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Effect of Cold-Water Immersion and Proprioceptive Neuromuscular Facilitation (PNF) Stretching on Muscle Soreness Among Negeri Sembilan Junior League U19 Hockey Players

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Abstract | Muscle soreness is a common challenge faced by hockey players due to the high-intensity nature of the sport, which involves explosive movements, rapid direction changes, and physical contact. DOMS is an uncomfortable sensation, or the term used to describe the soreness, stiffness, tightness, swelling, and weakness of muscles, which is felt after performing a severe or unfamiliar exercise after 24 to 72 hours. Some studies suggested that cold water immersion could be an effective strategy for athletes to facilitate faster recovery, but further investigation is needed. Also, some studies have presented PNF stretching as a valuable opportunity to enhance recovery and reduce the impact of muscle soreness, but further research is required. The purpose of this study was to compare the effects of cold-water immersion and PNF stretching on reducing muscle soreness in Negeri Sembilan Junior League Hockey Players after a match. Ten participants underwent the CWI group and PNF stretching group. This study was a quasi-experimental design. The participants immersed their lower body for 15 minutes in cold water immersion (≤ 15 °C). For PNF stretching, starting with holding position for 10 seconds, the player pressed back against the trainer for 6 seconds. The trainer resists and keeps the leg in the same position. Finally, the player flexes his hip muscles as the trainer gently presses the leg as far as possible into the stretch. They are doing one repetition for each muscle. The participant's pain scale (PS), knee range of motion (ROM), and muscular power (PWR) were recorded at five-time frames before, immediately after the match, 24 hours, 48 hours, and 72 hours after treatment. The effects in muscle soreness scores between the two groups were analyzed using repeated measures ANOVA. The results indicated that both cold water immersion (CWI) and PNF stretching (PNF) had a significant effect on the pain scale (PS), knee range of motion (ROM), and muscular power (PWR) between five-time frames ($p < 0.05$). Therefore, there was a significant difference in effect between CWI and PNF stretching. It can be concluded that cold water immersion was the best treatment overall for hockey players to reduce soreness after a match or training.

Keywords: *Cold water immersion (CWI), PNF stretching (PNF), delay-onset muscle soreness (DOMS), pain scale (PS), range of motion (ROM), muscular power (PWR).*

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I. INTRODUCTION

Muscle soreness is a common challenge faced by hockey players due to the high-intensity nature of the sport, which involves explosive movements, rapid direction changes, and physical contact [1]. A person who experiences DOMS will experience illness and pain in the affected muscles, decrease in range of motion and loss of muscle strength [2]. DOMS also occurs when a person starts to increase exercise intensity. Typical symptoms of DOMS are muscular pain tenderness, muscle swelling, tightness and soreness [2]. Delayed-onset muscle soreness sometimes requires a week or at least three days to recover. Popular methods being used to get fast recovery are active recovery, massage, contrast hot and cold-water treatment, ice bath, and recently roller massage [3]. Other methods that can be used to prevent and treat DOM include stretching. This method aims to minimize DOM, reduce DOM time, speed up ROM recovery and improve muscle function [2]. Stretching exercises contribute to enhancing joint range of motion and flexibility, which are essential for various physical activities and overall well-being [4]. Additionally, consistent stretching exercises have been associated with reduced muscle soreness post-exercise and improved muscular coordination, both vital for athletes and individuals engaged in regular physical activity [4].

Cold-water immersion or ice therapy is defined as a therapeutic application of cold or ice to treat injuries or manage muscle soreness that results in a decrease in tissue temperature. Cold water immersion (CWI) is a popular recovery technique involving the immersion of the body in cold water or ice baths following intense physical activity. This method is widely used in sports and exercise contexts to reduce muscle soreness, inflammation, and perceived fatigue, as well as to promote recovery. It also involves using cold therapy to help reduce pain and swelling in the body. The study suggested that cold water immersion could be an effective strategy for athletes to facilitate faster recovery between training sessions or 3 competitions [5]. Proprioceptive Neuromuscular Facilitation (PNF) stretching is a technique used to increase flexibility and improve range of motion. It involves a combination of stretching and 2 contracting muscles. Typically, PNF stretching includes techniques like hold-relax and contract-relax, where muscles are stretched, then contracted isometrically against resistance, and then stretched further in the relaxed state. PNF stretching techniques often include partner assisted stretching, where one person provides resistance while the other stretches. This approach is widely utilized in rehabilitation and sports training due to its effectiveness in improving range of motion and muscle performance. Many therapists use PNF stretching to help people regain their range of motion after injury or surgery. PNF stretching stands as a valuable technique in the realms of rehabilitation, athletic training, and overall physical wellness.

II. METHODS

A. Subjects

The participants in this study were hockey players from Negeri Sembilan Junior League U19. Twenty male hockey players were randomly selected for either the cold-water immersion group (N = 10) or the PNF stretching group (N = 10). A consent form must be provided for each, and every instrument used in the study to guarantee that the participant voluntarily agreed to participate in the study. The criteria for subject inclusion were (1) Participants must be male hockey players from Negeri Sembilan Junior League with age below 19 years old, (2) Participants must play for more than 30 minutes, (3) Participants must be

physically healthy and free from injuries, (4) Participants must have no history of metabolic, cardiovascular or pulmonary diseases.

B. Instrumentation

i. Range of Motion

The researcher uses a goniometer, a device that measures joint angles. AROM will be measured by the participant bending their knee as far as possible, bringing their heel towards their buttocks, while keeping their hips neutral and not lifting off the surface. Then, the researcher will take measurements before the match, immediately after the match, 24, 48, and 72 hours after the treatment. The range of motion was measured at the knee, as that area is commonly affected by exercise induced muscle soreness. The researcher will record these measurements using an individual data form. Normal knee flexion typically ranges from 0 to 135-150 degrees [6].

ii. Pain scale

The participants were asked to rate their pain intensity at rest and during movement on a scale from 0 to 10. The participants measured their perception of pain by using the visual analogue scale, which is characterized by a 10-cm horizontal scale in which 0 = no pain, 1 to 3 = mild, 4 to 6 = moderate to severe, 7 to 9 = very severe and 9 to 10 = worst pain possible. The VAS was administered to the participants before the match, immediately after the match, 24 hours, 48 hours, and 72 hours after the treatment. The VAS scores were used to assess the effect of the interventions on pain intensity in the hockey players [7].

iii. Muscular power

To measure muscular power in this study, the researchers used The Vertical Jump Test. This test was a common method used to measure an individual's ability to generate force and power with their lower body muscle. The vertical jump test is 21 typically performed by having the individual stand next to a wall or a measuring device and reach up as high as possible. The difference in height between the individual's reach and the highest point of their jump is measured and recorded as their vertical jump height. The athlete repeated this process three times, and the average or best of the three jumps was calculated. This method allowed for more accurate and reliable measurements of the athlete's muscular power [8].

C. Procedure

The participants were involved in light training 1 day before a hockey match. 30 minutes of exercise can indeed induce muscle soreness in many individuals. DOMS is a natural part of the muscle repair and adaptation process, but it can be managed through strategies like gradual progression, proper warm-up and cool-down and recovery techniques such as foam rolling, sport massage, cold water immersion and PNF stretching [9]. The participants played 60 minutes of a competitive hockey match. Using a pain scale, knee range of motion, and muscular power, the researcher assessed the muscle soreness and muscle power of the participants following the match. After assessing the markers of exercise-induced muscle soreness, they undertook two recovery interventions, which are CWI and PNF stretching. The intervention was conducted on separate days, with one match and one intervention only. The participants undertook another intervention after the next match. The CWI intervention was conducted in a folding pool filled with ice and water at a

temperature of 15°C. The participants were instructed to immerse their entire body in the water for 15 minutes [10]. Then, for the PNF stretching intervention, the participant holds the holding position for 10 seconds and then contracts, which is pressed back against the researcher for 6 seconds. The researcher then resists and keeps the leg in the same position. Finally, the participant flexes his hip muscles as the researcher gently presses the leg as far as possible into the stretch. The researcher would raise the participant's leg until the participant felt a stretch 22 [11]. The researcher then assessed the pain scale, knee range of motion and muscular power before the match, immediately after the match, 24 hours, 48 hours, and 72 hours after the treatment. The researcher compared the results between the CWI and PNF stretching to understand its effectiveness as a recovery strategy for reducing muscle soreness.

D. Statistical Analysis

The researcher used a randomized controlled trial design to compare the effect of cold-water immersion (CWI) and PNF stretching on markers of exercise-induced muscle soreness among Negeri Sembilan Junior League U-19 Hockey Players. Data were collected using the Visual Analogue Scale (VAS) to measure pain scale, a goniometer to measure knee range of motion on knee flexion, and a vertical jump to measure muscular power. Before analyzing the data, the researcher checked for any missing or inconsistent values and performed basic cleaning procedures. The researcher then used JAMOVI 2.3.28, a statistical software, to perform statistical tests to compare the mean pain scores, knee range of motion and muscular power measurements between the cold-water immersion and PNF stretching groups. Then, the researcher used repeated measures ANOVA to compare the mean pain scores at each time point. The researcher chose those statistical tests because they were appropriate for comparing means between two independent groups and for analyzing repeated measures data. The researcher believed that those tests would provide accurate and reliable results and would allow to draw conclusions about the effectiveness of cold-water immersion and PNF stretching on reducing muscle soreness among Negeri Sembilan Junior League U-19 Hockey Players.

III. RESULTS AND DISCUSSION

All the results showed that there was a significant effect of cold-water immersion group and PNF stretching group for all the biomarkers, which is range of motion (ROM), pain scale (PS) and muscular power (PWR) between the five-time series. Table 1 showed that the main effect of pain scale, active range of motion of left and right knee and muscular power was significant with the value was 0.001. This proposes that there was a change in all the biomarkers between the treatments across the five-time series.

TABLE 1
MAIN EFFECT OF PAIN SCALE

Effect	*p*	Eta Square
PS	< 0.001	0.874
AROML	< 0.001	0.727
AROMR	< 0.001	0.829
PWR	< 0.001	0.444

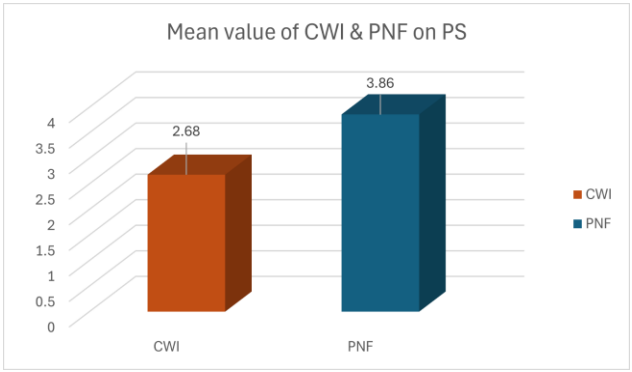

Fig. 1 Mean value of CWI and PNF on pain scale (PS)

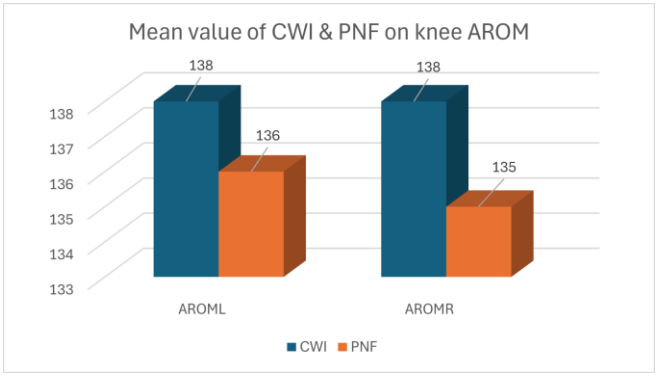

Fig. 2 Mean value of CWI and PNF on AROML and AROMR

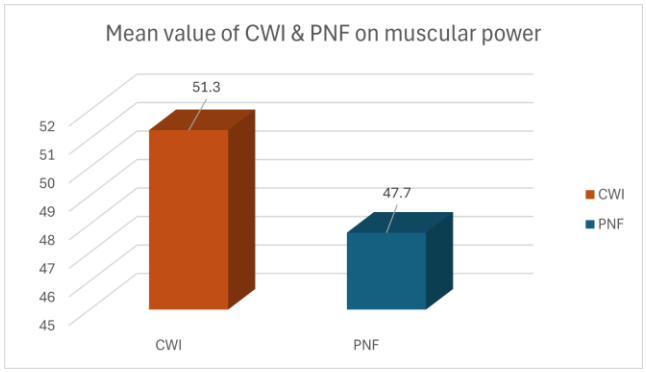

Fig. 3 Mean value of CWI and PNF on Muscular Power

Figure 1 shows each treatment has changes, which were a decrease for a five-time series. From the mean (M) value, it showed that the cold-water immersion (CWI) group had the lowest value for PS, which was 2.68, while the PNFF group had a value of 3.86, respectively. Figure 2 demonstrates each treatment change, which was an increment of both knee AROM for a five-time period. From the mean (M) value, it showed that the CWI group has the highest value for AROML and AROMR, which are both 138, compared to PNF, which has a value of 136 for AROML and 135 for AROMR. Figure 3 presents the mean value of muscular power (PWR) between CWI and PNF. According to the data, it showed that CWI group has the highest value, which is 51.3, compared to PNF group, which has a value of 47.7. Based on the current study, it showed that there was a significant effect on both treatment in terms of pain scale, active knee range of motion and muscular power. However, the result also showed that there is a significant difference effect for both treatments. It can be concluded that cold water immersion was the best treatment overall for the hockey players to reduce soreness after a match.

The purpose of this study was to compare the effects of cold-water immersion and PNF stretching on reducing muscle soreness in Negeri Sembilan Junior League Hockey Players after a match. Usually, cold water immersion and PNF stretching treatments are used to enhance the recovery of the hockey players. These treatments have had effects on three biomarkers in the body, which are the pain scale (PS), knee range of motion (ROM), and muscular power (PWR). These treatments gave a decrease in terms of PS and an increase in terms of ROM and PWR, which was based on the recovery time of the player.

Based on the result, CWI found to be more effective in reducing pain. Cold water immersion (CWI) can help relieve symptoms of delayed onset muscle soreness (DOMS) [12]. They found that applying CWI reduced pain sensations on the second and third days after measurement. This demonstrates that CWI treatments effectively minimize pain. Furthermore, this current study showed that range of motion and muscular power seem to have increased in the CWI group. CWI protocols, especially at temperatures between 10-15°C for durations of 10 minutes or more, were effective in enhancing ROM due to the decreased inflammation and muscle stiffness [8]. Also, cold water immersion (CWI) impaired muscle protein synthesis, it also highlighted its role in reducing acute muscle damage and soreness, aiding in faster recovery and improved performance in subsequent sessions [13].

In addition, this treatment reduced muscle injuries caused by muscle stretch or strain and reduced delayed onset muscle soreness (DOMS) that commonly happens after strenuous exercise, match or repetitive match. Based on the study, it showed that there was a significant effect on both treatments in terms of pain scale, active knee range of motion and muscular power.

IV. CONCLUSIONS

It can be concluded that cold water immersion was the best treatment overall for the hockey players to reduce soreness after a match. Overall results for the hypothesis were rejected because there was a significant effect of cold-water immersion and PNF stretching on pain scale, active knee range of motion and muscular power among hockey players. This indicated that the null hypothesis for a significant effect of cold-water immersion and PNF stretching on the pain scale, active knee range of motion, and muscular power was rejected. However, the null hypothesis for a significant difference effect of cold-water immersion and PNF stretching on the pain scale, active knee range of motion, and muscular power was rejected because there was a significant difference effect. Therefore, this current study can be applied to the entire athlete to promote effective recovery from repetitive or continuous matches.

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