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The Combination of Proprioceptive Neuromuscular Facilitation and Ice Massage: Does it Prevent Delayed Onset Muscle Soreness?

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Abstract Delayed onset muscle soreness is a process of adaptation from exercise that manifests as muscular discomfort. In general, proprioceptive neuromuscular facilitation stretching and ice massage are used for prevention. Nevertheless, the combination of the two methods requires more empirical evidence. The objective of this research was to see how efficient a combination of stretching, proprioceptive neuromuscular facilitation, and ice massage was at preventing delayed onset muscle soreness. The study method was an experiment using a pretest-posttest control group design. The data collection technique was observation and testing. In this research, the participants were 20 male sports students. Purposive sampling was the sampling technique used. The instruments used were a pain level questionnaire and a goniometer. The data obtained were analysed using the Wilcoxon test and the SPSS version 23 application. The findings of the research revealed that the combination of proprioceptive neuromuscular facilitation and ice massage was effective in preventing delayed onset muscle soreness with pain, range of motion, and function scale indicators, particularly for decreasing tenderness, increasing knee range of motion, sitting standing function scale, climbing stairs, and squatting. Stretching, proprioceptive neuromuscular facilitation, and ice massage might therefore be used to minimise delayed onset muscle soreness following exercise, particularly eccentric motions such as weight training.

Keywords Proprioceptive Neuromuscular Facilitation, Ice Massage, Delayed Onset Muscle Soreness

1. Introduction

Sport is a systematically performed activity [1]-[4]. A person may have soreness after doing sports activities. Acute muscle soreness refers to muscle soreness that occurs during the acute phase of exercise [5]. Later, up to

24-72 hours after exercising, muscle soreness can be felt, which is known as Delayed Onset Muscle Soreness (DOMS) [6]. High eccentric muscular contractions or unaccustomed activities are one of the causes of DOMS [6]. DOMS is frequently associated with lactic acid-induced discomfort, connective tissue injury, muscular stiffness, and inflammation [7].

Another research found that DOMS appears after vigorous exercise, with symptoms including stiffness and soreness in the afflicted soft tissues. This occurs several hours after exercise, peaking at one to three days [8]. Although any muscular work can elicit DOMS, it is primarily caused when athletes perform activities involving severe eccentric contractions [9]. Eccentric exercises are those that involve lengthy muscular contractions [10]. According to research on the correlation between muscle soreness and various types of muscle contractions, including isometric, concentric, and eccentric contractions, eccentric contractions are more prominent in affecting the incidence of DOMS [10].

Climbing and descending hills, ballistic workouts, plyometrics, and weight training involving excessive eccentric movements are examples of sports motions that can develop DOMS [9]. DOMS is thought to arise as a result of excessive lactate production and structural damage, according to several theories. Recent research suggests that the mechanism of DOMS is caused by strong sensory input from extra muscular connective tissue, which may have a significant effect on DOMS [9].

When weight training is anaerobic and endurance training is aerobic, the body adjusts to the intensity [11], [12]. Nonetheless, we frequently discover that after exercise, the body experiences soreness, which is an adaptation process; in scientific terms, this soreness process is known as DOMS [11] [8]. Yet, while this might be considered an adaptation process and is appropriate, it can interfere with the individual's training process if not treated or recovered properly. The soreness is caused by severe injury to the soft tissue of the muscular tendons [8].

The preceding description is of particular concern in terms of how to develop a solution to minimise and manage athletes who have DOMS. Aside from that, the authors observed at different sports clubs, some trainers and fitness instructors claimed that when athletes experience DOMS, the player is encouraged to rest for two days, then carry out therapy using the stretching approach. Trainers and fitness instructors believe that it is unclear what type of stretching is being performed, whether passive and active static stretching, dynamic stretching, or Proprioceptive Neuromuscular Facilitation (PNF). Furthermore, numerous athletes claimed that when feeling muscular soreness, it is common to practise compressing using ice, but they do not fully grasp how long and how many times this therapy is performed. It may be stated that cases of DOMS are frequently the consequence of inadequate treatment.

Next, according to multiple research, the most often utilised therapies and strategies for dealing with DOMS, in general, include cryotherapy [13], massage [14], stretching [15], and ice massage [16]. Based on these studies, cryotherapy, massage, stretching, and ice compresses have a positive effect on reducing caused by DOMS [13]-[16], but Connoly, Sayers, and McHugh found interesting evidence stating that ice massage is a treatment that was not effective, but this was due to only 1 sample being used and it was only applied 15 minutes, 24 hours, or 48 hours after practise [17]. This is an interesting argument; further experiments with more samples and well-planned treatments are required.

Only a few relevant studies, such as a comparison of static stretching and PNF to reduce DOMS [18], and then a combination of PNF and cryotherapy to reduce DOMS [19] have been discovered. As a result, the objective of this study is to provide knowledge of therapy to minimise DOMS using the PNF and Ice massage combination approach and to assess if this method can empirically prevent DOMS in athletes based on observation and document analysis. The authors hypothesise that a combination of PNF stretching and ice massage has a positive effect on DOMS prevention.

2. Materials and Methods

2.1. Participants and Study Design

The research method was a field testing experiment with a one-group pretest-posttest control design approach [20] [17], with two groups consisting of one that received stretching and ice massage treatment and the other that served as the control group. Twenty students from the Sports Student Activities Unit served as samples. There are 13 participants in the football branch, 2 in athletics, 1 in futsal, 1 in badminton, 1 in gate ball, 1 in judo, and 1 in rugby. Athletes aged 18-25 years, male, and willing to become study subjects as indicated by completing an informed consent form were included in the sample selection criteria. Athletes who have health issues or who have been injured are excluded from the sample. A pain scale was used to evaluate sensations of soreness, a goniometer was used to measure leg muscles, and movement function was utilised to test leg muscles.

2.2. Instrument and Statistical Analysis

The data analysis technique used the Wilcoxon nonparametric test, which was to compare the pre-test in the intervention group and the post-test in the intervention group using the SPSS version 23 application. The research instrument used a validated questionnaire, the DOMS questionnaire included: (1) history of DOMS, (2) location of DOMS, (3) symptoms of DOMS, (4) triggers of DOMS, (5) and handling of DOMS. Points on examination include (1) range of motion (ROM), (2) pain scale, (3) and function scale. All instruments are presented in tables 1, 2, and 3 as follows:

Table 1. The instruments used in the pre-test - post-test

No	Component	Sub. Component	Technique	Data Scale
1.	Anamnesis	a. DOMS location	Questionnaire	Numeric
		b. DOMS duration	Questionnaire	Ratio
		c. DOMS symptoms	Questionnaire	Nominal
		d. DOMS trigger	Questionnaire	Nominal
		e. DOMS Handling	Questionnaire	Nominal
2.	Examiner	a. Pelvis	ROM	Ratio
		Adduction		
		Abduction		
		Endorotation		
		Exortation		
		b. Knee	ROM	Ratio
		Flex		
		Extension		
		c. Ankle	ROM	Ratio
		Dorsiflexion		
		Plantar flexion		
		Inversion		
		Eversion		
3.	Pain Scale	a. Rest Pain	Scale	Ordinal
		b. Tenderness	Scale	Ordinal
4.	Function Scale	a. Walk	Scale	Ordinal
		b. Sit down and stand back up	Scale	Ordinal
		c. Climbing up the stairs	Scale	Ordinal
		d. Squat	Scale	Ordinal

Information:
Pain scale: assessed by measuring resting pain and tenderness in the leg and surrounding muscles. Furthermore, the sample assesses pain intensity on a scale of 0-3.
ROM: assessed by measuring the angle in degrees at the hip, ankle and knee joints.
Function scale: assessed through walking movements, sitting and standing again, climbing stairs then squatting which is measured from 0-3.

Table 2. Pain measurement scale

Group		Pre-test Pain Scale		Post-test Pain Scale	
		During break	When pressed	During break	When pressed
PNF & Ice Massage	No Pain	7	6	8	7
	Mild pain	3	2	2	2
	Moderate pain	0	1	0	1
	Severe pain	0	1	0	0
Total		**10**	**10**	**10**	**10**
Control	No Pain	8	7	6	0
	Mild pain	1	2	1	7
	Moderate pain	1	1	3	2
	Severe pain	0	0	0	1
Total		**10**	**10**	**10**	**10**

Table 3. Function measurement scale

Group		Pre-test Functional Scale				Post-test Function Scale			
		Road	Sit & Stand	Climbing up the stairs	Squat	Road	Sit & Stand	Climbing up the stairs	Squat
PNF & Ice Massage	No Pain	0	0	0	0	0	0	0	0
	Mild pain	0	1	1	1	0	1	1	1
	Moderate pain	2	2	3	3	1	1	3	3
	Severe pain	8	7	6	6	9	8	6	6
Control	No Pain	0	0	0	0	0	1	1	4
	Mild pain	0	0	0	0	1	1	1	0
	Moderate pain	0	1	1	1	3	7	8	6
	Severe pain	10	9	9	9	6	1	0	0

2.3. PNF and Ice Massage Stretching Intervention Program

The research sample received an intervention in the form of PNF stretching and ice massage with the following procedures: (1) the instructor gave an explanation and clarified the objective of the PNF and ice massage exercises; (2) the sample was given PNF intervention and ice massage and measured the feeling of soreness that was felt using a pain scale, goniometer leg ROM, and movement function; (3) the intervention group was given PNF before performing an exercise. After the exercise, the samples received 15 minutes of ice massage; and (4) the intervention lasted for 18 minutes for PNF and 11 minutes for ice massage. In detail, PNF and Ice massage intervention programs are described in tables 4 and 5 as follows:

Table 4. Proprioceptive Neuromuscular Facilitation (PNF) Stretching Program

No	Figure	Procedure	Dose
1.		The sample posture is cross-legged, with both hands on the toes and the body bowed. The position of instructor behind the sample is placed on the sample's knees. The groyne muscle is stretched downwards for a few seconds until the pain limit is reached, and then the sample performs counter motions from the instructor.	Duration: 2 minutes Reps: 3x Counts: 1-6 relax Count:7-10 counter motions
2.		The sample position is lying on the floor. The instructor's position is holding the feet and then pushing forward the hamstring muscles by placing the hands on the soles of the feet and knees. The motion is carried out by stretching the hamstring muscles forward for a few seconds until the sample feels the pain limit then the sample performs a counter-movement from the instructor. This action is performed with the right and left legs alternately.	Duration: 2 minutes Reps: 3x Counts: 1-6 relax Count:7-10 counter motions
3.		The sample position is lying on the floor with legs crossed. The position of the instructor is standing where the palm of the right hand is behind the bent knee and the palm of the left-hand holds the sole of the sample's feet. This movement aims to stretch the gluteus downwards for a few seconds. The sample then performs a counter motion upwards. This action is performed with the right and left legs alternately.	Duration: 2 minutes Reps: 3x Counts: 1-6 relax Count:7-10 counter motions

Table 4 continued

4.		The sample position is lying on the floor and both hands are beside the body. The instructor's position is to push the sample's knee forward by placing the palm of the left hand on the sample's right knee which is bent and the palm of the right-hand makes a holding motion. This movement aims to stretch the gluteus downwards. The sample performs a counter motion upwards. This motion is performed by the right and left legs alternately.	Duration: 2 minutes Reps: 3x Counts: 1-6 relax Count:7-10 counter motions
5.		The sample position is lying on the floor, while the instructor's position is pushing the sample's knees which will be bent forward by placing the palms of the hands on the sample's knees. The movement is made to stretch the gluteus downward for a few seconds to the point of pain where the sample makes a counter motion upwards.	Duration: 2 minutes Reps: 3x Counts: 1-6 relax Count:7-10 counter motions
6.		The sample position is lying on the floor with arms stretched beside the body. The instructor's position is to push the knees forward using the feet where the hands hold the knees and palms. This movement is done by stretching the hamstring and gastric forward a few seconds to the point of pain. The sample then performs counter motions.	Duration: 2 minutes Reps: 3x Counts: 1-6 relax Count:7-10 counter motions
7.		The sample position is lying on the floor with both arms stretched out to the sides of the body. The instructor's position is to push the knee of the sample which is bent crosswise downward by placing the palm of the left hand and the palm of the right hand holding the shoulder. This movement stretches the gluteus and iliotibial bands downward until they are painful. The sample then makes counter motions upward direction. This motion is performed by the right and left legs alternately.	Duration: 2 minutes Reps: 3x Counts: 1-6 relax Count:7-10 counter motions
8.		The subject's position is prone on the floor with the arms beside the body. The instructor's position is to lift the sample's thigh, with the knee position and the position of the right hand holding the pelvis and the left palm holding the ankle joint. This movement aims to stretch the quadriceps upwards for a few seconds to the limit of pain and the sample performs a downward resistance movement. This motion is performed by the right and left legs alternately.	Duration: 2 minutes Reps: 3x Counts: 1-6 relax Count:7-10 counter motions
9.		The sample position is prone where the hands are at the side of the body. The instructor lifts the sample's thigh inward with the knee and the position of the right palm is to hold the pelvis and the left palm holds the knee joint. This action aims to stretch the iliotibial band muscle inward for a few seconds to the point of pain limit. The sample moves against the outside. This motion is performed by the right and left legs alternately.	Duration: 2 minutes Reps: 3x Counts: 1-6 relax Count:7-10 counter motions

Table 5. Ice Massage Program

No	Figure	Procedure	Dose
1.		The sample carried out the ice massage treatment assisted by an instructor on the hamstring muscles using rubbing and massaging techniques.	2 minutes
2.		The sample carried out the ice massage treatment assisted by an instructor on the quadricep muscles using rubbing and massaging techniques.	2 minutes
3.		The sample carried out the ice massage treatment assisted by an instructor on the iliotibial muscle using rubbing and massaging techniques.	2 minutes
4.		The sample carried out the ice massage treatment assisted by an instructor on the tibialis anterior muscle using rubbing and massaging techniques.	2 minutes
5.		The sample carried out the ice massage treatment assisted by an instructor on the tibialis anterior muscle using rubbing and massaging techniques.	1 minute
6.		The sample carried out the ice massage treatment assisted by an instructor on the knee joint using rubbing and massaging techniques.	1 minute
7.		The sample carried out the ice massage treatment assisted by an instructor on the Achilles and ankle tendons using rubbing and massaging techniques.	1 minute

3. Results

The results of the hypothesis test to assess the effectiveness of PNF with ice massage to prevent DOMS are presented in tables 6, 7 and 8 as follows:

3.1. Pain Scale

Table 6. Pain Scale Hypothesis Test

Group	Pain Scale	Pre-test	Post-test	Significance	Description
PNF & Ice Massage	During break	0.30	0.20	0.317	Not significant
	When pressed	0.55	0.13	0.317	Not significant
Control	During break	0.3	0.7	0.317	Not significant
	When pressed	0.4	1.4	0.021	Significant

3.2. Function Scale

Table 7. Function Scale Hypothesis Test

Group	Function Scale	Pre-test	Post-test	Significance	Description
PNF & Ice massage	Walk	2.8	2.9	0.317	Not significant
	Sit and stand	2.6	2.7	0.317	Not significant
	Climb up the stairs	2.5	2.5	1.000	Not significant
	Squat	2.5	2.5	1.000	Not significant
Control	Walk	3.00	2.5	0.059	Not significant
	Sit and Stand	2.9	1.8	0.004	Significant
	Climb up the stairs	2.9	1.7	0.002	Significant
	Squat	2.9	1.2	0.004	Significant

Based on Table 6 above, the intervention group at rest and when pressed the significance value of >0.05 means there is no significant effect on PNF stretching and ice massage to prevent DOMS, then the control group at rest the significance value of >0.05 means there is no significant effect while when pressed the significance value of <0.05 means there is a significant effect, but the change is negative, namely an increase in pain.

Based on Table 7 above, the results of the function scale analysis including walking, sitting and standing, climbing stairs, and squatting found a significance value of >0.05 meaning that the effectiveness of PNF stretching intervention and ice massage was not significant to prevent DOMS. Then in the control group of road function analysis, a significance value of >0.05 was found to be insignificant, while in the function of sitting and standing, climbing stairs and squatting, a significance value of <0.05 was found, meaning that there was a significant change, but the change was negative, namely a decrease in function. Then in the intervention group, it can be said that there is no impairment of function.

3.3. Range of Motion (ROM)

Table 8. Intervention and Control Group ROM Hypothesis Test

Group	Joints	Motion	Mean		Significance	Description
			Pre-test	Post-test		
PNF and Ice Massage (Right)	Pelvis	Adduction	14.6	15.10	0.159	Not significant
		Abduction	44.60	48.70	0.008	Significant
		Endorotation	32.90	34.00	0.168	Not significant
		Exortation	34.60	38.60	0.027	Significant
	Knee	Flex	140.70	142.70	0.011	Significant
		Extension	6.20	7.20	0.014	Significant
	Ankle	Dorsiflexion	10.00	11.00	0.074	Not significant
		Plantar flexion	37.10	38.00	0.159	Not significant
		Inversion	28.30	32.00	0.017	Significant
		Evesion	18.90	21.70	0.017	Significant
PNF and Ice Massage (Left)	Pelvis	adduction	15.50	16.60	0.026	Significant
		Abduction	44.70	48.20	0.011	Significant
		Endorotation	34.10	36.90	0.027	Significant
		Exortation	32.00	35.80	0.017	Significant
	Knee	Flex	141.10	143.30	0.017	Significant
		Extension	7.50	8.30	0.023	Significant
	Ankle	dorsiflexion	8.90	9.50	0.084	Not significant
		Plantar flexion	33.50	35.80	0.109	Not significant
		Inversion	26.50	30.30	0.017	Significant
		Evesion	19.00	23.40	0.031	Significant
Control (Right)	Pelvis	adduction	15.30	12.20	0.005	Significant
		Abduction	41.20	39.50	0.108	Not significant
		Endorotation	31.20	27.70	0.024	Significant
		Exortation	38.30	36.10	0.159	Not significant
	Knee	flex	126.70	119.70	0.028	Significant
		Extension	6.20	5.90	0.680	Not significant
	Ankle	dorsiflexion	16.70	15.90	0.356	Not significant
		Plantar flexion	34.10	30.80	0.150	Not significant
		Inversion	28.40	24.80	0.084	Not significant
		Evesion	20.40	18.00	0.147	Not significant
Control (Left)	Pelvis	adduction	14.30	12.50	0.016	Significant
		Abduction	46.50	42.10	0.102	Not significant
		Endorotation	34.60	30.70	0.013	Significant
		Exortation	34.00	31.30	0.106	Not significant
	Knee	flex	124.30	121.20	0.011	Significant
		Extension	5.50	4.50	0.084	Not significant
	Ankle	dorsiflexion	17.20	16.50	0.260	Not significant
		Plantar flexion	30.80	29.70	0.766	Not significant
		Inversion	26.20	23.10	0.024	Significant
		Evesion	18.70	17.80	0.438	Significant

Based on table 8 above, it has been found, ROM in the intervention group, which included the pelvis, knee, and ankle joints in the motion on the right, had a significance value of <0.05, with as many as six motions having significant changes, while four motions had no significant changes due to a significance value of >0.05. The motions of the pelvis, knee, and ankle on the left received a significance value of <0.05 in the intervention group, where eight motions created significant changes and two motions did not produce significant changes with a significance value of >0.05.

Furthermore, in the control group, the joints on the right movement, which included the pelvis, knee, and ankle joints, obtained a significance value of > 0.05, where seven motions did not create changes and three motions produced significant changes with a significance value of <0.05. In the control group, the pelvis, knee, and ankle motions on the left received a significance value of >0.05, with five motions did not cause significant changes and five motions producing significant changes with a significance value of <0.05.

Significant changes occur in the control group. Yet, due to the decrease in motion, these alterations result in negative changes. After two days of training, the PNF and ice massage groups experienced an increase in ROM but did not develop DOMS. Participants in the control group experienced a decrease in ROM and an increase in DOMS problems.

4. Discussion

The objective of this research was to examine how stretching Proprioceptive Neuromuscular Facilitation (PNF) combined with ice massage could help minimise Delayed Onset Muscle Soreness (DOMS). According to the findings of the authors' research, PNF stretching combined with ice massage is capable of preventing DOMS, which includes soreness, Range of Motion (ROM), and functional scales that yield favourable outcomes. The combination of PNF stretching and ice massage to prevent DOMS showed no significant effect on pain in the intervention group at rest or when pressured. Then, when pressed, there is a significant change in the control group, indicating that the major change is a negative change caused by an increase in soreness. As a result, even though the soreness occurred after two days of exercise, the PNF stretching intervention combined with ice massage reduced soreness at rest and when pressed.

According to the functional scale results, walking, sitting and standing, climbing stairs, and squatting are insignificant in delivering PNF training treatments paired with ice massage to avoid DOMS. In the control group, there was no significant change in walking function, but there were substantial changes in sitting and standing, climbing stairs, and squatting, but these significant changes had a negative effect, namely a decline in function. The PNF and ice massage intervention group did not experience functional impairment, but the control group did because of an increase in DOMS after two days of exercise.

According to the results of the Range of Motion (ROM) in the PNF and ice massage groups, the motions on the right side of the six movements showed significant changes, while the four movements did not. There is no significant change on the left. The motions on the right side of the eight movements did not change significantly in the control group, and the three motions did not produce change significantly. Six motions in the left motion control group showed no significant changes, while four motions created significant changes. Significant changes, in this case, are negative since they reduce movement. Overall, the PNF and ice massage groups improved their ROM after two days of treatment and did not have DOMS. This is inversely proportional to the control group, which had a decrease in ROM, implying that the control group had an increase in DOMS.

In medical science, pain treatment is classified as either pharmacological or non-pharmacological [21]. Non-pharmacological management is an attempt to diminish and eliminate pain through massage treatment, hot compress therapy, and ice. Pharmacological management is a partnership of physicians and nurses who offer medications to lessen and relieve soreness [21]. Pharmacological management is a partnership of doctors and nurses who offer medications to diminish and relieve soreness. Non-pharmacological treatment offers the advantages of being effective, easy, and inexpensive, with few side effects. It can also promote enjoyment by controlling sensations [22].

Cold water immersion, cold gel, ice packs, and ice massage are all treatments used to speed up recovery after strenuous exercise [23]. Ice packs can be administered to places that are uncomfortable or opposed to the pain sites but are still associated with soreness [24]. Within the first 24 to 48 hours after experiencing discomfort, this takes 5 to 10 minutes [21]. Subsequently, according to Smeltzer and Bare, an ice pack was applied to the injury site for 20 to 30 minutes over the first 24 and 48 hours following the injury to alleviate soreness [25]. Prior research has found that ice massage produces vasoconstriction at the cellular level and reduces cell metabolism (reducing oxygen demand) [26]. Capillary permeability and discomfort will be decreased, as will the release of inflammatory mediators [26]. Ice massage therapy will decrease soreness transmission through the stimulation of large-diameter fibres in the spinal cord, acting as a counterirritant that reduces soreness perception to the brain [26].

Prior research supports the authors' findings that PNF stretching and vitamin C supplementation can decrease soreness and enhance ROM following static (isometric) strength training [27]. It will strengthen the capacity to hold the body or support joint functional capacities such as walking, sitting and standing again, climbing stairs, and

squatting in addition to lowering discomfort [27]. Then, performing PNF exercises on a regular and consistent basis can help to maintain and develop ROM, muscular power, and muscle strength [23], [24]. According to the authors' findings, the intervention group performed PNF stretching mixed with ice massage and had greater outcomes than the control group in avoiding DOMS.

5. Conclusions

Based on the findings and discussion, it is reasonable to conclude that PNF stretching and a combination of ice massage are effective for preventing DOMS with soreness, ROM, and functional scale indicators. This is mostly used to reduce pressure sores, increase knee ROM, sit and stand scales, climb stairs, and squat. Thus, PNF stretching and ice massage can be used to avoid DOMS. The results of this study can provide consideration, support and contribution of thought to stakeholders in recovery management, especially in treatment using PNF & Ice Massage to reduce DOMS. However, bearing in mind that this study has limitations, namely a relatively small sample research, therefore, further research is expected to use a larger sample and a variety of sports.

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