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ACTIVATION WARM-UPS ENHANCE CHANGE OF DIRECTION PERFORMANCE IN UNIVERSITY ATHLETES

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ABSTRACT

Change-of-direction (COD) ability is a critical component of performance in many team sports, yet practical methods to acutely enhance COD remain underexplored. This study aimed to determine whether adding a brief, targeted warm-up focused on gluteal muscle activation to a general warm-up could acutely improve COD performance in university athletes. Seventeen male athletes participated in a two-day, parallel-group controlled trial. On both days, all participants completed a standardized general warm-up. On the second day, the experimental group performed an additional three-minute targeted warm-up (band squats, band lateral walks, skater hops), while the control group proceeded directly to testing. COD performance was assessed using the Lane Agility Drill before and after intervention. The main result was that only the experimental group, which received targeted activation exercises, showed a significant improvement in COD performance ($p < .01$), whereas the control group showed no significant change. These findings suggest that a short, muscle-specific warm-up can effectively and immediately enhance COD ability, even without high-intensity or specialized equipment. The study's limitations include a small, homogeneous sample of male university athletes and the use of a single COD test, which may restrict generalizability. Future research should examine whether similar effects occur across other populations and sports, and with various COD assessments. Practically, the protocol offers a simple, time-efficient approach for coaches and athletes to optimize performance in settings where rapid directional changes are essential. The originality of this study lies in demonstrating that acute performance gains can be achieved through accessible, field-based exercises integrated into existing warm-up routines.

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INTRODUCTION

Change of direction (COD) ability is a critical performance factor in team sports such as soccer, basketball, and rugby, where athletes frequently need to execute rapid, precise directional changes in response to dynamic game scenarios (Sheppard & Young, 2006). Efficient COD performance offers a competitive edge, enabling players to evade opponents and adapt swiftly to tactical situations (Brughelli et al., 2008). COD ability differs from agility in that it emphasizes the physical execution of directional changes, excluding perceptual-cognitive elements such

as reaction time and decision-making (Sheppard & Young, 2006; Young et al., 2002).

Warm-up routines are a critical part of athletic preparation, enhancing physical performance by increasing muscle temperature, improving joint mobility, and stimulating neural activation. They also reduce the risk of injury by promoting muscle and tendon suppleness, increasing blood flow, and preparing the body for the specific demands of competition or training. Effective warm-ups should avoid inducing fatigue, gradually increase in intensity, and include sport-specific activities to maximize their

benefits (Bishop, 2003; Fradkin et al., 2010).

While general warm-up protocols have been extensively studied, targeted warm-ups that emphasize sport-specific movement patterns and activate relevant muscle groups may offer additional benefits (McGowan et al., 2015). For example, dynamic stretching and specific activation exercises have shown promise in improving sprint and jump performance (Herman & Smith, 2008). However, research focusing on warm-up protocols specifically designed to enhance COD performance remains limited.

One potential mechanism underlying the efficacy of targeted warm-up exercises is post-activation performance enhancement (PAPE), defined as acute improvements in voluntary performance after a conditioning activity (Blazevich & Babault, 2019; Prieske et al., 2020). Although “post-activation potentiation (PAP)” has historically been used broadly, recent reviews recommend distinguishing PAP—a twitch-based mechanistic potentiation quantified with electrically evoked contractions—from PAPE, the voluntary performance response typically evident minutes after preparatory activity. PAP-related processes (e.g., myosin regulatory light-chain phosphorylation) may contribute, whereas in applied settings PAPE likely reflects the combined influence of increased muscle temperature and transient neural readiness (Hodgson et al., 2005; Blazevich & Babault, 2019; Prieske et al., 2020). While PAPE is traditionally associated with high-intensity exercises typically performed in weight training facilities, recent research suggests that moderate-intensity exercises incorporated into warm-up routines can also elicit PAPE effects (Seitz & Haff, 2016; Wilson et al., 2013). These moderate-intensity exercises are practical for athletes during competition warm-ups and can be performed on the field without a weight-training room. Therefore, incorporating moderate-intensity, PAPE-inducing exercises into targeted warm-ups may

enhance COD performance by activating key muscle groups essential for efficient directional changes. This approach emphasizes practicality in competitive settings. Thus, while PAPE may contribute to performance improvements, this study focused on the practical benefits of targeted warm-ups incorporating moderate-intensity exercises.

Despite the recognized importance of COD ability and warm-up strategies, previous research has primarily focused on comparing dynamic and static stretching exercises, with findings indicating that dynamic stretching may enhance power and agility performance more effectively than static stretching (McMillian et al., 2006; Taylor et al., 2009). However, these studies have not specifically examined the acute effects of brief, practical, targeted warm-up protocols incorporating moderate-intensity PAPE exercises on COD performance. Therefore, there is a gap in the literature regarding the efficacy of such warm-up strategies, which this study aimed to address.

This study aimed to evaluate the effectiveness of a targeted warm-up protocol on COD performance in university-level athletes. The warm-up included exercises targeting muscles crucial for COD movements, particularly the gluteal muscles, which are essential for pelvic control and lateral stabilization. These muscles are recognized as key contributors to efficient cutting maneuvers and COD performance (Cole et al., 2016; Marshall et al., 2014). We hypothesized that incorporating a brief, targeted warm-up protocol would significantly enhance COD performance compared to a general warm-up alone.

METHODOLOGY

Participants and Sample Size

Determination

Seventeen male university athletes participated in this study. All participants were

enrolled in the Department of Sports Education at Biwako Gakuin University and regularly engaged in sports practice at least three times per week. The participants' mean age, height, and body mass were 18.4 ± 0.7 years, 171.4 ± 6.5 cm, and 65.8 ± 4.9 kg, respectively. To avoid the confounding effects of sex-related differences in physical characteristics and performance, only male athletes were included in this study. All participants reported no musculoskeletal injuries in the three months prior to the study. Informed consent was obtained from all individual participants included in the study. None of the participants had prior experience with the Lane Agility Drill, as confirmed during pre-enrollment screening; baseline familiarity with the test was equivalent across groups. The study was conducted in accordance with the Declaration of Helsinki and was approved by the Institutional Review Board of Biwako Gakuin University (approval number: 04-001).

To determine the required sample size, a priori power analysis was conducted using G*Power software (version 3.1). Based on preliminary measurements conducted on 15 participants, a correlation coefficient of 0.89 was identified among repeated measures. Given this high correlation and the anticipated small effect size (Cohen's $f = 0.17$) for the effects of low-intensity warm-up interventions on COD performance, this estimate was supported by previous research indicating that low-intensity dynamic stretching and muscle activation protocols tend to yield smaller effect sizes compared to high-intensity conditioning activities (Behm & Chaouachi, 2011; Seitz & Haff, 2016; Wilson et al., 2013). These studies collectively suggest that low-intensity warm-ups typically yield small effect sizes on athletic performance measures. Given these considerations, the following parameters were used for the power analysis:

effect size $f = 0.17$, alpha level $\alpha = .05$, power $1 - \beta = 0.80$, number of groups = 2, and number of measurements = 2 (accounting for the repeated-measures design). The calculation indicated that a total sample size of 18 participants was required. One participant withdrew during Test 2, resulting in a final sample size of 17 participants. While this reduction may slightly affect statistical power, it is considered minimal and has been accounted for in the data analysis.

Experimental Design

A two-day, parallel-group controlled protocol was employed to investigate the effects of a targeted warm-up on COD performance. On Day 1, all participants performed a standardized general warm-up (7 minutes; see *Procedures*), rested for 3–5 minutes, and then completed a baseline COD test (Test 1; Lane Agility Drill). After Test 1, participants were assigned to the control group ($n = 8$) or the experimental group ($n = 9$) using a performance-matched, mechanical allocation (rank-ordered Test 1 times with alternating assignment) to balance baseline COD performance. On Day 2, the control group replicated the Day 1 pre-test sequence—general warm-up followed by a 3–5-minute rest—before Test 2, whereas the experimental group performed the same general warm-up, followed by a 3-minute targeted activation, and then the same 3–5-minute rest before Test 2. We enforced a minimum rest of ≥ 3 minutes and operationally kept all intervals within 3–5 minutes to balance fatigue dissipation with the time course of acute performance benefits reported after moderate-intensity primers (Seitz & Haff, 2016; Wilson et al., 2013).

Procedures

On Day 1, participants completed a general warm-up lasting approximately 7 minutes,

which included light aerobic exercises such as jogging, high knees, butt kicks, and jumping jacks to elevate muscle temperature and prepare the body for physical activity. This was followed by dynamic stretching exercises targeting major muscle groups. The stretches included forward bends for the hamstrings and lower back, side bends for the oblique muscles, straddle stretches for the inner thighs, and movements like the World's Greatest Stretch, a deep lunge with both hands on the floor inside the front foot, an elbow-to-instep reach, followed by thoracic rotation and an overhead reach toward the front knee, to enhance flexibility and mobility. After the warm-up, participants rested for at least 3 minutes; due to the sequential timed trials, actual rest ranged from 3 to 5 minutes for all participants before performing Test 1 (Lane Agility Drill). The drill was set up according to standardized protocols described in previous research (Milan et al., 2019; Stojanovic et al., 2019), empha-

sizing its reliability and validity as a measure of change-of-direction performance. Covering approximately 30 meters, the setup required participants to sprint, slide steps, and backpedal within the specified area, as illustrated in Figure 1. Participants were instructed to exert maximal effort while maintaining proper technique; any deviations, such as touching cones or performing prohibited cross-over steps, resulted in trial repetition. Performance times were measured to the nearest 0.01 seconds using the BROWER Timing System (Brower Timing Systems, Draper, UT, USA), recognized for its accuracy in athletic performance testing. Each participant completed one trial, and the primary outcome measure was the total time to complete the Lane Agility Drill. By utilizing this widely acknowledged and efficient method in a controlled, replicable manner, the study ensured that results were both reliable and comparable to prior research (Milan et al., 2019; Stojanovic et al., 2019).

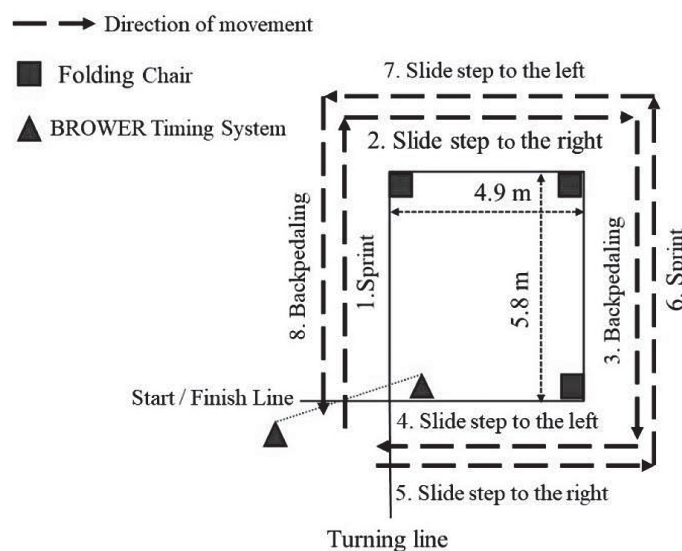


Figure 1. Schematic representation of the Lane Agility Drill.

Note. The drill involves sprinting, lateral slide steps, and backpedaling. The setup includes folding chairs as markers.

On Day 2, participants followed their assigned condition (control or experimental) determined after Day 1. Both groups performed

the same general warm-up as on Day 1. The control group replicated the Day 1 pre-test sequence—general warm-up followed by a

3–5-minute rest—before Test 2. The experimental group performed a targeted warm-up to activate muscle groups critical for COD movements, with particular emphasis on the gluteal muscles. The targeted warm-up, lasting approximately 3 minutes, consisted of Band Squats, Band Lateral Walks, and Skater Hops (Cole et al., 2016). For the Band Squats, participants performed 10 repetitions with a resistance band (Spartacus, normal strength; third of five levels) placed around the lower legs just below the knees to engage the gluteus medius and minimus (Figure 2A). Emphasis was placed on maintaining knee alignment over the toes and activating the gluteal muscles during

the upward phase. In the Band Lateral Walks, participants walked laterally to the right for 15 meters, then to the left for 15 meters, while maintaining a slight squat and constant tension on the band to engage the hip abductors (Figure 2B), with the band kept below the knees throughout. The Skater Hops involved performing 10 lateral jumps per side, mimicking a speed skater's movement, with emphasis on explosive lateral movement and balance upon landing (Figure 2C). After the targeted activation, participants rested for ≥ 3 minutes (actual 3–5 minutes) before Test 2. The targeted warm-up was supervised to ensure correct form and safety.

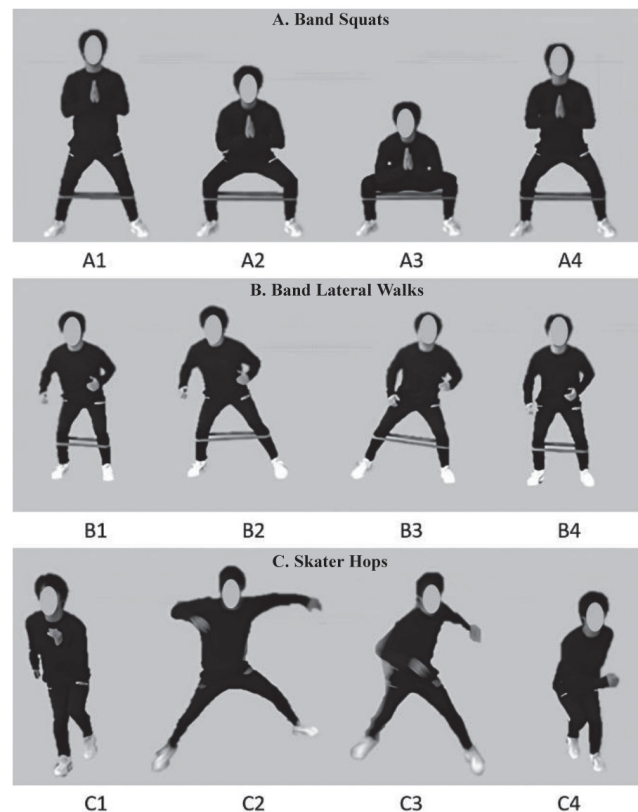


Figure 2. Targeted warm-up exercises for change of direction performance.

Notes. (A) Band Squats: Start from position A1, lower to the bottom position (A3), move through A4, and return to the starting position (A1).

(B) Band Lateral Walks: Example of moving to the participant's left. Begin in position B1, lift the left foot (B2), step to the left (B3), and return to the original stance (B4).

(C) Skater Hops: Example of hopping to the participant's left. Start with a single-leg stance (C1), kick with the right leg to hop left, move to position C3, and land in position C4.

Statistical Analysis

Data were analyzed using SPSS Statistics software (version 29.0.0.2, IBM Corp., Armonk, NY, USA). Descriptive statistics are presented as mean \pm standard deviation (SD). A two-way repeated-measures analysis of variance (ANOVA) was conducted to examine the effects of group (control vs. experimental) and time (Test 1 vs. Test 2) on COD performance. The interaction effect between group and time was assessed to determine if changes over time differed between groups. When a significant interaction was found, post hoc analyses with the Bonferroni correction were performed to identify specific differences. Effect sizes were calculated using partial

eta squared (η^2) for ANOVA results and Cohen's d for pairwise comparisons. Statistical significance was set at $p < .05$. Assumptions of normality and homogeneity of variances were assessed using the Shapiro-Wilk and Levene's tests, respectively, with no violations observed.

RESULTS

The purpose of this analysis was to evaluate changes in COD performance, as measured by Lane Agility Drill times, before and after the intervention. Descriptive statistics are presented as *mean \pm SD* (Table 1).

Table 1. Lane Agility Drill times (sec), mean \pm SD.

Group	Test 1 (sec)	Test 2 (sec)
Control ($n = 8$)	12.83 \pm 0.53	12.86 \pm 0.47
Experimental ($n = 9$)	12.90 \pm 0.67	12.44 \pm 0.67

At Test 1, the overall mean completion time was 12.87 \pm 0.61 seconds. Based on these results, participants were divided into the control group ($n = 8$; 12.83 \pm 0.53 seconds) and the experimental group ($n = 9$; 12.90 \pm 0.67 seconds) to ensure comparable baseline performance. At Test 2, the control group had a mean completion time of 12.86 \pm 0.47 seconds. The experimental group had a mean completion time of 12.44 \pm 0.67 seconds at Test 2. The overall mean at Test 2 was 12.64 \pm 0.62 seconds.

A two-way repeated measures ANOVA was conducted to examine the effects of time (Test 1 vs. Test 2) and group (control vs. experimental) on COD performance. The measurement values and analysis results are illustrated in Figure 3. There was a significant interaction effect between time and group ($F(1,15) = 5.927$,

$p < .05$, $\eta^2 = .283$), suggesting that the change in performance over time differed between the control and experimental groups.

Post hoc comparisons with the Bonferroni correction were conducted to explore the interaction effect. In the experimental group, completion times significantly decreased from Test 1 to Test 2 ($p < .01$, Cohen's $d = -0.682$), whereas the control group showed no significant change ($p = .840$, Cohen's $d = 0.063$). There were no significant differences between the experimental and control groups at Test 1 ($p = .821$, Cohen's $d = 0.216$) or at Test 2 ($p = .186$, Cohen's $d = 0.912$).

Assumptions of normality and homogeneity of variances were met, as indicated by non-significant Shapiro-Wilk and Levene's tests.

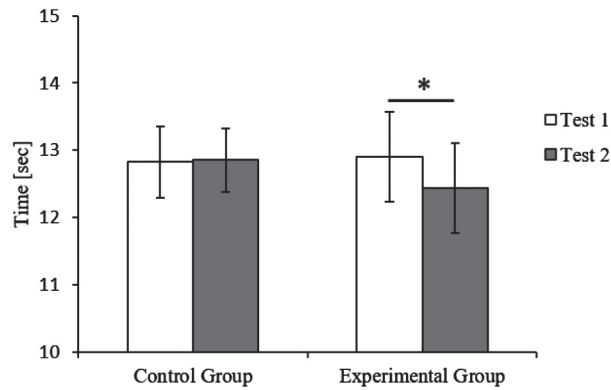


Figure 3. Mean completion times (\pm SD) for the Lane Agility Drill in the control and experimental groups at Test 1 and Test 2.

Note. A significant interaction effect between time (Test 1 vs. Test 2) and group (control vs. experimental) was observed ($p < .05$). The experimental group demonstrated a significant decrease in completion time from Test 1 to Test 2 ($p < .01$), whereas no significant change was observed in the control group. Error bars indicate standard deviations.

DISCUSSION

Effectiveness and Mechanisms of the Targeted Warm-Up

Interpreting the results, the significant improvement in COD performance for the experimental group suggests that the targeted warm-up was effective in enhancing COD speed. The decrease in Lane Agility Drill completion times indicates that activating specific muscle groups crucial for COD movements can lead to immediate performance benefits. In contrast, the control group did not exhibit significant changes between Test 1 and Test 2, highlighting the added value of the targeted exercises over a general warm-up alone.

The observed performance enhancement in the experimental group can be attributed to several potential mechanisms. The targeted warm-up focused on activating the glutes through exercises such as Band Squats, Band Lateral Walks, and Skater Hops. These muscles are essential for pelvic control and lateral stabilization, which are critical during rapid directional changes (Cole et al., 2016). By specifically engaging these muscles, the warm-up may have improved neuromuscular readiness and movement efficiency.

Additionally, incorporating moderate-intensity activation may have produced post-activation performance enhancement (PAPE)—acute improvements in voluntary performance following a conditioning activity. PAPE is thought to emerge from a combination of short-term physiological changes (increased muscle temperature, transient neural readiness) together with PAP-related mechanisms (e.g., myosin regulatory light-chain phosphorylation), with their relative contributions depending on task and timing (Blazevich & Babault, 2019; Prieske et al., 2020; Hodgson et al., 2005). Consistent with this view, moderate-intensity, equipment-free primers embedded within warm-ups can elicit immediate performance benefits (Seitz & Haff, 2016; Wilson et al., 2013). Our findings align with this pattern, suggesting that practical, moderate-intensity activation within a warm-up can acutely enhance COD performance.

Another possibility is that the three additional minutes of activity in the experimental condition elicited non-specific warm-up/volume effects—higher muscle/core temperature, greater musculotendinous compliance, and

transient neural readiness—that contributed to the improvement independent of gluteal specificity. The most parsimonious interpretation is that both gluteal-specific activation and these general volume effects jointly enhanced COD performance.

Practical Applications

The findings have practical significance for athletes and coaches in sports where COD ability is crucial. Since the targeted warm-up protocol required only an additional three minutes beyond the general warm-up, it offers a time-efficient method to enhance performance. Implementing such a warm-up can be particularly beneficial in competitive settings where maximizing COD performance can provide a competitive edge, especially given that overly prolonged warm-ups may lead to fatigue and decreased efficacy (Fradkin et al., 2010).

Moreover, the exercises used in the targeted warm-up are practical and do not require access to a weight room or specialized equipment. This makes it feasible to perform on the field or court, allowing athletes to benefit from specific PAPE effects without the need for high-intensity conditioning activities. Consistent with findings, moderate-intensity PAPE exercises are shown to effectively enhance neuromuscular readiness and subsequent performance without inducing excessive fatigue, reinforcing the practicality of this approach (McGowan et al., 2015). Incorporating targeted movements that activate key muscle groups may enhance performance, supporting the notion that specificity in warm-up routines is essential for optimizing athletic outcomes.

Regarding the likely duration of benefit, prior evidence on moderate-intensity primers suggests that performance enhancements typically emerge after ≥ 3 minutes of recovery and can persist for several minutes thereafter; me-

ta-analytic estimates indicate a favorable window roughly within 3–10 minutes, depending on conditioning intensity and training status (Wilson et al., 2013; Seitz & Haff, 2016). In applied settings, we therefore recommend scheduling COD tasks within 3–8 minutes after the activation and considering a brief re-activation if delays exceed 10–15 minutes (McGowan et al., 2015).

Limitations and Future Research

This study has several limitations that should be acknowledged. The participants were university athletes from various sports disciplines, which means their specialized training and skill levels were not uniform. Additionally, only male athletes were included, so the findings may not be generalizable to female athletes or other populations. Future research could focus on specific sports or include a broader range of participants to determine whether the targeted warm-up has differential effects depending on sex, sport, or competitive level.

Additionally, the study utilized only one type of COD test—the Lane Agility Drill. Incorporating multiple COD assessments could provide a more comprehensive understanding of how the targeted warm-up influences different aspects of COD ability. Employing biomechanical analyses in future studies could also help clarify the specific neuromuscular and mechanical mechanisms underlying the observed performance improvements.

Moreover, because the experimental condition added ≈ 3 minutes of activity and the overall warm-up intensity was not equated across groups, we cannot fully attribute the improvement to gluteal-specific activation. A portion of the effect may derive from non-specific warm-up/volume influences (e.g., higher temperature, greater musculotendinous compliance, transient neural readiness). Future studies should include a time-matched sham protocol

and standardize or monitor intensity (e.g., heart rate, RPE) to isolate the specificity of the effect.

Finally, the recovery between the preparatory activity and testing was standardized to ≥ 3 minutes and operationally constrained to 3–5 minutes by the sequencing of timed trials. While this improves ecological realism, it does not identify each athlete's optimal interval or the time course of effect decay. Future work should systematically vary recovery (e.g., ≥ 3 , 5, 7, 10 minutes) to characterize durability and inter-individual differences.

CONCLUSION

The results of this study indicate that supplementing a standard general warm-up with brief, targeted gluteal activation exercises can acutely improve COD performance in male university athletes. This enhancement was observed only when the targeted protocol was added, highlighting the value of muscle-specific preparation even without high-intensity or specialized equipment. The protocol's simplicity and ease of field application distinguish it from previous, less accessible interventions, making it especially relevant for coaches and practitioners seeking efficient performance enhancement strategies. However, these findings are limited by the participant sample (male university athletes) and the use of a single COD test, which may restrict generalizability. Further studies should investigate whether similar benefits occur in other populations and with different agility assessments. The study emphasizes that even modest adjustments to warm-up routines, focusing on muscle-specific activation, can deliver meaningful improvements in sport-specific performance.

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