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The effect of cold water immersion on arm muscle strength in the basketball team

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Abstract

The goal of this study is to determine the effect of cold water immersion on the arm muscle strength of the basketball team at SMA Negeri 3 of Malang City. This research utilizes an experimental study method. The design used in this research is the "One-group pretest-posttest design". The results of the study show that the pretest results for the arm muscle strength of the female's basketball team indicate an average arm muscle strength score of 14.33 for the pull test and 15.50 for the push test, whereas the posttest results for arm muscle strength become 14.33 for the pull test and 15.66 for the push test. The significance values obtained are 1.000 for the pull test and 0.802 for the push test. Meanwhile, the results for the male's basketball team indicate that the pretest results for arm muscle strength show an average arm muscle strength score of 20.33 for the pull test and 24.16 for the push test, while the posttest results become 22.16 for the pull test and 25.91 for the push test. The significance values obtained are 0.042 for the pull test and 0.006 for the push test. Thus, it can be concluded that there is no effect of recovery using cold water immersion on the arm muscle strength of the female's basketball team at SMA Negeri 3 of Malang City, but there is an effect of recovery using cold water immersion on the arm muscle strength of the male's basketball team at SMA Negeri 3 of Malang City.

Keywords: arm muscle strength; basketball; cold water immersion

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INTRODUCTION

Sport is a physical activity enjoyed by many people, as everyone can choose the type of sports they prefer. In the Indonesian Law (UUD RI) No. 3 concerning the national sports system, it is stated that besides being a medium for achievement, sports can also serve as recreation (Yuliandra & Fahrizqi, 2019). According to Fatahillah (2018), participating in sports is essential for people of all backgrounds to maintain physical health. Among many sports in Indonesia, one of the most popular is basketball. Basketball, according to Widarto et al. (2021), is a sport involving a large ball that is played using the hands, and it is also one of the most competitive team sports. The objective of basketball is to score as many points as possible by delivering the ball into the opponent's basket while also defending one's own basket from opponents aiming to score points. Complex movements or combinations of multiple actions

such as walking, running, and jumping, are seen in basketball games (Nugroho & Gumantan, 2020).

Basketball is a sport that demands high levels of physical activity, as players must run, walk, jump, and perform other movements. Moreover, basketball requires skill, mastery of the game, and effective strategies. Each basketball player must be proficient in basic techniques such as dribbling, passing, shooting, catching, and rebounding. Mastering these basic techniques is crucial, particularly in passing, shooting, and rebounding. These techniques serve as essential offensive strategies often used to score points in a game (Putri et al., 2020). To support it, excellent achievements of this sport are based on technical mastery, tactics, mental toughness, and optimal physical condition (Nugroho & Yuliandra, 2021). Basketball is a sport that demands strong arm muscles, which play a vital role in executing fundamental basketball techniques such as dribbling, passing, and shooting (Putri & Rifki, 2020).

Arm muscle strength is an important fundamental physical requirement for achieving success in basketball. According to Putri et al. (2020), one of the factors that hinder players from reaching maximum performance is poor arm muscle strength during a basketball game. Arm muscle strength is the capacity of the arm muscles to use their maximum energy in contraction or movement (Nuryadi, 2019). Therefore, arm muscle strength is essential in basketball, especially in dribbling, shooting, and passing techniques. To maintain good physical condition, it is necessary to also consider the recovery methods after training. The application of recovery is crucial after physical activity, as it is the process of returning the body to its normal condition after training (Koesherawati et al., 2022). Given the importance of recovery, few studies have examined the effect of cold water immersion (CWI) on arm muscle strength, especially within the basketball team at SMA Negeri 3 of Malang City. By implementing recovery using the CWI method, faster recovery can be achieved, which will positively impact the maintenance of physical condition, particularly in muscle recovery.

Cold Water Immersion (CWI) is a method that athletes can use to shorten recovery time and return to pre-training form. The immersion method in cold water, often referred to as cold water immersion, is one of the most effective recovery techniques today (Firmanus et al., 2023). The purpose of applying the CWI method is to assess its impact on arm muscle strength. According to Kusuma et al. (2020), CWI effectively reduces lactate levels, muscle soreness, and stress after exercise. Similarly, research by Harun & Sahedi (2021) demonstrates that after high-intensity training, CWI has a significant effect on faster muscle soreness recovery. Additionally, a study by Nurusyaikhi et al. (2023) shows that one of the main benefits of the CWI method is reducing delayed onset muscle soreness, thereby improving physiological and

psychological recovery after exercise. By enhancing recovery and the cumulative impact of elevated training levels, CWI helps the improvement of training quality and eventually conduct the competitive performance through a better recovery. The commonality in these studies is that the CWI method yields faster and more effective muscle recovery, helping maintain physical condition in preparation for subsequent training or competitions.

Based on this discussion, recovery using the CWI method has been shown to expedite muscle recovery after training. Therefore, the concern of post-training recovery is crucial for the basketball team to maintain physical readiness for the next practice or competition. Accordingly, this study aims to contribute to developing effective muscle recovery methods for basketball teams. Although numerous studies have explored various recovery methods, no research has examined CWI's effect on arm muscle strength, particularly in the basketball team at SMA Negeri 3 of Malang City. This is the basis for proposing this research, titled "The Effect of Cold Water Immersion on Arm Muscle Strength in the Basketball Team at SMA Negeri 3 of Malang City".

METHOD

This study employs an experimental research design. The design used in this study is the "One-group pretest-posttest design", which involves a single group with a pretest conducted before the treatment and a posttest afterward. The design can be illustrated as follows:

Table 1. One Group Pretest-Posttest Design

Subject	Pretest	Treatment	Posttest
R	O_1	X	O_2

Source: (Winarno, 2018)

Description:

R : Basketball Team at SMA Negeri 3 of Malang City

O_1 : Pretest

X : Treatment using cold water immersion

O_2 : Posttest

In the One-group pretest-posttest design, the researcher will initially conduct a pretest on the experimental group using the expanding dynamometer test to determine the arm muscle strength before the treatment. After conducting the pretest, the researcher will administer recovery using cold water immersion as the treatment for the experimental group. This research was conducted in Malang City, East Java Province, specifically at SMA Negeri 3 of Malang City. The study was carried out from July to August, with a total of 18 sessions, including both

the pretest and posttest. The sample for this study was selected using total sampling technique, encompassing all members of the population, which consists of 24 basketball athletes (12 female athletes and 12 male athletes) from SMA Negeri 3 of Malang City.

The test used is the expanding dynamometer test, which measures the strength of the tensile test and the push test of the arm muscles. The test norms are as follows:

Tabel 1. Norms of Pull Test Arm Muscle Strength (Expanding Dynamometer Test) in Men and Women

No.	Norm	Men (kg)	Women (kg)
1.	Very good	> 44	> 44
2.	Good	35 – 43.5	35 – 43.5
3.	Medium	26 – 34.5	26 – 34.5
4.	Less	18 – 25.5	18 – 25.5
5.	Very less	< 17.5	< 17.5

Source: Wiriawan (2017)

Tabel 2. Norms of Push Test Arm Muscle Strength (Expanding Dynamometer Test) in Men and Women

No.	Norm	Laki-laki (kg)	Perempuan (kg)
1.	Very good	> 44	> 44
2.	Good	35 – 43.5	35 – 43.5
3.	Medium	26 – 34.5	26 – 34.5
4.	Less	18 – 25.5	18 – 25.5
5.	Very less	< 17.5	< 17.5

Source: Wiriawan (2017)

Data collection procedures in this study used documentation and tests. The test used was the Expanding Dynamometer Test. The test was given to the testi before (pretest) and after (posttest) the testi was given treatment. The data analysis technique involves univariate analysis to assess the data distribution or normality using the Shapiro-Wilk Test, with the criterion that the p-value must be greater than alpha (0.05). For bivariate analysis, the Paired Sample T-test is used to compare the means of two data sets (pre-treatment and post-treatment data). The results of the data analysis are considered significant if $p < 0.05$ and not significant if $p > 0.05$.

RESULTS

In this study, data were obtained from the results of pretests and postests conducted on basketball team athletes at SMA Negeri 3 Malang City who had been given treatment in the form of cold water immersion, and the data from this study will be presented in several tables, as follows:

Demographic Test

Table 4. Respondent Characteristics Based on Age

Characteristics	Mean	Minimal	Maximal	Std. Deviation
Age	16.41	16.00	18.00	0.583

From the data in the table above, it can be concluded that the average of the respondents' age is 16.41 years, with the youngest being 16 years and the oldest 18 years.

Table 5. Respondent Characteristics Based on Gender

Characteristics	n	%
Gender:		
Females	12	50.0
Males	12	50.0

Based on the table above, the number of respondents in this study is evenly distributed across both genders.

Table 6. Respondent Characteristics Based on the Values of Pull Test and Push Test for Females

Characteristics	n	Mean	Min-Max	Std. Deviation
Pre-Test				
Pull Test	12	14.33	10-19	2.570
Push Test	12	15.50	9-20	3.343
Post-Test				
Pull Test	12	14.33	10-20	3.256
Push Test	12	15.66	8-21	4.206

Table 4 shows the average pretest score on the pull test as 14.33, and on the push test as 15.50, with the lowest score for the pull test is 10 and the highest is 19, while the lowest score for the push test is 9 and the highest is 20. In terms of posttest scores, the average score for the pull test is 14.33, and for the push test is 15.66, with the lowest pull test score being 10 and the highest is 20, and the lowest push test score being 8 and the highest is 21.

Table 7. Respondent Characteristics Based on the Values of Pull Test and Push Test for Males

Characteristics	n	Mean	Min-Max	Std. Deviation
Pre-Test				
Pull Test	12	20.33	11-37	6.773
Push Test	12	24.16	14-37	7.321
Post-Test				
Pull Test	12	22.16	11-39	7.553
Push Test	12	25.91	17-40	7.102

Table 5 shows the average pretest score for the pull test as 20.33 and for the push test as 24.16, with the lowest pull test score being 11 and the highest is 37, while the lowest push test score is 14 and the highest is 37. Meanwhile, for the posttest scores, the average score on the pull test is 22.16, and for the push test is 25.91, with the lowest pull test score being 11 and the highest is 39, and the lowest push test score being 17 and the highest is 40.

Normality Test

Table 8. Normality Test Results

Variables	Normality Test Results	Descriptions
Pull Test		
Females		
Pre-Test	0.118	Normal data distribution
Post-Test	0.247	Normal data distribution
Males		
Pre-Test	0.090	Normal data distribution
Post-Test	0.823	Normal data distribution
Push Test		
Females		
Pre-Test	0.722	Normal data distribution
Post-Test	0.293	Normal data distribution
Males		
Pre-Test	0.749	Normal data distribution
Post-Test	0.778	Normal data distribution

The results of the normality test on the pull and push test variables for females show a normal distribution of data in both pretest and posttest, so comparative analysis can be conducted using the Dependent T-test. Similarly, the results of the normality test on the pull and push test variables for males also show a normal data distribution in the pretest and posttest, allowing for comparative analysis using the Dependent T-test.

Dependent T-test

Female

Table 9. Comparison of Pull Test Before and After Treatment

Variable		Mean	95% CI	Mean Difference	P value
Pull Test	Before	14.33	-0.93 – 0.93	0.00	1.000*
	After	14.33			

According to Table 7, the average pull test result is 14.33 before and after the treatment. Additionally, statistical test results show no significant difference between the pull test before and after the treatment (p value = 1.000).

Table 10. Comparison of Push Test Before and After Treatment

Variable		Mean	95% CI	Mean Difference	P value
Push Test	Before	15.50	-1.59 – 1.26	-0.16	0.802*
	After	15.66			

In Table 8, the average push test result is 15.50 before the treatment, increasing to 15.66 afterward. Statistical test results indicate no significant difference between the push test before and after the treatment (p value = 0.802).

Male

Table 11. Comparison of Pull Test Before and After Treatment

Variable		Mean	95% CI	Mean Difference	P value
Pull Test	Before	20.33	(-3.58) – (-0.08)	-1.83	0.042*
	After	22.16			

In Table 9, the average pull test result is 20.33 before the treatment, increasing to 22.16 afterward. Statistical test results reveal a significant difference between the pull test before and after the treatment (p value = 0.042).

Table 12. Comparison of Push Test Before and After Treatment

Variable		Mean	95% CI	Mean Difference	P value
Push Test	Before	24.16	(-2.87) – (-0.62)	-1.75	0.006*
	After	25.91			

In Table 10, the average push test result is 24.16 before the treatment, increasing to 25.91 afterward. Statistical test results indicate a significant difference between the push test before and after the treatment (p value = 0.006).

DISCUSSION

The study results show that for the female basketball team, the pretest scores for arm muscle strength averaged 14.33 for the pull test and 15.50 for the push test, while the posttest scores were 14.33 for the pull test and 15.66 for the push test. The significance values were 1.000 for the pull test and 0.802 for the push test, indicating that recovery using cold water immersion had no effect on arm muscle strength in the female basketball team at SMA Negeri

3 of Malang City. However, the study results for the male basketball team showed that the pretest scores for arm muscle strength averaged 20.33 for the pull test and 24.16 for the push test, while the posttest scores increased to 22.16 for the pull test and 25.91 for the push test. The significance values were 0.042 for the pull test and 0.006 for the push test, indicating that recovery using cold water immersion affected arm muscle strength in the male basketball team at SMA Negeri 3 of Malang City.

This study finds that recovery using cold water immersion (CWI) can aid in faster muscle recovery on post-training. CWI is proven to be very effective in helping the basketball athletes at SMA Negeri 3 of Malang City to accelerate muscle recovery and reduce fatigue after training or competition. As a result, athletes can return to conduct the training more effectively and consistently while reducing the risk of injury that may hinder athletic performance. Although no significant effect was observed in the female basketball team, the effect was evident in the male basketball team, indicating that recovery using CWI significantly impacted arm muscle strength. This difference is attributed to testosterone differences between male and female teams, which significantly affects muscle development during regular training.

According to Bhasin et al. (2001), male have much higher testosterone levels than women. Adult males typically have around 300–1000 nanograms per deciliter (ng/dL) of testosterone, whereas females have around 15–70 ng/dL. Testosterone plays an important role in muscle growth, allowing the males to build muscle mass more quickly and efficiently than females. Meanwhile, Kraemer & Ratamess (2005) explain that testosterone is an anabolic hormone that enhances protein synthesis in muscles. This increase in synthesis allows muscles to grow larger and stronger after training. Since males have higher testosterone levels, they gain greater anabolic benefits, speeding up the muscle-building process compared to females. Additionally, Vingren et al. (2010) explain that testosterone also plays a role in fat metabolism. Males generally have less body fat than females, who tend to have a higher body fat percentage due to the influence of estrogen. Greater muscle mass in males helps burn more calories and speeds up metabolism, making muscle-building more efficient. Besides testosterone, other genetic and physiological factors contribute to muscle development differences between males and females. For example, females have more estrogen, which affects fat distribution and muscle development (West & Phillips, 2010).

Additionally, in the Long-Term Athlete Development (LTAD) model, the age of 16–18 years for team sports like basketball is generally in the "Train to Compete" phase. In this phase, athletes begin to focus on more intense competition preparation, including enhancing technical, tactical, and physical skills to compete at a high level. However, even in this "train to compete"

phase, athletes are not yet fully "ready to compete" at the highest level. They are still in the process of developing advanced skills and optimal physical conditioning for more serious competition (Balyi, 2004). This could be one of the reasons why CWI did not affect arm muscle strength in the female basketball team, as athletes at this age are still in physical development stages, and adaptation to various recovery methods such as CWI may not be as effective as it would be for physiologically mature athletes. Additionally, arm muscle strength may not yet be a primary focus in their training program, given that basketball demands more dominance from the lower and core muscles compared to arm muscles.

Cold Water Immersion (CWI) is commonly used to accelerate recovery post-training and reduce muscle soreness that often occurs after intense exercise, such as Delayed Onset Muscle Soreness (DOMS). According to Linola (2022), CWI is proven effective in reducing pain intensity due to DOMS, particularly in the gastrocnemius muscle. Research shows that CWI reduces pain by up to 77.5% in soccer players after intensive training. However, CWI's effects on junior athletes (ages 16–18) may vary due to factors such as gender, age, and training intensity. In some cases, no significant effect of CWI on arm muscle strength was observed in female athletes compared to male athletes. This may relate to hormonal differences, muscle distribution, or varying body adaptation to recovery. The effect of CWI on arm muscle strength in junior athletes, particularly females, may be less clear. In males, higher testosterone levels can accelerate muscle adaptation to strength training, allowing CWI’s pain and inflammation reduction effects to be more quickly felt. In females, due to lower testosterone levels, muscle response to strength training, including recovery, may differ. This may explain why the female team in this study did not experience an increase in arm muscle strength after CWI, while the male team showed a difference.

Specific research on the effects of CWI on arm muscle strength remains limited. Most studies focus on large muscle groups, such as the legs and back, as these are more associated with dominant sports activities in the lower body. However, studies such as those described in research by Fatoni & Nugroho (2019) on CWI's effects on leg muscles showed a reduction in perceived pain but no significant change in muscle endurance after recovery with CWI, whether at 15ºC or 25ºC. This indicates that even though CWI effectively reduces pain, its recovery potential may be more limited in terms of enhancing the strength or endurance of smaller muscles like the arms.

This study finds no effect of CWI on arm muscle strength in the female basketball team, whereas a significant effect was observed in the male basketball team, making this study a new finding. This result could be attributed to several factors, including (1) hormonal differences

between male and female athletes, (2) slower muscle adaptation in females, and (3) muscle size and composition, as arm muscles may have less blood flow compared to large muscles as in the legs, potentially making CWI less effective on smaller muscles.

CONCLUSION

Based on the results and discussion of this study, it can be concluded that recovery using cold water immersion (CWI) has no effect on the arm muscle strength of the female basketball team at SMA Negeri 3 of Malang City. However, there is an effect of recovery using cold water immersion on the arm muscle strength of the male basketball team at SMA Negeri 3 of Malang City. This can be caused by several factors, including hormonal differences between male and female athletes, then caused by different muscle adaptations in women may be slower and the last is due to differences in muscle size and composition.

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