Effects of a Static and Dynamic Stretching Program on Flexibility, Strength, and Speed of School-Age Children

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Abstract

This study investigated the effect of an eight-week program of static and dynamic stretching on the range of motion (ROM) of the joints of the lower limbs, the 20 m sprint, and the performance of the standing long jump (LJ) and the drop jump (DJ 20 cm). Forty-two volunteers participated in this study. Subjects were randomly assigned to three groups: 15 to the static stretching group, 15 to the dynamic stretching group, and 12 to the control group. The eight-week stretching routine was designed to stretch all the major muscle groups in the lower extremities. Stretches were performed three days per week, once per day for 10 s and for three repetitions. Data were analyzed using two-way repeated measures ANOVA with post-hoc analysis (Tukey's). Significance was set at $p \leq 0.05$. Statistical analysis indicated significant improvements after the stretching exercises of ROM and in the performance for both groups in the sprints and LJ. DJ results showed improvement in the jump height of DJ for both stretching groups. Results showed that the program has a positive effect on the ROM of the joints, as well as the speed and jumping ability of the subjects.

Keywords: Flexibility, range of motion, power, maximal strength, jumps, children

Introduction

Many researchers and sports scientists indicate that stretching exercises have beneficial effects on athletic performance, including flexibility improvement (43, 44), muscle stiffness reduction (17, 32), injury protection (27, 28), reflective interceptor reduction (28, 32, 37), running economy improvement (29), and muscle preparation for accepting mechanical load (30). Previous research also showed an increase in performance after a stretching program (28, 35).

The beneficial effect of stretching was recently examined, and the opposite effect was supported. Consequently, stretching adversely affects the ability of muscles to produce maximum force, while sports activities that activate the stretch-shortening cycle (SSC) are more affected.

Several researchers report that an acute bout of stretching has resulted in the reduced performance of the muscular system, specifically in the production of maximum isometric (6, 7, 22, 25), concentric (21, 15), or isokinetic force (6, 20); in the reduction of the height of squat jump (SJ) (4, 42), countermovement jump (CMJ) (4, 34), and drop jump (DJ) (41); and in a negative effect on running speed (23) and muscle endurance (24). Furthermore, a review (11) concluded a slight, if any, connection between stretching before exercise and the potential for injury.

However, evidence is insufficient on the effect of a stretching program that takes place three or four times a week for a few weeks on the performance of power and speed in sporting activities. Studies (10,40) concerning the flexibility of hamstrings and their isokinetic performance have shown an increase in muscle flexibility and isokinetic power, although applying these findings to activities under closed kinetic chain conditions is impossible. Running economy (8), performance in bench press (39), and CMJ (14) are improved.

An examination (16) on the effect of a 10-week program of static stretching (SS) on the flexibility (sit and reach), strength (1RM), endurance, and speed (20 m) of the lower limbs of university students has shown an improvement in all variables. On the contrary, an SS program of hamstring muscles has not shown (1) a significant effect on range of motion (ROM), running speed (55 m), and vertical jump of university students. Limited work has been conducted to examine the effect of stretching on children. Improvement in ROM, maximum isometric strength, and speed of concentric contractions were reported when low loads were provided to children (13). The ROM of the knee joint and the strength of children were also improved when an SS program was applied to the hamstring muscles (26).

Information concerning the effect of long-term stretching on muscle function is limited. Furthermore, a lack of knowledge shows the effect of different stretching programs, such as static or dynamic programs, on the lower-limb performance of school-age children. Consequently the purpose of this study was to examine the effect of DS and SS on the strength, flexibility, and speed of school-age children.

Methods

Subjects

The participants were 42 boys in their first year of secondary school and were 13.1 ± 0.6 years old. The subjects were distributed randomly into three groups: the first group (n = 15) performed dynamic stretching (DS), the second group (n = 15) performed SS, and the third group (n = 12) served as the control group (CG) and did not perform any stretching program (Table 1).

Table 1: Measurements of Anthropometric Variables

TEAM	DS (n = 15)	SS (n = 15)	CG (n = 12)
HEIGHT	162.2 ± 7.82	161.5 ± 8.42	159.1 ± 6.12
WEIGHT	55.2 ± 13.2	54.2 ± 11.9	53 ± 11.15

Flexibility measurement: The measurements were made with a Lafayette Gallehon Goniometer (model 01135) using fixed mounting points on the body and were performed by the same examiner.

Standing long jump: Each examined student stood behind a line marked on the ground with his feet slightly apart. The jump was started by bending the knees and hips and dipping in a squat position with the arms extended behind the body. A two-foot take-off and landing was performed with the arms swinging and the knees bent to provide forward drive. The subject was instructed to jump as far as possible and to land on both feet without falling backwards. Initially, the subject performed three submaximal-effort jumps to warm up, which was then followed by three jumps with maximum effort. Each jump took place after interval breaks of 1 min, and the best jump was used (16).

Sprint (20 m): The speed of 20 m from initial starting position to an upright position was used. Each examined student made three sub-maximal efforts to warm up, and then three repetitions with maximal efforts were performed. A rest period of 3 min was the break between each maximum effort. The time for the best effort was used for further examination (16).

Drop jump (DJ 20 cm): Each examined student was first instructed to stand upright on a step 20 cm high, and then to fall from the step and land on the ground with both feet to make a vertical jump. In this vertical jump with an initial downward acceleration, acting muscles were stretched prior to contraction, which led to a rapid activation cycle.

Measurements of the DJ were made on the Kistler (Type 9281 CA) force plate, which was equipped with four piezoelectric transducers (Figure 1). To fully exploit the characteristics of the piezoelectric crystal, which is a measure of the force plate system, the force plate was placed on the ground via a special mounting frame (Type 9423). The suspension frame is made of concrete ground in accordance with the manufacturer's specifications to ensure leveling and high rigidity.

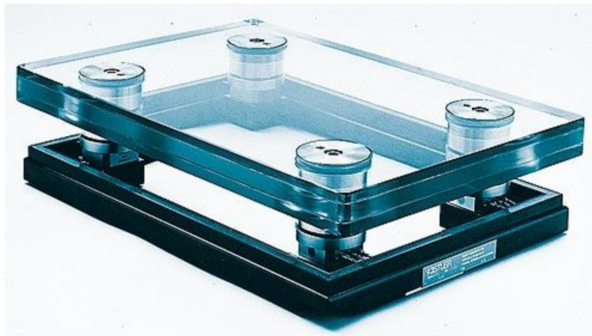

Figure 1: Kistler force plate (Type 9281 CA)

Results

The results of the eight-week stretching program are shown in Table 2.

Table 2: Results of the Stretching Program

	variable name	abbreviation	unit measurement	Dynamic Stretcing			Static Stretching			Control Group		
				Pre	After	p	Pre	After	p	Pre	After	p
1	20m Sprint	t20	sec	4,19± 0,31	3,90± 0,33	0,001	4,24± 0,29	3,86± 0,17	0,001	3,92± 0,32	3,89± 0,30	0,2 16
2	Standing long jump	SLj	cm	165±29	171±27	0,050	161±22	168±20	0,003	153±27	160±30	0,0 63
3	Hip Flexion	Hip F	Grad (o)	86± 9,1	81± 9,2	0,012	83± 7,7	77± 6,8	0,000	86± 3,6	87± 3,8	0,1 36
4	Hip Extension	Hip Ex	Graf (o)	7±4,9	13± 3,2	0,001	7± 3,7	11± 3,4	0,004	10± 3,5	9± 3,5	0,1 47
5	Hip Abduction	Hip Ab	Graf (o)	33± 5,4	42± 6,1	0,001	34± 4,1	38± 4,4	0,001	36± 4,1	37± 4,1	0,5 60
6	Knee Flexion	Knee F	Graf (o)	142± 6,5	150± 7,8	0,001	145± 6,9	149± 6,9	0,001	144± 6,2	145± 6,4	0,5 65
8	DJ Height	DjH	cm	17,58± 4,9	21,25± 5,9	0,002	18,57 ±6,5	20,66 ±5,8	0,033	18,25± 7,3	16,41± 6,3	0,0 83

Flexibility: The results of the eight-week stretching program show a clear improvement in the ROM of all joints.
Hip Flexion: The DS group showed an improvement of 5.7%, from 86.40° to 81.46°. For the SS group, an improvement of 6.8% was observed, from 82, 53° to 76,86°. The CG showed no change.

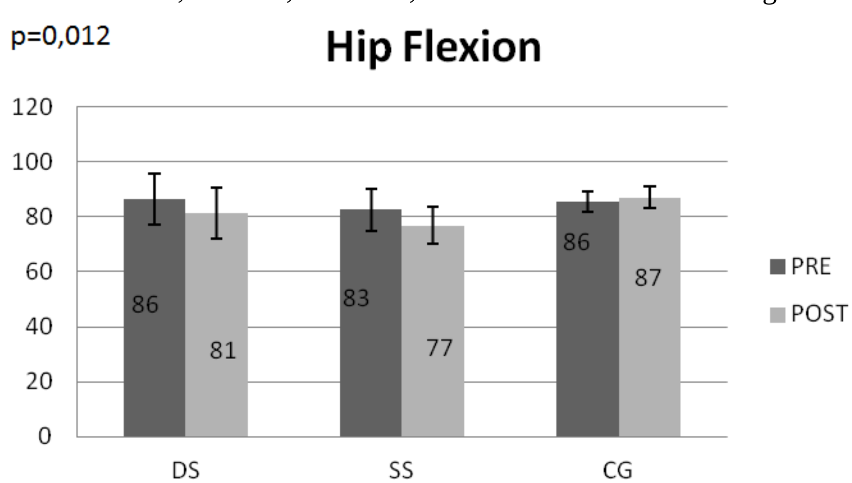

Figure 2: Pre- and Post-Values of hip Flexion for all Groups

Hip Extension: The DS group showed an improvement of 85%, from 7 to 13°. The SS group showed an improvement of 57%, from 7 to 11°. The CG showed no change.

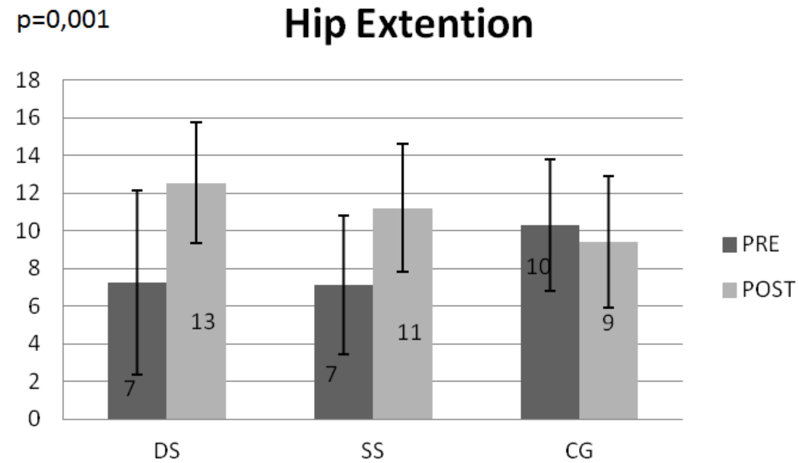

Figure 3: Pre- and Post-Values of hip Extension for all Groups

Hip Abduction: The DS group showed an improvement of 27%, from 33 to 42°. The SS group showed an improvement of 12%, from 34 to 38°. The CG showed no change.

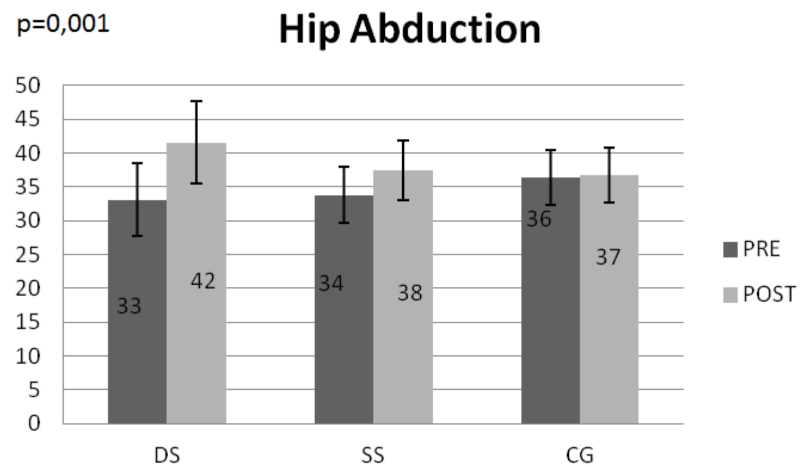

Figure 4: Pre- and Post-Values of Hip Abduction for all Groups

Knee flexion: The DS group showed an improvement of 5.6%, from 142 to 150°. The SS group showed an improvement of 2.8%, from the 145 to 149°. The CG showed no change.

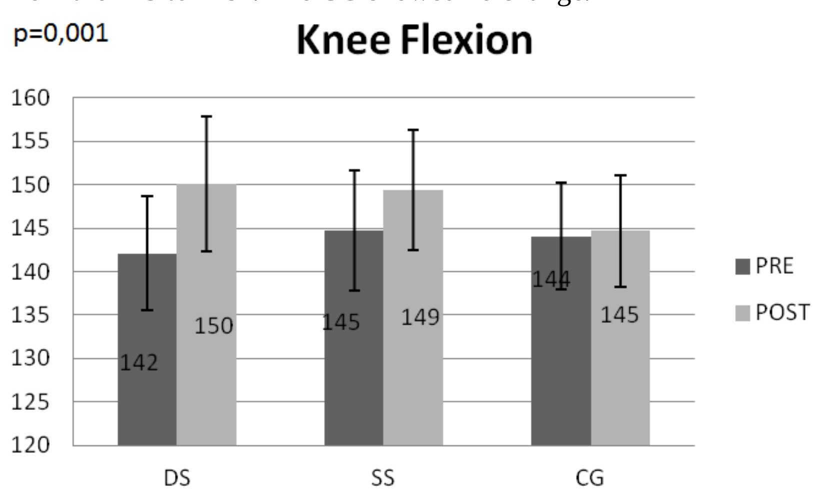

Figure 5: Pre- and Post-Values of Knee Flexion for all Groups

20 m sprint: The DS group showed an improvement of 7%, from 4.19 s to 3.90 s. The SS group showed an improvement of 8.9%, from 4.24 s to 3.86 s. The CG showed no change.

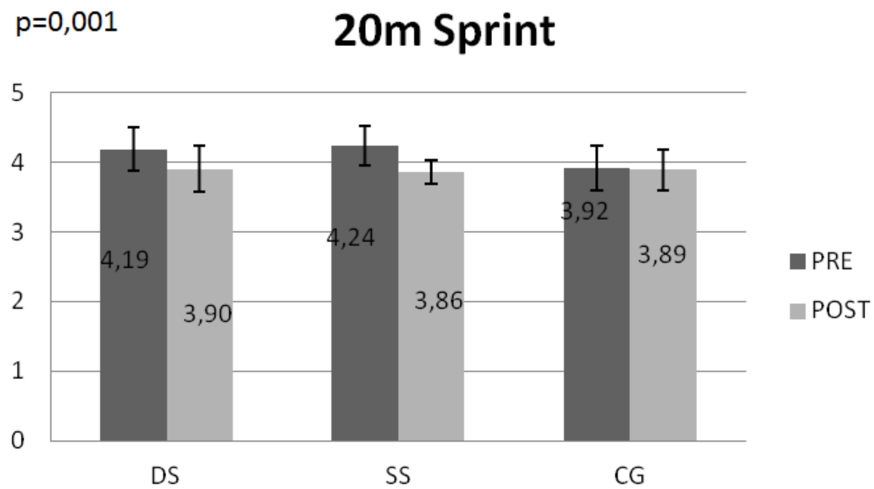

Figure 6: Pre- and Post-Values of 20 m Sprint Time for all Groups

Standing long jump: The DS group showed an improvement of 3.6%, from 165 to 171 cm. The SS group showed an improvement of 4.3%, from 161 to 168 cm. The CG showed no change.

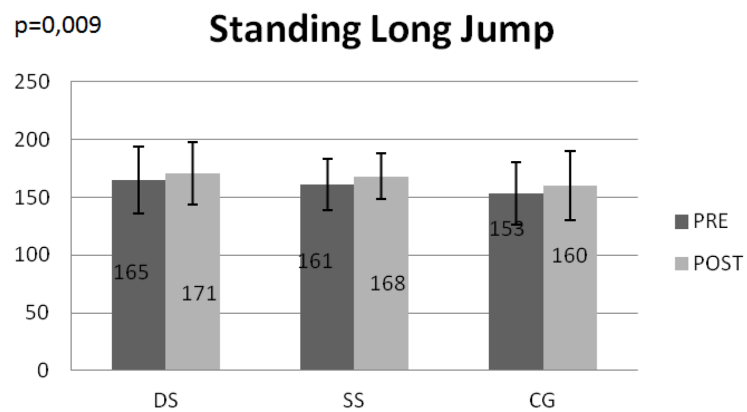

Figure 7: Pre- and Post-Values of LJ for all Groups

Drop jump: The DS group showed an improvement of 21%, from 17.6 to 21.3 cm. The SS group showed an improvement of 11.3%, from 18.6 to 20.7 cm. The CG showed no change.

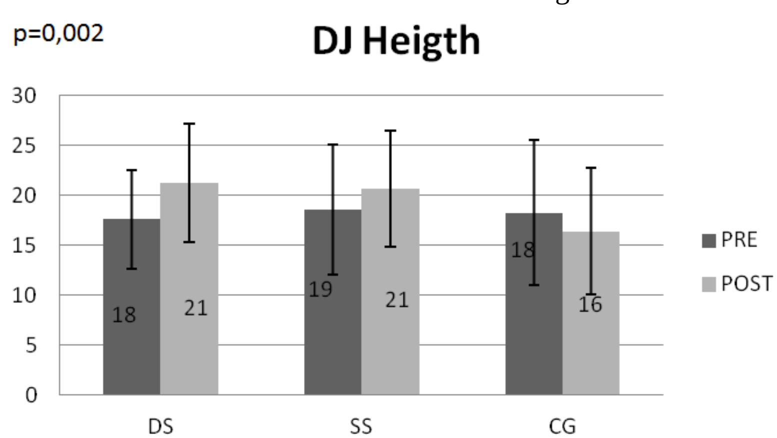

Figure 8: Pre- and post-values of DJ for all groups

Discussion

Although still undetermined, the effect of long-term stretching on muscle function, especially on children, is very important knowledge to have. Therefore, this study examined the effect of a DS and SS program on the characteristics of the power and speed of school-age children. For flexibility, an improvement was observed in the ROM of all joints of the subjects who participated in both eight-week SS and DS programs.

These results agree with those of Kokkonen (16), who reported that the distance of sit-and-reach test increased by 18.1%. The abovementioned results are in accordance with those of Tabary (31), who reported that stretching the soleus in animals resulted in a 20% increase in the number of sarcomeres in series. Those changes increased muscle capability to a new functional length. In addition, Williams (36) stated that 30 min of daily stretching is enough to increase the number of “in series” sarcomeres. Similar results about flexibility improvement were reported by Behm (2), who stated that flexibility improved by 11.8% in sit-and-reach test, 19.7% in hip extension, and 13.4% in hip flexion after a four-week stretching training. Improvements in flexibility in sit-and-reach test were also reported by Turki-Belkhiria (33) after eight weeks. The subjects of the two groups performed dynamic stretches during warm up. The first subgroup performed SDS, and the second one performed ADS. The improvement was 57.6% for SDS and 45.1% for ADS. No change was observed in the CG.

For the 20 m sprint, a decrease was observed in the time needed for a specific distance after the eight-week stretching program of both groups. The results were similar to those of Kokkonen (16), who reported that the STR group decreased the time by 1.3% after stretching, whereas the CG showed no change. On the contrary, Bazzet (1) reported no statistically significant change in 55 m sprints after a six-week stretching program. Caplan (3) reported an increase of 7.1% and 9.1% in stride length after four weeks of stretching of the SS group and the PNF group respectively. The authors interpreted the improvement in stride length based on the compliance adaptation of the series elastic elements (SEE) of the muscle–tendon unit, which was proven to affect muscle performance. Kubo (17) showed that muscular performance was increased as the compliance of the tendon–aponeurosis complex increased. In the present study, stretch training probably altered the structure of the muscles, thus increasing the compliance of the SEE.

According to Wilson (38), the time decrease after the stretching program might be explained by the capability of the muscle to store and release the elastic energy from the more compliant SEE. On the contrary, Turki-Belkhiria (33) reported no effect on sprint test and proposed as interpretation that sprint and RSA necessitate rapid SSC contractions with very brief durations of ground contact times. The dynamic stretches were performed slowly, smoothly, and continuously without abrupt vertical or horizontal changes of direction and, therefore, would not have placed any such positive training stresses on the subjects’ stretching program for both groups.

During the DJ with fast SSC, an improvement was observed in the high jump after a six-week stretching program for both groups. Our results do not agree with those of Behm (2), who reported no significant change in the DJ after a four-week stretching program. For the performance in LJ, an increase was seen in distance after the eight-week program for both groups (SS and DS). The results agreed with those of Kokkonen (16), who reported that the STR group improved by 2.3%, whereas the CG showed no change.

A probable explanation for the improved capability of the muscle to store and release the elastic energy from the more compliant SEE after pre-stretching was stated by Wilson (38). According to the author, an improvement was observed in the performance of the rebound bench press after an eight-week stretching program. Mann and Jones (19) suggested that the key attributes of DS include enhanced motor unit excitability and improved kinaesthetic sense. These attributes lead to improved proprioception and pre-activation, which are probably responsible for the increases in DJ in the present study. Coutinho (5) reported a 5% increase in length and a 4% increase in the number series sarcomeres after 40 min stretching for three times a week. Positive strength effects might be caused by improvements in muscle length. These changes in muscle length may be responsible for the force and velocity production on a specific contraction velocity (18). As shown by the results of the present study, the eight-week stretching program had positive effects on most of the variables, which are probably based on the improvement in muscle length and the positive changes in viscoelastic properties that appeared to be more effective and more functional as more elastic energy is stored and used (31,38).

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