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Effect Of Ultrasound Versus Cryotherapy On Blood Lactate Levels In Delayed Onset Of Muscle Soreness

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Abstract
Delayed Onset of Muscle Soreness (DOMS) is commonly associated with high-intensity or unfamiliar physical activity, leading to symptoms like muscle pain, stiffness, and discomfort. This study compared the effects of ultrasound and cryotherapy on blood lactate levels in individuals experiencing DOMS. Thirty sedentary participants aged 18-25 were randomly assigned to three groups: a control group (Group A) received no treatment, an ultrasound group (Group B) received 5 minutes of pulsed ultrasound at 0.8 w/cm², and a cryotherapy group (Group C) received 15 minutes of ice pack application. DOMS was induced through a 40-minute skipping exercise, with blood lactate levels measured pre-exercise, 8 hours pre-exercise and at 24-, 48-, and 72-hours post-treatment. The results showed that both ultrasound and cryotherapy significantly reduced blood lactate levels compared to the control group. Cryotherapy demonstrated more substantial impact on reducing blood lactate, particularly at 72 hours post-exercise when compared to Ultrasound therapy. These findings align with previous research suggesting cryotherapy's effectiveness in enhancing muscle recovery and reducing inflammation. Ultrasound therapy also aided in lactate reduction, likely through improved blood flow and muscle oxygenation. In conclusion, cryotherapy may offer a superior advantage over ultrasound for managing DOMS, making it a preferable option for faster recovery. Further research with larger samples and varied populations is recommended to expand on these findings and refine recovery strategies in athletic and clinical settings
Keywords: *Delayed on set of muscle soreness, Ultrasound therapy, Cryotherapy, Blood lactate Physiotherapy*

INTRODUCTION

Lactate, a byproduct of anaerobic muscle metabolism, tends to accumulate in muscle tissue and blood during high-intensity exercise, where aerobic pathways alone cannot meet energy demands. This accumulation, which results from an increased reliance on glycolytic pathways, leads to muscle fatigue by lowering intracellular pH levels. Blood lactate measurements, commonly used in clinical exercise testing and athletic performance assessments, often indicate a shift from aerobic to anaerobic activity, reflecting the muscle's escalating energy needs. During this process, an excessive buildup of lactate can contribute to delayed onset muscle soreness (DOMS) – a condition characterized by muscle pain, stiffness, and discomfort that peaks at 24 to 72 hours after a high intensity or unaccustomed exercise exertion. Research attributes DOMS to various factors, including metabolic byproducts, muscle fiber stress, and inflammatory responses, all of which can disrupt normal muscle function. [1,2,3,4,5,6,7]

In sports and rehabilitation, treatments like Cryotherapy, which applies cooling to decrease inflammation and tissue damage, has been historically popular due to its accessibility and straightforward application. Ultrasound therapy, on the other hand, may relieve pain and improve muscle flexibility by causing mechanical oscillations within the tissue. Although previous studies have examined the effect of cryotherapy on blood lactate levels associated with DOMS, the role of ultrasound remains less explored, and studies that compared the combined effects of these two modalities on DOMS recovery is scarce. This study seeks to address this gap by evaluating and comparing the individual effects of ultrasound and cryotherapy on blood lactate levels, with the aim of providing insights that could optimize recovery strategies in both athletic and clinical settings. [8,9,10,11]

METHODOLOGY

This study was conducted at the Guru Nanak University, Department of physiotherapy, Hyderabad, Telangana, India. The sample size consists of 30 subjects (both males and females) and were selected through simple random sampling who met the following inclusion criteria: sedentary individuals aged 18-25, no respiratory complications, no hearing problems, no previous sports background, and no prior exercise programs. Individuals with a previous history of injuries, cardiovascular or neurological impairments were excluded from this study. The total duration of the study was three consecutive days.

Subjects were randomly divided into three groups (n=10 each) after obtaining informed consent. Each group performed a 40-minute skipping exercise to induce delayed onset muscle soreness (DOMS), and blood lactate was measured before exercise, 8 hours post-exercise, and treatment was given 24 hrs 48hrs and 72 hrs post exercise.

Group A (Control): No treatment was administered to the subjects in this group after exercise. Blood lactate was measured pre-exercise, 8 hours post-exercise, and at 24, 48, and 72-hours post-exercise.

Group B (Ultrasound): Subjects in this group were given 10 minutes of pulsed ultrasound at 0.8 w/cm² on the calf muscle. subjects were positioned in prone or side-lying. Blood lactate was recorded before exercise, 8 hours post-exercise, and following treatment at 24, 48, and 72 hours.

Group C (Cryotherapy): Subjects in this group were given cryotherapy. The subjects were made to lie down in prone position and ice packs was applied for 15 mins on calf muscle. Blood lactate measurements were taken pre-exercise, 8 hours post-exercise, and at 24, 48, and 72 hours after treatment.

Fig.1 skipping

fig 2 cryotherapy

fig 3 ultrasound therapy

RESULTS

Table 1 is calculating the mean and standard deviation for blood lactate levels between pre-exercise – post exercise, post treatment - 24 hours BL, post treatment - 48 hours BL and post treatment - 72 hours BL in control group. The mean and standard deviation for blood lactate level between pre-exercise (3.4000, 1.07497) – post exercise (7.1000, 2.46982), post treatment (7.1000, 2.46982) – 24 hours BL (2.8000,

1.22927), post treatment (7.1000, 2.46982) – 48 hours BL (4.6000, 1.77639) and post treatment (7.1000, 2.46982) – 72 hours BL (2.3000, 0.82327) in control group.
TABLE 2 is calculating the significance for blood lactate levels in control group. The significance value for pre-exercise – post exercise BL is 0.002, post treatment - 24 hours BL is 0.000, post treatment - 48 hours BL is 0.054 and post treatment - 72 hours BL is 0.001 which are compared to p $p<0.05$. This indicates that there is statistically significance difference between pre-exercise – post exercise BL, post treatment - 24 hours BL, post treatment - 72 hours BL but there is no significant difference between post treatment - 48 hours BL in control group.
GRAPH 1 is comparing the mean values between pre-exercise – post exercise BL, post treatment - 24 hours BL, post treatment - 48 hours BL and post treatment - 72 hours BL in control group. This shows that there is significant difference between pre-exercise- post exercise BL, post treatment - 24 hours BL, post treatment - 72 hours BL and there is no significant difference between post treatment - 48 hours BL in control group.

Table- 1 calculating the mean and standard deviation for blood lactate levels between pre-exercise – post exercise, post treatment CONTROL GROUP

CONTROL GROUP				
		Mean	N	Std. Deviation
Pair 1	PRE-EX_BL	3.4000	10	1.07497
	POST EX BL	7.1000	10	2.46982
Pair 2	POST EX BL	7.1000	10	2.46982
	Post treatment BL24	2.8000	10	1.22927
Pair 3	POST EX BL	7.1000	10	2.46982
	Post treatment BL48	4.6000	10	1.77639
Pair 4	POST EX BL	7.1000	10	2.46982
	Post treatment BL72	2.3000	10	.82327

Table- 2 calculating the significance for blood lactate levels in control group. The significance value for pre-exercise – post exercise CONTROL GROUP

CONTROL GROUP					
		Paired Differences	T	Df	Sig. (2-tailed)
		Mean			
Pair 1	PRE-EX_BL - POST_EX BL	-3.70000	-4.454	9	.002
Pair 2	POST EX_BL – post treatment BL24	4.30000	7.435	9	.000
Pair 3	POSTEX_BL – post treatment BL48	2.50000	2.216	9	.054

Pair 4	POST EX BL - – post treatment BL72	4.80000	5.237	9	.001

Graph- 1 comparing the mean values between pre-exercise – post exercise BL control group

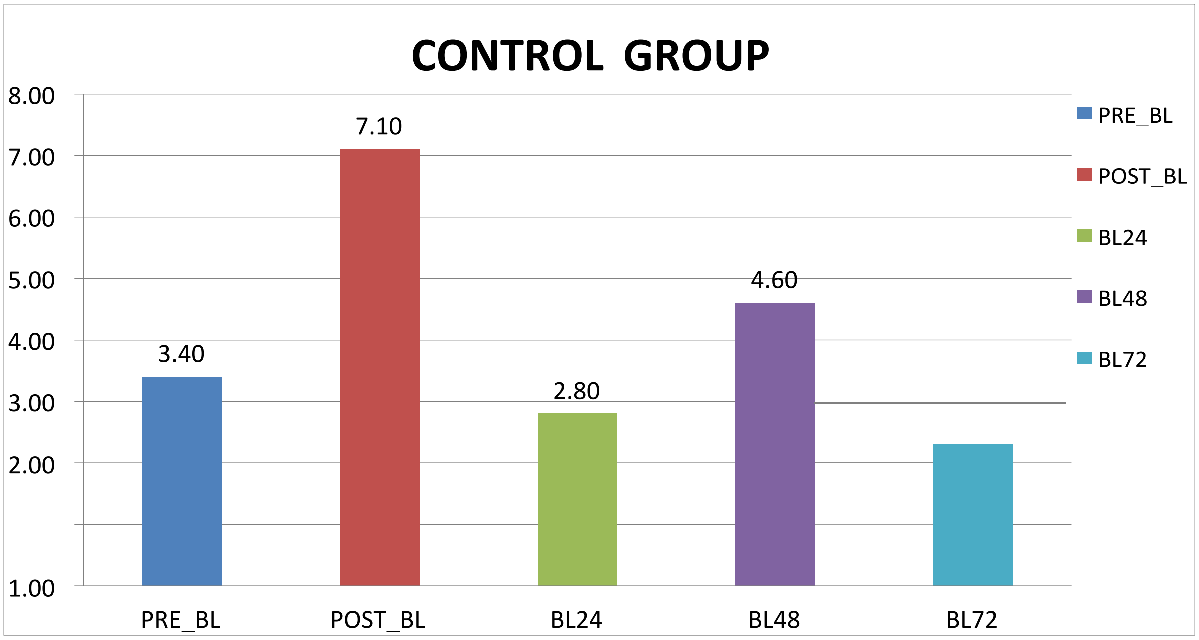

Table 3 is calculating the mean and standard deviation for blood lactate levels between pre-exercise – post exercise, post treatment - 24 hours BL, post treatment- 48 hours BL and post treatment- 72 hours BL in ultrasound group. The mean and standard deviation for blood lactate level between pre-exercise (2.6000, 0.9371) – post exercise (7.8000, 3.65331), post treatment (7.8000, 3.65331) – 24 hours BL (3.1500, 1.43314), post treatment (7.8000, 3.65331) – 48 hours BL (4.4500, 2.00236) and post treatment (7.8000, 3.65331) – 72 hours BL (2.5800, 0.60148) in ultrasound group

TABLE 4 is calculating the significance for blood lactate levels in ultrasound group. The significance value for pre-exercise- post exercise BL is 0.002, post treatment- 24 hours BL is 0.004, post treatment- 48 hours BL is 0.023 and post treatment - 72 hours BL is 0.002 which are compared to $p<0.05$. This indicates that there is statistically significance difference between pre-exercise- post exercise BL, post treatment- 24 hours BL, post treatment- 48 hours BL and post treatment- 72 hours BL in ultrasound group. **GRAPH 2** is comparing the mean values between pre-exercise- post exercise BL, post treatment- 24 hours BL, post treatment- 48 hours BL and post treatment- 72 hours BL in ultrasound group. This shows that there is significant difference between pre-exercise- post exercise BL, post treatment- 24 hours BL, post treatment- 48 hours BL and post treatment - 72 hours BL in ultrasound group.

Table- 3 calculating the mean and standard deviation for blood lactate levels ultrasound group

		Mean	N	Std. Deviation
Pair 1	PRE-EX BL	2.6000	10	.93571
	POST EX BL	7.8000	10	3.65331
Pair 2	POST EX BL	7.8000	10	3.65331
	post treatment BL24	3.1500	10	1.43314

Pair 3	POST EX BL	7.8000	10	3.65331
	post treatment BL48	4.4500	10	2.00236
Pair 4	POST EX BL	7.8000	10	3.65331
	post treatment BL72	2.5800	10	.60148

Table- 4 calculating the significance for blood lactate levels in ultrasound group

		Paired Differences	T	Df	Sig. (2-tailed)
		Mean			
Pair 1	PRE-EX BL – POST EX BL	-5.20000	-4.291	9	.002
Pair 2	POST EX BL – post treatment BL24	4.65000	3.818	9	.004
Pair 3	POST EX BL – post treatment BL48	3.35000	2.725	9	.023
Pair 4	POST EX BL - post treatment BL72	5.22000	4.429	9	.002

Graph- 2 comparing the mean values between pre-exercise- post exercise BL, post treatment ultrasound group.

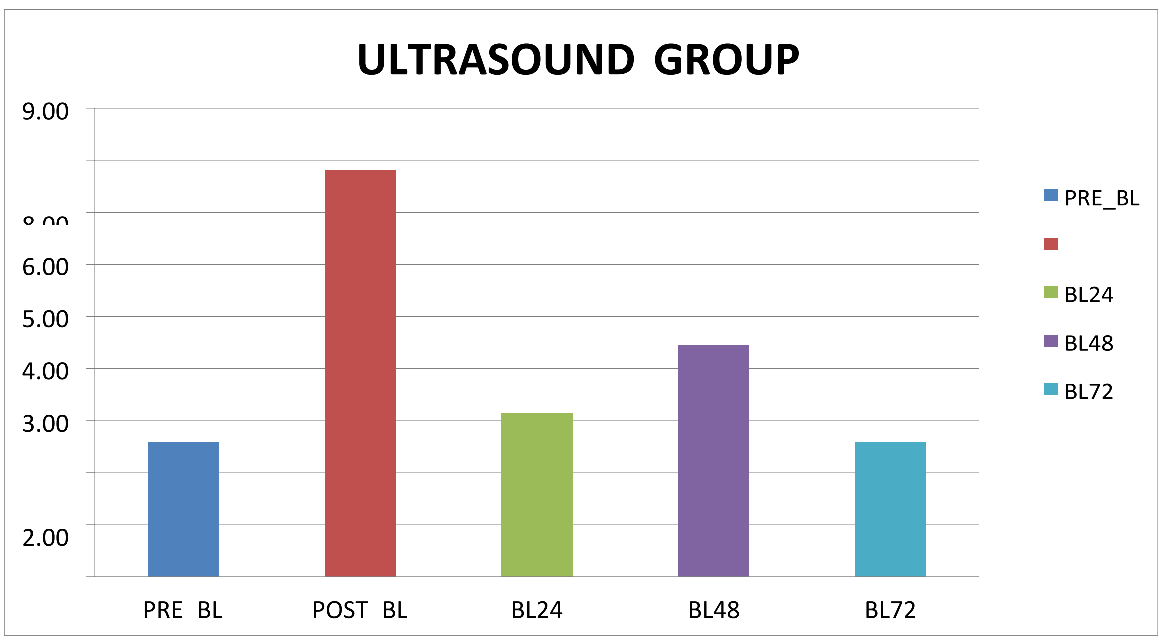

TABLE 5 is calculating the mean and standard deviation for blood lactate levels between pre-exercise – post exercise, post treatment- 24 hours BL, post treatment- 48 hours BL and post treatment - 72 hours BL in cryotherapy group. The mean and standard deviation for blood lactate level between pre-exercise (3.3900, 1.19299) – post exercise (9.5900, 3.59705), post treatment (9.5900, 3.59705) – 24 hours BL (2.7400,0.72142), post treatment (9.5900, 3.59705) – 48 hours BL (3.8100, 1.95531) and post treatment (9.5900, 3.59705) – 72 hours BL (2.3100, 0.70938) in cryotherapy group.

TABLE 6 is calculating the significance for blood lactate levels in cryotherapy group. The significance value for pre-exercise- post exercise BL is 0.000, post treatment- 24 hours BL is 0.000, post treatment- 48 hours BL is 0.000 and post treatment - 72 hours BL is 0.000 which are compared to $p<0.05$. This indicates that there is statistically significance difference between pre-exercise- post exercise BL, post treatment - 24 hours BL, post treatment- 48 hours BL and post treatment- 72 hours BL in cryotherapy group. **GRAPH 3** is comparing the mean values between pre-exercise- post exercise BL, post treatment- 24 hours BL, post treatment- 48 hours BL and post treatment - 72 hours BL in cryotherapy group. This shows that there is significant difference between pre-exercise- post exercise BL, post treatment- 24 hours BL, post treatment- 48 hours BL and post treatment - 72 hours BL in cryotherapy group.

Table- 5 calculating the mean and standard deviation for blood lactate levels between pre-exercise – post exercise, post treatment cryotherapy group

		Mean	N	Std. Deviation
Pair 1	PRE_BL	3.3900	10	1.19299
	POST EX_BL	9.5900	10	3.59705
Pair 2	POST EX_BL	9.5900	10	3.59705
	BL24 post Treatment	2.7400	10	.72142
Pair 3	POST_BL	9.5900	10	3.59705
	BL48 post Treatment	3.8100	10	1.95531
Pair 4	POST_BL	9.5900	10	3.59705
	BL72 post Treatment	2.3100	10	.70938

Table- 6 calculating the significance for blood lactate levels in cryotherapy group. The significance value for pre-exercise- post exercise BL cryotherapy group

		Paired Differences Mean	T	Df	Sig. (2-tailed)
Pair 1	PRE_BL – POST EX_BL	-6.20000	-5.990	9	.000
Pair 5	post Treatment - BL24	6.85000	6.067	9	.000
Pair 6	post Treatment - BL48	5.78000	5.508	9	.000
Pair 7	post Treatment - BL72	7.28000	6.649	9	.000

Graph- 3 comparing the mean values between pre-exercise- post exercise BL cryotherapy group

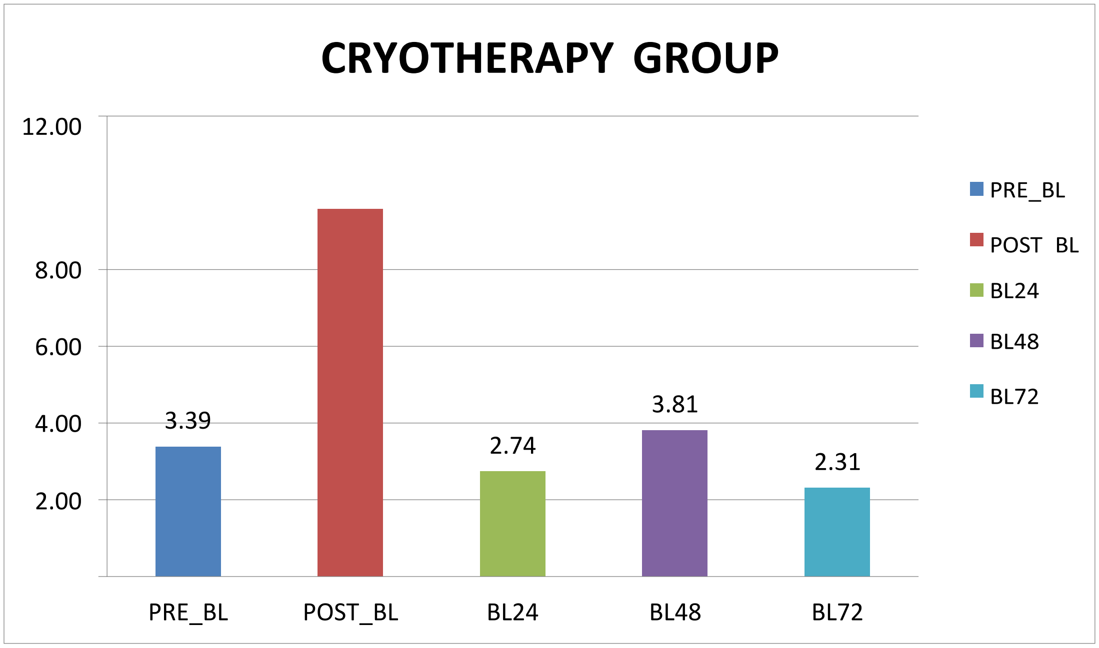

Table 7 is calculating the mean and standard deviation for pre-exercise, post exercise, 24 hours, 48 hours and 72 hours blood lactate levels within the groups. The mean and standard deviation of blood lactate levels in control (3.4000, 1.07497), ultrasound (2.6000, 0.93571) and cryotherapy (3.3900, 1.19299) groups. The mean and standard deviation of blood lactate levels in control (7.1000, 2.46982), ultrasound (7.8000, 3.65331) and cryotherapy (9.5900, 3.59705) cryotherapy. The mean and standard deviation of blood lactate levels in 24 hours- control (2.8000, 1.22927), ultrasound (3.1500, 1. 43314) and cryotherapy (2.7400, 0.72142) groups. The mean and standard deviation of blood lactate levels in 48 hours- control (4.6000, 1.77639), ultrasound (4.4500, 2.00236) and cryotherapy (3.8100, 1.95531) groups. The mean and standard deviation of blood lactate levels in 72 hours- control (2.3000, 0.82327), ultrasound (2.5800, 0.60148) and cryotherapy (2.3100, 0.70938) groups.

TABLE 8 is calculating the significance values of blood lactate levels in pre, post, 24 hours, 48 hours and 72 hours within the groups control, ultrasound and cryotherapy. The significance value of blood lactate level in pre (0.180), post (0.235), 24 hours (0.701), 48 hours (0.624) and 72 hours (0.618) where the values are higher than p= 0.05. This indicates that there is no significant difference in blood lactate levels within the three groups.

GRAPH 4 is comparing the mean values of blood lactate levels in pre, post, 24 hours, 48 hours and 72 hours within the groups control, ultrasound and cryotherapy. This shows that there is no significant difference within the three groups**.**

Table- 7 calculating the mean and standard deviation for pre-exercise, post exercise within the groups

		N	Mean	Std. Deviation
PRE_EX BL	CONTROL	10	3.4000	1.07497
	ULTRASOUND	10	2.6000	.93571
	CRYOTHERAPY	10	3.3900	1.19299
	Total	30	3.1300	1.10333
	CONTROL	10	7.1000	2.46982
	ULTRASOUND	10	7.8000	3.65331

POST EX_BL	CRYOTHERAPY	10	9.5900	3.59705
	Total	30	8.1633	3.34483
Post treatment BL24	CONTROL	10	2.8000	1.22927
	ULTRASOUND	10	3.1500	1.43314
	CRYOTHERAPY	10	2.7400	.72142
	Total	30	2.8967	1.14093
Post treatment BL48	CONTROL	10	4.6000	1.77639
	ULTRASOUND	10	4.4500	2.00236
	CRYOTHERAPY	10	3.8100	1.95531
	Total	30	4.2867	1.87924
Post treatment BL72	CONTROL	10	2.3000	.82327
	ULTRASOUND	10	2.5800	.60148
	CRYOTHERAPY	10	2.3100	.70938
	Total	30	2.3967	.70441

Table- 8 calculating the significance values of blood lactate levels in pre, post, 24 hours, 48 hours and 72 hours within the groups control, ultrasound and cryotherapy

		Sum of Squares	df	Mean Square	F	Sig.
PRE_BL	Between Groups	4.214	2	2.107	1.830	.180
	Within Groups	31.089	27	1.151		
	Total	35.303	29			
POST_BL	Between Groups	32.981	2	16.490	1.528	.235
	Within Groups	291.469	27	10.795		
	Total	324.450	29			
BL24	Between Groups	.981	2	.490	.360	.701
	Within Groups	36.769	27	1.362		
	Total	37.750	29			
BL48	Between Groups	3.521	2	1.760	.481	.624
	Within Groups	98.894	27	3.663		
	Total	102.415	29			
BL72	Between Groups	.505	2	.252	.491	.618
	Within Groups	13.885	27	.514		
	Total	14.390	29			

Graph- 4 comparing the mean values of blood lactate levels in pre, post, 24 hours, 48 hours and

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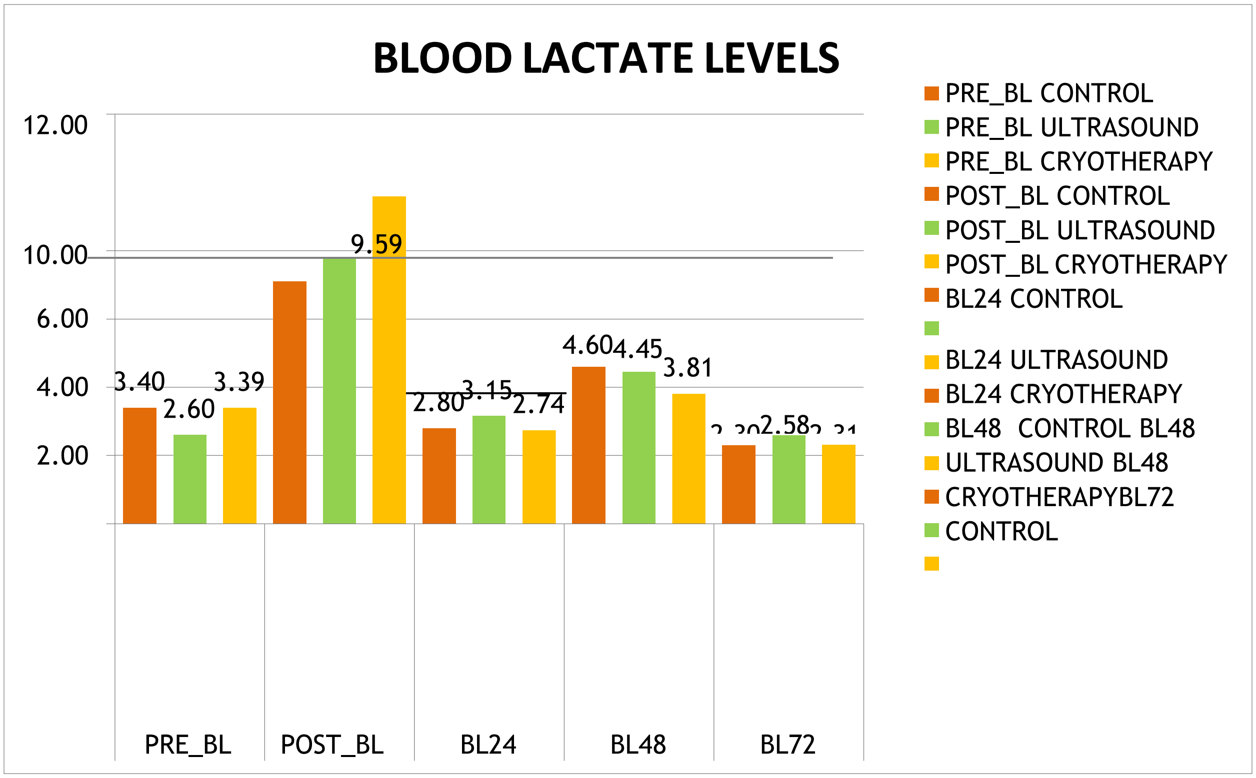
72 hours within the groups control, ultrasound and cryotherapy



DISCUSSION

The current study investigated the efficacy of electrotherapeutic techniques in reducing blood lactate levels related with delayed onset muscle soreness (DOMS). The comparison was made between control group (Group A) with ultrasound group (Group B) and cryotherapy group (Group C). The participants were engaged in a 40-minute skipping session, with blood lactate measured at baseline, 8 hours later, and again at 24, 48, and 72-hours after the treatment.

The findings suggest that the blood lactate levels were significantly reduced in both the ultrasound (Group B) and cryotherapy (Group C) compared to the control (Group A). Control group showed no significant changes post-exercise and at 48 hours, with a p-value of 0.054, while ultra sound group and Cryotherapy group showed significant differences ($p = 0.023$ and $p < 0.001$, respectively). At 72 hours post-exercise, all the three groups showed significant decrease in blood lactate levels, with Group C (cryotherapy group) achieved the most significant effect. [(14)]

This study was supported by another study done by Bieuzen et al.which has outlined the mechanism for lactate clearance, noting that increased blood flow to muscles may improve lactate oxidation, causing removal of blood lactate from the muscle to other tissues, and its conversion back to energy sources. This faster recovery potentially mitigates calcium release from the sarcoplasmic reticulum and prevents interference with calcium-troponin binding, thus maintaining contractile force. [(12)]

Further supporting the current study, another study done by Langer et al. showed that ultrasound facilitates lactate reduction through acoustic energy absorption, which increases blood flow, promoting stable cavitation, and thereby enhancing muscle oxygenation. [(14)] Similarly, Khashbat et al. reinforced my study concluding that cryotherapy helps in lactate clearance by limiting blood and lymph vessel permeability, there by reducing inflammation-induced secondary muscle damage. [(13)]

The significant reductions in DOMS-induced pain in the ultrasound and cryotherapy groups at 48 and 72 hours align with earlier studies by Kakaraparthi et al. and others. These studies highlighted the efficacy of cryotherapy on pain reliving mechanism, such as reduced nerve conduction, reduced muscle spasms, and tissue vasoconstriction, that are linked to pain inhibition. ([15,16,17]) Other studies have reported the benefits of ultrasound on muscle recovery and reduced DOMS, attributing these effects to the heating and mechanical forces generated by the therapy, which enhance tissue extensibility and reduce muscle spasm. [18,19]

CONCLUSION

In conclusion, both ultrasound and cryotherapy showed beneficial effects in decreasing blood lactate levels and reducing pain associated with DOMS. Application of Cryotherapy showed significant improvement over ultrasound on DOMS Thus, cryotherapy may be advisable over ultrasound for faster recovery from DOMS which is most significant for sports performance. However, future studies should explore larger sample sizes, diverse populations, and various sports, and on other outcome measures to deeply analyze the recovery modalities.

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Authors' contributions

All authors involved in Methodology, investigation, formal analysis, writing review & editing, and supervision; data collection, investigation, and writing original draft. All authors reviewed the manuscript.

Availability of data and materials: Data available within the article.

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Declarations

Conflict of interest: The authors declare that they have no conflict of interest.

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