

The effect of proprioception training on lower extremity response time in kung fu athletes: Responses between dominant and non-dominant feet

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Abstract

Background and Study Aim Proprioceptive training influences neuromuscular control and reaction time in athletes. Its impact on response time in different limbs remains an area of interest. This highlights the need for further research to identify effective training approaches. The present study examined the immediate effects of proprioceptive training on response times in the dominant and non-dominant feet of kung fu athletes.

Material and Methods The sample included 21 female volunteer kung fu athletes (age: 14.43 ± 1.21 years; height: 157.90 ± 4.59 cm; weight: 53.10 ± 8.26 kg; sports experience: 8.24 ± 2.41 years). Response times were measured before and after proprioceptive training using the Light Trainer Pro device. One-way repeated measures ANOVA assessed the effects of proprioceptive training. A paired t-test compared pretest-posttest response time differences between the dominant and non-dominant feet.

Results A significant effect of proprioceptive training on response times was found ($p < 0.05$). In the pretest, no significant difference was observed between the dominant and non-dominant feet ($p > 0.05$). However, in the post-test, the response time of the dominant foot was significantly lower than that of the non-dominant foot ($p < 0.05$). The dominant foot's response time significantly decreased after proprioceptive training ($p < 0.05$), while no change was observed for the non-dominant foot ($p > 0.05$). No significant difference was found in the pretest-posttest response time changes between the dominant and non-dominant feet ($p > 0.05$).

Conclusions Acute proprioceptive training improved the response time of the dominant foot in kung fu athletes. Proprioceptive training programs may enhance athletes' performance before training and competition.

Keywords: athletes, proprioceptive training, response time, Kung Fu

Introduction

Proprioceptive training is widely used in sports to enhance neuromuscular control and movement efficiency. In kung fu, where rapid and precise responses are essential for performance, optimizing reaction time is particularly important. Understanding its effects on the dominant and non-dominant limbs can help develop targeted training strategies for kung fu athletes.

Proprioception is defined as awareness of position and movement. It includes elements such as static position, displacement, speed, acceleration, and the force and effort exerted by muscles [1]. Joint positions and movements rely on neurons located in the skin, muscles, joints, tendons, and ligaments, making them a key aspect of proprioception [2].

Proprioceptive training aims to enhance kinesthetic awareness of body posture and movement

[3, 4]. It also develops complex neuromuscular mechanisms, including balance, somatosensory stimulation, and joint repositioning [4, 5]. Common exercises involve maintaining balance with eyes closed, using a balance board or ankle disk, standing on one leg while throwing and catching a ball, and dribbling a ball [6, 7, 8]. These activities improve adaptability to changing conditions [9] and help athletes make rapid movement adjustments based on visual and tactile inputs [10].

Systematic reviews indicate that proprioceptive training positively influences various aspects of sports performance. Reported benefits include enhanced physiological capacity, explosive power, postural stability, balance, and muscle activation. Additionally, it improves knee joint position awareness, reduces chronic joint instability, and enhances agility, passing, dribbling, and ball control skills [11].

Studies on athletes have primarily examined the chronic effects of proprioceptive training [11].

Research on its acute effects has shown mixed results. Some studies report improvements in both static and dynamic balance [12], while others indicate gains in dynamic balance but no significant changes in static balance [13]. Additionally, proprioceptive training has been found to increase quadriceps strength [14] and reduce response time [15].

Reaction is the process in which a stimulus reaches the central nervous system via nerves, is processed, and then triggers a return signal to activate the relevant muscle [16, 17]. Response time refers to the interval between the initiation of neurological processes in reaction to a stimulus and the start and completion of the resulting movement [18]. This process begins with the retina cycle and concludes with muscle activation [19, 20]. Response time is defined as the ability to execute a movement in the shortest possible time and to coordinate body parts efficiently [21].

Rivera et al. [9] reported that proprioceptive exercises enhance the ability to adapt quickly to changing conditions. Additionally, proprioceptive training contributes to stimulus-response synchronization, improving joint stability performance [22]. These findings support the hypothesis that proprioceptive training may be beneficial in reducing response time.

Response time is a fundamental factor that allows athletes to perform at their best in many sports. The ability to quickly decide on and execute a movement underscores its importance [23]. In kung fu, which translates to “martial art” in Chinese [24], rapid responses to an opponent’s attacks are crucial. This makes it an ideal sport for studying environmental perception.

Kung fu involves punches, kicks, jumps, and the use of various weapons. However, its core elements include postural control, flexibility, and circular movements [25]. Developing both the dominant and non-dominant limbs to a similar level may provide an advantage over athletes who rely primarily on their dominant side [26].

The tendency of one side of the body to be more specialized for certain movements is known as lateralization [27]. This phenomenon has been studied in athletes by several researchers [28, 29, 30]. In a study by Arguz et al. [28], basketball players’ response times for the dominant and non-dominant hands and feet were analyzed during warm-up. The results indicated that the dominant hand exhibited a faster response time.

Despite extensive research on proprioceptive training and response time, there is still no consensus on the most effective methods for optimizing neuromuscular responses in athletes. Studies have produced mixed findings, particularly regarding the effects on dominant and non-dominant limbs. Some report improvements in

dynamic balance and muscle activation, while others indicate limited benefits for static balance and joint stability. This variability suggests the need for further research to refine training protocols and develop more effective approaches for enhancing response time. Identifying targeted proprioceptive training strategies could provide valuable insights for improving athletic performance across different sports disciplines.

In martial sports such as kung fu, both feet are developed to complement each other. While the dominant foot is generally preferred for offensive movements, the non-dominant foot plays a significant role in defense, posture, and movement skills. This posture enhances the athlete’s body flexibility and strength, allowing for a more dynamic and effective combat performance. Therefore, the aim of this study is to investigate how acute proprioceptive training affects the response times of the dominant and non-dominant feet in kung fu athletes.

Materials and Methods

Participants

The sample consisted of 21 female volunteer kung fu athletes (age: 14.43 ± 1.21 years; height: 157.90 ± 4.59 cm; weight: 53.10 ± 8.26 kg; sports experience: 8.24 ± 2.41 years). Athletes with no injuries in the preceding six months were included in the study. Before participation, all athletes were informed about the study details. The research was approved by the Ethics Committee (Date: 11.11.2024, Decision number: 119).

Study Design

This study employed a within-subjects repeated-measures design. To eliminate the learning effect, response time measurements were randomly taken for the dominant and non-dominant foot. Athletes participated in measurements on different days, but response times for both feet were recorded on the same day. All experiments were conducted in a laboratory setting at the same time of day to maintain comparable chronobiological conditions. Before proprioceptive training, the movements were demonstrated both verbally and practically. The number of repetitions and the duration of exercises were monitored and implemented by the researchers.

Proprioceptive Training

The proprioceptive training session consisted of a sequence of exercises performed on a Bosu ball, emphasizing awareness and control of the lower limbs. The exercises were conducted with the Bosu ball positioned side up. The training protocol was adapted from previously established proprioceptive training programs [31, 12]. The exercise program is presented in Table 1.

Visual Response Time

The response times of athletes for their dominant and non-dominant foot were measured both before and after proprioceptive training. To minimize learning and practice effects, the measurements were conducted in a randomized order for the dominant and non-dominant foot. The response time was assessed using the Light Trainer Pro system (Light Trainer® Visuo-Motor Devices Company) (Figure 1). This device consists of a lighted disk with eight RGB LEDs and is controlled via a smartphone or tablet. The experimental design involved measuring the athletes' response time to extinguish the illuminated target on the disk. During the test, athletes were randomly positioned on a level surface in a semicircle. They responded to a visual stimulus by using either the dominant or non-dominant foot to deactivate a sequence of five targets. The setup included a 180° semicircle, with each light disc positioned at 45° intervals. The lights, numbered 1 to 5, were calibrated according to the athletes' height. After each light was turned off, athletes were instructed to reposition their dominant or non-dominant foot to the starting position [32, 33].

Statistical Analysis

The data in this study are presented as the mean \pm standard deviation (SD). The normality assumption for the ANOVA model was tested using the Shapiro-

Wilk test. One-way repeated measures ANOVA was conducted to assess the effects of proprioceptive training. Post hoc comparisons were performed using the Bonferroni correction.

A paired t-test was used to compare pre-test and post-test response time differences between the dominant and non-dominant foot. Effects with $p < 0.05$ were considered statistically significant. All statistical analyses were performed using SPSS 26.0.

Results

The mean, standard deviation, minimum, and maximum values for age (years), height (cm), body weight (kg), and sports experience (years) of the kung fu athletes are presented in Table 2.

Figure 2 illustrates the changes in response times before and after proprioceptive training for both the dominant and non-dominant foot. As shown in Figure 2, a significant effect was found for response times across the measurements ($F(3,60) = 9.471$; $p < 0.001$; $\eta^2 = .321$). In the pre-test, there was no significant difference in response time between the dominant and non-dominant foot ($p = .104$). However, in the post-test, the response time of the dominant foot was significantly lower than that of the non-dominant foot ($p = .036$). The response time of the dominant foot significantly decreased after proprioceptive training ($p = .024$), whereas no significant change was observed for the non-

Table 1. Proprioceptive Exercise Session

No	Exercises	Duration
1	Squat on Bosu	10 r
2	Standing on two legs on Bosu	60 s
3	Standing on one leg on Bosu (right/left)	60 s + 60 s
4	Standing on one leg on Bosu, throwing and catching a ball (right/left)	60 s + 60 s
5	Jumping on two legs on Bosu	10 r
6	Jumping on one leg on Bosu (right/left)	10 r
7	Standing on two legs with eyes closed on Bosu	60 s
8	Standing on one leg with eyes closed on Bosu (right/left)	60 s + 60 s

Note: s – seconds; r – repetitions.



Figure 1. Assessment of reaction time response (32).

Table 2. Descriptive information about the participants

Variable	N	Mean	Std. Deviation	Minimum	Maximum
Age (years)	21	14.43	1.21	12.00	16.00
Height (cm)	21	157.90	4.59	148.00	167.00
Body weight (kg)	21	53.10	8.26	41.00	69.00
Sports experience (years)	21	8.24	2.41	5.00	12.00

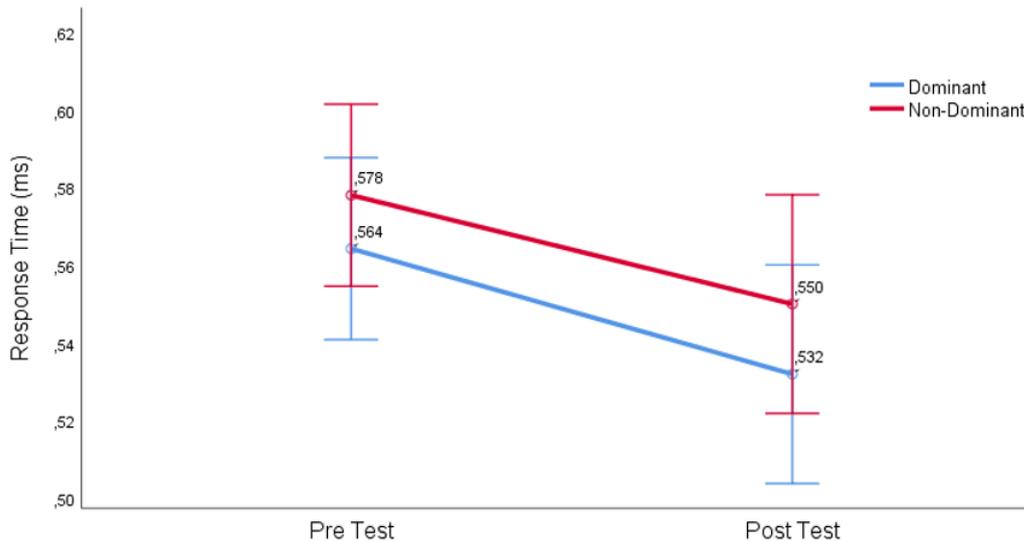


Figure 2. Response times after proprioceptive training. The error bars indicate the standard error of the mean.

dominant foot ($p = .084$). No significant difference was found between the dominant foot ($M = .032$, $SD = .046$) and the non-dominant foot ($M = .028$, $SD = .048$) in pre-test and post-test response time differences ($t = .297$, $df = 40$, $p = .768$).

Discussion

This study examined the effect of acute proprioceptive training on the response times of the dominant and non-dominant feet in female kung fu athletes. The results showed no significant difference in response times between the dominant and non-dominant foot before training. However, after acute proprioceptive training, the response time of the dominant foot improved significantly more than that of the non-dominant foot.

Compared to traditional exercise methods, proprioceptive training enhances muscle activation, sensorimotor performance, central nervous system function, and arousal levels during exercise [34, 35, 36, 11]. These factors may contribute to a reduction in response time following proprioceptive training. A similar study also reported a decrease in response time after acute proprioceptive training [15].

The literature on the acute effects of proprioceptive training remains limited. However, several studies have examined its chronic effects. For example, an 8-week proprioceptive training

program significantly improved response time and dominant hand-eye coordination skills [37]. Bokil et al. [38] found that a 6-week upper extremity proprioceptive training program enhanced response time in table tennis athletes. Another study reported statistically significant reductions in visual, auditory, and compound response time performance following proprioceptive training [39].

The primary objective of proprioceptive training is to enhance proprioceptive function, a complex neuromuscular process responsible for the natural awareness of body position and movement [4, 36, 3]. Additionally, proprioceptive sensory stimulation has been shown to improve exercise performance by enhancing balance, postural stability, muscle activation, joint stability, and functional mobility of the lower extremities [40, 11]. Consequently, this training method may contribute to a reduction in response time by increasing the functional speed of the nervous system.

Brighenti et al. [29] reported that after a warm-up activity, the dominant leg showed greater improvement compared to the non-dominant leg. Similarly, the present study found that acute proprioceptive training significantly enhanced the response time of the dominant foot relative to the non-dominant foot. This suggests that proprioceptive training has a more pronounced

effect on the functional speed of the dominant foot, which is used more frequently.

Several studies have indicated that proprioceptive training positively influences response time [37, 15]. Ceylan and Saygin [37] found that an 8-week proprioceptive training program improved visual response time in students. Mazbouh et al. [15] examined the effects of a 2-week, 6-session proprioceptive training program on response time and observed improvements in the training group compared to the control group. Both studies emphasized that long-term (chronic) proprioceptive training contributes to improvements in response time.

Long-term training programs may be challenging for athletes seeking rapid performance gains. However, acute proprioceptive training sessions that enhance performance could be implemented before training or competition. The present study demonstrated that acute proprioceptive training functionally improved standing response time.

Athletes who develop both their dominant and non-dominant feet to the same level may gain an advantage over those who focus on only one foot. The findings of this study indicate that acute proprioceptive training improved the response time of the more developed foot. However, limited research has examined the effects of acute proprioceptive training on the response time of both dominant and non-dominant feet.

Due to this gap in the literature, studies investigating the effects of warm-up activities on dominant and non-dominant feet, such as those by Brighenti et al. [29] and Arguz et al. [28], were considered for comparison. Brighenti et al. [29] found that a 10-minute warm-up had a greater effect on postural control in the dominant leg compared to the non-dominant leg. Arguz et al. [28] examined the response times of dominant and non-dominant hands and feet in basketball players following a warm-up. Their findings showed that warm-up activities improved the response times of both the dominant and non-dominant hands. However, no significant difference was observed in the reaction times of the dominant and non-dominant feet before and after the warm-up.

In contrast, the present study demonstrated that acute proprioceptive training significantly improved the reaction time of the dominant foot. This suggests that proprioceptive training may have a more direct influence on neuromuscular response compared to traditional warm-up activities.

Limitations and Future Research

This study has certain limitations that should be considered when interpreting the results. First, the participants were adolescent kung fu athletes with a young age profile and amateur-level experience. As a result, the findings may not be generalizable to athletes of different age groups, skill levels, or sports disciplines. Future research should include a broader age range, various sports, and different experience levels to provide a more comprehensive understanding of the acute effects of proprioceptive training.

Additionally, this study focused primarily on the impact of proprioceptive training on response time. However, response time alone does not fully capture all factors influencing athletic performance. Future research should examine additional variables such as agility, sprint performance, balance, technical skills, and performance sustainability to offer a more holistic perspective. Addressing these gaps in future studies will contribute to the development of evidence-based training protocols applicable across different sports.

Conclusions

This study contributes to the growing body of evidence on the importance of short-term proprioceptive training in athletes. Proprioceptive training has both acute and long-term effects on neuromuscular performance. From a practical perspective, the ability to respond quickly is essential for executing kung fu techniques effectively. Therefore, these findings offer valuable insights for coaches and practitioners in designing pre-match routines to enhance athletic performance.

Conflict of Interest

The authors declare no conflicts of interest related to this study.

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