

# The effect of sports specific warm-up on lower and upper extremity visual response time in female athletes

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Authors' Contribution: A – Study design; B – Data collection; C – Statistical analysis; D – Manuscript Preparation; E – Funds Collection

## Abstract

**Background and Study Aim** Response time is one of the important parameters affecting performance in sports. The aim of this study was to investigate the visual response time of the upper (hand) and lower (foot) extremities after a warm-up activity applied to female football and volleyball players.

**Material and Methods** Eleven female football players and eleven volleyball players, aged  $19.27 \pm 1.93$  years, with a height of  $164.90 \pm 8.07$  cm, body weight of  $57.00 \pm 6.01$  kg, and  $6.40 \pm 2.36$  years of sports experience, participated in the study as volunteers. Visual response times for the upper and lower extremities were measured before and after the warm-up protocol. The warm-up began with static stretching exercises for 2 minutes. This was followed by aerobic jogging for 2.5 minutes at a heart rate of approximately 140 beats per minute. After that, activities involving dynamic joint mobility were performed for 5 minutes. Finally, a 2.5-minute, three-stage sport-specific warm-up was completed. In total, the warm-up protocol lasted 17 minutes.

**Results** Volleyball players' upper extremity visual response time did not show significant differences before and after warm-up ( $Z = -1.561$ ,  $p = 0.119$ ). Significant differences were found in the upper extremity visual response time of football players before and after warm-up ( $t = 2.887$ ,  $p = 0.016$ ). No significant difference was found in the comparison of volleyball and football players' pre-warm-up ( $t = 1.905$ ,  $p = 0.071$ ) and post-warm-up ( $U = 43.000$ ,  $p = 0.247$ ) two-hand visual response times. A significant difference was found in the comparison of volleyball players' lower extremity visual response times before and after warm-up ( $Z = -2.674$ ,  $p = 0.007$ ). No significant difference was found in the comparison of lower extremity visual response times of football players before and after warm-up ( $t = 2.132$ ,  $p = 0.059$ ). A significant difference was determined in the comparison of lower extremity visual response times of volleyball and football players before warm-up ( $t = 3.307$ ,  $p = 0.004$ ) and after warm-up ( $U = 20.000$ ,  $p = 0.008$ ).

**Conclusions** The findings highlight the importance of sport-specific warm-up protocols in preparing athletes for optimal performance. Implementing appropriate warm-up strategies can therefore be a key factor in maximizing athletic performance and maintaining long-term physical health in female athletes.

**Keywords:** female, response time, football, volleyball, warm up.

## Introduction

In competitive sports, quick and efficient response times are crucial for optimal performance. Athletes rely heavily on both upper and lower extremity visual response times to react to dynamic and unpredictable situations during play. Understanding how these warm-up protocols influence reaction times could provide valuable insights for improving athletic performance and reducing the risk of injury. Therefore, it is essential to investigate the impact of targeted warm-up exercises on visual response times in both the upper and lower extremities.

In this context, warm-up activities affect the athlete's physiological and psychological performance before training and competition,

regardless of the sport branch [1]. Although warm-up can have various interpretations, it is commonly understood as preparation for any training session or competition [2]. In sports, the term "warm-up" is defined as a preparatory exercise period that aims to improve performance in the following competition or training session [3]. Warm-up is essential for achieving maximum efficiency from the athlete. It also plays a key role in preventing injuries [4]. Warming up before training or competition creates beneficial changes in the athlete's physical condition, reducing the risk of injury. For example, a 15–20-minute warm-up helps reduce muscle stiffness and shortens muscle contraction time. It also facilitates oxygen utilization, prepares the heart for intense activity, and mentally prepares the athlete for training or competition [5].

Athletes generally prefer a warm-up protocol that begins with moderate running, followed by

static stretching. Some studies suggest that static stretching before exercise improves posture, reduces the risk of injury, and enhances performance [6]. To achieve maximum performance, it is important for athletes to reach an optimal level both physically and psychologically. As a result, the pressure, stress, and anxiety on athletes are often very high. Under this pressure, athletes must maintain their motor skills at the best possible level to make quick decisions [7].

One of the most important of these behaviors is reaction time (response time), which is a key parameter for performance [8]. Reaction time refers to the interval between the onset of a stimulus at the receptor and the moment the muscle responds with an action [9]. Achieving the best results in sports undoubtedly requires a high level of cognitive, perceptual, motor, and physical abilities. Compared to most other activities, sports competitions place significant demands on the visual system [10].

The visual system is the most complex of all sensory systems. It plays a dominant role by generating feedback and influencing other sensory systems. Good vision involves exceptional perceptual abilities, where information is gathered through the eyes and sent to the brain. The brain then interprets this information and initiates the appropriate physical actions [11].

The sense of vision accounts for 80% to 90% of all human sensory information. As a result, researchers are increasingly recognizing the importance of visual perception as a key factor influencing athletes' performance in sports. Effective collection and analysis of data from both central and peripheral vision can significantly impact athletes' coordination and motor abilities [12].

In summary, numerous studies have highlighted the critical role of warm-up protocols, visual perception, and reaction time in enhancing athletic performance and reducing the risk of injury. Research has demonstrated that both static stretching and sport-specific warm-ups can positively influence athletes' physical and cognitive readiness. Additionally, the importance of the visual system in coordinating motor responses has been well-established. However, despite these findings, there remains a need for more detailed studies to fully understand the specific effects of warm-up activities on visual response times, particularly in different sports and among female athletes.

Therefore, the aim of this study was to examine the effects of warm-up activities specific to hand-based sports (e.g., volleyball) and foot-based sports (e.g., football) on visual response time. Additionally, the study aimed to evaluate the applicability of these activities across different sports branches based on the results obtained.

## Materials and Methods

### *Participants*

A total of 22 female athletes (11 football and 11 volleyball players) participated in the study. Nineteen of the participants were university students. The athletes' average age was  $19.27 \pm 1.93$  years, with an average height of  $164.90 \pm 8.07$  cm, body weight of  $57.00 \pm 6.01$  kg, and  $6.40 \pm 2.36$  years of sports experience. Before the study, the purpose and the tests to be conducted were explained to all participants in detail. Additionally, the Voluntary Consent Form, which provided information about the study, was read to the athletes, and their written consent was obtained. Ethics Committee approval for this study was obtained from the Selçuk University Faculty of Sports Sciences, Non-Interventional Clinical Research Ethics Committee.

### *Study Design*

#### *Warm-up Activity*

The warm-up activity lasted a total of 17 minutes. It began with static stretching exercises targeting the thigh, calf, shoulder, and hip muscles for 2 minutes, with participants holding each stretch for 15 seconds at the end of the range of motion. This was followed by 2.5 minutes of aerobic jogging, during which participants maintained a heart rate of approximately 140 beats per minute. Finally, dynamic joint mobility exercises were performed for 5 minutes. These activities included lateral and circular movements of the hips, up-and-down, back-and-forth, and open-and-close movements of the arms. They also involved jumping up and tapping the feet on the hips, swinging the trunk backward from the right and left sides, side running with knee lifts, and cross-stepping in both directions. Additionally, vertical and lateral jumps, as well as accelerated sprints, were performed. Afterward, a 3-stage sport-specific procedure lasting 2.5 minutes was performed for each group [13, 14]. For volleyball players:

- 1) Finger and cuff passes,
- 2) Forward, right, and left blocking,
- 3) Ball reception and spiking.

For football players:

- 1) Short and long passes,
- 2) Dribbling,
- 3) Shooting exercises.

Visual reaction time measurements were taken within 5 minutes after the warm-up protocol ended. Passive rest periods of 1 minute were given at the end of the sessions.

#### *Visual Response Time*

The research group participated in measurements to determine visual response time both before and after the warm-up. To minimize learning and practice effects, participants were randomly

assigned to upper extremity (hand) or lower extremity (foot) tests. Response times were then measured using the Light Trainer Pro system (Light Trainer® Visuo-Motor Devices Company). This device consists of a light disc with 8 RGB LEDs that can be controlled via a tablet or smartphone (Figure 1). It was used to measure reaction time based on the athletes deactivating the illuminated disc. This measurement protocol was adapted from [15] and [16]. Six discs were mounted on a flat iron platform, with magnets on the back of the discs to determine hand visual reaction time. The discs were placed at three different distances from the participant's hand: zero, shoulder, and random distances. For the zero distance, a light disc was mounted on the platform, and the participant was instructed to place their hand right next to the disc (with both hands together) to perform the test.

For the shoulder distance, the participant was instructed to place the tested hand one shoulder-width away from the light disc. Participants stood facing the iron platform at arm's length and were instructed to raise their arms to chest level, with their palms lightly touching the platform (starting position). They were then instructed to deactivate the lights as quickly as possible by bringing their hands close to the flashing light (within 10 cm). After switching off the light, participants had to return their arms to the starting position. The measurements were configured using the smartphone controller, and a 30-second rest was given between each trial. Visual response time (in milliseconds) for the hands, both before and after

the warm-up, was recorded by the device. Three measurements were taken for each hand, and the averages were used in the analyses. The lower extremity (foot) measurement protocol was adapted and organized according to [17].

The following instructions were given to the participants for the lower extremity task. Participants were randomly positioned in a semicircle with both feet to respond to a visual stimulus and deactivate a series of 5 targets, in order to minimize learning and practice effects. They stood in front of a 180° semicircle, with each light disc placed at 45° increments around the semicircle. The distance of the lights, numbered 1 to 5, was adjusted according to each participant's leg length. After extinguishing each light, participants were instructed to return their feet to the starting position.

#### Statistical Analysis

All measurements in the study were presented as mean and standard deviation (Std. Deviation). Based on the results of the normality distribution, the independent t-test and Mann-Whitney U test were used to compare two independent groups, while the paired t-test and Wilcoxon test were used to compare two dependent groups. Statistical data were analyzed using the SPSS (version 22.0) software package.

## Results

Figure 2 shows the hand visual response times of volleyball and football players. No significant difference was found in the comparison of hand



**Figure 1.** Light Trainer Pro system.

visual response times for volleyball players before and after the warm-up ( $Z = -1.561$ ,  $p = 0.119$ ). However, a significant difference was found in the comparison of hand visual response times for football players before and after the warm-up ( $t = 2.887$ ,  $p = 0.016$ ). No significant difference was observed when comparing the hand visual response times of volleyball and football players both before ( $t = 1.905$ ,  $p = 0.071$ ) and after the warm-up ( $U = 43.000$ ,  $p = 0.247$ ).

Figure 3 presents the foot visual response times of the participants. A significant difference was found in the comparison of volleyball players' foot visual response times before and after the warm-up ( $Z = -2.674$ ,  $p = 0.007$ ). No significant difference was observed in the comparison of football players' foot visual response times before and after the warm-up ( $t = 2.132$ ,  $p = 0.059$ ). A significant difference was determined when comparing the foot visual response times of volleyball and football players

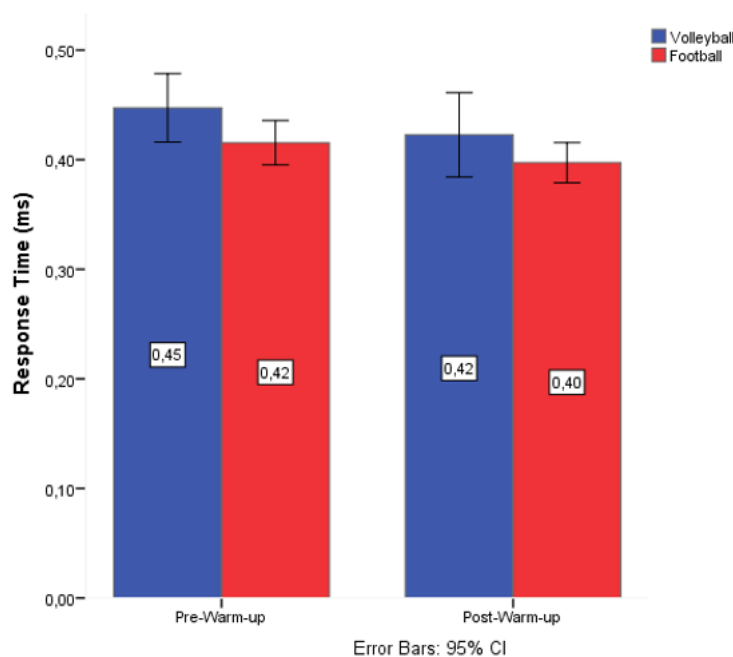


Figure 2. Hand visual response times.

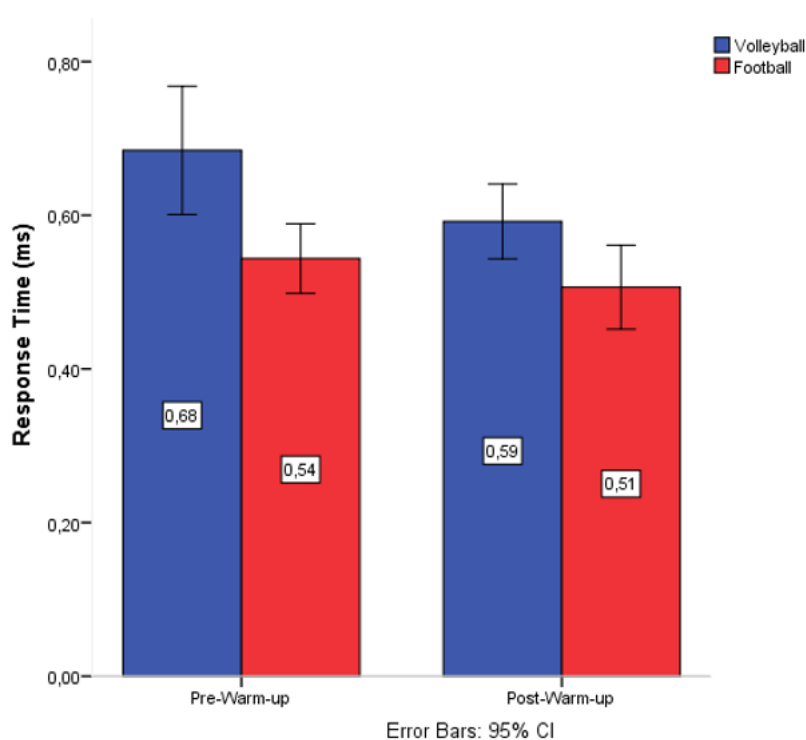


Figure 3. Foot visual response times.

both before ( $t = 3.307$ ,  $p = 0.004$ ) and after the warm-up ( $U = 20.000$ ,  $p = 0.008$ ). This difference indicated that volleyball players had a greater decrease in visual response time than football players after the warm-up.

## Discussion

The aim of this study was to investigate the effects of sport-specific warm-up activities on the hand and foot visual response times of female athletes. The results revealed no significant difference in the hand visual response times between volleyball and football players after the warm-up. Volleyball players' hand response times did not change before or after the warm-up. However, football players showed significantly faster response times after the warm-up compared to before. This result suggests that football players experienced a greater improvement in their visual responses following the sport-specific warm-up. There was a significant change in foot visual response times after the branch-specific warm-up. It was found that volleyball players' foot visual response times improved more than those of football players after the warm-up. However, football players had faster response times both before and after the warm-up. This suggests that the warm-up activities specific to volleyball are more effective than those for football in improving foot visual response times. It has been noted that athletes' dominant limbs (e.g., hand or foot) tend to show less improvement in response times after the warm-up compared to their less dominant limbs, due to the nature of the sport. This may suggest that the frequently used limbs of athletes are already close to their optimal performance level in terms of response time.

It has been noted that response time, which positively affects performance, is faster in athletes with similar technical and fitness levels, and athletes with shorter response times tend to develop more quickly. Moreover, this effect is even more significant across different sports disciplines. During training and competition, an athlete who executes movements faster than their opponent gains a competitive advantage. This is supported by the results of the study by Kockum et al. [18], where the authors note that elite-level athletes typically have shorter response times compared to amateur-level athletes.

According to the findings of the study, no difference was observed in the hand visual response times of volleyball and football players after the sport-specific warm-up compared to pre-warm-up. However, football players showed a significant improvement in visual response time after the warm-up. Some studies have examined the effects of warm-up activities on various parameters. In one such study, it was reported that a 25-minute warm-up had no significant effect on the visual response

times of the dominant and non-dominant hands of basketball players. This result suggests that warm-up activities may not lead to a significant improvement in visual response times or may not cause notable differences in response times between players [19].

In another study, the effect of warm-up activity on upper extremity (hand) reaction time was examined, and it was reported that warm-up activity did not significantly affect reaction time [20]. These findings are consistent with our study and suggest that the effects of sport-specific warm-up activities on visual response time may be limited. However, in contrast to our study, a different investigation examined the reaction times of participants from seven different sports (football, volleyball, handball, boxing, arm wrestling, basketball, and rugby), including football and volleyball players, and found differences in visual reaction times between the branches [21].

In another study [14], it was found that a warm-up involving core exercises and elastic bands had a greater impact on sprint time, jump height, medicine ball throwing speed, and handball throwing performance compared to a traditional warm-up, as well as core and elastic band warm-up activities. In the literature, studies investigating the effects of sport-specific warm-up activities on the visual reaction time of female athletes are limited. Existing research examines warm-ups across different sports and under various parameters. Therefore, this study makes a unique contribution to the literature by focusing on female athletes and incorporating branch-specific warm-up activities.

In sports where competition is highly important, lower extremity (foot) performance parameters are equally critical. The lower extremities play a key role in an athlete's performance, enabling fundamental movements such as running, changing direction, and jumping [22]. Therefore, just as with the upper extremities, it is essential for athletes to demonstrate quick response times, which is a key performance parameter, in their lower extremities as well.

According to the findings of the study, volleyball players showed greater improvement in response times than football players after the branch-specific warm-up activity. However, football players had better foot response times than volleyball players both before and after the warm-up. This suggests that football players may naturally have faster response times or may have developed this skill more effectively due to the demands of their sport. In a study supporting our findings, reaction times across three different sports (football, volleyball, and wrestling) were compared, and it was reported that football players had shorter reaction times than both volleyball and wrestling players [23]. However, some studies have reported that warm-up activities did not affect the reaction times of the lower extremities (foot) [19, 24].

In contrast to these findings, our study showed a significant improvement in foot visual response times for volleyball players after the sport-specific warm-up. However, similar to previous studies, the foot response times of football players did not show a significant change after the warm-up. These results suggest that the effectiveness of warm-up activities may vary depending on the specific demands of each sport and the limbs predominantly used by the athletes. Furthermore, the improvements in volleyball players' foot response times may indicate that sport-specific warm-ups are more beneficial for certain types of movements and muscle groups.

In conclusion, this study demonstrated that sport-specific warm-up activities have varying effects on visual response times in female athletes, depending on the sport and the extremity involved. Volleyball players showed greater improvements in foot visual response times after the warm-up, while football players exhibited faster baseline response times but did not significantly benefit from the warm-up. These findings highlight the importance of tailoring warm-up protocols to the specific demands of each sport. However, the study has some limitations, including the relatively small sample size and the focus on only two sports. Additionally, the study

did not account for potential individual differences in physical conditioning or prior warm-up habits. Future research should explore a broader range of sports and include a larger, more diverse group of athletes to better understand the generalizability of these results.

## Conclusions

The results show that the effects of branch-specific warm-up activities on hand and foot response times differed between football and volleyball players. Football players outperformed volleyball players in both hand and foot response times. However, a significant improvement in foot response times was observed in volleyball players after the sport-specific warm-up, while football players maintained overall faster response times after the warm-up. These findings suggest that the specific demands of each sport and the warm-up activities may influence athletes' response times in different ways.

This study was presented as an oral presentation at the VII INCES International Science, Culture and Education Congress, held from April 28 to May 1, 2024.

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Cite this article as:

Gögebakan R, Baştürk D, Arguz A, Bayraktar Y, Erkmén N, Say S. The effect of sports specific warm-up on lower and upper extremity visual response time in female athletes. *Physical Education of Students*, 2024;28(5):296–302. <https://doi.org/10.15561/20755279.2024.0506>

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Received: 02.09.2024

Accepted: 06.10.2024; Published: 30.10.2024