investigation corroborate the findings of these studies, the aforementioned hamstring stretching exercises were carried out twice during classes, immediately after warm-up (for 3 minutes) and at the end of the class (for 2 minutes)[24,25], whereas in the present study, stretching exercises were only performed during the warm-up period.

The results of this study corroborate the evidence reported in previous research on the effects of extracurricular stretching-based intervention programs on flexibility in children. Flexibility increased significantly after supplemental interventions consisting of three weekly sessions over 15 weeks or four weekly sessions over 31 weeks respectively[26,27]. An increase in the number of weekly PE classes also improves flexibility in adolescents after a 16-week intervention[28].

Indeed, both intramural intervention programs conducted during PE classes and extramural or extracurricular programs are effective in improving the flexibility of children and adolescents[24,28]. Nevertheless, the practical aspects of implementing these programs must be taken into account. Extramural programs mandate that other professionals be hired, require available space and infrastructure, and may be associated with lower adherence, as sessions take place during the free time period of children. Intramural programs can be a good alternative due to superior adherence, as these interventions are carried out by teachers or coached during school hours and within school facilities.

Therefore, the intervention program described herein is highly applicable from a practical standpoint, as it not only took place during school hours, but during the warm-up period present in most PE classes[14]. Moreover, it did not interfere with the planning or execution of other class content due to the brief nature of the intervention (8 minutes). This unique characteristic enables the inclusion of this and similar programs in the planning of PE classes, which are usually relatively short and are rarely used to their fullest advantage due to a variety of factors[29].

There appear to be no contraindications to stretching-based warm-up in the population of this study, as it consisted of schoolchildren taking part in Physical Education classes, who do not require top performance as elite athletes, for instance, would. Furthermore, PE classes take place twice weekly, which increases the benefit of the flexibility improvements achieved in terms of a potential decline in performance of motor tasks that require strength during the first few minutes of classes. In training programs that consist of several weekly sessions, flexibility training can take place at specific moments during each session, unlike in a school environment, where there is little time to include all components of the routine during PE classes. Hence, in view of the little time required for the study intervention, it can be included in PE classes without major detriment to planning and execution of other curricular content.

Some limitations of this study should be taken into account. Sit-and-reach test performance depends on several muscle groups, such as the erector spinae, hip rotator, and gastrocnemius muscles[30]. Therefore, we were unable to detect specific segmental changes or deficiencies, although the stretching routine used in the intervention was designed to exercise various muscle groups. Another limitation of the sit-and-reach test is its standardized nature, which does not permit adjustment for subjects who have disproportions in upper and lower extremity length. Nevertheless, this limitation did not impede identification of the effect of the intervention on flexibility, as the post-intervention results of each subject were compared with their baseline (pre-intervention) values.

We suggest that future studies compare the effect of intervention programs at more regular intervals. Such a design would enable determination of when flexibility improves or plateaus over the course of the intervention period. Furthermore, the chronic effects of other warm-up models on other physical capabilities and in other populations should be studied. According to the results obtained in this study, stretching-based warm-up routines can increase flexibility significantly in children. Therefore, stretching exercises can be included in the warm-up routines of physical education classes if these have improvement of flexibility as an objective.

CONCLUSION

Static stretching during warm-up had a chronic effect of improving flexibility in the male and female intervention groups after 16 weeks. No similar effect occurred in the control groups. This model appears adequate to the reality of physical education classes, as it is brief and successfully increases flexibility in children.

REFERENCES

1. Jones MA, Stratton G, Reilly T, Unnithan VB. Biological risk indicators for recurrent non-specific low back pain in adolescents. Br J Sports Med 2005;39(3):137-40.
2. Mikkelsson LO, Nupponen H, Kaprio J, Kautiainen H, Mikkelsson M, Kujala UM. 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. Br J Sports Med 2006;40:107-13.
3. Jones MA, Stratton G, Reilly T, Unnithan VB. A school-based survey of recurrent non-specific low-back pain prevalence and consequences in children. Health Educ Res 2004;19(3):284-9.
4. Skaggs DL, Early SD, D'Ambra P, Tolo VT, Kay RM. Back pain and backpacks in school children. J Pediatr Orthop 2006;26(3):358-63.
5. Graup S, Santos SG, Moro ARP. Estudo descritivo de alterações posturais sagitais da coluna lombar em escolares da Rede Federal de Ensino de Florianópolis. Rev Bras Ortop 2010;45(5):453-9.
6. Pelegrini A, Silva DAS, Petroski EL, Glaner MF. Aptidão física relacionada à saúde de escolares brasileiros: Dados do projeto Esporte Brasil. Rev Bras Med Esporte 2011;17(2):92-6.
7. Bergmann GG, Araújo MLB, Garlipp DC, Lorenzi TDC, Gaya A. Alteração anual no crescimento e na aptidão física relacionada à saúde de escolares. Rev Bras Cineantropom Desempenho Hum 2005;7(2):55-61.
8. Nilsen TI, Holtermann A, Mork PJ. Physical exercise, body mass index, and risk of chronic pain in the low back and neck/shoulders: Longitudinal data from the Nord-Trondelag health study. Am J Epidemiol 2011;174(3):267-73.
9. Koumantakis GA, Watson PJ, Oldham JA. Trunk muscle stabilization training plus general exercise versus general exercise only: Randomized controlled trial of patients with recurrent low back pain. Phys Ther 2005;85(3):209-25.
10. Sjolie AN. Low-back pain in adolescents is associated with poor hip mobility and high body mass index. Scand J Med Sci Sports 2004;14(3):168-75.
11. Ewert T, Limm H, Wessels T, Rackwitz B, von Garnier K, Freumuth R, et al. The comparative effectiveness of a multimodal program versus exercise alone for the secondary prevention of chronic low back pain and disability. PMR 2009;1(9):798-808.
12. Fanuchi GL, Stewart A, Jordaan R, Becker P. Exercise reduces the intensity and prevalence of low back pain in 12-13 year old children: a randomized trial. Aust J Physiother 2009;55:97-103.
13. Jones M, Stratton G, Reilly T, Unnithan V. The efficacy of exercise as an intervention to treat recurrent nonspecific low back pain in adolescents. Pediatr Exerc Sci 2007;19(3):349-59.
14. Braga VMS, Silva AEL, Gress FAG, Krug A. Relação entre índices antropométricos e resposta da pressão arterial ao exercício em crianças. Rev Educ Fis/UEM 2006;17(1):19-26.
15. Faigenbaum AD, Belluci M, Bernieri A, Bakker B, Hoorens K. Acute effects of different warm-up protocols on fitness performance in children. J Strength Cond Res 2005;19(2):376-81
16. Faigenbaum AD, McFarland JE, Kelly NA, Ratamess NA, Kang J, Hoffman JR. Influence of recovery time on warm-up effects in male adolescent athletes. Pediatr Exerc Sci 2010;22(2):266-77.
17. Needham RA, Morse CI, Degens H. The acute effect of different warm-up protocols on anaerobic performance in elite youth soccer players. J Strength Cond Res 2009;23(9):2614-20.

18. Di Cagno A, Baldari C, Battaglia C, Gallotta MC, Videira M, Piazza M, et al. Pre-exercise static stretching effect on leaping performance in elite rhythmic gymnasts. J Strength Cond Res 2010;24(8):1995-2000.
19. Duncan MJ, Woodfield LA. Acute effects of warm up protocol on flexibility and vertical jump in children. JEP 2006;9(3):9-16.
20. Olsen OE, Myklebust G, Engebretsen L, Holme I, Bahr R. Exercises to prevent lower limb injuries in youth sports: cluster randomized controlled trial. BMJ 2005;330:449.
21. Soligard T, Myklebust G, Steffen K, Holme I, Silvers H, Bizzini M, et al. Comprehensive warm-up programme to prevent injuries in young female footballers: cluster randomised controlled trial. BMJ 2008;337:a2469.
22. Guedes DP, Guedes JERP. Manual prático para avaliação em Educação Física. Barueri: Manole; 2006.
23. Taylor KL, Sheppard LM, Lee H, Plummer N. Negative effect of static stretching restored when combined with a sport specific warm-up component. J Sci Med Sport 2009;12(6):657-61.
24. Baranda PS, Rodrígues PL, Santonja FM, López PA, Andújar P, Ferrer V, et al. Effect of hamstring stretching exercises on the toe-touch test in elementary school children. J Hum Mov Stud 2006;51:277-89.
25. Rodríguez PL, Santonja FM, López-Miñarro PA, Baranda OS, Yuste JL. Effect of physical education stretching programme on sit-and-reach score in schoolchildren. Science & Sports 2008;23:170-5.
26. Stephens MB, Wentz SW. Supplemental fitness activities and fitness in urban elementary school classrooms. Fam Med 1998;30(3):220-3.
27. Santonja FM, Baranda PS, Andújar P, García PLR, López Miñarro PA, Jordana MC. Effects of frequency of static stretching on straight-leg raise in elementary school children. J Sports Med Phys Fitness 2007;47(3):304-8.
28. Ardoy DN, Fernández-Rodríguez JM, Ruiz JR, Chillón P, España-Romero V, Castillo MJ, et al. Improving physical fitness in adolescents through a school-based intervention: the EDUFIT study. Rev Esp Cardiol 2011;64(6):484-91.
29. Guedes DP, Guedes JERP. Esforços físicos nos programas de Educação Física escolar. Rev paul Educ Fís 2001;15(1):33-44.
30. Holt LE, Pelham TW, Burke DG. Modifications to the Standard Sit-and-Reach Flexibility Protocol. J Athl Train 1999;34(1):43-47.

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