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**Original Article**

# Effects of Cool-Down Exercise and Cold-Water Immersion Therapy on Basic Fitness and Sport-Specific Skills among Korean College Soccer Players

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**Abstract**

**Background:** We aimed to examine the effects of cool-down exercise and cold-water immersion therapy on agility, speed, power, balance, and sport-specific skill performance in college soccer players, and to provide baseline data for the development of effective recovery programs.

**Methods:** In August 2020, 21 male college soccer players in Seoul, Korea, were randomly divided into the following groups: control group (CG, n=7), cool-down exercise group (CDG, n=7), and cool-down exercise plus cold-water immersion group (CDCWG, n=7). Agility, speed, power, balance, and sport-specific skill performance were assessed before and after the intervention.

**Results:** No significant differences in Southeast Missouri (SEMO) Agility Test, 20-m sprint test, vertical jump test, or Y-balance test (right) were observed among the groups; however, there was a significant effect of time ($P<0.05$) and a significant time × group interaction ($P<0.05$). Significant effects of time ($P<0.001$), group ($P=0.043$), and a time × group interaction ($P=0.009$) were observed in the Y-balance test (left). There were no between-group differences in the 22-m dribble test, shooting test (left), or shooting test (right); however, there were significant effects of time ($P<0.05$) and significant time × group interactions ($P<0.05$). No significant effects of group or time × group interactions were observed for the kicking test (left or right); however, there were significant effects of time ($P<0.001$).

**Conclusion:** Addition of cold-water immersion therapy to a recovery program including cool-down exercise can promote recovery of basic and sport-specific abilities among college soccer players.

**Keywords:** Cool-down exercise; Cold-water immersion; Physical fitness; Soccer, Muscle fatigue

## Introduction

Soccer is among the most popular team sports worldwide (1). Winning a soccer match requires both strategy and technical skill, with high level of physical fitness required to successfully implement these skills and strategies (2). A soccer game is a high-intensity race in which repetitive jumping and sprinting movements are performed with maximum intensity to gain a possessive advantage of the ball (3). However, loss of physical energy begins to occur at 60–90% of the maximum intensity, leading to a state in which repeated muscle contraction, movement, and maximum power can no longer be sustained. This difficulty in maintaining tissue excitation substantially hinders both the technical and strategic aspects of competitive play (4-5). Therefore, soccer players must minimize fatigue during or after training for a given period until the next training session or competition. As such, the recovery program is an essential component of training for successful teams.

Exercise-induced damage to muscle tissue, which produces adverse effects on exercise performance, is associated with the intensity, type, and time of exercise. The need for continuous motion on the field, such as high-intensity intermittent running and jumping, and instantaneous acceleration and deceleration over the course of a match can lead to muscle damage and fatigue (4-5). Thus, both recovery from fatigue and the actual training process are essential for improving athletic performance (6).

There are several means by which recovery from fatigue can be achieved, including sports massage (7), active recovery (8), cold-water immersion (9), and whole-body vibration (10). Among such methods, previous studies have reported that cool-down exercise can gradually reduce muscle load after exercise; prevent hypothermia, dizziness, and fainting immediately following exercise; increase intravenous reflux and recovery; attenuate muscle cramps; and decrease muscle pain (4,6). Cold-water immersion is a form of "cryotherapy" that minimizes edema due to bleeding by reducing blood supply, attenuates muscle damage, and promotes recovery following high-intensity exercise (11). Despite evidence regarding the benefits of both cool-down exercise and cryotherapy, no studies have compared the extent to which these techniques are effective, compared to static rest, and their effectiveness to improve athletic performance remains to be sufficiently verified.

Therefore, we aimed to examine the effects of cool-down exercise and cold-water immersion therapy on basic components of physical fitness (e.g., agility, speed, power, and balance) and sport-specific skills (e.g., dribbling, shooting, and kicking) in college soccer players, and to provide baseline data for effective recovery programs for college soccer players.

## Methods

### *Participants*

The study was conducted in August 2020 and included 21 players registered with the Korean Football Association. All study participants provided informed consent, and the study design was approved by the Korea National Sports University (IRB number: 20200612-043). The characteristics of the participants are listed in Table 1.

**Table 1:** Participant characteristics

| *Group* | *n* | *Age (yr)* | *Height (cm)* | *Weight (kg)* | *Body mass index (kg/m²)* | *Body fat (%)* | *Skeletal muscle mass (kg)* |
|---|---|---|---|---|---|---|---|
| Control | 7 | 20.28 ± 1.11 | 181.27 ± 6.42 | 75.72 ± 4.10 | 23.04 ± 0.59 | 12.68 ± 2.25 | 37.68 ± 2.48 |
| Cool-down exercise | 7 | 20.28 ± 0.95 | 179.57 ± 6.76 | 74.94 ± 6.81 | 23.19 ± 0.65 | 12.44 ± 2.62 | 37.32 ± 3.86 |
| Cool-down exercise plus cold-water immersion | 7 | 19.85 ± 0.89 | 177.12 ± 9.03 | 72.37 ± 8.62 | 22.98 ± 0.75 | 13.30 ± 1.91 | 35.62 ± 4.72 |

Values are means ± standard deviations

Once enrolled, participants were randomly allocated to three different recovery method: a control group (CG, n=7), a cool-down exercise group (CDG, n=7), and a cool-down exercise plus cold-water immersion group (CDCWG, n=7). Exclusion criteria were the presence of musculoskeletal injury of the lower limbs in the preceding 6 months and physical limitations that would hinder participation in the recovery programs.

### *Basic physical fitness*

The Southeast Missouri (SEMO) Agility Test assesses an individual's ability to move the body forward, backward, and sideways. In this study, measurements were obtained as participants ran sideways from A to B, ran backward from B to C, ran forward from C to A, ran from A to D, ran forward from D to B, and finally ran sideways from B to A. The temporal resolution of the SEMO was 0.1 s. Speed was assessed using a 20-m sprint test. The test was performed twice and the best result (i.e., shortest time in s) was recorded. Power was assessed using a countermovement jump test, measured a TKK-5406 instrument (TAKEI, Japan), and the maximum height reached while in the upright position after a vertical jump with maximal recoil was recorded. The test was performed twice and the best result was recorded. The Y-Balance Test Kit™ (Functional Movement Systems, Danville, VA) was used to evaluate dynamic balance at the ankle. Details regarding the procedures for obtaining measurements in the Y-balance test can be found in Powden et al (13).

### *Sport-specific skills*

A 22-meter dribble test was used to assess a player's ability to dribble the ball accurately and quickly despite changes in speed within short and narrow spaces. Each player waited 50 cm away from the starting line. At the signal by the investigator, the player began dribbling through both zigzag and 10-m straightaway sections, spaced 2 m apart, requiring acceleration and deceleration between a series of cones. A penalty of 2 s was imposed each time the player knocked a cone over, passed by a cone, or did not turn around. The test was performed twice, and the best result was recorded.

In the shooting speed test, players were positioned 11 m away from the goal and the shooting speed of an instep kick was recorded using a speed gun with a precision of 0.1 s (Bushnell, USA). The test was performed twice and the best result was recorded.

The kick accuracy test was scored as follows: The player was positioned 34 m away from a circle drawn within a square. If a kicked ball stopped within the circle, the player was awarded 3 points. If the ball stopped within the square outside the circle, the player was awarded 1 point. However, if the ball failed to enter the circle, the player was awarded 0 points. Each player was allowed five kicks, and the total score was recorded.

### *Recovery program*

A pretest was conducted at 9:00 AM on day 1. After completing the basic physical fitness and sport-specific skill assessments, players participated in a high-intensity practice soccer game (exercise) for 90 min. Following the practice game, the CG engaged in 15 minutes of static stabilization (sit and rest), while the CDG walked on the field at a speed of 5 km/h for 10 minutes and then performed free exercise, including stretching for 5 minutes. The CDCWG was allowed to participate in the CDG program, following which they were completely submerged in water with a temperature of 10 °C up to the iliac crest for an additional 10 min (12). A posttest, including both basic physical fitness and sport-specific skill assessments, was conducted at 9:00 AM on day 2.

### *Statistical analysis*

All values were reported as the mean ± standard deviation using Windows SPSS version 21.0 (IBM Corp., Armonk, NY, USA). A repeated-measures analysis of variance was performed to evaluated differences according to time, group, and time × group interactions. If significant differences were observed, a post hoc paired *t*-test was used to examine group differences. The level of statistical significance was set at $P<0.05$.

## Results

The changes in basic physical fitness parameters observed following participation in each recovery program are reported in Table 2. Although there was no significant group effects for the SEMO Agility Test ($P$=0.125), 20-m sprint ($P$=0.074), and vertical jump ($P$=0.813), there was a significant effect of time ($P$<0.00) and a time × group interaction ($P$<0.001).

**Table 2:** Changes in basic physical fitness parameters for each recovery method

| *Item* | | | *Pre* | *Post* | *Significance* |
|---|---|---|---|---|---|
| Agility (s) | SEMO agility test | CG | 11.31 ± 0.69 | 11.97 ± 0.73$^{c}$ | T: $P$<0.001$^{***}$ |
| | | CDG | 10.82 ± 0.52 | 11.20 ± 0.55$^{c}$ | T×G: $P$<0.001$^{***}$ |
| | | CDCWG | 10.94 ± 0.77 | 11.00 ± 0.60 | G: $P$=0.125 |
| Speed (s) | 20-m sprint | CG | 3.67 ± 0.28 | 4.12 ± 0.13$^{c}$ | T: $P$<0.001$^{***}$ |
| | | CDG | 3.60 ± 0.45 | 3.78 ± 0.13$^{c}$ | T×G: $P$<0.001$^{***}$ |
| | | CDCWG | 3.44 ± 0.33 | 3.51 ± 0.25 | G: $P$=0.074 |
| Power (cm) | Vertical jump | CG | 71.00 ± 5.53 | 67.28 ± 5.34$^{c}$ | T: $P$<0.001$^{***}$ |
| | | CDG | 70.14 ± 3.80 | 67.28 ± 3.90$^{c}$ | T×G: $P$<0.001$^{***}$ |
| | | CDCWG | 70.85 ± 6.89 | 70.28 ± 7.38 | G: $P$=0.813 |
| Y-Balance test (cm) | Left | CG | 87.47 ± 1.81 | 85.86 ± 2.30$^{c}$ | T: $P$<0.001$^{***}$ |
| | | CDG | 88.48 ± 2.77 | 86.92 ± 2.96$^{b}$ | T×G: $P$=0.009$^{**}$ |
| | | CDCWG | 90.46 ± 2.55 | 90.21 ± 3.05 | G: $P$=0.043$^{*}$ |
| | Right | CG | 88.10 ± 1.97 | 86.19 ± 2.34$^{c}$ | T: $P$<0.001$^{***}$ |
| | | CDG | 89.61 ± 3.85 | 87.98 ± 4.22$^{a}$ | T×G: $P$=0.011$^{*}$ |
| | | CDCWG | 90.76 ± 3.68 | 90.72 ± 4.05 | G: $P$=0.174 |

Values are means ± standard deviations.
CG, control group; CDG, cool-down exercise group; CDCWG, cool-down exercise plus cold-water immersion group; SEMO: Southeast Missouri; T, time; G, group; T×G, interaction.
$^{*}P$<0.05, $^{**}P$<0.01, $^{***}P$<0.001; tested via analysis of variance with repeated measures
$^{a}P$<0.05, $^{b}P$<0.01, $^{c}P$<0.001; tested via paired $t$-test (post hoc)

Post hoc analysis revealed significant differences between the pretest and posttest for these three tests for the CG (all $P$<0.001) and CDG (all $P$<0.001), but not the CDCWG. Significant effects of time ($P$<0.001), group ($P$=0.043), and a significant time × group interaction ($P$=0.009) were identified for the Y-balance test (left). Post hoc analysis revealed significant differences between the pretest and posttest for the CG ($P$<0.001) and CDG ($P$<0.01), but not the CDCWG. There were no between-group differences in the Y-balance test (right) however ($P$=0.174), although a significant effect of time ($P$<0.001) and a significant time × group interaction ($P$=0.011) were identified. Post hoc analysis again revealed significant differences between the pretest and posttest for the CG ($P$<0.001) and CDG ($P$<0.05), but not the CDCWG.

Changes in sport-specific skill performance between the pretest and posttest are shown in Table 3. While there were no significant between-group differences for the 22-m dribble test ($P$=0.377), there was a significant effect of time ($P$<0.001) and a significant time × group interaction ($P$<0.001). Post hoc analysis revealed significant differences between the pretest and posttest in the CG ($P$<0.001) and CDG ($P$<0.001), but not the CDCWG. Similarly on the shooting test, although there were no between-group differences (left, $P$=0.294; right, $P$=0.348), there were significant effects of time (both $P$<0.001) and significant time × group interactions (both $P$<0.001). For both the left and right shooting test, post hoc analysis revealed significant differences between the pretest and posttest in the CG ($P$<0.001), but not the CDG or CDCWG. There was no significant effect of group (left, $P$=0.457; right, $P$=0.059) or a time × group interaction (left, $P$=0.358; right, $P$=0.137) in the kick test; however, there was a significant effect of time (both $P$<0.001). For the left kick test, post hoc analysis revealed significant differences between the pretest and posttest in the CG ($P$<0.001), but not the CDG or CDCWG. For the right kick test, post hoc analysis revealed significant differences between the pretest and posttest in the CG ($P$<0.001) and CDG ($P$<0.001), but not the CDCWG.

**Table 3:** Changes in sport-specific skill performance for each recovery method

| *Item* | | | *Pre* | *Post* | *Significance* |
|---|---|---|---|---|---|
| Dribbling (second) | 22-m dribble | CG | 12.70 ± 0.54 | 13.44 ± 0.65[c] | T: $P$<0.001*** |
| | | CDG | 12.32 ± 0.74 | 12.78 ± 0.80[c] | T×G: $P$<0.001*** |
| | | CDCWG | 13.02 ± 0.82 | 13.01 ± 0.84 | G: $P$=0.377 |
| Shooting (km/h) | Left | CG | 97.71 ± 4.85 | 93.42 ± 4.68[c] | T: $P$<0.001*** |
| | | CDG | 97.42 ± 3.55 | 97.28 ± 2.98 | T×G: $P$<0.001*** |
| | | CDCWG | 98.71 ± 1.97 | 98.28 ± 1.25 | G: $P$=0.294 |
| | Right | CG | 103.28 ± 5.87 | 97.00 ± 5.74[c] | T: $P$<0.001*** |
| | | CDG | 102.42 ± 2.69 | 102.00 ± 2.51 | T×G: $P$<0.001*** |
| | | CDCWG | 104.14 ± 5.78 | 103.71 ± 4.95 | G: $P$=0.348 |
| Kicking (points) | Left | CG | 7.28 ± 1.88 | 5.42 ± 1.39[c] | T: $P$<0.001*** |
| | | CDG | 7.85 ± 1.77 | 6.28 ± 1.88 | T×G: $P$=0.358 |
| | | CDCWG | 7.57 ± 1.51 | 6.23 ± 1.70 | G: $P$=0.457 |
| | Right | CG | 8.00 ± 1.41 | 6.28 ± 0.75[c] | T: $P$<0.001*** |
| | | CDG | 8.42 ± 0.97 | 7.57 ± 0.97[c] | T×G: $P$=0.137 |
| | | CDCWG | 8.85 ± 1.67 | 8.28 ± 0.95 | G: $P$=0.059 |

Values are means ± standard deviations.
CG, control group; CDG, cool-down exercise group; CDCWG, cool-down exercise plus cold-water immersion group; T, time; G, group; T×G, interaction.
*$P$<0.05, **$P$<0.01, ***$P$<0.001; tested via analysis of variance with repeated measures
[c]$P$<0.001; tested via paired $t$-test (post hoc)

## Discussion

Herein, we examined the effects of cool-down exercise and cold-water immersion therapy on several elements of basic physical fitness and sport-specific skills among college soccer players. Our results indicate that combining cool-down exercise with cold-water immersion could improve the effectiveness of the recovery program among college soccer players.

Çakır and Şenel (14) who reported significant differences in results on the Illinois Agility Test between the control group and cold-water immersion group following muscle damage, consistent with our findings. Therefore, cold-water immersion therapy leads to rapid physiological recovery, thereby restoring agility. The concentration of lactate in the blood is used as a predictor of recovery from fatigue and exercise capacity. Blood lactate increases rapidly during high-intensity exercise and excess lactic acid accumulation in the body decreases the ability to synthesize the energy required for exercise (15). Cold-water immersion therapy has been reported to decrease the lactic acid concentration (16), which may explain the observed recovery of agility in the posttest in our study. Together, these findings suggest that cold-water immersion can help to accelerate recovery in college soccer players.

Speed is among the most important components of physical fitness required in soccer games. Elite bicycle motocross riders who chose cold-water immersion therapy as a recovery method exhibited increases in maximum sprint power, as well as reduced delayed muscle pain and fatigue (17). Cold-water immersion therapy tends to improve the recovery of anaerobic power after exercise, which is consistent with our findings (18). High-intensity training or competition causes muscle damage, which results in inflammatory reactions and oxidative stress, and cold-water immersion therapy has been shown to attenuate these responses, thereby promoting recovery (19-20). Consequently, our results suggest that cold-water immersion after exercise mitigates inflammatory reactions and reduces the release of muscle-damage triggers, resulting in rapid recovery of speed. Therefore, cold-water immersion therapy may be appropriate for restoring speed in college soccer players.

The ability to generate maximum force in a short period of time is defined as power, which is an essential component of physical fitness for most athletes. Cold-water immersion increased the perceived level of recovery by improving jump performance (i.e., power) and reducing pain after exercise. In a study of elite basketball players (21). Cold-water immersion immediately after a game was associated with a 45% increase in jump performance, which is similar to the results of our study (22). Therefore, cold-water immersion aids in the recovery of power by alleviating muscle fatigue and pain.

Balance ability can be defined as the ability to maintain posture and form during exercise without falling. For soccer in particular, handling the ball with one foot requires one to maintain balance while on one foot, with stamina being a critical factor for maintaining balance when heading, running, shooting, and changing direction quickly (1,5). Consistent with our findings, a previous study reported significant recovery of balance relative to the control group in female karate athletes who underwent cold-water immersion therapy after competition (23). These results suggest that cold-water immersion can attenuate decreases in joint range of motion caused by muscle pain, thereby restoring balance ability. Muscle pain is a reaction similar to the acute inflammatory response and may result in a decrease in flexibility due to stiffening of the joints and tissues around the joints (24). Cold-water immersion minimizes bleeding by constricting blood vessels in the area affected by muscle pain and suppresses the inflammatory reaction and development of edema by lowering the intracellular metabolic rate (25). These mechanisms may explain the finding that cold-water immersion therapy was effective in restoring balance ability in college soccer players.

Dribbling, defined as the controlled movement of the ball using one's feet, shooting, and kicking are essential technical skills in soccer (5). Our findings indicated that cold-water immersion therapy promoted recovery of these sport-specific abilities. Cold-water immersion therapy following high-intensity exercise or competition can promote the recovery of physical fitness, with a combination of cold temperature and hydrostatic pressure for optimal recovery (18). Cold-water immersion therapy reduces muscle damage and delayed-onset muscle pain in elite players, which may help to promote the recovery of exercise performance (26-27).

The limitations of our study should be acknowledged in the interpretation of results. First, because the participants were recruited from a local area registered with the Korean Football Association in Seoul, they did not represent the entire population of college soccer players in Korea. Second, the sample size of this study was small (n=21), and only men participated, limiting the generalizability of our results. Future studies should include female participants to determine whether there are sex-based differences in the recovery of basic fitness and sport-specific abilities following cold-water immersion therapy. Third, cold-water immersion was applied in a relatively acute setting in this study and we did not conduct follow-up testing to investigate the long-term effects of the intervention. Fourth, we did not investigate variations in water temperature, exercise time, exercise duration, or exercise intensity; therefore, further studies are required.

## Conclusion

Addition of cold-water immersion therapy to a recovery program including cool-down exercise can help to restore agility, speed, power, and balance ability following high-intensity activity among college soccer players. Recovery of these major physical fitness factors also resulted in positive effects on sport-specific skills such as dribbling, shooting, and kicking. Further studies are required to determine the long-term effects of the intervention, as well as the effects of water temperature, exercise time, exercise duration, and exercise intensity.

## Ethical considerations

Ethical issues (Including plagiarism, misconduct, data fabrication and/or falsification, double publication and/or submission, redundancy, etc.) have been completely observed by the authors.

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## Conflict of interest

The authors have no conflicts of interest to declare.

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