Static and Dynamic Acute Stretching Effect on Gymnasts’ Speed in Vaulting

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Although warm-up and stretching exercises are routinely performed by gymnasts, it is suggested that stretching immediately prior to an activity might affect negatively the athletic performance. The focus of this investigation was on the acute effect of a protocol, including warm-up and static and dynamic stretching exercises, on speed during vaulting in gymnastics. Eleven boys were asked to perform three different protocols consisting of warm-up, warm-up and static stretching and warm-up and dynamic stretching, on three nonconsecutive days. Each protocol was followed by a “handspring” vault. One-way analysis of variance for repeated-measures showed a significant difference in gymnasts’ speed, following the different protocols. Tukey’s post hoc analysis revealed that gymnasts mean speed during the run of vault was significantly decreased after the application of the static stretching protocol. The findings of the present study indicate the inhibitory role of an acute static stretching in running speed in young gymnasts.

Introduction

Warm-up and stretching exercises have become an accepted way of preparing athletes’ musculoskeletal system before any physical activity. Shellock and Prentice (34) suggested that warm-up and stretching exercises might decrease muscles, tendons and ligaments viscosity, which results in increased joints range of movement and limitation of muscle and joints injuries. Research exists that supports stretching exercises, performed with any stretching technique, such as static, dynamic or proprioceptive neuromuscular facilitation, have a positive impact on the enhancement of joints mobility (8,13,18,31) and that increased mobility results in a reduction of muscle injury (28,34) and a better athletic performance (1,3).

In gymnastics, warm-up and stretching exercises are routinely performed by athletes during daily training. Moreover, the enhancement of gymnasts’ physical abilities is very important for all events. Concerning vaulting, an ability that determines an athlete’s vault performance is running speed. Significant correlations have been found between gymnasts’ approach run speed and the difficulty rating

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as well as the quality of execution of the vault (35). However, running speed is not the only variable that determines vault performance, although it is important (32). With regard to the influence of stretching in speed performance, it has been reported that stretching exercises might increase running speed (chronic effect). Several researchers (1,14,21) attributed the enhancement of athletic performance after long-term stretching routines to increased mobility that had a positive impact in both force and speed. Moreover, Beaulieu (5) observed increases in speed in athletes performing combined force and stretching routines compared to athletes who didn’t perform stretching exercises. However, the acute effect of stretching in running speed development has not been investigated.

Recently, studies on different athletes have shown that static stretching exercises, immediately prior to performing maximum force or torque production activities, reduced performance (17,26). Decreased vertical jump performances were, also, revealed following different stretching protocols (6,16). Moreover, research on competitive female gymnasts has shown that a static stretching protocol preceding drop jump reduces vertical jump significantly about 8.2% (20). Although the most common way of stretching in gymnastics is static stretching, several authors suggested that dynamic stretching was of particular relevance to the athletic movement reality (1). Dynamic stretching is closer to the majority of speed events. As reported by De Vries (7) the measurement of dynamic, rather than static flexibility, might reveal more about an athlete’s potential performance in such activities. In power activities, such as gymnastics, all events and particularly floor exercises and vaulting include dynamic stretching elements during the exercises’ execution.

So far, the acute effect of static and dynamic stretching exercises on maximal speed has not been studied on gymnasts and in particular on children, who participate in majority in artistic gymnastics. Such evidence would be of practical significance, as it would show that including stretching as part of a pre-activity warm-up might affect negatively the athletic performance. The focus of this investigation was on the acute effect of a protocol including warm-up and static and dynamic stretching exercises on speed, during the running part of a “handspring” vault in gymnastics.

**Methods**

**Subjects**

Eleven healthy prepubescent boys (1st Tanner stage) participated in this study. All athletes were competing in D category official competitions according to the Hellenic Gymnastics Federation. Their mean age, mass and height were 9.8 ± 0.8 years, 28.1 ± 4.4 kg and 130.1 ± 4.5 cm, respectively. The training age of the participants was 3.1 ± 0.9 years and they were training in a total of time of 18 hours per week, regularly throughout the year. Parents and coaches gave their consent before engaging in the investigation.

**Procedures and Stretching Protocols**

The athletes were asked to follow 3 different protocols before the running of vaulting on 3 nonconsecutive days: (a) a general warm-up only, (b) a general warm-up and static stretching exercises and (c) a general warm-up and dynamic stretching exercises. Subjects were tested randomly for all 3 conditions. Every stretching
condition was represented by 4 or 3 gymnasts on each day. Each protocol was followed by a “handspring” vault, in order to measure the running speed. All gymnasts were naïve to the purpose of the study. Any changes in flexibility as a result of static and dynamic stretching exercises were not determined, because all athletes attained their maximal joint ranges. Besides, a recent study indicated a non-significant difference in flexibility examining the pre-treatment and post-treatment sit-and-reach values (6).

All 3 protocols included a general warm-up, which consisted of 5 minutes general exercises such as jogging, jumping and short sprints. The purpose of the warm-up was to raise muscles’ temperature in order to prepare the body for vigorous exercises. The second protocol consisted of a general warm-up followed by 2 static stretching exercises that were focused on major lower limb muscle stretching. The first exercise was performed in a sitting position on the floor with the legs extended together (pike position) and the ankles in dorsal flexion. The gymnasts flexed their trunk forward to the fullest extend pulling their toes with their hands and trying to touch their thighs with their belly, in order to stretch hamstrings and calf muscles (Figure 1a). On the second exercise, the participants were lying on their back with the legs bent, their heels just to the outside of the hips and their ankles in plantar flexion. They kept their knees on the floor, hands straight up aligned to the body and trying to touch the floor with their back, in order to stretch quadriceps and tibialis anterior muscles (Figure 1b). Each static stretching position was held steady for 30 seconds to a point of limitation before pain would develop. As to other protocols (20, 26, 30), the period of 30 seconds stretching was chosen to ensure a maximum range of motion and a sufficient stretch stimulus for the muscles. According to Möller et al (22) this effect lasts up to 90 minutes.

The third protocol consisted of the same general warm-up, followed by dynamic stretching exercises for the same muscle groups as in the second protocol. The gymnasts in an upright position were swinging their lower limb in a dynamic fashion through their maximal range of motion (without feeling pain) as fast as possible for 30 seconds. The opposite hand was gripping a solid support at shoulders height. During forward movement (hip flexion), the knee was extended and the ankle in dorsal flexion. In the backward movement (hip extension), the knee was flexed after passing the support leg with the ankle in plantar flexion. The same procedure was followed concerning the contralateral limb (Figure 2). This protocol was designed according to the dynamic stretching principles (2,37) and considering the neurophysiological mechanisms that are activated during fast movements (1,2,7,37) in order to stretch the same muscle groups as in the static protocol.

Figure 1 — Piking (a) and lying knees flexed (b) positions included in the static stretching protocol.
Static and dynamic stretching exercises were performed twice with a 30 seconds rest between each. The experimenter and the coach supervised so that the participants performed appropriately (positions and movements) until the exercises’ completion. All athletes executed all exercises unaided and they performed a “handspring” vault 60 seconds after the completion of each protocol.

**Speed Measurement**

Running speed was measured using 4 pairs of photocells (TAG HEUER, double contact), placed every 5 meters (0 m, 5 m, 10 m, 15 m) in the vaulting runway at gymnasts’ shoulders height. The fourth pair of photocells was positioned 3.5 meters from the front side of the horse. Each athlete started standing, running from the same point (1–2 meters behind the first pair of photocells) and he reduced or augmented the board distance from the horse at a convenient point (0.90–1.20 meters beyond the last pair of photocells). The total running distance was about 20 meters. All gymnasts repeated the executions of the vaults under the same conditions (time, temperature, light) and with the same instruments arrangement (photocells, board and horse placement and starting point).

The athletes performed a low difficulty vault, that is “handspring.” However, the execution of this vault requires the development of a high speed on the runway. This basic vault was selected because it was executable from all athletes and it contains important technical elements that are fundamental for the successful performance of more complex vaults. All participants performed 2 vaults with a rest of 2 minutes between each. Speed data of the best “handspring” execution, which was determined according to the code of points of International Gymnastics Federation, was selected for further elaboration.
Statistical Analysis

The effect of different protocols preceding the running of vaulting was determined using one-way analysis of variance (ANOVA) for repeated-measures. Any significant differences found by the one-way repeated-measures ANOVA were followed by Tukey’s post hoc analysis. Statistical significance was set at $p < 0.05$ level.

Results

Following the different protocols, one-way repeated-measures ANOVA revealed a significant effect in gymnasts’ mean speed during the 0–15 m run of vaulting ($F_{2,32} = 7.501, p < 0.01$). Concerning the 5–10 m and 10–15 m running parts, significant differences ($F_{2,32} = 4.214, p < 0.05$ and $F_{2,32} = 7.375, p < 0.01$, respectively) were found. No main effect for any treatment ($F_{2,32} = 2.474, p > 0.05$) was found in the ANOVA in 0–5 m running part.

The gymnasts’ mean speed during the run of vault (0–15 m) was significantly decreased after the application of static stretching exercises ($p < 0.01$) (Figure 3).

Concerning the different running parts, there were significant differences between speed performance, following warm-up and static stretching exercises in 5–10 m ($p < 0.05$) and 10–15 m ($p < 0.01$), but not in 0–5 m ($p > 0.05$) (Figure 4).

Contrariwise, non-significant differences were observed between speed performance (0–15 m), following warm-up and dynamic stretching exercises ($p > 0.05$).
Discussion

This study investigated the effect of acute muscle static and dynamic stretching on the gymnasts’ running speed during vaulting. The main finding was that a significant decrease in mean running speed occurred following an acute static stretching protocol, while no modification was observed after dynamic stretching protocol. In our knowledge no bibliographic data were found concerning the effects of muscle stretching on running speed especially in gymnasts. However, relatively few studies have concentrated upon stretching methods, which affect power activities, such as vertical jump (6,20,25) and maximal force production (9,17,24,26).

McNeal and Sands (20) reported that, there is a reduction in drop jump performance after a static stretching protocol, in female gymnasts competitive levels 7–9 years. Furthermore, Nelson et al (25) have shown vertical jump performance to be impaired by a preceded muscle static stretching. On the contrary, Church et al (6) demonstrated that vertical jump was significantly decreased after proprioceptive neuromuscular facilitation stretching compared with static stretching treatment. Concerning maximal force production, investigators reported that a regimen of acute static stretching, focused on thigh muscles, inhibited the 1RM lift of knee extension and flexion (17) and the maximal isokinetic torque (26). In the case of a prolonged static stretching treatment, isometric voluntary strength decreased and this acute effect insisted for up to one hour after the stretch (9). In addition, Nelson

![Figure 4](image-url)
and Kokkonen (24) found that a significant decrease in 1RM performance for the same muscle group occurred, also, after ballistic stretching. This finding is in accordance with the present study, although the observed speed decrease after dynamic stretching protocol was not significant (Figures 3 and 4).

Concerning the different running parts of the vaulting after the static stretching protocol, speed was negatively influenced only in 5–10 m and 10–15 m and not in 0–5 m. This might be explained by the fact that the gymnasts are accustomed to start their vaulting running from a stand-up position with a short run and to increase running speed gradually, unlike the sprinters who accelerate from the beginning, applying maximal forces to the ground. Even though, according to Sands and McNeal (33) the running speed is not maximal in a basic skill like a “hand-spring” vault, the development of a large velocity is necessary for a successful vault in children of this competitive level. Gymnasts are asked to achieve larger horizontal velocity at the end of the runway and before the phase of the board touchdown (36). In the present study, the static stretching protocol decreased running speed during the acceleration phase (5 m to 15 m). This acute effect of a static stretching treatment has also been shown to occur in vertical jump (6,20,25) and in maximal force production protocols (17,24,26).

In the present study a decline in athletes’ speed was observed after the static stretching protocol. The static stretching treatment might have a negative impact in athletic performance through mechanical or/and neuromuscular mechanisms. A possible mechanical mechanism is a stretch induced decrease in musculotendinous passive or active stiffness (19,30). Wilson et al. (38) suggested that there is a significant relationship between musculotendinous stiffness and force production. A stiff musculotendinous system allows for improved isometric and concentric force production. Moore (23) gave an alternative explanation about maximal force decrement related to the change in musculotendinous stiffness. After muscle stretching, the joint proprioreceptors (Golgi tendon organs) respond by producing a reflexive inhibition of both the muscle and its synergists (23). As pointed out by Rosenbaum and Hennig (29), the reduction in maximal force production after static stretching exercises is due to neuromuscular factors. These authors indicated that the H-reflex was depressed as a result of acute stretching. This finding supports the neurological explanation for stretch induced compromise in performance. A potential mechanism for the decrease in post-stretch performance might be a reduction of motoneuron excitability (12). Other investigators attributed the force deficit after static stretching exercises to a reduction in the sensitivity of muscles spindles (4).

Concerning the dynamic stretching protocol, no effect was detected in gymnasts’ speed performance. This could be attributed to neurological mechanisms (myotatic reflex) involved during ballistic stretching activities to produce the autogenic inhibition (27). It was found that the magnitude of the myotatic reflex is related to the stretching velocity (10,11). More the stretch is fast, more the action potential of the myotatic reflex is important and this could have a high mechanical effect in musculotendinous stiffness (15). This is probably an explanation why the speed performance was not changed during vaulting after dynamic stretching protocol, although a slight reduction of running speed was observed. Therefore, further work is required to explain this phenomenon.

Concerning the post-stretching impaired speed performance we suggest that both neurological and mechanical factors could be present. Regardless of the mecha-
nism responsible, the findings of the present study indicate the inhibitory role of an acute static stretching in running speed for young gymnasts. It seems unlikely, however, that this effect would have occurred in pubertal and elite athletes, since they don’t have to develop a high velocity in order to execute a low difficulty vault such as “handspring.” Of course, this may be the case in lieu of high difficulty exercises requiring high velocity. Besides, the acute static stretching effect is not necessarily evoked in females, which are usually more flexible than males. These speculations remain to be tested by future research.

Although static stretching is beneficial for gymnasts’ flexibility development, in some events such as vaulting, where success is related to running speed, it is not advisable to include static stretching exercises just prior vault execution, as this might be detrimental to performance. Further work is required to clarify this suggestion and to establish the neuro-physiological mechanisms responsible for the findings.

References


