ORIGINAL ARTICLE

Effects of different types of warm-ups on performance by young volleyball players

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ABSTRACT

The study aimed to compare the impact of warm-up with dynamic stretching (DS), warm-up with foam roller (FR), and warm-up with a combination of FR and DS (CO) on the performance of movement indicators in tests conducted on young volleyball players (n = 8, age = 15.4 ± 0.5 years, height = 176.3 ± 8.6 cm, weight = 64.5 ± 10.9 kg) during the competition year 2021/2022. To assess the effects of warm-up methods (DS, FR, CO), performance in various movement tests was compared. The tests included the sit and reach test (SR), a 1 kg ball throw in a kneeling position (H1), squat jump (SJ), countermovement jump (CMJ), sit-up test (SU), E-Test (ET), and run to cones (RC). The One-way ANOVA analysis did not reveal significant differences in the effects of DS, FR, and CO warm-ups (p > .05) across all investigated indicators. The effect size coefficient (η^2) indicated negligible differences ($\eta^2 < 0.01$), except for the ET indicator, where a small effect size ($\eta^2 = 0.028$, 95%CI: 0.04-0.31) favoured DS. These findings carry social importance as they contribute to enhancing the efficacy of warm-up routines, both in sports performance and health considerations.
Keywords: Performance analysis, Dynamic stretching, Foam rolling, Sports medicine, Sports performance, Sports training.

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INTRODUCTION

Many athletes incorporate stretching into their warm-up routine to enhance athletic performance and prime the body for training or competition (Gerdijan et al., 2021; Pescatello et al., 2014). The choice of stretching methods in warm-ups is a subject of ongoing debate (Shelton and Kumar, 2009).

According to Guissard and Duchateau (2004) and Weppler and Magnusson (2010), the impact of stretching exercises involves both mechanical factors (such as viscoelastic and plastic deformation of connective tissue) and nervous factors (including neuromuscular relaxation and modification of sensation). Dynamic stretching, among various warm-up techniques, has gained global popularity and is widely recommended (Behm et al., 2004).

Studies investigating dynamic stretching have reported positive effects on various aspects, including increased flexibility (Ryan et al., 2014; Haff and Triplett, 2015), enhanced muscle strength (Faigenbau et al., 2006), improved sprint performance (Brahim and Chan, 2022), and improved explosive power performance (Hough et al., 2009; Perrier et al., 2011). Rubini et al. (2007) noted that dynamic stretching with low to moderate intensity movements raises body temperature, enhances motor unit excitability, improves countermovement jump (CMJ) performance (Dalrymple et al., 2010), and fosters kinaesthetic awareness (Mann and Jones, 1999). Another method currently used in warm-up process by athletes is self-massage (self-myofascial release - SMR) (Popelka and Pivovarniček, 2022).

According to Cheatham (2015), SMR is popular in rehabilitation and among athletes to enhance myofascial mobility. This warm-up technique involves using foam rollers of various densities, targeting specific muscle groups, and was developed as an alternative warm-up method (Lee et al., 2018). Higher-density rollers are considered more suitable for SMR, as suggested by Curran et al. (2008), although Cheatham et al. (2018) and Yanaok et al. (2021) found no significant differences when using foam rollers with different densities. SMR helps release muscle and tendon tension, soft tissue adhesions, and scar tissue, potentially increasing the range of motion in the knee joint without compromising muscle performance (Macdonald et al., 2013).

Opinions regarding the use of a foam roller in warm-ups to enhance range of motion (ROM), flexibility, and performance vary. Wiewelhove et al. (2019) suggest that the effects of using a foam roller in warm-ups on jump performance, strength, and recovery are generally small and negligible. However, in specific cases, such as enhancing performance and flexibility in sprinting or reducing the sensation of muscle pain, the effects may be relevant. Gerdijan et al. (2021) highlight that, despite numerous empirical studies on stretching, there are ongoing dilemmas regarding the appropriate type of stretching, with often contradictory study results. As a result, several authors (Kirmizigil et al., 2014; Popelka and Pivovarniček, 2018; Stojanovic et al., 2020) aim to compare different warming-up methods or their combinations to determine the most suitable warm-up approach.

Su et al. (2017) conducted a study comparing static stretching, dynamic stretching, and self-massage during warm-up. They observed a significant improvement in quadriceps and ischiocrural flexibility after self-massage compared to static stretching. Peacecock et al. (2014) examined a warm-up routine that included both dynamic warm-up exercises and a self-myofascial release session using total-body foam rolling. This combined routine led to overall enhancements in athletic performance testing.

On the contrary, Richman et al. (2019) investigated the combined effects of self-massage with a foam roller and dynamic stretching on various parameters, including range of motion, jumping, sprinting, and agility.

Their research has proven that the change in sit-and-reach (SR) after foam rolling session (SMR) was significantly greater than the change seen in SR after light walking (LW), although the total changes seen in each condition were not statistically different after the addition of dynamic stretching (DS). Squat jump (SJ) and countermovement jump (CMJ) improved by 1.72 ± 2.47 cm and 2.63 ± 3.74 cm (p = .070, p = .070), with no significant change to drop jump (DJ), sprint, and the agility T-Test. Self-myofascial release in the form of foam rolling after a general warm-up and preceding a dynamic stretching DS session seems to improve Squat jump and countermovement jump with no detriment to flexibility, drop jump, sprint, and agility performance in comparison with light walking and dynamic stretching.

The study by Konrad et al. (2021) suggests that athletes may not necessarily need to combine stretching with foam rolling, as no additional effect was observed. However, for increased performance, the combination of foam rolling followed by stretching could result in greater improvements. Another study by Seçer and Özer Kaya (2022) found that both DS and DS combined with FR improved flexibility and agility without affecting balance. The combination of DS and FR was not superior to DS alone in terms of improving flexibility and agility. Both methods proved effective as warm-up protocols to enhance factors related to injury risk and performance. Further research on the combined effects of foam rolling and dynamic stretching is needed.

In a preliminary study conducted by Popelka and Pivovarniček (2022), similar effects were observed in warm-ups using foam rolling and dynamic stretching on the performance of motion tests in young volleyball players. However, this study utilized a two-group experimental design. The current study aims to compare the effects of warm-ups involving foam rolling, dynamic stretching, and a combined approach (foam rolling + dynamic stretching) on the performance of movement tests in young volleyball players, utilizing a sequential experiment with a single group where all three warm-up types are implemented. Consistent with the findings of pilot study (Popelka and Pivovarniček, 2022), we also anticipate a comparable (though not statistically significant) impact of all three warm-up methods.

MATERIAL AND METHODS

Participants

The experimental sample comprised young volleyball players participating in the competition year 2021/2022 (n = 8, age = 15.4 ± 0.5 years, body height = 176.3 ± 8.6 cm, body weight = 64.5 ± 10.9 kg). To be included in the research evaluation, participants were required to fully complete the entire study, ensuring 100% participation from each individual. All study participants received clear instructions on the procedures and confirmed their participation by providing informed consent. The research protocol was approved by the Ethical Committee at the respective university. Measurements were conducted in compliance with the ethical standards outlined in the Declaration of Helsinki and the ethical guidelines for research in sport and exercise science (Harriss and Atkinson, 2015).

Organisation of research

The research was conducted during the competition year 2021/2022, spanning from January 24, 2022, to March 29, 2022. On Monday, January 24, 2022, incoming testing was carried out for all players, involving measurements of body weight and height. Performance measurements in motion tests after stretching (DS = dynamic stretching; FR = foam rolling; CO = combination of FR and DS) took place from January 25, 2022, to March 29, 2022.

On January 25, 2022 (Tuesday), the players underwent the DS warm-up. Subsequently, on January 27, 2022 (Thursday), they completed the FR warm-up, and on February 1, 2022 (Tuesday), the CO warm-up.

These three warm-ups then alternated in that order every Tuesday and Thursday. Participants completed a total of 6 warm-ups for each type, each followed by testing of the studied movement indicators. For each warm-up type in the order DS, FR, CO, six measurements were performed. The level in the tests of the investigated indicators was calculated as the average level of six measurements for each type of warm-up (DS, FR, CO). A summary of the basic volume indicators for individual types of warm-ups is presented in Table 1. Prior to each warm-up session, the participants engaged in a uniform 3-minute warm-up routine. The FR and CO warm-up included the use of a Liveup® sports foam roller (Nantong Liveup Sports Co., Ltd, China).

Table 1. The fundamental quantitative measurements of the employed warm-up methods.

Warm-up	Duration (min)	Number of exercises	Length of each exercise (s)	Rest in between Exercises (s)	Number of repetitions
Dynamic Stretching (DS)	11-12	13	35-40	10-12	10-12
Foam Rolling (FR)	11-12	13	40-45	8-10	18-20
Combination (FR + DS)	11-12	FR 13 DS 13	FR 15-20 DS 15-20	6-8	FR 8-10 DS 5-6

Note. (min) = minutes. (s) = seconds. DS = dynamic stretching; FR = foam rolling.

Measurements

The following tests were used in the research:

The sit and reach test (SR) was employed to evaluate flexibility in the lower back and hamstrings. The outcome of a single measurement was the distance reached by the middle fingers during a forward bend, recorded in centimetres on the sit and reach box with a precision of 0.1 cm. Higher number means bigger overhang – better flexibility.

The test – 1 kg ball throw in kneeling position (H1) was used to determine the explosive power of the dominant upper limb. The result of one measurement was the throwing distance measured in meters with accuracy of 1 cm.

To assess the height of a vertical jump, the Squat Jump (SJ) and Countermovement Jump (CMJ) tests were conducted and analysed using Myotest PRO (Myotest SA, Switzerland). The measurement outcome for SJ and CMJ was the average height of the three best jumps out of five, performed in accordance with the Myotest methodology, with a precision of 0.1 cm.

The Sit-Up Test (SU), lasting for 30 seconds, was conducted to assess the explosive and endurance power of abdominal muscles. The measurement outcome for a single trial was the number of repetitions performed in sit-ups within the 30-second time frame.

The E-Test (ET) was employed to measure special speed. The outcome for an individual measurement was the time in seconds (s), with an accuracy of 0.1 s, during which the participant completed the "*E*"-shaped track in the shortest time possible.

The run to cones (RC) was utilized to assess endurance in speed. The result for a single measurement was the time in seconds (s), with an accuracy of 0.1 s, in which the participant completed the "*fan*"-shaped track in the shortest time possible.

Data analysis

We employed One-way analysis of variance (OW-ANOVA) to assess the significance of differences in the effects among the individual types of warm-ups. Due to the small sample size (n = 8), acknowledging the potential for a high error in statistical tests of type II (β), we utilized effect size to evaluate differences between DS, FR, and CO. The effect size was indicated by the coefficient η^2, with minimal values for effect evaluation: $\eta^2 > 0.01$ – small effect, $\eta^2 > 0.06$ – medium effect, $\eta^2 > 0.14$ – large effect (Cohen, 1998). The Levene test verified the Homogeneity of Variance condition for OW-ANOVA. The probability of type I error (alpha, α) was set at .05. Statistical analysis was conducted using SPSS Statistics version 28 software (IBM, Armonk, NY, USA).

RESULTS

The statistical analysis conducted through One-way ANOVA (Table 2) revealed no significant differences in the effects of DS, FR, and CO warm-ups ($p > .05$) across all investigated indicators (SR, H1, SJ, CMJ, SU, and RC). The effect size coefficient also indicated no significant difference ($\eta^2 < 0.01$) for any of the mentioned indicators. The only exception was observed in the case of the ET indicator, where the value of $\eta^2 = 0.028$ indicated a small effect, suggesting differences in warm-up effectiveness in favour of DS.

Table 2. Statistical evaluation of the comparison of the used types of warm-ups for performance in tests of movement indicators in a sample of young volleyball players (n = 8).

Movement indicator	**Warm-up**			**Statistical analysis**		
	DS	FR	CO	One-way ANOVA	Effect size (ES)	
	M SD	M SD	M SD		ES value	ES level
SR	6.8 6.1	6.7 6.3	7.2 6.2	$F_{(2.21)} = 0.012$, $p > .05$	$\eta^2 = 0.001$ (95%CI: 0.04-0.31)	no effect
H1	11.54 2.0	11.61 1.7	11.72 1.8	$F_{(2.21)} = 0.019$, $p > .05$	$\eta^2 = 0.002$ (95%CI: 0.04-0.31)	no effect
SJ	38.2 5.3	38.0 5.3	38.1 5.2	$F_{(2.21)} = 0.001$, $p > .05$	$\eta^2 = 0$ (95%CI: 0.04-0.31)	no effect
CMJ	44.8 5.5	44.7 5.3	44.7 5.4	$F_{(2.21)} = 0.002$, $p > .05$	$\eta^2 = 0$ (95%CI: 0.04-0.31)	no effect
SU	27.4 1.9	27.1 1.7	27.4 1.8	$F_{(2.21)} = 0.052$, $p > .05$	$\eta^2 = 0.005$ (95%CI: 0.04-0.31)	no effect
ET	20.4 1.4	20.8 1.0	20.9 1.8	$F_{(2.21)} = 0.308$, $p > .05$	$\eta^2 = 0.028$ (95%CI: 0.04-0.31)	small effect
RC	63.6 4.9	63.7 5.2	63.5 4.9	$F_{(2.21)} = 0.098$, $p > .05$	$\eta^2 = 0$ (95%CI: 0.04-0.31)	no effect

Note. DS = dynamic stretching; FR = foam rolling; CO = combination of FR and DS; M = Mean; Standard Deviation; SR = The sit and reach test (in centimetres); H1 = The test – 1 kg ball throw in kneeling position (in meters); SJ = Squat jump (in centimetres); CMJ = Countermovement jump (in centimetres); SU = The sit-up test (in the number of repetitions); ET = The E-Test (in seconds); RC = The run to cones = (in seconds).

DISCUSSION

The primary outcome of our study indicates that there were not statistically significant ($p > .05$), or practical ($\eta^2 < 0.01$) differences observed among the employed warm-up methods – dynamic stretching, warm-up with a foam roller, and a combination of dynamic stretching and foam rolling – regarding the assessed movement indicators in young volleyball players. This outcome aligns with our initial hypothesis and the findings from the preliminary study (Popelka and Pivovarniček, 2022). The sole distinction in performance after each type of warm-up was identified in the running E-test. Although the statistical analysis did not reveal a notable difference in this instance (F (2.21) = 0.308, $p > .05$), the effect size coefficient indicated a minimal effect of differences ($\eta^2 = 0.028$; 95%CI: 0.04-0.31) in favour of dynamic stretching compared to the other exercise methods.

Our findings regarding the Sit and Reach test (SR) do not align with the outcomes reported in studies by Su et al. (2017) and Wiewelhove et al. (2019), which suggested that self-massage has a more effective impact compared to dynamic stretching. Similarly, Behara and Jacobson (2017) observed a difference in hip flexion with self-massage (FR) versus dynamic stretching ($p = .0001$). The reason for this disparity may be attributed to the fact that in Behara and Jacobson's research (2017), rolling on one muscle part lasted 60 seconds, whereas in our study, participants spent 45 seconds on one muscle part during self-massage, representing a 15-second difference. This perspective is further supported by the findings of Smith et al. (2018), who observed self-massage ($p = .003$) to be more effective compared to dynamic stretching, with subjects spending 60-65 seconds on one muscle part. However, they noted that this effect diminishes rapidly. In our research, we utilized a softer roller compared to Behara and Jacobson's (2017) study, given the age of our participants (15.38 ± 0.54 years). Based on this, we believe that the duration of self-massage and the hardness of the roller may have influenced the more positive effect of self-massage compared to dynamic stretching on hip flexion. Our results align with studies by Richman et al. (2019), Konrad et al. (2021), and Seçer and Kaya (2022), where no significant changes ($p > .05$) in flexibility were observed compared to dynamic stretching when combined. Similar to our research, the study by Kashara et al. (2023), which aimed to compare the combined effects of FR and SS or DS with various intervention orders, did not find differences in CMJ ($p = .056$, d = 0.31). Additionally, the study by Lin et al. (2020) did not confirm differences in effects ($p > .05$) between dynamic stretching and a combination of dynamic stretching and self-massage with a vibrating foam roller. Although Lin et al. (2020) used a vibrating roller in their research and we used a foam roller without vibration, we believe that this may not have a large impact on the final result. This was confirmed, for example, by the study of Nakamura et al. (2022), who compared the effects of foam rolling with and without vibration on passive and active plantar flexor muscle properties. Their results showed a similar increase in dorsiflexion range of motion ($p < .01$, d = 0.51; $p < .01$, d = 0.65, respectively) and passive torque at dorsiflexion range of motion ($p = .02$, d = 0.51 and $p < .01$, d = 0.65, respectively) after foam rolling and vibration foam rolling. Comparing our results in the SJ test, we found that Richman et al. (2018) did not record a difference in a combined warm-up versus dynamic stretching (1.72 ± 2.47 cm, $p = .07$).

Other studies, such as Behara and Jacobson (2017), who used a harder roller in the warm-up compared to us, also did not find significant differences ($p > .05$) between dynamic stretching and the use of a foam roller in the VJ (vertical jump) peak power test ($p = .45$), VJ average power ($p = .16$), VJ peak velocity ($p = .25$), VJ average velocity ($p = .23$), peak knee extension torque ($p = .63$), average knee extension torque ($p = .11$), peak knee flexion torque ($p = .63$), or average knee flexion torque ($p = .22$). In a similar study, Smith et al. (2018) found that vertical jump height immediately after treatment for DS and FR+DS (combo) was significantly greater than the control and FR counterparts ($p = .002$). Vertical jump height for DS and combo was also significantly greater than FR counterpart at 5 minutes after treatment ($p < .001$). Based on their findings, they state that foam rolling does not seem to enhance VJ height.

It is essential to acknowledge the limitations of our study. The primary limitation is the small sample size, attributed to the high probability of type II error (β). We attempted to partially address this issue by utilizing the coefficient η^2. Our study employed a one-group time-step experimental design without a control group. Although having a control group would be methodologically more accurate, practical considerations prevented us from subjecting some young volleyball players to the used movement tests without warm-up, posing a potential risk of injuries. While it would be methodologically advantageous to create three performance-homogeneous and numerically sufficient experimental samples, with each sample completing all three warm-up methods gradually, logistical, and ethical considerations made this challenging. Future research endeavours might benefit from such an approach to enhance the objectivity of results and mitigate potential biases.

CONCLUSIONS

The objective of the study was to compare the impact of warm-up methods involving dynamic stretching, foam rolling, and a combination of dynamic stretching with foam rolling on the performance of movement tests among young volleyball players. The results of our research indicate that the warm-up techniques employed did not yield statistically significant or practically distinct effects on the performance in the selected movement tests among young volleyball players, aligning with our initial assumptions. These findings offer valuable insights and foundational material for volleyball and fitness coaches, as well as individuals interested in warm-up procedures and fitness training, particularly for young volleyball players. Nonetheless, these results also serve as motivation to pursue further research, exploring the most effective warm-up strategies for diverse age groups of athletes.

AUTHOR CONTRIBUTIONS

JP: Study design, data collection, manuscript preparation. GB: Manuscript preparation. PP: Statistical analysis, manuscript preparation. All authors have read and agreed to the final version of the manuscript.

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DISCLOSURE STATEMENT

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