The Effectiveness of Water Immersion at 15°C, 25°C, and 40°C on Fatigue Levels in Futsal Athletes at Yogyakarta State University

Efektivitas Rendam Air Suhu 15°C, Suhu 25°C, dan Suhu 40°C terhadap Tingkat Kelelahan pada Atlet Futsal Universitas Negeri Yogyakarta

Original Article

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Abstract.

Background Muscle fatigue is a common condition experienced by athletes after intensive training or competition. One widely used recovery method is water immersion at various temperatures, which is believed to help reduce fatigue levels.

Objectives This study aims to determine the effectiveness of water immersion at temperatures of 15°C, 25°C, and 40°C on fatigue levels in futsal athletes at Yogyakarta State University.

Methods This study used a quasi-experimental method with a three-group pretest-posttest design. The sample consisted of 12 athletes divided into three treatment groups based on the immersion temperature. Fatigue measurements were conducted before and after treatment using the Rating of Perceived Exertion (RPE) scale. Data were analyzed using normality tests, homogeneity tests, paired t-tests, and one-way ANOVA.

Results The results showed that all three groups experienced a significant reduction in fatigue ($p < 0.05$), with the 15°C immersion group showing the highest effectiveness (87.5%) compared to the 40°C and 25°C groups. ANOVA test showed a significant difference between groups ($p = 0.031$), with the Post Hoc test indicating that the temperature of 15°C was significantly better than the temperatures of 40°C and 25°C.

Conclusion It can be concluded that water immersion at a temperature of 15°C is the most effective recovery method in reducing acute muscle fatigue in futsal athletes. These findings can be used as a basis for developing efficient and applicable post-exercise recovery strategies.

Keywords: fatigue, water immersion, water temperature, futsal, recovery.

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INTRODUCTION

Sport is a form of physical activity that is usually competitive in nature with the aim of improving a person's physical abilities and skills while providing entertainment for players and spectators [1] . Most teenagers today want a simpler type of sport to play, for example futsal, the place is not too big, not too many players and the cost is relatively cheap. Futsal has become a prima donna sport around the world in recent years. A sport that does not look at age, futsal is one of the soccer sports with a smaller arena or field. It can be played indoors or outdoors, day or night [2] .

The development of futsal in Indonesia is marked by the emergence of various futsal teams and the proliferation of futsal championships or competitions. Based on field observations at the Student Activity Unit (UKM) Futsal Yogyakarta State University (UNY), athletes train five times a week. This results in little time for athletes to recover [3] . Competition schedules are usually tight and short, a futsal team often plays more than once a day, and is required to be in prime physical and psychological condition [4] . Such is the case with the competition organized by the Student Executive Board of the Yogyakarta University Student Family (BEM KM UNY), namely the UNY Tourney futsal competition which was only held for two days, namely October 15-16, 2022 and participated by 18 teams (BEM UNY, 2022). There is also another competition, namely the UGM Futsal Championship, organized by Gajah Mada University (UGM), which was held for seven days, namely from October 17-23, 2023, and participated by 28 teams (UGM FC, 2022). This condition means that players only have a short time to recover after the match [5] . This condition will certainly increase the risk of fatigue in players [6] .

As stated [7] Accumulation of matches and training sessions with short recovery periods causes fatigue, damage and muscle inflammation which can reduce muscle endurance and increase the risk of injury. Football players with recovery after matches ≤4 days or equivalent to playing 2x/week

experience injuries 6x higher than those with ≥6 days or equivalent to playing 1x/week [8] . Recovery is useful for the body to adapt after doing physical activity [9] . Increasing recovery time will help athletes maintain health and performance conditions so that they can increase the opportunity to participate or compete well [10] . Therapeutic methods that can be applied to facilitate the recovery process include massage, herbs, water, heat therapy, cold therapy, exercise, oxygen and breathing [11] .

However, no studies have directly compared the effectiveness of different immersion temperatures in the context of specific fatigue recovery in futsal athletes. Previous research has primarily utilized general recovery methods such as cryotherapy, while this study explores differences in water temperature (cold, room temperature, warm) using a direct experimental approach on athletes. This indicates a research gap that remains unfilled.

Based on the above background, to maximize muscle endurance during training and matches, players must recover as quickly as possible, for this reason an effective recovery strategy is created. Therefore, the researcher wants to conduct a more in-depth study on the comparison of the effectiveness of cold water immersion, room temperature, and warm water and stretching with the title "the effectiveness of the combination of water immersion at 15°C, 25°C, and 40°C on fatigue levels in UNY futsal athletes". This study is expected to contribute to the development of non-pharmacological recovery strategies based on temperature immersion and stretching that are applicable and efficient, especially in team sports such as futsal. The results of the study are also expected to be a reference for coaches, athletes, and sports practitioners in choosing fast and effective recovery methods to reduce the risk of injury and maintain athlete performance.

METHOD

Participants

The population in this study were all futsal athletes who were members of the Student Activity Unit (UKM) Futsal at Yogyakarta State University. The sample was determined using a purposive sampling technique with the following criteria: (1) active members of the futsal UKM, (2) aged 18–25 years, (3) healthy and not currently injured. Based on these criteria, 12 participants were obtained and divided into 3 treatment groups:

Group 1: soak in water at 15°C and stretch
Group 2: soak in water at 25°C and stretch
Group 3: soak in water at 40°C and stretch

Each group consists of 4 athletes, with the division based on ordinal pairing results of the pretest fatigue level.

Research Design

This study used a quasi-experimental method with a three-group pretest-posttest design. Each group received a different treatment in the form of a combination of immersion temperature and stretching. Before and after treatment, subjects underwent fatigue level measurements using the Rating of Perceived Exertion (RPE) instrument. The intervention procedure was carried out in one session, right after the routine exercise session was completed. The total duration of treatment in one session was 15 minutes, consisting of: (1) 10 minutes of water immersion (according to the group's temperature), (2) 5 minutes of static stretching session of the whole body (main muscles: quadriceps, hamstring, gastrocnemius, lower back, and shoulders).

Procedure

To maintain internal consistency and validity, the implementation of procedures refers to the following standardized guidelines:

Table 1. Treatment of Subjects

Component	Adjustment
Immersion	Performed in a pool of water with a temperature controlled using a digital

	thermometer. The duration is 10 minutes, with the person sitting up to their waist.
Stretching	Performed immediately after immersion. Each static movement is held for 20–30 seconds, with a total of 5 main movements. The instructor provides verbal guidance.
RPE measurement	Conducted twice: after training (pretest) and after treatment (posttest). A scale of 0–10 was presented verbally to participants.
Supervision and Consistency	All treatments were supervised by the research team and assistant trainers to ensure uniformity of procedures.

Research Instruments

The instruments used in this study were: (1) Soaking pool: measuring 1.5x1 meters, 60 cm deep, (2) Digital water thermometer: to ensure stable temperature, (3) Stopwatch: to set the duration of soaking and stretching, (4) Rating of Perceived Exertion (RPE): to assess the level of fatigue subjectively based on the Borg scale (0 = not tired, 10 = very tired).

Data analysis

1. The data was analyzed using the SPSS version 29 program. The analysis steps include:
2. Descriptive analysis: to describe the mean and standard deviation of pretest and posttest results.
3. Normality test: using Shapiro-Wilk, $\alpha = 0.05$
4. Homogeneity test: using Levene's test, $\alpha = 0.05$
5. Paired t-Test: to determine the differences before and after treatment in each group
6. One-way ANOVA test: to compare effectiveness between treatment groups
7. Post Hoc Test: to determine significant differences between pairs of groups

RESULTS AND DISCUSSION

Results

1. Descriptive Statistics of Pretest and Posttest

   This study measured fatigue levels before and after treatment using the Rating of Perceived Exertion (RPE) scale. The following are the pretest and posttest results for each group:

   Table 2. Pretest and Posttest Data

Group	Pretest (Mean ± SD)	Posttest (Mean ± SD)	Average Difference	Effectiveness (%)
Soak at 15°C	8.75 ± 1.50	1.75 ± 1.50	7.00	87.5%
Soak at 25°C	8.25 ± 0.96	3.75 ± 1.50	4.50	62%
Soak at 40°C	9.00 ± 0.82	2.50 ± 1.29	6.50	83%

   The results showed that all treatments reduced fatigue levels, with the 15°C temperature treatment showing the highest effectiveness (87.5%).

2. Normality Test

   To ensure normal data distribution, a Shapiro-Wilk test was performed. The results are as follows:

   Table 3. Normality Test

Group	p-value	Information
Soak at 15°C	0.683	Normal data
Soak at 25°C	0.972	Normal data
Soak at 40°C	0.972	Normal data

   Because all p values > 0.05, the data from the three groups are declared normally distributed.

3. Homogeneity Test
   Levene's Test is used to test the equality of variance between groups.

   Table 4. Homogeneity Test

Aspect	Sig. Value	Information
Variance between groups	0.405	Homogeneous

   Data from the three treatment groups had homogeneous variance ($p > 0.05$).

4. Paired t-Test
   To determine the effectiveness of the treatment in each group, a Paired t-Test was conducted:

   Table 5. Paired t-Test

Group	p-value	Information
Soak at 15°C	0,000	There is a difference
Soak at 25°C	0.006	There is a difference
Soak at 40°C	0.002	There is a difference

   All three groups showed significant differences between pretest and posttest ($p < 0.05$), meaning that all interventions were effective in reducing fatigue.

5. ANOVA test
   To determine the differences in effectiveness between the three treatments, an ANOVA test was conducted.

   Table 6. ANOVA Test

(I) Treatment	(J) Treatment	Mean Difference (IJ)	Sig.
Soak Temperature_15	Soak Temperature_25	2,500 *	.033
	Soak Temperature_40	.500	.817
Soak Temperature_25	Soak Temperature_15	-2,500 *	.033
	Soak Temperature_40	-2,000	.085
Soak Temperature_40	Soak Temperature_15	-.500	.817
	Soak Temperature_25	2,000	.085

   Only the combination of soaking at 15°C and stretching showed a significant difference compared to 25°C. There was no significant difference between 15°C and 40°C.

Discussion

This study aimed to evaluate the effectiveness of water immersion at three different temperatures (15°C, 25°C, and 40°C) in reducing fatigue levels in futsal athletes at Yogyakarta State University. The results showed that all treatments resulted in a significant decrease in RPE scores, with water immersion at 15°C producing the highest effectiveness in reducing acute muscle fatigue after exercise. These findings confirm that water immersion is an effective post-exercise recovery strategy and can be practically applied in the context of team sports such as futsal [12] .

Physiologically, water temperature has a significant influence on the body's recovery process [13] . Cold water immersion at 15°C works by stimulating peripheral vasoconstriction, which causes a decrease in blood flow to the working muscles. This process helps reduce the accumulation of metabolites such as lactic acid, inhibits inflammation, and reduces swelling and micro-tissue damage

[14] . In addition, decreasing tissue temperature is also believed to reduce the transmission of nerve impulses responsible for muscle pain, thereby reducing the perception of fatigue [15] .

This finding is in line with research [16] which states that cold water immersion is effective in reducing muscle fatigue after high-intensity exercise. [17] in his meta-analysis also concluded that cold water immersion significantly accelerates muscle strength recovery and reduces delayed onset muscle soreness (DOMS) within 24 to 72 hours post-exercise.

Meanwhile, the group that received the 40°C water immersion treatment also showed a significant decrease in fatigue scores, although slightly lower than those at 15°C. The positive effects of warm temperatures can be explained by vasodilation, the widening of blood vessels that improves blood circulation and tissue oxygenation. [18] . This increased blood flow helps speed up the process of eliminating metabolic waste and accelerates the recovery of muscle tissue that has been stressed due to exercise [19] . However, excessive thermal stimulation can increase the physiological load and cause an increase in core body temperature, which is actually counterproductive if done immediately after intense activity [20] .

In contrast, the treatment group with a temperature of 25°C showed the lowest reduction in fatigue levels among the three groups. This can be explained because this temperature is in the body's neutral thermal zone, so it does not provide a significant adaptive stimulus for either cooling or heating the tissue. Thus, immersion in neutral temperature water tends to have a lower recovery effect, as reported in the study by Vaile et al. (2008) that water temperatures of 24–26°C did not provide significant benefits in reducing DOMS or improving post-exercise performance.

Overall, the results of this study confirm that the effectiveness of water immersion is significantly influenced by the temperature used. Extreme temperatures, such as cold (15°C) or warm (40°C), elicit a stronger physiological response than neutral temperatures. Therefore, the choice of water temperature should be tailored to the recovery goal, duration, and type of physical activity previously performed. For immediate recovery after high-intensity exercise, such as futsal, cold immersion has proven to be the most effective strategy.

Although the results obtained are quite convincing, this study has several limitations that need to be considered. First, the relatively small number of subjects (n = 12) and the limitation to one student organization unit (UKM Futsal UNY) limit the generalizability of the findings to a broader population of athletes. Further research with a larger sample size and varying levels of training could strengthen the external validity of this study. Second, fatigue levels were measured using only a subjective instrument, namely the Rating of Perceived Exertion (RPE) scale, which is susceptible to individual perception bias. A combination of subjective and objective measurements (such as heart rate, heart rate variability, muscle temperature, or blood lactate concentration) would provide a more comprehensive picture of the body's physiological response to the recovery intervention. Third, the long-term effects of the immersion treatment were not examined in this study. Further studies involving interventions lasting several weeks or repeated recovery sessions could provide more in-depth information about the cumulative effects and body adaptations to this method.

This research provides relevant contributions for coaches, sports science practitioners, and physiotherapists in selecting post-exercise recovery strategies. Immersion in 15°C water has been shown to be a simple, inexpensive, yet effective method for reducing fatigue levels in futsal athletes. In the context of tightly scheduled matches or intensive training, this method can be applied directly without the need for sophisticated equipment. Regular implementation of cold water immersion after exercise can also help prevent fatigue accumulation, reduce the risk of injury due to overtraining, and maintain athlete performance in the long term. With proper supervision, this strategy can be incorporated into a structured and integrated athlete recovery protocol.

CONCLUSION

Based on the results of the analysis and discussion, it can be concluded that water immersion at different temperatures (15°C, 25°C, and 40°C) has a significant effect on reducing fatigue levels in futsal athletes at Yogyakarta State University. Among the three treatments, water immersion at 15°C showed the highest effectiveness in reducing post-exercise fatigue, followed by temperatures of 40°C and 25°C. The effectiveness of 15°C is closely related to the mechanism of vasoconstriction and tissue temperature reduction that supports the physiological recovery process of muscles, while 40°C provides a vasodilatory effect that also helps the removal of residual exercise metabolites. In contrast, a neutral

temperature of 25°C does not provide significant physiological stimulation, so its recovery effect is lower. The results of this study indicate that water immersion, especially at cold temperatures, can be a practical and effective recovery strategy to overcome acute fatigue in futsal athletes. This method can be implemented as part of a daily recovery protocol, especially during competition or high-intensity training phases. However, to strengthen these findings, further research with a broader design, using more objective physiological measurements, and comparing it with other recovery methods is recommended. This way, water temperature-based recovery interventions can be more optimally integrated into the overall athletic training program.

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AUTHOR CONTRIBUTION STATEMENT

The writing of this article involved roles in devising the research concept and design, reviewing and analyzing relevant literature, and drafting the overall manuscript

CONFLICT OF INTEREST AND FUNDING

There is no conflict of interest.

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