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RESEARCH ARTICLE / ARAŞTIRMA MAKALESI

# Acute Effects of Dynamic Warm-Up and Foam Roller Applications on Performance in Adolescent Male Volleyball Players

*Dinamik Isınma ve Foam Roller Uygulamalarının Adolesan Erkek Voleybolcularda Performans Üzerine Akut Etkisi*

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## ABSTRACT

**Objective:** In recent years, the positive effects of self-myofascial release on sports performance have been reported. The aim of this study is to compare the acute effects and continuity of effects of dynamic warm-up (DW) and foam roller (FR) applications on various performance values in male volleyball players.

**Material and Methods:** 22 adolescent male volleyball athletes were included in this study. Demographic information has been collected. Athletes were divided into 3 different groups (Control-FR-DW). The participants in the control group underwent a 5-minute jog, the FR group underwent jog and FR application to bilateral lower extremity muscles, and the DW group underwent jog and DW exercises. All athletes were tested for ROM, jumping, agility and speed 5 times in total, before, immediately after (0. min), 5. min., 10. min. and 15. min.

**Results:** The study was completed with 22 adolescent male volleyball players. In the control group, no statistically significant changes were observed (p>0.05). In the FR group, significant improvements were identified in measurements at 0-5-10-15 minutes (especially at 0-5-10 minutes) compared to pre-application measurements for ROM, jumping, speed, and agility metrics (p<0.05). While no significant changes were observed in jump test values compared to baseline measurements in the DW group (p>0.05), significant improvements were identified in other performance parameters at 0-5 minutes, showing less magnitude and duration compared to the FR group (p<0.05).

**Conclusion:** FR application provides more improvement in performance parameters in adolescent volleyball players compared to jogging and DW exercises and these positive effects last relatively longer.

**Keywords:** Adolescent, exercise, muscle relaxation, performance, volleyball

## ÖZ

**Amaç:** Son yıllarda kendi kendine masaj tekniği ile miyofasiyal gevşetmenin sporda performans üzerine olumlu etkileri bildirilmiştir. Bu çalışmanın amacı erkek voleybolcularda dinamik ısınma (DI) ve foam roller (FR) uygulamalarının çeşitli performans değerleri üzerine akut etkileri ve etkilerin sürekliliğini karşılaştırmaktır.

**Gereç ve Yöntem:** Çalışmaya 14-18 yaş arasındaki 22 adolesan erkek voleybol sporcusu dahil edildi. Katılımcıların demografik bilgileri kaydedildi. Sporcular, 3 farklı gruba (Kontrol-FR-DI) ayrıldı. Kontrol grubundaki katılımcılara 5 dakikalık jog koşusu, FR grubundaki katılımcılara koşuya ek olarak bilateral alt ekstremite kaslarına FR uygulaması, DI grubuna ise koşuya ek olarak DI egzersizleri uygulandı. Tüm sporcular uygulama öncesi, hemen sonrası (0.dk), 5. dakika, 10. dakika ve 15. dakikada olmak üzere toplamda 5'er kez EHA, sıçrama, çeviklik ve sürat testlerine alındı.

**Bulgular:** Çalışma toplam 22 adolesan erkek voleybolcu ile tamamlandı. Kontrol grubunda, değerlendirilen tüm performans ölçümlerinde uygulama öncesi değerlerle, 0-5-10-15. dk'larda yapılan ölçümler arasında istatistiksel olarak anlamlı bir değişim tespit edilmedi (p>0,05). FR grubunda ise uygulama öncesi yapılan ölçümlere kıyasla 0-5-10-15. dk'larda (özellikle 0-5-10. dk) yapılan EHA, sıçrama, sürat ve çeviklik

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ölçümlerinde anlamlı gelişmelerin olduğu belirlendi (p<0,05). DI grubundaki ölçümlerde sıçrama testi değerlerinde uygulama öncesi değerlere kıyasla anlamlı değişiklik tespit edilmezken (p>0,05), diğer performans parametrelerinde FR grubuna kıyasla daha az oranda ve daha kısa süreklilik gösterecek şekilde 0-5. dk ölçümlerinde anlamlı gelişmeler tespit edildi (p<0,05).

**Sonuç:** FR uygulaması adolesan voleybolcularda yalnızca jog koşusuna ve jog koşusuna ek olarak yapılan DI egzersizlerine kıyasla EHA, sıçrama, sürat ve çeviklik gibi performans parametreleri üzerinde daha fazla gelişim sağlamakta ve ortaya çıkan bu olumlu etkiler nispeten daha uzun sürmektedir.

**Anahtar Kelimeler:** Adolesan, egzersiz, kas gevşemesi, performans, voleybol

## INTRODUCTION

Nowadays, various methods are employed in sports to enhance performance and prevent sport-related injuries. Warm-up exercises performed prior to sports activities constitute one of the primary methods used for these purposes. In this context, low-intensity aerobic exercises, as well as static and dynamic stretching exercises, can be cited as examples of pre-exercise warm-up routines (1). Some studies have demonstrated that static stretching exercises within warm-up protocols have negative effects on anaerobic performance (2,3). Conversely, research has reported that dynamic stretching exercises improve various performance parameters such as jumping and sprinting (4). Dynamic warm-up (DW), broadly defined, is known to increase muscle temperature, thereby enhancing muscle flexibility and instantaneous power (5). Accordingly, DW has become a frequently utilized method in recent years to both improve performance and reduce sports injuries.

Recently, myofascial release has also become a widely used method for warm-up and performance enhancement (6). The primary aim of this technique is to increase flexibility by relaxing the fascia that surrounds the muscle tissue. Therefore, although it is commonly applied during post-injury rehabilitation and recovery phases after exercise, it is also considered suitable for use as part of a warm-up protocol (7). Furthermore, a self-administered form of this technique, known as Self-Myofascial Release (SMR), has gained popularity due to its ease of application without assistance. Foam rollers (FR) are among the most utilized equipment for implementing this method. Typically, FRs are placed under large muscles or muscle groups such as the quadriceps, adductors, calf muscles, hamstrings, gluteals, and trapezius, and muscle relaxation is achieved through repeated back-and-forth movements (1). Some studies in the literature have reported that FR exercises and DW produce similar results in jump and strength performance parameters, while FR exercises contribute more positively to joint range of motion (8). Additionally, other research indicates that the positive effect of FR exercises on joint range of motion surpasses that of static and dynamic stretching, and that both DW and FR exercises have a greater positive impact on muscle strength compared to static warm-up (9).

Consequently, sports coaches have recently begun incorporating FR application into warm-up protocols prior to training sessions and competitions. While numerous studies compare static warm-up and dynamic warm-up methods, there are relatively few investigations comparing dynamic warm-up exercises and foam rolling applications in volleyball players, indicating a need for further research. Although the acute effects of dynamic warm-up and foam rolling have been widely studied in adult populations, there is a lack of research directly comparing these interventions in adolescent athletes, especially regarding the duration and sustainability of performance improvements (6, 8, 10). The present study aims to compare the acute effects and the sustainability of these effects of dynamic warm-up and foam roller applications on various performance parameters in adolescent male volleyball players.

## MATERIAL AND METHODS

A prospective, controlled, crossover randomized study was designed to evaluate the acute effects and the sustainability of these effects of DW and FR applications on performance parameters such as joint range of motion (ROM), jumping ability, agility, and speed in adolescent male volleyball players. The study received approval from the local ethics committee under approval number 332 dated November 18, 2022. Data collection was conducted at the Department of Sports Medicine , Suleyman Demirel University, between December 1, 2022, and February 1, 2023.

Participants included licensed volleyball players aged 14 to 18 years who were actively engaged in sport; had no musculoskeletal injuries within the last six months; had not undergone musculoskeletal surgery in the past year; had no musculoskeletal conditions preventing functional testing; did not use any ergogenic aids such as caffeine or other performance-enhancing substances; and had been playing volleyball under license for at least one year. All testing sessions were conducted at the same time of day, in a temperature-controlled indoor sports hall, to ensure standardization of environmental conditions.

Sample size determination was performed using the G*Power software version 3.1.9.4. Based on a statistical power of 95%, a Type I error rate of 5%, and an effect size of 0.41 derived from a relevant study in the literature (10), a minimum sample size of 14 participants was required. All eligible professional athletes without health problems were informed about the purpose of the study. After obtaining written and verbally informed consent from 22 athletes meeting inclusion criteria and their guardians, descriptive data were recorded by the research team. Subsequently, the athletes were randomized in a crossover design and assigned to the Control, FR, or DW groups by drawing lots. Randomization was conducted by generating a random allocation list using computer software. As there were 22 athletes in total, the groups included 7 or 8 participants each. The draw was performed in the presence of an independent observer to ensure impartiality. Participants attended three intervention sessions in the same sports hall, scheduled one week apart. This one-week interval served as a wash-out period to minimize potential carry-over effects between sessions. The group allocations and study protocol are summarized in Table 1.

Participants in the control group underwent performance tests-including joint range of motion (ROM), jumping, agility, and speed-five times in total: before the warm-up, immediately after (0 min), and at the 5th, 10th, and 15th minutes following a 5-minute jog at a steady pace.

**Table 1. Group Allocation and Study Design**

| n = 22 (Number of Participants) | Week 1 | Week 2 | Week 3 |
|---|---|---|---|
| n=8 | FR | DW | Control |
| n=7 | DW | Control | FR |
| n=7 | Control | FR | DW |

*FR:Foam Roller, DW: Dynamic Warm-ups*

In the FR group, participants performed the same 5-minute jog followed by an FR application. A high-density ethylene-vinyl acetate cylindrical foam roller (Sanctband™ Active Foam Roller), measuring 15 cm in diameter and 30 cm in length, was used. The FR application duration of 60 seconds per muscle group was selected based on the protocol recommended by MacDonald et al. (11). The FR protocol applied to different muscle groups was similar to that used by Smith et al. (12). Specifically, a total of 8 minutes of FR stretching (2 sets × 4 muscle groups × 60 seconds) was performed on bilateral lower extremity muscles: quadriceps, hamstrings, gluteus maximus, and gastrocnemius. As with the control group, all athletes underwent the same battery of tests (ROM, jump, agility, and speed) before FR application, immediately after (0 min), and at the 5th, 10th, and 15th minutes post-application.

In the DW group, in addition to the 5-minute jog, participants performed DW exercises targeting the same muscle groups. During these exercises, athletes were instructed to achieve the greatest possible joint range of motion. The initial stretch involved standing while flexing the hip and knee joints; the athlete was asked to pull the knee of the stretching leg as close to the abdomen as possible. In the next movement, without flexing the knee, the athlete flexed the hip to lift the leg forward and upward. The subsequent movement required the athlete to flex the knee and bring the heel toward the buttocks. Finally, during walking, the athlete was instructed to dorsiflex the ankle by pulling the toes of the non-supporting foot toward themselves as much as possible during the stance phase. These DW exercises closely resembled those recommended by Smith et al. (12). Similar to the FR group, each of the bilateral lower limb muscles-quadriceps, hamstrings, gluteus maximus, and gastrocnemius-was targeted for 60 seconds each, totaling 8 minutes (2 sets × 4 muscle groups × 60 seconds). All athletes in this group were tested for ROM, jump, agility, and speed before the DW protocol, immediately after (0 min), and at 5th, 10th, and 15th post-exercise.

### *Assessment of Joint Range of Motion (ROM)*

The joints related to the muscles targeted by the interventions were evaluated for ROM. All participants were assessed bilaterally in the supine position for hip flexion/extension, knee flexion/extension, and ankle dorsiflexion/plantarflexion. Measurements were performed using a goniometer (Baseline Stainless Steel Goniometer; Fabrication Enterprises Inc., Elmsford, NY, USA) and recorded in degrees (°).

### *Agility Assessment*

Agility was evaluated using the T-Test, which consists of four touch points arranged in a T-shape within a 10 m by 10 m area (Figure 1). Participants were required to complete a sequence of directional movements between these points as quickly as possible. A distinguishing feature of this test compared to other agility tests is that the participant always maintains forward gaze while changing directions via lateral shuffling or backward running. The test involves two 90° turns, one 180° turn, and covers a total distance of 40 meters, including 10 m forward, 10 m right, 10 m left, and 10 m backward movements (13). Timing was measured with a photoelectric timing system (DSD Laser System, León, Spain).

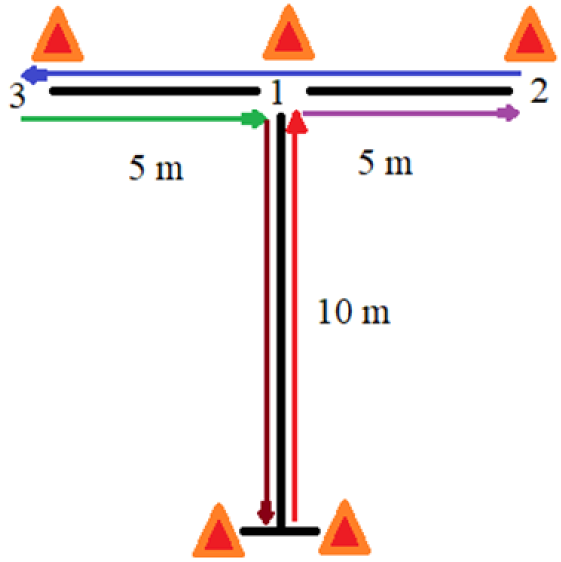


**Figure 1.** T-Test, which consists of four touch points arranged in a T-shape within a 10 m by 10 m area

### *Vertical Jump Height Assessment*

The squat jump (SJ) test was used to assess vertical jump height, an important indicator of athletic performance in volleyball. During the SJ test, athletes were instructed to maintain a squat position for approximately 3 seconds before jumping upon command. Measurements were obtained using a vertical jump measurement device (Takei T.K.K.5406 Jump MD [Jump Meter], Japan) (Figure 2). Prior to jumping, the device's belt was secured over the athlete's iliac crest. Participants were asked to keep their hands at hip level and perform three maximal jumps. The highest value among the three jumps was recorded in centimeters (14).

**Figure 2.** Vertical jump measurement device

### *Speed Assessment*

A 10-meter sprint test was employed to evaluate speed (15). The 10 m sprint test was chosen as it reflects the short, explosive movements and rapid direction changes characteristic of volleyball, and is widely used to assess volleyball-specific speed and agility. Athletes began the test upon an auditory signal, passing through the starting gates of a photoelectric timing system (DSD Laser System, León, Spain), and sprinted as fast as possible to cross the finish gate located 10 meters away. Each participant performed two trials, and the best time in seconds was recorded for analysis.

### *Statistical Analysis*

Data obtained from the study were analyzed using IBM SPSS Statistics version 26.0 (IBM Corp., Armonk, NY, USA). Descriptive statistics including mean, standard deviation, median, and interquartile range were calculated. The Shapiro-Wilk test was used to assess the normality of variables. For variables with normal distribution, repeated measures ANOVA with a mixed design was used to compare measurements before intervention, immediately after (0 minute), and at the 5th, 10th, and 15th minutes post-intervention. Tukey's post hoc test was applied for subgroup comparisons. For variables that did not show normal distribution, the Friedman test was used for repeated-measures comparisons across time points. When significant differences were found, pairwise comparisons were performed using the Wilcoxon signed-rank test with Bonferroni correction. For between-group comparisons of non-normally distributed variables, the Kruskal-Wallis test was used, with Dunn's multiple comparison test applied for subgroup analyses. Categorical variables were compared using the chi-square test. A p-value of less than 0.05 was considered statistically significant.

## RESULTS

The study was completed with a total of 22 adolescent male volleyball players, with a mean age of 15.27 ± 1.24 years. The participants' average body mass index (BMI) was 19.83 ± 2.32 kg/m², and their mean duration of sports participation was 2.5 ± 1.37 years (Table 2).

Hip (flexion-extension), knee (flexion-extension), and ankle (plantar flexion-dorsiflexion) joint range of motion (ROM) measurements were taken five times: before the intervention, immediately after, and at 5th, 10th, and 15th minutes post-intervention. No statistically significant changes were observed in any of the ROM measurements within the control group ($p > 0.05$, Table 3). In the FR group, compared to baseline values, statistically significant improvements were detected in all measurements except knee extension angle at the 10th and 15th minutes ($p < 0.05$) (Table 3). Similarly, in the DW group, statistically significant improvements were found immediately after the intervention ($p < 0.05$) (Table 3). At the 5th and 10th minutes, significant improvements were present in all ROM values except knee extension ($p < 0.05$) (Table 3). However, at 15 minutes post-intervention, no statistically significant changes were observed in any measurements except ankle dorsiflexion ($p > 0.05$, Table 3).

**Table 2. Demographic Characteristics of the Participants**

| | | n=22 (Mean±SD) |
|---|---|---|
| Age (years) | | 15,27±1,24 |
| Height (cm) | | 175,59±8,68 |
| Body Weight (kg) | | 61,37±9,57 |
| BMI (kg/m²) | | 19,83±2,32 |
| Duration of Sports Participation (years) | | 2,50±1,37 |
| Lower Extremity Length (cm) | Right | 93,32±5,12 |
| | Left | 93,48±5,19 |
| Dominant Upper Extremity | Right (n/%) | 21 / %95,5 |
| | Left (n/%) | 1 / %4,5 |
| Dominant Lower Extremity | Right (n/%) | 21 / %95,5 |
| | Left (n/%) | 1 / %4,5 |
| Position | Setter (n/%) | 4 / %18,2 |
| | Outside Hitter (n/%) | 8 / %36,4 |
| | Middle Blocker (n/%) | 5 / %22,7 |
| | Libero (n/%) | 3 / %13,6 |
| | Opposite Hitter (n/%) | 2 / %9,1 |

*BMI: Body Mass Index, n: Sample Size, Mean: Average, SD: Standard Deviation, cm: centimeters, kg: kilograms, kg/m²: kilograms per square meter, %: percent*

Regarding other performance tests, no statistically significant changes were observed in the control group's squat jump test, 10 m sprint test, or agility T-test measurements at any time point before or after the intervention ($p > 0.05$, Table 4, Figures 3-5).

## DISCUSSION

Enhancing athletic performance and protecting athletes from sports-related injuries are fundamental responsibilities of sports physicians. Recent research has reported positive effects of self-administered myofascial release techniques on sports performance. This study aimed to compare the acute effects and the sustainability of DW and FR applications on joint range of motion (ROM), jumping ability, agility, and speed in adolescent male volleyball players.

Due to the importance of ROM in athletic performance, numerous studies have investigated the effects of various warm-up protocols on joint flexibility (16,17). While the control group showed no significant changes in ROM, both the FR and DW groups demonstrated improvements, with FR effects persisting longer. However, the limited follow-up period restricts our ability to draw conclusions about the true duration of these effects, and future studies should include longer observation intervals. Significant improvements in hip flexion, hip extension, knee flexion, and ankle plantarflexion ROM values continued until the 10th minute. Su et al. reported similar findings, demonstrating that FR had a more favorable effect on hip and knee ROM compared to dynamic and static warm-up protocols (9). Smith et al. found significant acute increases in ROM in the FR group compared to controls, which dissipated after 5 minutes (12). Although Smith et al. did not find a superiority of FR over DW regarding acute ROM increases, both methods positively influenced flexibility (12). Several studies similarly observed immediate ROM improvements with FR, though they did not report sustained effects as seen in the current study (8,11). Variations in findings may be attributed to differences in measurement techniques-goniometric assessment in the current study versus indirect tests such as sit-and-reach or modified Thompson in previous research-as well as differences in FR device types, application methods, and durations.

**Table 3. Joint Range of Motion (ROM) Measurement Results and Changes by Groups**

| | | Pre-Intervention (Mean ± SD) | 0 min | | 5 min | | 10 min | | 15 min | | Partial $\eta^2$ |
|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | Δ | %95 CI | Δ | %95 CI | Δ | %95 CI | Δ | %95 CI | |
| Control | Hip Flexion (°) | 119,45±2,46 | -0,142 | +0,51/-0,78 | -0,181 | +0,37/-0,73 | +0,091 | +0,63/-0,45 | -0,183 | +0,45/-0,81 | 0,057 |
| | Hip Extension (°) | 17,50±2,13 | +0,501 | +0,99/+0,01 | +0,553 | +1,13/-0,04 | +0,272 | +0,88/-0,34 | +0,322 | +0,90/-0,27 | 0,117 |
| | Knee Flexion (°) | 136,59±3,29 | +0,554 | +1,24/-0,15 | +0,683 | +1,43/-0,70 | +0,139 | +0,88/-0,61 | +0,182 | +0,82/-0,45 | 0,094 |
| | Knee Extension (°) | 0,50±0,60 | +0,219 | +0,62/-0,17 | +0,142 | +0,53/-0,26 | 0 | +0,39/-0,39 | 0 | +0,35/-0,35 | 0,145 |
| | Ankle PF (°) | 43,41±4,46 | -0,09 | +0,49/-0,68 | -0,05 | +0,49/-0,58 | -0,090 | +0,50/-0,68 | -0,051 | +0,46/-0,55 | 0,037 |
| | Ankle DF (°) | 16,38±1,62 | +0,231 | +0,80/-0,34 | +0,181 | +0,77/-0,41 | +0,321 | +0,88/-0,24 | 0 | +0,45/-0,45 | 0,110 |
| FR group | Hip Flexion (°) | 119,55±2,18 | **+3,910*** | +4,55/+3,27 | **+3,550*** | +4,01/+3,00 | **+2,55*** | +3,09/+2,00 | **+1,590*** | +2,22/+0,96 | 0,774 |
| | Hip Extension (°) | 18,05±2,08 | **+2,961*** | +3,45/+2,46 | **+3,181*** | +3,77/+2,59 | **+2,462*** | +3,06/+1,85 | **+1,272*** | +1,86/+0,69 | 0,755 |
| | Knee Flexion (°) | 136,73±2,66 | **+3,642*** | +4,33/+2,95 | **+3,412*** | +4,16/+2,66 | **+2,462*** | +3,20/+1,71 | **+1,411*** | +2,04/+0,77 | 0,747 |
| | Knee Extension (°) | 0,45±0,51 | **+1,00*** | +1,39/+0,61 | **+0,857*** | +1,26/+0,47 | +0,364 | +0,75/-0,03 | +0,179 | +0,53/-0,17 | 0,385 |
| | Ankle PF (°) | 43,36±4,24 | **+3,050*** | +3,63/+2,46 | **+2,857*** | +3,40/+2,33 | **+2,180*** | +2,78/+1,59 | **+1,500*** | +2,01/+0,99 | 0,744 |
| | Ankle DF (°) | 16,36±1,73 | **+2,911*** | +3,48/+2,34 | **+3,00*** | +3,59/+2,41 | **+2,051*** | +2,60/+1,49 | **+1,500*** | +1,95/+1,05 | 0,743 |
| DW group | Hip Flexion (°) | 119,55±2,18 | **+1,819*** | +2,46/+1,18 | **+1,141*** | +1,69/+0,59 | **+0,637*** | +1,18/+0,09 | +0,231 | +0,86/-0,40 | 0,386 |
| | Hip Extension (°) | 18,00±2,18 | **+1,274*** | +1,77/+0,77 | **+1,230*** | +1,82/+0,64 | **+0,677*** | +1,29/+0,07 | +0,355 | +0,95/-0,22 | 0,415 |
| | Knee Flexion (°) | 136,64±2,75 | **+1,551*** | +2,24/+0,86 | **+1,729*** | +2,48/+0,98 | **+0,821*** | +1,57/+0,07 | +0,458 | +1,09/-0,18 | 0,381 |
| | Knee Extension (°) | 0,41±0,59 | **+0,594*** | +0,98/+0,20 | +0,321 | +0,72/-0,08 | +0,231 | +0,62/-0,16 | -0,052 | +0,31/-0,40 | 0,217 |
| | Ankle PF (°) | 44,73±4,38 | **+1,408*** | +1,99/+0,82 | **+1,461*** | +1,99/+0,92 | **+0,863*** | +1,46/+0,27 | +0,501 | +1,01/-0,05 | 0,337 |
| | Ankle DF (°) | 16,41±1,59 | **+1,407*** | +1,98/+0,84 | **+1,644*** | +2,22/+1,05 | **+0,962*** | +1,51/+0,40 | **+0,590*** | +1,04/+0,14 | 0,363 |

*FR: Foam Roller, DW: Dynamic Warm-Ups, Δ: Difference of each measurement compared to pre-intervention mean value, 95% CI: 95% Confidence Interval, °: degree, PF: Plantar Flexion, DF: Dorsiflexion, Mean: Average, SD: Standard Deviation, +: Increase, -: Decrease. *: Indicates statistically significant change compared to pre-intervention mean value. Significance level was accepted as p < 0.05.*

**Table 4. Control Group's Other Performance Test Results and Changes**

| | | Pre-Intervention (Mean ± SD) | 0 min | | 5 min | | 10 min | | 15 min | | Partial η² |
|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | Δ | %95 CI | Δ | %95 CI | Δ | %95 CI | Δ | %95 CI | |
| Control | SJ Jump Test (cm) | 54,00±8,02 | +0,50 | +2,65/-1,65 | +0,861 | +3,38/-1,65 | -0,409 | +1,72/-2,54 | -1,361 | +0,63/-3,36 | 0,118 |
| | Agility T-Test (s) | 10,81±1,03 | -0,109 | +0,14/-0,38 | -0,073 | +0,09/-0,24 | -0,030 | +0,18/-0,24 | +0,050 | +0,28/-0,18 | 0,287 |
| | 10 m Sprint Test (s) | 1,74±0,13 | -0,027 | +0,02/-0,08 | -0,014 | +0,04/-0,05 | +0,001 | +0,04/-0,04 | +0,021 | +0,07/-0,02 | 0,187 |
| FR group | SJ Jump Test (cm) | 53,73±8,50 | **+4,271*** | +6,42/+2,12 | **+4,587*** | +7,11/+2,08 | **+2,410*** | +4,54/+0,28 | +1,367 | +3,13/-0,86 | 0,514 |
| | Agility T-Test (s) | 10,63±1,05 | **-0,362*** | -0,11/-0,61 | **-0,319*** | -0,16/-0,49 | -0,057 | +0,15/-,27 | +0,010 | +0,24/-0,21 | 0,377 |
| | 10 m Sprint Test (s) | 1,71±0,13 | **-0,113*** | -0,06/-0,16 | **-0,10*** | -0,06/-0,15 | **-0,079*** | -0,04/-0,12 | **-0,068*** | -0,02/-0,11 | 0,486 |
| DW group | SJ Jump Test (cm) | 54,27±8,56 | +1,093 | +3,24/-1,06 | +1,091 | +3,61/-1,42 | -0,141 | +1,99/-2,26 | -1,681 | +0,31/-3,68 | 0,160 |
| | Agility T-Test (s) | 10,80±0,94 | **-0,410*** | -0,16/-0,66 | **-0,393*** | -0,23/-0,56 | -0,152 | +0,06/-0,36 | +0,053 | +0,27/-0,18 | 0,036 |
| | 10 m Sprint Test (s) | 1,68±0,12 | **-0,071*** | -0,02/-0,12 | **-0,073*** | -0,03/-0,12 | **-0,050*** | -0,002/-0,09 | -0,017 | +0,02/-0,07 | 0,246 |

*FR: Foam Roller, DW: Dynamic Warm-Ups, Δ: Difference of each measurement compared to pre-intervention mean value, 95% CI: 95% Confidence Interval, SJ: Squat Jump, cm: centimeters, s: seconds, m: meters, Mean: Average, SD: Standard Deviation, +: Increase, -: Decrease. *: Indicates statistically significant change compared to pre-intervention mean value. Significance level was accepted as p < 0.05.*

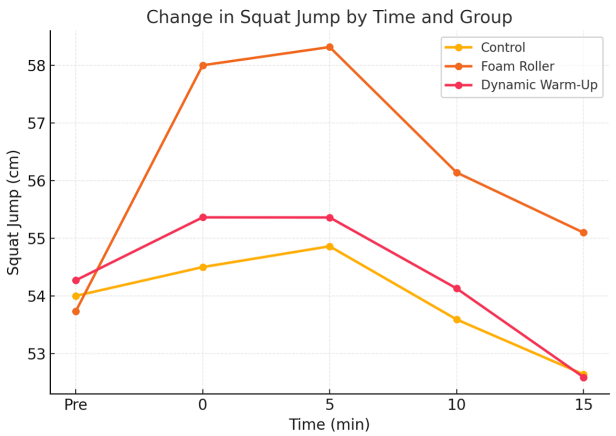


**Figure 3.** Change in squat jump performance over time according to intervention groups.

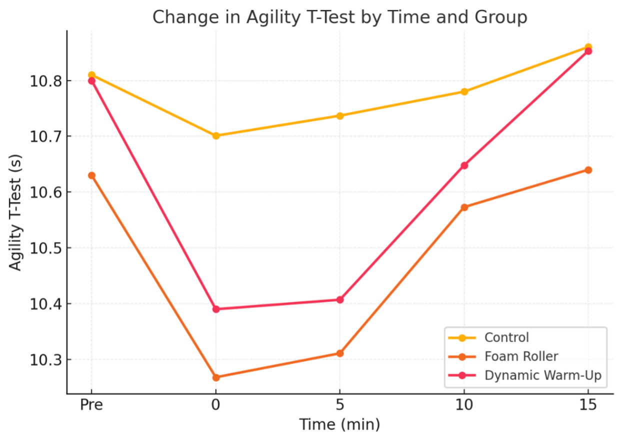


**Figure 4.** Change in agility T-test performance over time according to intervention groups.

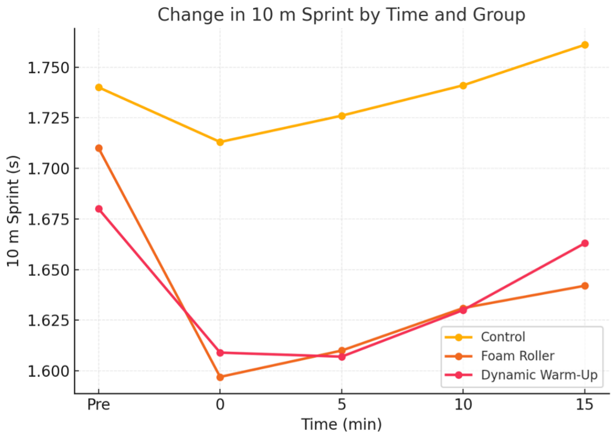


**Figure 5.** Change in 10-meter sprint performance over time according to intervention groups.

Regarding SJ performance, no significant changes were noted in control and DW groups, whereas the FR group demonstrated significant improvements immediately post-intervention and at 5 and 10 minutes. Peacock et al. observed statistically significant increases in vertical jump height when combining dynamic warm-up with FR compared to dynamic warm-up alone (13). Although the positive effects of FR alone were identified, their study differed by combining FR with DW and using a single measurement time point (13). Richman et al. similarly reported significant improvements in SJ performance following FR application, consistent with our findings (10). Smith et al. included control, FR, DW, and combined FR+DW groups, finding significant increases in vertical jump height in DW and FR+DW groups, with the latter maintaining improvements up to 15 minutes post-intervention (12). Literature reveals mixed findings regarding jump performance, with FR alone providing beneficial effects, and greater improvements observed when combined with DW. Further research is needed to clarify the duration of acute effects of different warm-up protocols on jump performance.

In terms of agility, no significant improvements were detected in the control group, whereas both FR and DW groups showed significant improvements post-intervention, which persisted at 5 minutes. Lopez-Samanes et al. reported greater acute improvements in agility with DW compared to FR in elite tennis players (19); however, differences in participant demographics and study design may explain discrepant results. Richman et al. found that FR and DW similarly enhanced agility, aligning with our findings (10). Overall, few studies have examined the comparative effects of FR and DW on agility; based on existing literature and our results, neither method appears superior in enhancing agility test performance.

For 10-meter sprint performance, no significant improvements were observed in controls, whereas both FR and DW groups exhibited significant enhancements immediately post-intervention. Improvements persisted until 15 minutes in the FR group and until 10 minutes in the DW group. Lopez-Samanes et al. found greater but statistically non-significant sprint time improvements following DW compared to FR (19). Richman et al. similarly reported positive effects of both FR and DW on sprint performance (1). Peacock et al. demonstrated statistically significant improvements in sprint speed following FR application (18). Although our results are consistent, their study differed by combining DW and FR and not assessing longer-term effects. The literature on the duration of acute effects of DW and FR in adolescent athletes remains limited, positioning the current study as a pioneer in this area.

The more sustained benefits of FR in our study may be explained by both neuromuscular and psychological mechanisms. Foam rolling has been shown to temporarily decrease muscle stiffness and enhance fascial mobility, possibly prolonging performance improvements (16). Additionally, self-myofascial release may raise the pain threshold and improve proprioception, supporting longer-lasting gains (8). In line with this, some studies demonstrated that foam rolling significantly increases pressure pain threshold, supporting a role for central pain modulation. Psychologically, the relaxing effect and increased sense of readiness after FR could further contribute to maintained performance enhancements (Aboodarda et al., 2015).

Although FR showed superior and more sustained benefits compared to DW, the underlying mechanisms remain speculative. Further research with objective neuromuscular assessments and psychological measures would help clarify the pathways involved.

### Limitations

This study has several limitations. First, the sample included only male adolescent volleyball players, which limits the generalizability of the findings to female athletes. Second, no long-term follow-up beyond 15 minutes was conducted, so the duration of the observed effects remains unclear. Although the sample size exceeded the minimum required by the a priori power analysis, the relatively small cohort and the inclusion of multiple time-point comparisons may limit the detection of small between-intervention differences.

## CONCLUSION

FR applications lead to greater and longer-lasting improvements in ROM, jump height, speed, and agility compared to jogging alone or jogging combined with DW exercises in adolescent volleyball players. The present results underscore the importance of timing warm-up interventions appropriately. If performance enhancements are short-lived, as with dynamic warm-up, athletes should initiate their activities soon after the intervention. If effects are more prolonged, as with foam rolling, greater flexibility in timing is possible. These insights may help coaches and practitioners optimize warm-up protocols to maximize performance benefits.

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***Ethics Committee Approval / Etik Komite Onayı***

The study protocol was approved by the Süleyman Demirel University Clinical Research Ethics Committee, Isparta, Türkiye (Decision no: 332, Date: 18/11/2022).

***Conflict of Interest / Çıkar Çatışması***

The authors declared no conflicts of interest with respect to authorship and/or publication of the article.

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***Author Contributions / Yazar Katkıları***

Concept: HTA, RKE, CÇ; Design: HTA, RKE, SE, CÇ; Supervision: CÇ, SE; Materials: HTA, RKE, ASU; Data Collection and/or Processing: HTA, RKE, ASU; Analysis and/or Interpretation: RKE, SE, CÇ; Literature Review: HTA, RKE, ASU; Writing Manuscript: HTA, RKE, ASU; Critical Review: SE, CÇ. All authors contributed to the final version of the manuscript and approved the final manuscript.

***Dissemination***

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