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ACUTE EFFECTS OF LOW- AND HIGH-VOLUME STRETCHING ON FITNESS PERFORMANCE IN YOUNG BASKETBALL PLAYERS

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Abstract The purpose of this study was to examine the acute effects of low- and high-volume static and proprioceptive neuromuscular facilitation (PNF) stretching on fitness performance in young basketball players. Twenty-three healthy male basketball players (age 13.6 ± 0.5 years old, weight 60 ± 8.4 kg, height 174.7 ± 7.5 cm, BMI 19.6 ± 1.6, and basketball training experience 2.5 ± 0.5 years) performed 5 different warm-up protocols in randomly assigned order: (a) no stretching (NS), (b) low-volume static stretching (LVSS), (c) high-volume static stretching (HVSS), (d) low-volume PNF stretching (LVPNF), and (d) high-volume PNF stretching (HVPNF). The low- and high-volume protocols were completed with 2 and 4 sets of stretches respectively. Analysis of the data revealed that vertical jump, long jump and 4 x 15m standing start running performance declined significantly following LVSS, HVSS, LVPNF, HVPNF as compared to NS ($p<0.05$). Also, vertical jump, long jump and 4 x 15m standing start running performance were significantly reduced following HVSS as compared to LVSS ($p<0.05$). Vertical jump and 4 x 15m standing start running performance were significantly reduced following HVPNF as compared to LVPNF ($p<0.05$). There were no significant differences in flexibility following the 5 warm-up treatments. It appears that pre-performance static and PNF stretches (especially if they are high in volume) may negatively affect motor performance skills in young basketball players.

Key words: Warm-up, flexibility, motor performance skills, youth basketball

INTRODUCTION

There has been considerable research on athletic warm-ups. Warm-ups conducted before a physical activity is a universally accepted practice with the objective of preparing athletes physically and mentally for optimum performance [18]. Warm-ups traditionally contain some stretching protocols such as static, PNF and dynamic methods addressed to specific muscles involved in the subsequent activity. An important role in the construction of a warm-up is the nature of the specific sport. If training programs are to achieve optimal preparation of players, they should be suited to the sports game (in this case, basketball) [19]. Basketball requires high intensity, non-continuous activity that includes many sprints of different duration, rapid acceleration, jumping, agility, and so on [20]. Young basketball players usually perform stretches as part of the warm-up routine before training sessions or sport events and the majority of basketball coaches believe that pre-exercise stretching (PES) is beneficial in decreasing injury rates, increasing mental preparation and are without obvious drawbacks. This may be due to long medical and coaching traditions that have recommended PES, as well as many anecdotal reports of injuries having occurred on the rare occasions when previously injury-free basketball players neglected to stretch before exercise. However, a number of recent findings indicate that incorporation of static stretches in a warm-up routine decreases speed [10, 11, 18, 21, 24], strength [12], power [25], jump performance [7, 8, 13, 16, 20, 23, 25] and agility [15]. It is evident that there is a large gap between the results of the research and its application by athletes and coaches.

To create a basketball warm-up, the first step is to decide which components should be included and the volume and intensity of the warm-up need to be determined. The combination of these variables will affect injury rate and athletic performance.

To date, no research has investigated the acute effects of different volume of static and PNF stretching on fitness performance in young basketball players. The purpose of this investigation was to determine the effects of different stretching routines on the fitness performance in young basketball players.

Based on previous findings, we hypothesized that static and PNF stretching will have detrimental effects on motor performance skills and that high-volume static and PNF stretching will demonstrate more intense negative effects on performance then low-volume static and PNF stretching.

MATERIALS AND METHODS

SUBJECTS AND PROCEDURES

Twenty-six healthy young male basketball players, aged 13-14 years, who are members of the Basketball Club Panthers (Serbia) volunteered to participate in this study. However, three subjects did not complete all study procedures as a result of scheduling conflicts, and the final sample consisted of 23 boys (weight 60 ± 8.4 kg, height 174.7 ± 7.5 cm, BMI 19.6 ± 1.6, and basketball training experience 2.5 ± 0.5 years).

The subjects were required not to consume food for two hours prior to testing. There was a minimum 48-hour rest period between each test conditions to prevent any training effects. Trials took place at the same time each day to avoid any diurnal variations. The subjects and their parents were informed of the nature of this project and consent was obtained before the study started. The coaches were carefully informed about the experimental procedures and the possible risk and benefits of the project. With the approval of the local committee of ethics they provided written consent to participate in this study, which conformed to the Declaration of Helsinki.

WARM-UP PROTOCOLS

Five different warm-up protocols were used to assess their effects on the vertical jump, long jump, 4 x 15 m standing start running and stand and reach flexibility performance.

No stretch (NS) intervention involved an aerobic warm-up that consisted of moderate intensity, gross body movements designed to increase body core temperature, increase body flow and lubrication to the joints (running 800m, forward skips 4 x 30m, side shuffles 4 x 30m, backwards skips 4 x 30m).

A **low-volume static stretching (LVSS)** intervention incorporated the same aerobic warm-up as the NS trial followed by 4 static stretching exercises, focusing on the lower body. The static stretches used were #21 (gastrocnemius), #69 (hamstrings, modified with the subject holding own leg), #101 (hip flexor and quadriceps, modified with vertical thigh and trunk alignment) and #114 (gluteals) described by Alter (1996). Each stretch was held for 20 seconds at a point of mild discomfort, relaxed for 5 seconds, and then repeated for another 20 seconds before moving onto the opposite leg or next stretch.

A **high volume static stretching (HVSS)** involved the NS warm-up and the same static stretching procedure as the LVSS trial, but performed in 4 sets instead of 2. A **low-volume PNF (LVPNF)** consisted of the same general NS warm-up, followed by PNF of the hamstrings and quadriceps. The method used was the contract-relax agonist-contract (CRAC) [1]. “The antagonist was passively stretched by the investigator until the subject felt tightness. This was followed by an isometric contraction on the antagonist of the subject for 10 seconds. The subject then forcefully contracted the agonist muscle for 10 seconds followed by another passive stretch of the antagonist” [6]. This procedure was repeated twice for each muscle group. Both legs were stretched in methods that isolated each leg individually.

A **high-volume PNF (HVPNF)** involved the same protocol as LVPNF, but here the PNF procedure was repeated four times for each muscle group

FITNESS TESTS

The subjects performed the vertical jump, long jump, 4 x 15m standing start running, and the stand and reach flexibility test following standardized protocols [14]. The best score of 3 trials for each test (2 trials for 4 x 15m standing start running) was recorded to the nearest 1.0 cm or 0.1 second. The testing procedures used in this study were designed to be similar to testing procedures used in youth basketball programs as the validity and reliability of these tests have been well established [14]. All subjects had prior experience performing these tests as part of their sports training programs, so we did not include a practice session. We had a high degree of test-retest reliability (R = 0.91 to 0.96).

1. **Standing long jump**. *Instruments*: a tape measure; long jump landing mat. *Task*: the subjects began the long jump with their toes behind the marked line fixed at the 0-cm mark on the mat. The distance from the rearmost heel strike to the starting line was measured.

2. **Vertical jump**. *Instruments*: marked wall; a piece of chalk. *Task*: the subject stands sideways toward a wall and reaches up with the hand closer to the wall. Keeping the feet flat on the ground, the point of the fingertips is marked (the standing reach height). The subject jumps as high as possible and touches the wall at the highest point of the jump. The difference in distance between the standing reach height and the jump height provides the result.

3. **The 4 x 15m standing start running**. *Instruments*: a stopwatch (1/10 seconds); marker cones. *Task*: marker cones and lines are placed 15 meters apart. Start with a foot at the start line. When instructed by the timer, the subject runs to the opposite line, turns around and returns to the starting line. This is repeated two times without stopping. At each marker both feet must fully cross the line.

4. **Stand and reach flexibility test**. *Instruments*: a ruler, a box. *Task*: the subject stands on the box with legs stretched, and bends down to touch the ruler as far as possible. With hands on top of each other, the subject reaches out and holds that position for between one and two seconds while the distance is recorded. Both knees should be locked. The initial ruler value of the scale is raised 20 cm above the level of the upper edge of the box.

After each warm up protocol was completed, the subjects had a recovery period of 3 min. The same researchers tested the same subjects following the same test order (vertical jump, long jump, stand and reach flexibility test and 4 x 15m standing start running). All subjects completed the test battery in less than 15 minutes.

STATISTICAL ANALYSIS

One-way repeated-measures ANOVA was used to compare the performances after 5 different warm-up protocols. When a significant F value was obtained, Bonferroni post hoc comparisons were used to identify pairwise differences. The data is expressed as means ± standard deviation. Statistical significance was set at $p \leq 0.05$ and all analyses were carried out using the SPSS statistical package (version 10.0; SPSS Inc, Chicago, IL).

RESULTS

Performance of the long jump was significantly greater after protocol NS than after protocols LVSS, HVSS, LVPNF and HVPNF [F (2.06, 45.28) = 27.07, $p \leq 0.05$; Figure 1].

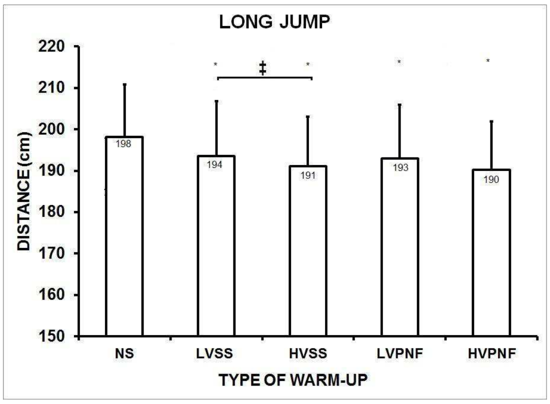

Figure 1. Long jump performance after 5 warm-up protocols. NS indicates no stretching; LVSS, low volume static stretching; HVSS, high volume static stretching; LVPNF, low volume PNF; HVPNF, high volume PNF. *Significantly different from NS; ‡Significant differences between LVSS and HVSS (P ≤ 0.05)

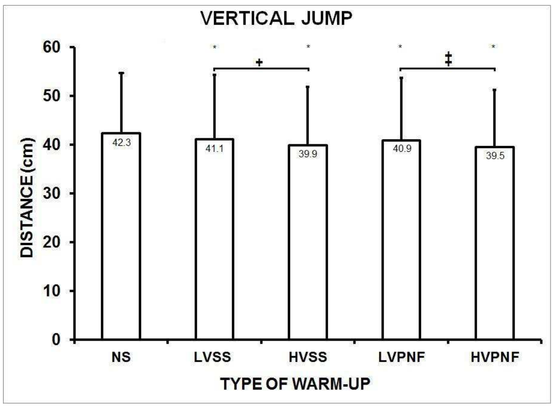

Figure 2. Vertical jump performance after 5 warm-up protocols. NS indicates no stretching; LVSS, low volume static stretching; HVSS, high volume static stretching; LVPNF, low volume PNF; HVPNF, high volume PNF. *Significantly different from NS; +Significant differences between LVSS and HVSS; ‡ Significant differences between LVPNF and HVPNF (P ≤ 0.05)

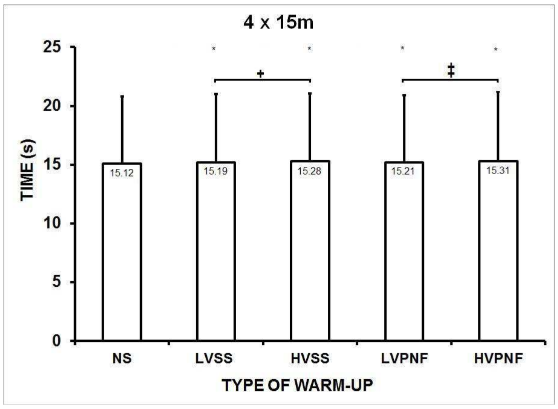

Figure 3. A 4x15m standing start running performance after 5 warm-up protocols. NS indicates no stretching; LVSS, low volume static stretching; HVSS, high volume static stretching; LVPNF, low volume PNF; HVPNF, high volume PNF. *Significantly different from NS; +Significant differences between LVSS and HVSS; ‡ Significant differences between LVPNF and HVPNF (P ≤ 0.05)

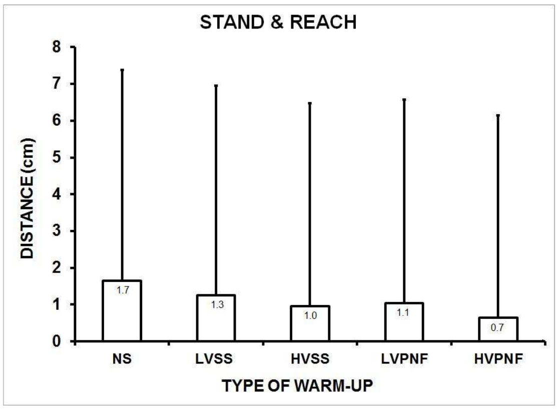

Figure 4. Stand and reach performance after 5 warm-up protocols. NS indicates no stretching; LVSS, low volume static stretching; HVSS, high volume static stretching; LVPNF, low volume PNF; HVPNF, high volume PNF

There was also significant decrease in performance between LVSS and HVSS trials (2.6 cm; 1.3%). Performance of the vertical jump was significantly greater after protocol NS than after protocols LVSS, HVSS, LVPNF and HVPNF [F (1.87, 41.18) = 37.95, p≤0.05; Figure 2]. Vertical jump height was found to be significantly higher for LVSS compared to HVSS (1.2 cm; 2.9%) and for LVPNF compared to HVPNF (1.3 cm; 3.2%). Performance on the 4 x 15 m standing start running was significantly greater after protocol NS than after protocols LVSS, HVSS, LVPNF and HVPNF [F (2.34, 51.46) = 40.41, p≤0.05; Figure 3.]. Also, 4 x 15 m standing start running time was found to be significantly lower for LVSS compared to HVSS (0.09sec; 0.6%) and for LVPNF compared to HVPNF (0.1sec; 0.66%). No significant differences between warm-up trials were observed for the stand and reach [F (1.83, 40.39) = 6.09, p≤0.05; Figure 4].

DISCUSSION

The results from this study indicate that static and PNF stretching have detrimental effects on motor performance skills under the experimental conditions used in this study. Warm-up protocols that included static and PNF stretching significantly decreased the performance of vertical jump, long jump and 4 x 15 m standing start running. Also, our data supported the hypothesis that high-volume static and PNF stretching had more intense negative effects on motor performance skills than low-volume static and PNF stretching.

To our knowledge, no other authors have examined the effects of different stretching volume on fitness performance of young basketball players. The decrease in motor performance skills linked to static and PNF stretching has been shown in a number of times in adults [6, 7, 10, 15, 18, 21, 23, 24, 25] and in children and adolescents [8, 9, 16, 22]. However, the effects of different stretching volume involved in these studies have not been examined.

Low- and high-volume static and PNF stretching resulted in a significant decrease in long jump performance. The results of the present study are consistent with previous studies that examined the use of static stretching in pre-event warm-up [8, 9]. The young athletes performed significantly better after the low-volume static stretching as compared with the high-volume static stretching protocol.

The results of this study demonstrate a reduction in vertical jump performance following an acute bout of static and PNF stretching. Our results are consistent with those of other investigators who found negative effects of static and PNF stretching on vertical jump performance in children [13, 16, 22] and adults [4, 6, 7, 23, 25].

In the present study low- and high-volume static and PNF were compared, with the high-volume stretch modality showing a significant decrease in vertical jump performance compared to the low-volume stretch regime. The decreases in jump height linked to the employment of the high-volume static [13, 16, 23], and PNF stretching [4, 6] are well documented and thus not surprising.

Our results show that the time of the 4 x 15m standing start running was significantly increased when performed after static and PNF stretching. Also, the high-volume protocols showed a significantly greater impact than the low-volume protocols. Previously, it has been shown that sprint time (acceleration and velocity) decreased when the warm-up included static stretching [11, 18, 21, 22]. Andrejić [2] studied the effects of static stretching on subsequent repeated sprint ability (RSA) and change of direction speed (CODS) performance. These results suggest that an acute bout (4 min) of static stretching of the lower limbs during recovery periods between efforts may compromise the RSA performance but has less effect on the CODS performance. Amiri-Khorasani et al [2] also reported significant decreases in agility time after no stretching, compared to static stretching.

One previous study [15] suggested that limiting the stretches to short durations would minimize decreases in power-based performance in professional athletes. In the study participants used 5 static stretching exercises and they held the stretch for 30 seconds. Participants were told to stretch until they approached the end of range of motion but within the pain threshold. A 20 second rest was allowed between each stretch. The difference between this and our study design may explain why the static stretching produced performance decreases in this study protocol. We stretched muscles for greater durations than Little and Williams [15], who may have avoided elicit neural and excessive mechanical force inhibitory mechanisms [12] by using 30 second stretch duration during pre-competition warm-ups. Also, Little and Williams [15] did not conduct performance analysis immediately after stretching. Extra warm-up activity after stretching may have reversed any decrease in muscular compliance and associated decreased neural drive initiated by stretching.

Similar to previous findings [6, 8] our results indicate that there are no significant differences between warm-up trials for the low back and hamstring flexibility. Previous research has suggested that differences in arm and leg lengths significantly influence performance on the stand and reach test and that stand and reach performance is only moderately correlated with hamstring flexibility [3]. As a result, it may be that the stand and reach test as used in the present study is not appropriate to detect any changes in flexibility as a result of the warm up protocol. This may be particularly so when considering the ages of the boys who participated, as maturation related changes in body dimensions could have influenced the performance on the stand and reach test independent of any change in flexibility.

A limitation of our study is that we did not have a control condition with which to compare the other warm-up treatments. Also, the young athletes' intensity during the warm-up was not confirmed by heart rate or body temperature. This investigation addressed the acute responses to different warm-up protocols in trained young basketball players and the results from this study should not be generalized to recreationally trained children because an individual's training level may affect the responses to postactivation potentiation [5].

CONCLUSION

Currently, there is little convincing scientific evidence supporting the anaerobic performance-enhancing potential of static and PNF stretching. Thus, it appears that PES may significantly reduce motor performance skills in young basketball players. The results of this study suggest that the use of high-volume static and PNF stretching can lead to greater acute negative effects on motor performance skills in young basketball players. However, no differences in hamstring and low back flexibility were found across warm up protocols.

Participants in youth basketball and other youth sports that require running, jumping and other types of explosive power should be aware that static and PNF stretching (especially if they are high in volume) just before exercise can cause a temporary reduction in motor performance and should probably be avoided before competition.

PRACTICAL APPLICATION

The impact of different types of warm up protocols on young basketball players' performance is clearly an unresolved issue that has not yet been satisfactorily investigated. This issue is one that is also of interest to physical education teachers, youth sports coaches and sports scientists.

The possibility that static and PNF stretching could result in a reduction of motor performance skills could have important implications for conditional trainers, basketball coaches and other professionals who typically encourage young athletes to engage in some type of warm-up before practice and competition. The findings of the current study will help basketball coaches and other professionals to optimize warm-up procedures for young athletes.

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