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Original empirical article

AN INVESTIGATION INTO THE EFFECTS OF DIFFERENT WARM-UP PROTOCOLS ON FLEXIBILITY AND JUMPING PERFORMANCE IN YOUTH

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Abstract. *The purpose of this study was to determine the effectiveness of different warm-up protocols on the flexibility and jumping performance in boys (13 - 14 yr). Twenty participants (49.7 ± 9.7 kg; 162.2 ± 10.7 cm) who have been taking basketball classes completed 4 different warm-up protocols. The participants performed each warm-up protocol on nonconsecutive days, and the order in which the protocols were performed was randomized. Each warm-up protocol consisted of a 5-minute moderate-intensity jog followed by either: no stretching (NS), static stretching (SS) dynamic exercises (DY1), or dynamic exercises plus 5 drop jumps from 30-cm boxes (DY2). The results indicated that dynamic warm-up protocols resulted in a significantly greater jumping performance than static stretching conditions. The vertical jump performance was significantly greater after DY1 (38.8 ± 8.0cm) and DY2 (36.6 ± 8.3cm) compared to SS (34.9 ± 7.7cm), and the long jump performance was significantly greater after DY1 (206.7 ± 33.9cm) and DY2 (199.5 ± 35.5cm) compared to SS (187.7 ± 30.5cm). No significant differences between DY1, DY2 and SS were observed for flexibility performance. These findings indicated that moderate-intensity dynamic exercises may be the most effective warm-up protocol for enhancing jumping performance in boys.*

Key words: *stretching, dynamic exercises, explosive muscle power, sit and reach.*

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INTRODUCTION

Static stretching (SS) has been widely promoted before performing physical activity as a method of preventing injury and improving physical performance (Shrier, 2005). Recently, numerous studies have documented the limited injury reducing effects of pre-event SS (Herbert and Gabriel, 2002; Pope, Herbert, Kirwan and Graham, 2000) and the detrimental acute effects of SS on the vertical jump (Faigenbaum, Bellucci, Bernieri, Bakker and Hoorens, 2005; Faigenbaum et al., 2006b; Faigenbaum et al., 2010; Gelen, Saygin, Karacabey and Kilinc, 2008; McNeal and Sands, 2003; Needham, Morse and Degens, 2009; Siatras, Papadopulos, Mameletzi, Gerodimos and Kelis, 2003) and long jump ability (Faigenbaum et al., 2005; Faigenbaum et al. 2006a) in youth. Some authors have suggested that SS before competition may hinder performance and prompted recommendations that SS be omitted or replaced by dynamic movements during the pre-event warm-up routine (Faigenbaum et al., 2005, 2006a, 2006b; Siatras et al., 2003; Thompsen, Kackley, Palumbo and Faigenbaum, 2007; Young and Behm, 2003; Young and Elliott, 2001; Yamaguchi, Ishii, Yamanaka and Yasuda, 2007).

Chu (1998) and Faigenbaum (2000) reported that a dynamic warm-up is safe and appropriate for youth. A dynamic warm-up protocol typically includes moderate and high intensity hops, skips, jumps, leg swinging, fast strides and various movement-based exercises. Dynamic exercise may create an optimal environment for power production by increasing motor unit recruitment, increasing muscle spindle firing, increasing activity of the synergist musculature, reducing inhibition of the Golgi tendon organ and enhancing the neuromuscular system (post-activation potentiation), which in turn may allow for greater jumping effort during subsequent exercises (Hilfiker, Hubner, Lorenz and Marti, 2007).

Some authors believe that the use of drop jumps (eccentric contraction) during a warm-up may recruit more muscle fibers and require a more neural adaptation and, therefore, lead to an increase in fitness performance (Faigenbaum et al., 2005; Hilfiker et al., 2007; Saez, Gonzales and Izquierdo, 2007). The possibility that dynamic warm-up protocols with drop jumps could result in ever greater gains in jumping performance could have important implications for physical education teachers and youth sport coaches.

Based on the research to date, and the methodological design relative to current athletic practice, this study investigated the acute effect of different warm-up protocols on the sit-and-reach, vertical jump and long jump performance in youths. Based on previous findings, it was hypothesized that a dynamic warm-up would positively influence flexibility and the jumping performance in youths and that a static stretching warm-up protocol would decrease jumping performance in youths.

THE METHOD

Twenty-two healthy boys, who are members of the Ljupče Španac school basketball team (Bela Palanka, Serbia) volunteered to participate in this study. However, two of the participants did not complete all study procedures as a result of scheduling conflicts, and the final sample consisted of 20 boys (age, 13.4 ± 0.5 years old; weight, 49.7 ± 9.7 kg; height, 162.2 ± 10.7 cm; and basketball training experience 1.5 ± 0.5 years)

The participants 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. The trials took place at the same time of the day to avoid any diurnal

variations. The participants and their parents were informed about the nature of this project and consent was obtained from them before the study started.

Four different warm-up protocols were used to assess their effects on the vertical jump, long jump, and sit and reach flexibility performance. The no stretch (NS) protocol consisted of 5 minutes of moderate to high intensity jogging. A static stretching (SS) protocol incorporated 5 minutes of moderate to high intensity jogging as the NS trial, followed by five static stretching exercises focusing on the lower body. The static stretching used included the hamstring stretch, low-back and hip stretch, inner-thigh stretch, quadriceps stretch and calf stretch (Faigenbaum and Westcott, 2000). Each stretch was held for 20 seconds at a point of mild discomfort, followed by a 5 second break, and then repeated for another 20 seconds before the participant moved onto the opposite leg or next stretch. The dynamic exercise (DY1) protocol consisted of the same general NS warm-up, followed by moderate-intensity to high-intensity dynamic exercises. The dynamic warm-up exercises used were: the high knee skip, high knee run, butt kick, carioca, lateral shuffle, walking lunge, side to side kick and front-and-back kick. More detailed descriptions of these stretches can be found in the National Basketball Conditioning Coaches Association volume (NBCCA, 2007). The DY2 protocol involved the same 8 dynamic exercises as the DY1, plus 5 drop jumps from 30cm boxes.

The tests selected for the evaluation of fitness performance were: the vertical jump, long jump and the sit and reach flexibility test. Standardized protocols for fitness testing were followed according to the previously described methods (Safrit, 1995). The best score of 3 trials for each test was recorded to the nearest 1.0cm. After each warm-up protocol was completed, the participants had a 2 minutes recovery period. The same researchers tested the same participants following the same order of tests (the vertical jump, the long jump, the sit-and-reach). Each participant completed all the study procedures within 12 days.

Descriptive statistics for all the fitness variables are expressed as mean ± SE. We calculated a 1-way, repeated-measures ANOVA to analyze the differences among the criterion measures after the four warm-up protocols. When a significant F value was obtained, Bonferroni post hoc comparisons were used to identify pair-wise differences. The statistical significance was set at $P \leq .05$ and all the analyses were carried out using the SPSS statistical package (version 16.0; SPSS Inc, Chicago, IL).

RESULTS

As hypothesized, the dynamic warm-up protocols resulted in a significantly greater jumping performance than the static stretching condition. The performance of the long jump was significantly greater after the DY1 and DY2 protocols than after the NS and SS protocols [$F(2.58, 49.12) = 36.23$, $p \leq 0.05$; Figure 1.].

In addition, the performance of the vertical jump was significantly greater after the DY1 and DY2 protocols than after the NS and SS protocols [$F(2.91, 55.23) = 49.43$, $p \leq 0.05$; Figure 2.].

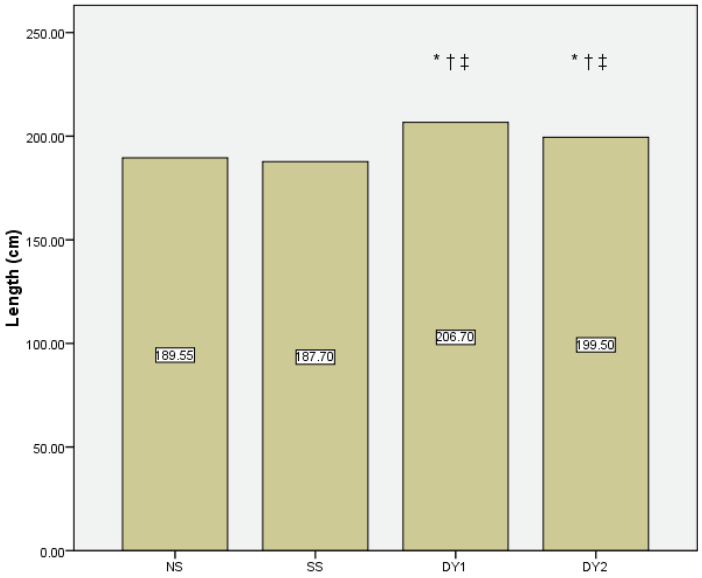

Fig. 1. Long jump performance after 4 warm-up protocols
NS indicates no stretching; SS, static stretching; DY1 dynamic exercises warm-up; DY2 dynamic exercises warm-up followed by 5 drop jumps. *Significantly different from NS; †Significantly different from SS; ‡ Significant differences between DY1 and DY2 ($P \leq 0.05$).

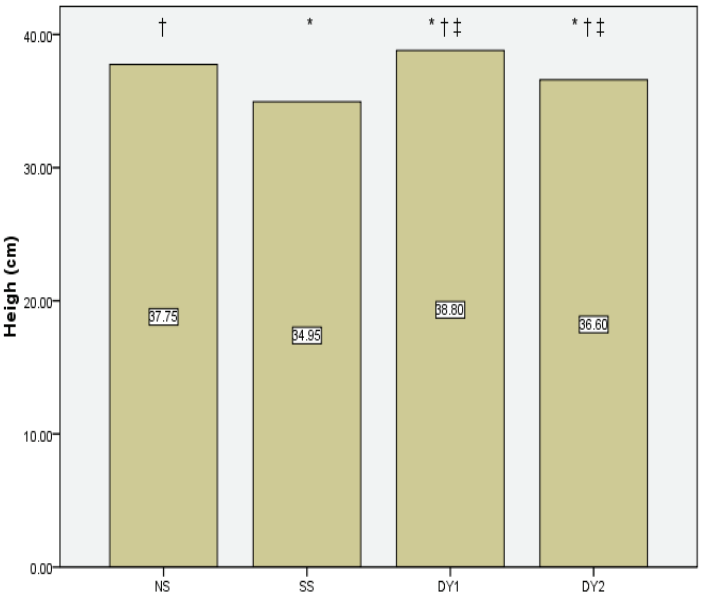

Fig. 2. Vertical jump performance after 4 warm-up protocols
NS indicates no stretching; SS, static stretching; DY1 dynamic exercises warm-up; DY2 dynamic exercises warm-up followed by 5 drop jumps. *Significantly different from NS; †Significantly different from SS; ‡ Significant differences between DY1 and DY2 ($P \leq 0.05$).

The sit-and-reach performance was found to be significantly lower for NS compared to SS, DY1 and DY2 protocols [$F(2.37, 45.02) = 24.07$, $p \leq 0.05$; Figure 3.].

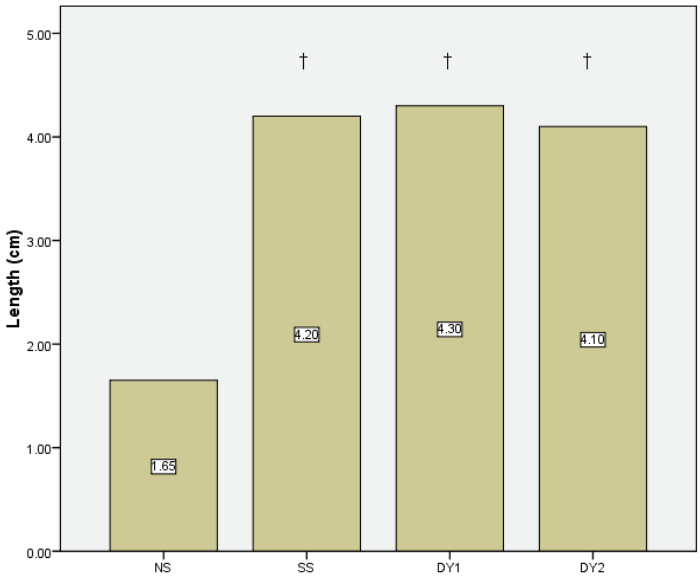

Fig. 3. Sit-andreach performance after 4 warm-up protocols
NS indicates no stretching; SS, static stretching; DY1 dynamic exercises warm-up; DY2 dynamic exercises warm-up followed by 5 drop jumps. †Significantly different from NS. ($P \leq 0.05$).

DISCUSSION

The results of this study demonstrate that warm-up procedures can significantly influence jumping performance in youths. The main finding was that the warm-up protocol that included dynamic exercises resulted in the superior performance of the long jump and vertical jump as compared to a warm-up protocol that included SS. These findings support a range of previous studies that reported short-term improvements in performance after a bout of warm-up dynamic exercise compared to SS (Faigenbaum et al, 2005, 2006a, 2006b; Siatras et al., 2003; Thompsen, Kackley, Palumbo and Faigenbaum, 2007; Young and Behm, 2003; Young and Elliott, 2001; Yamaguchi, Ishii, Yamanaka and Yasuda, 2007).

It was observed that DY1 may be the most effective warm-up for enhancing jumping performance in primary school boys. The long jump performance improved by 10.1% and 6.3%, respectively, after DY1 and DY2, when compared to SS. Furthermore, it is noted that vertical jump performance improved by 11.2% and 4.9%, respectively, after DY1 and DY2, when compared to SS. This finding may improve the understanding of the acute effects of different pre-exercise protocols on jumping performance, and may help develop effective warm-up protocols for youth sport practice and competition.

Research carried out by Faigenbaum et al. (2005) with a group of 11-year-old children has also reported that the vertical jump and long jump performance significantly decreased by 6.5% and 1.9% following SS, respectively, when compared to the performance of a dynamic warm-up protocol.

Cornwell, Nelson, Heinse and Sideway (2001) reported that pre-event SS significantly reduced vertical jump height by 4.4%. The results of the current study also support the findings of McNeal and Sands (2003) who detailed a 9.6% reduction in vertical jump height following an acute bout of static stretching in a group of teenage gymnasts.

Gelen et al. (2008) investigated the acute effects of SS on vertical jump performance in children. They reported a 5.2% decrease in vertical jump height between a general warm-up and SS after a general warm-up. Other studies found decreases in vertical jump performance after SS, ranging from -4.5% to -7.3% and-3.2% to -4.4% with and without counter movement, respectively (Cornwell et al., 2001; Wallmann, Mercer and McWhorter, 2005; Young and Behm, 2003).

Pre-event dynamic warm-up protocols may create an optimal environment for explosive force production by enhancing neuromuscular function (Faigenbaum et al. 2005). This phenomenon is referred to as post-activation potentiation and is believed to increase the rate of force development, thereby increasing speed and power production (Sale, 2002). Eight dynamic warm-up exercises used in the present study may have influenced the excitability of fast twitch motor units and therefore readied these units to play a more significant role during the vertical jump test.

It is noted that the vertical jump performance decreased by 2.9% after SS when compared to NS. These findings are consistent with previous studies involving youths and adults, which reported a reduction in vertical jump performance following an acute bout of SS averaged approximately 3–4%; range 0–8% (McHugh and Cosgrave 2010). Also, the findings of Shrier's (2004) research, which is supported by other reviews (Haff, 2006), reveals that pre-performance SS may significantly reduce performance outcomes.

The results of the current research do not support the addition of 5 drop jumps from 30cm boxes to a dynamic warm-up to increase the long jump and vertical jump in boys. Some authors noted an increase in the strength and power performance after a warm-up protocol with added drop jumps (Brandenburg and Czajka, 2010; Hilfiker et al 2007; Saez et al., 2007). However, the participants in these studies were adults with strength and plyometric training experience. Because excessive load may result in fatigue, it is possible that adding 5 drop jumps from 30cm boxes was too fatiguing for the young participants in this study.

Faigenbaum et al. (2005) examined the effect of acute bouts of static warm-up, dynamic warm-up and dynamic warm-up with drop jumps on the fitness performance in a group of 12-year-old children. The results of this study indicated that long jump and vertical jump performance significantly reduced following SS as compared to 10 minutes of dynamic exercise plus 3 drop jumps from 15-cm boxes. This research was based on a similar sample of participants, but we used a greater volume of jumps and higher drop jump boxes.

These results demonstrate no significant differences between the DY1, DY2 and SS protocols for flexibility performance. The results of the current study are consistent with other studies of dynamic warm-up protocols (Faigenbaum 2005; Young and Behm, 2003), and suggest that dynamic warm-up protocols may be as effective in increasing joint range of motion as static warm-up protocols. Additionally, there was a significant difference in low back and hamstring flexibility between the NS protocol and SS, DY1 and DY2 protocols. Five minutes of moderate to high intensity jogging (NS protocol) was insufficient for obtaining an optimal flexibility level. The findings of the current study suggest that an acute dynamic warm-up has greater applicability to enhance jumping performance in 13 to 14 year-old boys, compared to a SS warm-up protocol. No differences in hamstring and low back flexibility were found across the dynamics and SS warm-up protocols.

CONCLUSION

Traditional stretching routines performed during warm-up procedures before exercise can increase flexibility for a short time, but there is little scientific evidence that such routines can improve exercise performance. Therefore, moderate-intensity dynamic exercises may be more effective as a pre-event warm-up routine when the enhancement of power output in boys is at stake.

In practice, this information is highly important for youth sporting events in which jumping performance is fundamental, since a decrease in performance may hinder the final results. These findings may improve the understanding of the acute effects of different pre-exercise protocols on jumping performance, and may help develop effective warm-up protocols for youth sport practice and competition. However, further research which would examine the impact of warm-up protocols on the performance in children is needed to strengthen these conclusions. The underlying neuromuscular mechanisms that explain the performance enhancing effects of pre-event dynamic stretching also require further examination.

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ISTRAŽIVANJE EFEKATA RAZLIČITIH PROTOKOLA ZAGREVANJA NA GIPKOST I SKAKAČKE SPOSOBNOSTI MLADIH

Ognjen Andrejić

Ova studija je imala za cilj da utvrdi efikasnost različitih protokola zagrevanja na gipkost i skakačke sposobnosti kod dečaka starosti 13 do 14 godina. Dvadeset ispitanika (49,7 ± 9,7 kg; 162,2 ± 10,7 cm) članova košarkaške sekcije učestvovalo je u 4 različita protokola zagrevanja. Između svakog protokola napravljen je najmanje jedan dan pauze a redosled protokola bio je nasumičan. Svaki protokol zagrevanja se sastojao od 5 minuta trčanja srednjeg intenziteta (NS) posle čega je sledilo: statičko istezanje (SS), dinamičke vežbe (DY), ili dinamičke vežbe plus 5 skokova sa klupe visoke 30cm (DY2). Protokoli dinamičkog zagrevanja inicirali su značajno veće skakačke sposobnosti u poređenju sa protokolom statičkog istezanja. Performanse skoka u vis iz mesta bile su značajno bolje posle DY1 (38.8 ± 8.0cm) i DY2 (36.6 ± 8.3cm) u poređenju sa SS (34.9 ± 7.7cm), a performanse skoka u dalj iz mesta bile su značajno bolje posle DY1 (206.7 ± 33.9cm) i DY2 (199.5 ± 35.5cm) u poređenju sa SS (187.7 ± 30.5cm). Nisu uočene značajne razlike u gipkosti između DY1, DY2 i SS. Ovi nalazi ukazuju da su dinamičke vežbe umerenog intenziteta verovatno najefikasniji vid zagrevanja u pripremi dečaka za unapređenje skakačkih performansi.

Ključne reči: *istezanje, dinamičke vežbe, eksplozivna snaga, pretklon u sedu.*