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The Effects of Static and Dynamic Stretching Exercises' Order on Some Physical Fitness Factors in Elementary School Children

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Abstract

Background: Stretching exercises, in static and dynamic states, are used at the beginning of any sport activity in schools. The purpose of this study was to evaluate the effect of the order of static and dynamic stretching on some physical fitness factors in children.

Materials and Methods: This study was semi-experimental with repeated measures design. 30 participants were selected from female students studying in the fourth grade of elementary school in Miyaneh city, Iran, with cluster sampling. Subjects performed 3 stretching protocols (without stretching, dynamic after static stretching, and static after dynamic stretching) and dependent variables including reaction time, agility, power, speed and flexibility were measured before and after these protocols. In static stretching, stretch was maintained for 15 sec and in dynamic stretching, 5 repetitions of stretch (each repetition 15 sec) in 3 sets, with 10-sec rests between them, were performed. ANOVA with repeated measures and Bonferroni post hoc test were used to compare the effects of the 3 stretching protocols on the dependent variables.

Results: The mean and standard deviations of the subjects' age in this study was 10.18±0.8 years. Both dynamic after static and static after dynamic stretching had significant effects on reaction time ($p=0.001$), and flexibility ($p=0.008$ and $p=0.003$ respectively), but they didn't show any significant effect on agility, power and speed ($p=1.000$). Moreover, the order of stretches had no significant effect on measured factors ($p>0.05$).

Conclusions: Both stretching protocols improve reaction time and flexibility in children, but do not influence their agility, power and speed. Changing the order of performing of static and dynamic stretching does not make any change in the records of reaction time, agility, power, flexibility and speed.

Key Words: Static and dynamic stretching, agility, speed, flexibility, power.

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1- INTRODUCTION

Children's health is one of the priorities of many organizations such as the World Health Organization. Doing sports activities in schools is very important to improve students' physical fitness and prevent many diseases such as obesity and diabetes, as well as heart and respiratory diseases. Exercise classes in schools are conducted with the aim of improving physical fitness factors related to children's health and skills such as flexibility, balance, muscle strength, agility, speed, speed of reaction, etc. Sports teachers in schools use stretching exercises at the beginning of a physical education class to warm up. Stretching is commonly used as a part of warm-up program before sport activity to further improve maximal muscle function, to reduce muscle soreness, and to increase joint irritability. Different people typically consider stretching as part of pre-activity warm-up to improve performance and reduce the risk of injury from certain exercises (1). The best exercises for increasing flexibility of the body muscles are stretching exercises. Stretching exercises increase muscle length and reduce improper expansion of connective tissues. Stretching exercises are also used to increase the range of motion of the joints to prevent abnormal muscle contractions and to increase performance in exercise and other skills. Stretching exercises prevent muscle injury and stiffness. They also prevent the feeling of muscle pain and stiffness due to the formation of lactic acid in the muscle. Stretching exercises can also prevent muscle cramps (2, 3).

Extensive research has been done about the effect of various types of stretching exercises on various factors of health-related and skill-related physical fitness. The results of some studies on children and adolescents show that static stretching activity reduces the performance of vertical jump and long jump (4, 5), speed (6) and agility (4). Accordingly, some studies suggest that static stretching movements be replaced with dynamic stretching movements in schools (7). Similar results have been reported in some adult studies. The results of a research study that examined the effect of different tensile warm-up protocols on 20-meter sprint performance in trained soccer players showed a decrease in performance following static stretching and an increase in performance following dynamic traction (8). However, a review study shows clear evidence that short periods of static stretching do not adversely affect maximal muscle function, and this lack of muscle function following static stretching may be due to factors such as short stretching times (less than 90 seconds), intensity of stretching being less than pain threshold, the test used to assess the performance and subjects' physical fitness level (9). In another study conducted in 2006 on 18 professional soccer players, the researchers concluded that no significant difference was observed after static warm-up in sprinting. In other words, static stretching neither improved nor impaired performance (10). Literature of research shows both improved power performance, speed and jump following dynamic stretching and no effect of dynamic stretching on performance. For example, an article has reported that shorter periods of dynamic stretching do not have a detrimental or improving effect on performance, but longer periods of dynamic stretching improves performance. In fact, it seems that if the period of dynamic stretching be longer, its positive effects are greater (11). In 2009, an article entitled "Acute Effects of Dynamic Stretching, Static Stretching, and Aerobic Activity on Women's Muscle Performance" stated that time has an influential effect on the range of motion. But no significant difference was observed between any of

warming up conditions on each of the variables (12).

Therefore, considering the contradictory results of previous studies, the decision for abandoning static stretching and replacing it with dynamic stretching does not seem logical and requires further studies in this field. On the other hand, identifying the most useful warm-up programs before exercising in schools is very important. Since the combination of static and dynamic stretching movements is traditionally used by school teachers and trainers in school sports programs, the effect of combining static and dynamic stretching movements on different sports functions in children must be investigated. Also, the effect of the sequence of static and dynamic stretching movements on these functions remains questionable. The aim of the present study was, then, to evaluate the effects of static and dynamic stretching exercises order on the elements of physical fitness (including agility, reaction speed, speed, flexibility and power) of elementary school children. To control the effects of age and gender on the research results, only female students in the fourth grade of elementary school were examined.

2- MATERIALS AND METHODS

2-1. Subjects

*This study was semi-experimental with repeated measures design. The statistical population of the study comprised of the fourth grade elementary school girls in Miyaneh city, East Azerbaijan province, Iran. The statistical sample of the present study consisted of 30 fourth-grade elementary school female students in Miyaneh city, who were selected by cluster sampling. For this purpose, one district was randomly selected from the educational districts of Miyaneh city and then three schools were randomly selected from that district. From each school, 10 fourth grade students were randomly selected. Sample size was determined using G*POWER software based on the statistical test used in the study (ANOVA repeated measures) and effect size of 0.8.*

2-2. Experimental procedures and protocols

To conduct this research, explanations were given to subjects and their parents on how to perform the measurements and on the confidentiality of information. Then, a personal information questionnaire was distributed among the candidates. The questionnaire involved subjects' age, weight, height, having any chronic disease and physical fitness level, and was filled by subjects' parents. The consent form was also signed by the subjects' parents. The tests were performed in 3 weeks and in three sessions per week with an interval of at least 48 hours. In the first week, agility and flexibility tests, in the second week, reaction speed and power tests, and in the third week, speed tests were performed. Each child was randomly placed in one of the three stretching positions (without stretching, static after dynamic stretching and dynamic after static stretching), and then performed tests for measuring the dependent variables.

2-2-1. Non-stretching protocol

Warm-up for non-stretching protocol included 4 minutes jogging and for stretching protocols after 4 minutes jogging, in static stretching activity, stretching was held for 15 seconds and in dynamic stretching, 5 repetitions of 15 seconds were done in 3 sets with 10 seconds rest between sets. Then after 2 minutes of rest, the dependent variables were measured. Stretching movements in this study included stretching the muscles throughout the body (upper and lower limbs), in which similar muscles were used in both stretching programs (13).

2-2-2. Dynamic stretching protocol

In dynamic stretching activity, after 4 minutes of jogging, 5 repetitions of 15 seconds were performed in 3 sets with 10-second rests in between.

The dynamic stretching program included the following:

- *Ankle flexion: Jump gently so that the ankle is bent.*
- *Jumping with a slow run: Jumping run with the help of toes.*
- *Long knees: Bend the legs from the knees while running and raise them close to the chest in harmony with the hands.*
- *Raising the legs with a straight knee: Along with running slowly, they raised the legs with a straight knee and in harmony with the hands, they brought the hands to the legs near the chest.*
- *Small pair jump: jumping with bent knees while legs are apart shoulder-width.*
- *Running sideways: They started running sideways (both left and right) so that their legs did not cross.*
- *Squatting: One step to the side so that the legs are shoulder-width apart. Gradually, the person squatted with a fixed torso and stood up (both left and right).*
- *Carnival: Running sideways with one foot in front of the other, cross-legged or pelvic rotated.*
- *Long knee jump: Like a long knee, but they stood on the toes with pressure and left the ground, bringing the opposite hand and foot together with each step.*
- *Zigzag: Walk forward so that each time the legs are in front and the outer side of each other.*
- *Two long jumps and one short jump with the help of hands*
- *Running forward with each jump, bend one leg at the knee and raise the agreeing hand above the head.*
- *Gate: Open the legs from the hip to the side and rotate it forward and up and then bring the foot from the front to the ground (once right once left) (10)*

2-2-3. Static stretching protocol

The stretch was held for 15 seconds.

- *Quadriceps muscle: Standing on one leg, with the pelvis rotated posteriorly, hold one hand against the wall, bend the knee, grasp the ankle from behind, and pull as far back as possible so that the knee is perpendicular to the ground. They did it with both the right foot and the left foot.*
- *Hamstring: One step forward with the left leg bent at the waist to reach the left leg, both knees slightly bent, back and neck straight. Repeated with the right foot.*
- *Gastro: They stood 40 to 50 cm from the wall, bending their backs so that their heads reached the front of the wall and there was a stretch behind their knees. The heel was in contact with the ground on both feet.*
- *Soleus: One step forward with the left foot, bend the knee to semi-squat and repeat with the other foot.*
- *Adductors: In sitting position they bent both knees and brought the soles of the feet closer together and bringing both knees closer to the ground.*
- *Abductors of hip joint: The legs were 40 to 50 cm apart. The legs were brought to the ground by bending the knees and the pelvis was bent backwards, with the back and neck flat and perpendicular to the ground (Scott movement).*
- *Abductors of hip joint: Extend the right leg 40 to 50 cm, bend the right knee and bring the body closer to the ground*

and Stretched the left leg. They also tried on the other side.

- *Pull the hands up so that the whole body is pulled up and placed on the toes.*
- *Pulling the hands to the side: Raise the hands above the head and from the top to the right side (repeat the same thing to the left) (10).*

2-3. Measurement of dependent variables

In the present study, to measure flexibility, power, speed, agility and reaction speed, the flexibility box test, Sargent vertical jump test, 20 m sprint test, Illinois test and Nelson ruler test were used, respectively.

2-3-1. Measurement of flexibility

The person sits in front of the flexibility box with stretched knees and the upper body perpendicular to the legs, then extends the arms and extends the hands as far forward as possible and places it on the board. The obtained number was noted. This act was repeated twice and the highest number was recorded (7).

Fig. 1: *Flexibility test*

2-3-2. Measurement of power with Sargent vertical jump test

In this test, the subject stood against the wall while marking his hand with plaster. He touched the highest point of the wall with his hand. After marking the point, the subject was asked to jump upwards by bending the knees and to touch the highest point of the wall as much as possible at the peak of the jump (13). The test was performed three times.

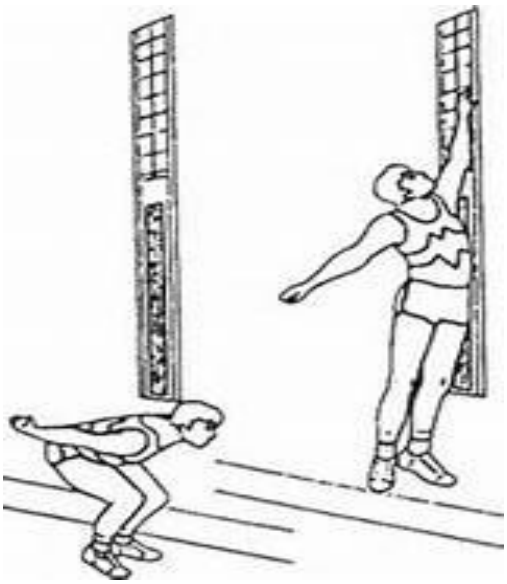

Fig. 2: Sargent vertical jump test

2-3-3. Measurement of speed

To measure this motor fitness factor, the subject stood in ready position and ran 20 meters, as fast as possible, to the finish line by go command. The time was calculated from the start to the time that subject crossed the finish line (13).

2-3-4. Measurement of agility

The Illinois Agility Test was used to measure agility. This test was performed in a space of 10 × 5 meters. 8 cones were arranged as shown in Figure 3. The distance between the cones (4 cones in the middle of the ground) is 3 meters and 30 centimeters. The subject initially lied forward on the floor (head towards the starting point) and got up quickly from the starting point (start) by the command of the examiner, and started to run with maximum speed in the direction of movement shown in the figure. After passing through the cones and when she passed the finish point, the stopwatch stopped and the elapsed time was recorded as the subject's record (13).

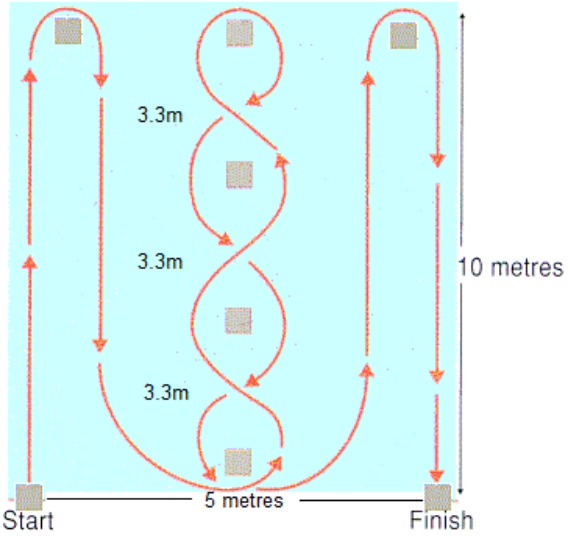

Fig. 3: Illinois test

2-3-5. Measuring of reaction speed

Nelson test was used to measure the reaction speed. The subject was asked to hold the ruler with his index and middle fingers. A wooden ruler was released from the space between the subject's two fingers, and the subject grabbed the ruler with both fingers as quickly as possible. The number shown by the subject's finger was recorded as her individual record (7).

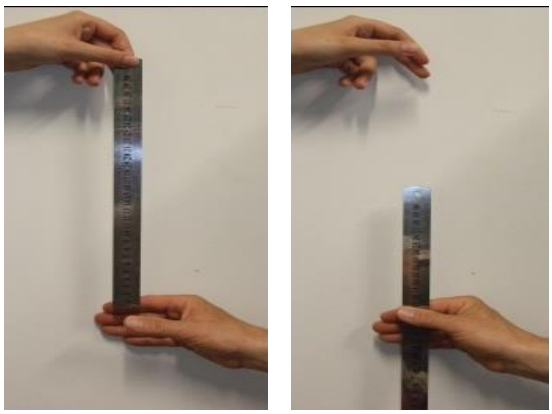

Fig. 4: Nelson Ruler test

2.4- Statistical Analysis

Descriptive statistics are expressed as means ± SD. The Kolmogorov–Smirnov test was used to test the normality of the distribution. Levene's test was used to determine variance differences between groups. To investigate the difference between the effect of the dynamic after static stretching, and static after dynamic stretching on the dependent variables; and the difference between each stretching state and without stretching state, repeated measures analysis of variance and Bonferroni post hoc test were used. SPSS software version 17.0 was used for data analysis. Significance level was considered 0.05.

3- RESULTS

Subjects' baseline characteristics are presented in **Table 1**.

The results of Kolmogorov-Smirnov test showed that the distribution of agility data ($p = 0.961$), reaction speed ($p = 0.842$), power ($p = 0.974$), speed ($p = 0.674$) and flexibility ($p = 0.922$) were normal. Also the condition of variance homogeneity of groups for agility ($p = 0.732$), reaction speed ($p = 0.431$), power ($p = 0.928$), speed ($p = 0.821$) and flexibility ($p = 0.867$) was established. Therefore, ANOVA repeated measures parametric test was used to compare the dependent variables in the three stretching states.

The results of ANOVA repeated measures test revealed that there was no significant difference among the three stretching states for the variables of agility ($p = 0.08$), power ($p = 0.075$) and velocity ($p = 0.327$). However, there was a significant difference between the three stretching states for the variables of reaction speed ($p = 0.001$) and flexibility ($p = 0.001$). Therefore, Bonferroni post hoc test was used for paired comparison of three stretching states for reaction speed and flexibility data.

The results of the Bonferroni post hoc test for paired comparison of the mean reaction velocity in the three stretching states are shown in **Table 2**.

Table-1: Demographic characteristics of research subjects, n=30

	Mean	SD	Minimum	Maximum	Number
Age (year)	10.18	0.6	9.1	10.8	30
Height (cm)	142.56	5.13	132	153	30
Weight (kg)	42.8	5.88	31.20	52.30	30

Table-2: Results of Bonferroni post hoc test for paired comparison of three stretching states for reaction speed

Comparison of two stretching positions	Standard Error	Mean difference	p-value
Without stretching position and dynamic after static stretching position	1.846	5.17	0.001
Without stretching position and static after dynamic stretching position	1.22	5.94	0.001
Dynamic after static stretching position and static after dynamic stretching position	1.486	0.770	0.638

These results of Bonferroni post hoc test showed that there was a significant difference between without stretching position and dynamic after static stretching position (p = 0.001), and between without stretching position and static after dynamic stretching position (p = 0.001), but there was no significant difference between dynamic after static stretching position and static after dynamic stretching position (p = 0.638).

The results of the Bonferroni post hoc test for paired comparison of the mean flexibility in the three stretching positions are shown in **Table 3**.

Table-3: Results of Bonferroni post hoc test for two by two comparisons of mean flexibility obtained in the three stretching positions

Comparison of two stretching positions	Standard Error	Mean difference	p-value
Without stretching position and dynamic after static stretching position	0.71	-2.36	0.008
Without stretching position and static after dynamic stretching position	0.68	-2.5	0.003
dynamic after static stretching position and static after dynamic stretching position	0.507	-0.13	1.000

The results of Bonferroni post hoc test indicated that there was a significant difference between without stretching position and dynamic after static stretching position (p = 0.008), and between without stretching position and static after dynamic stretching position (p = 0.003), but there was no significant difference between dynamic after static stretching position and static after dynamic stretching position (p = 1.000).

4- DISCUSSION

The aim of this study was to compare the effects of different orders of static and dynamic stretching exercises on agility,

strength, flexibility, speed and reaction speed among female students. To this purpose, the researchers examined the effects of the dynamic after static stretching protocol and the static after dynamic stretching protocol on reaction speed and flexibility of fourth grade elementary school female students. In result, a significant difference was observed between each of these positions and the non-stretching position, indicating that both protocols improve children's reaction speed and flexibility. Dynamic techniques increase metabolic processes that increase the body temperature, and thus reduce the viscosity of the muscle and allow the muscle to contract smoothly. The warmed muscle will easily coordinate with the incoming forces and lead to increased flexibility. In static stretching, the muscular spindle adapts and its activity stops. The result of this adaptation and subsequent relaxation is an increase in muscle length (14). In line with the results of the present study, some studies have shown that static and dynamic stretches increase muscle flexibility (15-17). However, the results of the present study are not consistent with Nasiri (18), who examined the effect of only static stretching movements and concluded that static stretching movements reduce reaction speed. In Nasiri's study, the subjects were male professional runners. Therefore, it seems that factors such as professionalism, duration of stretching, frequency of stretching, age and gender of the subjects can have a significant role in the occurrence of different results. As for the gender differences between the subjects, studies show that tendon and muscle stiffness in women is 29% lower than in men; and since stiffness is the main variable that is affected by stretching, it is possible that stretching responses differ between men and women (19). Therefore, it may be possible to consider the difference in the gender of the subjects in the present study (female children) with the mentioned contradictory research as an influential factor of contradiction. However, in the present study, comparing the effect of these two protocols on flexibility and reaction speed, no difference was observed between the effectiveness of the two protocols, and both had almost the same effect on flexibility as well as students' reaction speed. Therefore, it can't be concluded that one is preferred over the other position. In line with our results, Mohammadi (2009) demonstrated that there is no difference between stretching methods such as static and dynamic stretching on flexibility and both improve flexibility to the same extent. However, their results on reaction speed indicated that although both static and dynamic stretching methods improve reaction speed, the effect of dynamic stretching was greater (17).

The results of the present study showed that none of the combined stretching positions had an effect on students' agility. The results of this study are consistent with some studies (21-20). However, the results of research conducted in 2013 by Amiri-Khorasani and Fattahi-Bafghion on university football players showed that dynamic stretching improves agility and strength (22).

Also, in examining the effect of the dynamic after static stretching protocol and the static after dynamic stretching protocol on the speed and power of fourth grade female students, no significant difference was observed between each of the stretching conditions and the no-stretching condition, indicating the ineffectiveness of these two protocols. The proposed mechanisms regarding the effects of stretching on muscle function can be studied in two main parts: mechanical factors and neurological factors. In relation to mechanical factors, we can mention muscle stiffness and temperature. Static stretching reduces productive force by reducing muscle stiffness, while muscle

stiffness may be increased by dynamic stretching. Increasing the temperature also increases the ability of the Golgi tendon organs to expand the reflex of the muscle through spontaneous inhibition, so that the muscles that are heated are easily stretched. Optimal stretching helps the muscle to store energy in the tendon during extroverted contraction and uses it to produce more force for subsequent introverted contraction. In the latter case, static stretching has been shown to have negative effects on this cycle, but dynamic stretching has no negative effects (20, 14). It seems that the combination of static stretching with dynamic stretching in the present study eliminates the positive effects mentioned. Consistent with the results of the present study, Wong et al. (23) reported that performing static stretching with dynamic stretching movements reduces the positive effects of dynamic stretching on maximal strength activity. Neurological factors include inhibition of excitability of alpha motor neurons or the central nervous system, which leads to decreased muscle function following static stretching (24). Regarding the study of the effect of the static after dynamic stretching protocol, the results of this study are consistent with the research of little and Williams. (10), which is probably related to the type of stretching movements of the protocols. The results of this study are consistent with the study conducted by Curry et al., in 2009 (12), on the effect of the dynamic after static stretching protocol. However, it is not consistent with the research of Saqibjoo et al. (24) and Mohammadi (17), which can be attributed to the educational state of the participants (pre-trained) or the amount of time after stretching and before performance. On the other hand, it can be said that the type of stretching movements and muscles involved in stretching also affect the results of the strength test. It seems that different muscle stretches have different effects on the test results. For example, in the study of Saqibjoo et al. (24), stretching exercises were performed on only three muscle groups (quadriceps, hamstrings and twins), while in the present study, stretching was performed on all upper and lower torso muscles. Also, regarding the lack of effect of static and dynamic stretching activity sequence on speed, the results of this study are consistent with the research of Ramez et al. (19) and Chaouachi et al. (25). In 2010, Chavuchi et al. examined the effect of warm-up with static and dynamic stretching movements on agility, speed and jump performance in professional athletes and national champions. Despite expecting dysfunction of static stretching, no significant difference was observed except for the reduced speed performance due to Stretching. The researchers said that the lack of negative effect of stretching on performance may be due to the level of subjects' fitness.

4-1. Study Limitations

Our work had its limitations, such as the lack of boys and the small sample size used. Subjects' mental condition and their sleeping quality and quantity may have affected the results; not controlling them was then another limitation of the present study.

5- CONCLUSION

Based on the results, it can be concluded that the dynamic after static stretching and the static after dynamic activity improve reaction speed and flexibility in children, but these two protocols do not affect agility, power and speed. The results of the present study show that there is no significant difference between the effects of static and dynamic stretching activity on reaction speed, flexibility, power, agility and speed. The results of the present study are consistent with some of the results of previous studies but do not agree with others. This difference can be related to factors such as

age, gender, type of stretching movements, duration of stretching movements, time of the test, being beginner or professional, the presence or absence of rest between stretches and before the test.

6- CONFLICT OF INTEREST

None.

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