Acute Static Stretching Reduces Lower Extremity Power in Trained Children

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Several studies utilizing adult subjects have indicated that static stretching may reduce subsequent strength and power production, possibly for as long as an hour following the stretch. This observation has not been evaluated in children, nor in athletes accustomed to performing static stretches during strength/power type training sessions. The purpose of this investigation was to determine if an acute bout of passive, static stretching of the lower extremity would affect jumping performance in a group of young, female gymnasts. Thirteen competitive gymnasts (age 13.3 ± 2.6 yrs) performed drop jumps under two conditions: immediately following stretching and without prior stretching. The jumps were performed on separate days. The conditions were randomly ordered among the subjects. Time in the air (AIR) and ground contact time (CT) were measured during the drop jumps using a timing mat. Three different stretches of the lower extremity were conducted on each gymnast twice, each stretch being held for 30 seconds. Following the stretching condition, AIR was significantly reduced (.44 vs .46 sec, \( p < .001 \)), while CT was not different (.130 for both conditions, \( p > .05 \)). This study demonstrates that children’s lower extremity power is reduced when the performance immediately follows passive, static stretching, even in children accustomed to static stretching during training sessions involving explosive power.

Stretching exercises are often recommended for fitness participants and athletes as part of their warm-up activities (1,26). Stretching prior to physical activity has been recommended to help prevent injury (10,17) and improve performance (2,6), despite a lack of conclusive research to support these effects. The mechanism by which stretching may reduce the possibility of injury may be due to reduced musculoskeletal stiffness observed following stretching (14,19,28), which would potentially reduce the likelihood of muscle or tendon rupture during subsequent activity. However, several investigations have questioned the performance enhancement effect of acute passive stretching, in particular when the stretching was performed immediately prior to an activity requiring levels of strength or power production of the stretched muscles (7,8,9,12,18). For example, Kokkonen, Nelson, and Cornwell (12) reported an average loss of 1 repetition maximum (RM) strength...
in knee flexion of 7.3% and knee extension of 8.1% following approximately 20 minutes of static stretching for lower extremity muscles. Nelson, Cornwell, and Heise (18) showed that both counter movement and squat jump heights were significantly reduced following assisted static stretching of the hip and knee extensors. The authors indicated that stretching reduced the net force production, while the elastic properties of the muscles were unchanged. Fowles, Sale and MacDougall (9) indicated that reduced strength may persist for up to an hour following the cessation of passive, static stretching. The reduced strength may have been caused by impaired activation and contractile force of the involved muscles.

Gymnasts represent a group of athletes for whom stretching is a major component of training (21,22,23,24,25). Gymnasts often perform a variety of active and passive stretches as part of their warm-up, as well as during their sport-specific training activities. In light of the reported reductions in strength and power performance following static stretching in adult subjects, the purpose of this study was to investigate whether similar decrements are found in child subjects, in particular children accustomed to static stretching as a form of sport-specific training. The following study evaluated the jumping performance of young female gymnasts following a passive static stretching session compared to a non-stretch condition.

Methods

Participants

Thirteen female artistic gymnasts, competitors in the four artistic apparatus of vault, uneven parallel bars, balance beam, and floor exercise, participated in this study (age 13.3 – 2.6 yrs; height 149.2 – 11.8 cm; mass 44.0 – 11.9 kg). Gymnasts participated in sport specific training from 8-25 hours weekly and had been competitive gymnasts for at least one year. Informed consent and assent were obtained from all gymnasts and their parents prior to participation in this study, as required by the Institutional Review Board of Eastern Washington University.

Procedures

Testing was conducted over two consecutive days. On one day gymnasts underwent passive, static stretching of the lower extremity followed immediately by the performance of 3 trials of drop jumps (experimental condition). On a second day gymnasts performed the drop jumps without preceding stretching exercises (control). Conditions were randomly assigned. All testing occurred following the gymnasts’ usual warm-up activities as assigned by their sport coach. All gymnasts performed the same warm-up activities which were consistent from day to day.

Drop jumps were chosen for this study due to their increased demands on the stretch-shortening cycle and muscle stiffness (4). Moreover, many gymnastics skills such as tumbling and vaulting involve stretch-shortening cycle activities (15). Drop jump performance has also been shown to discriminate between high and lower skilled athletes in a group of talent-selected gymnasts, aged 9–11 years (16). The drop jumps were performed from a firm folded gymnastics mat (1 inch Ethfoam) .21 m in height onto a timing mat (NEWTEST Powertimer 1.0, Kiviharjuntie, Finland) placed over a concrete and carpeted surface (13). The timing mat recorded time in the air (AIR) and floor contact time (CT) to the nearest
millisecond by custom software (20). Jumps were performed barefoot to correspond to normal training practices. Gymnasts were instructed to keep their hands on their hips during the jumps in order to minimize the contribution of upper body motions to performance (29). Three trials were recorded.

Three passive, static stretching exercises were utilized in the experimental condition (Figure 1). These exercises are commonly utilized in gymnastics preparation. In the stair stretch subjects were instructed to lower their heels off the edge of a stair to their maximal range of motion. In the partner supine stretch the investigator applied resistance to the ball of the foot to maximally dorsiflex the gymnast’s ankle while keeping the leg straight. Finally, in the pike stretch, gymnasts assumed a seated pike position and were instructed to bend forward at the hips bringing their trunk forward toward their feet. The investigator then applied resistance to the feet to maximally dorsiflex the ankle. All stretches were assisted and supervised by the same investigator in order to minimize variability in stretching intensity. Each stretching position was maintained for 30 seconds (21,22,23,24,25). Stretch range of motion was taken to a point where the gymnast verbally indicated mild discomfort.

Analysis

Two dependent t-tests (two-tailed) were used to test for differences between the experimental and control performances for AIR and CT.

Results

Cronbach’s alpha reliability values were high for AIR (alpha > .98). CT reliability values were lower (alpha = .84 control, and .68 experimental). Due to the low reliability and significant difference between trials (p = .05) for the experimental CT, the first trial was dropped and the average of the remaining two trials was used for further data analysis (11). This improved reliability for this variable to alpha = .78. Two dependent t-tests were conducted to determine if passive, static stretching affected AIR or CT. Significance was determined at p < .05. It was found that following passive, static stretching AIR was significantly reduced ($t_{12} = 4.817; p < .001$), but CT was not affected ($t_{12} = 1.056; p = .312$) (Figure 2). To evaluate if an order effect existed for the assignment of condition, the results from gym-
nasts stretched on the first testing day were compared to those gymnasts stretched on the second testing day. The mean AIR value for gymnasts stretched on the first testing day was .365 sec (−.12) vs .370 (−.11) for gymnasts stretched on the second testing day (p = .937). These results indicate that it did not matter in which order the gymnasts were tested.

Discussion

The purpose of the present study was to assess whether static stretching of lower extremity musculature impaired jumping performance in trained girl gymnasts. The results of this study revealed that static stretching reduced jumping performance by 9.6 % on average compared to the control condition. These results support the findings in adult subjects that acute static stretching reduces strength and power performance (7,8,9,12,18). Nelson et al. (18) studied the effects of assisted, passive stretching exercises of the hip extensors and knee flexors in college-age males on squat and counter-movement jump performance in a counter-balanced design. The average reduction in performance due to the stretching protocol was 4.3% and 4.4% for the squat and counter-movement jumps, respectively. The results of the present study indicate that the stretching protocol resulted in a greater reduction in jumping performance than reported by Nelson et al. (18). The jumping task for the current study involved a drop jump rather than the counter-movement and squat jumps studied by Nelson et al. (18). A drop jump is an activity which involves a greater reliance on the stretch-shortening cycle action of the involved muscles than found in counter-movement and squat jumps (4,5,30). It may be that the effects of static stretching are more detrimental for activities with a high component of stretch-shortening cycle actions, which may explain the differing magnitude of affects found.

Figure 2 — Flight time and ground time of drop jump performances.

* p < .05
Nelson et al. (18) suggested that the stretching protocol reduced the force production capacity of the lower extremity, due to the significantly reduced maximal vertical force at take-off for both jumps following stretching. Reduced force production following static stretching has been reported by several other investigators (3, 8, 9, 12, 19). Rosenbaum and Hennig (19) studied the effects of static stretching of the triceps surae group on Achilles tendon reflex activity, using a similar stretching protocol as was used in the current study (3 exercises, 30 seconds each). The investigators reported a reduction in tendon tap force of 5%, and force rise rate of 8%. Fowles et al. (9), using a more prolonged stretching protocol (13 stretches of 135 sec each) reported an average reduction in maximal voluntary contraction of the triceps surae of 28% in college age males and females. It may be that an inverse relationship exists between the duration of stretching and the decrement in performance in tasks requiring high force or power. Future research should investigate static stretching protocols of differing durations, and the relative influence of static stretching on activities with varying intensities of stretch-shortening cycle action.

The mechanism accounting for reduced muscle strength and power performance following static stretching is unknown. Reductions in muscle stiffness have been proposed (12), and have been demonstrated to occur in both rabbit (27) and human preparations (14) following stretching. Stretching protocols have been shown to reduce passive peak force, suggesting that the muscle has become more compliant (19). A more compliant muscle tissue may reduce power performance by placing the contractile elements in a less-than-optimal point in their length:tension relationship, thereby reducing their ability to produce force rapidly. A significant reduction in muscle activity (EMG) immediately following a stretching protocol has been reported by Fowles et al. (9). This decreased activation appeared to recover within 15 minutes following stretching. Kokkonen, Nelson and Cornwall (12) have also suggested that an alteration in the sensitivity of joint or muscle proprioceptors may occur following stretching. Golgi tendon organs react to high tension loads by reflexively inhibiting the muscle being stretched and its synergists. Pain receptors also inhibit muscle activation. The current investigation did not assess force production or muscle activation characteristics in the gymnasts, so it is not possible to imply mechanistic correlates for the observed jumping decrements. Future studies should investigate the mechanisms underlying reductions in power performance in children, and include maturational and training effects.

References


