Journal of Iranian Medical Council, Volume 7, Issue no. 4
http://dx.doi.org/10.18502/jimc.v7i4.16644

Original Article

Impact of Advanced High-Power Pain Threshold Static Ultrasound and Muscle Energy Technique on Pain Thresholds and Functional Improvement in Myofascial Trigger Points

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Abstract

Background: Myofascial Pain Syndrome (MPS) is a prevalent condition characterized by tense muscle bands and hypersensitive Trigger Points (TrPs), contributing to musculoskeletal pain. The objective of this study is to investigate and assess the effectiveness of Advanced High-Power Pain Threshold Static Ultrasound (AHPPTSU) and Muscle Energy Technique (MET) in altering pain thresholds and enhancing functional outcomes in individuals with myofascial trigger points.

Methods: In this randomized clinical trial involving 86 individuals with TrPs in the upper trapezius muscle, the participants were divided into experimental and control groups. 33 males and 53 females, underwent six sessions of treatment over two weeks. A repeated measure Analysis of variance was used to compare baseline values and altered values at 1 and 2 weeks.

Results: The study demonstrated that the Pressure Pain Threshold (PPT) and the Neck Pain Disability Index (NPDI) score, showed a significant improvements in participants receiving AHPPTUS in experimental group compared to the other group. Experimental group showed a significantly greater improvement in PPT (p=0.001) and both groups experienced a significant enhancement in function. However, when comparing the two groups, experimental group showed a significantly greater improvement (p=0.001). Importantly, no adverse effects were reported in either group.

Conclusion: In the treatment of myofascial trigger point, AHPPTSU can be considered as an alternative therapy method, which is more effective than previously used High-Power Pain Threshold Static Ultrasound (HPPTSU) therapy and it also shortens the total treatment protocol to 2 weeks.

Keywords: Myofascial pain syndrome, Neck pain, Pain threshold, Trigger points

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Received: 20 Jan 2024
Accepted: May 11 2024

Citation to this article
Singh AK, Ali K. Impact of Advanced High-Power Pain Threshold Static Ultrasound and Muscle Energy Technique on Pain Thresholds and Functional Improvement in Myofascial Trigger Points. *J Iran Med Counc.* 2024;7(4):811-20.

Introduction

Myofascial Pain Syndrome (MPS) is a common musculoskeletal disorder characterized by taut bands and hypersensitive points in muscles, often diagnosed by identifying Myofascial Trigger Points (MTrPs) (1). These Trigger Points (TrPs), both active and latent, can cause pain, muscle weakness, and limited range of motion. The syndrome significantly affects overall quality of life and emotional well-being (2,3).

In physical therapy, Ultrasound (US) with deep heat is widely used for its therapeutic effects. A novel approach, High-Power Pain Threshold Static Ultrasound (HPPTUS), involves applying continuous ultrasound waves until the patient experiences discomfort. The therapist maintains the intensity at that level for 4 to 5 seconds, followed by a reduction to half of that intensity for a 15-second duration in a static position. Research has shown that three sessions of HPPTUS (HPPTUS-3) were more effective in alleviating pain associated with active TrPs compared to conventional approaches (4,5).

A recent study sought to improve the effectiveness of HPPTUS by increasing the intensity and frequency of the treatment, as well as incorporating non-thermal effects at lower intensities (6). The investigation assessed Pressure Pain Threshold (PPT) and disability at baseline, after the third and sixth treatments, using validated measurement methods like pressure pain algometer and neck pain disability questionnaire. Previous research has posited that repeated exposure to painful stimuli can induce neuroplastic changes in the brain, potentially leading to an increase in pain threshold. This phenomenon has sparked interest in investigating the potential ramifications of such adaptations (7).

Despite previous studies indicating the effectiveness of HPPTUS in relieving pain from active TrPs, there is a notable gap in the literature regarding the combined efficacy of Advanced High-Power Pain Threshold Static Ultrasound (AHPPTUS) with Muscle Energy Technique (MET). The existing research does not adequately address the comparative effectiveness of these combined modalities in altering pain thresholds and improving functional outcomes in individuals with MTrPs. Thus, there is a need for further investigation to determine the potential synergistic effects of these treatments and their comparative effectiveness in clinical practice. Therefore, the objective of this study is to investigate and assess the effectiveness of AHPPTUS and MET in altering pain thresholds and enhancing functional outcomes in individuals with MTrPs.

Materials and Methods

In this randomized clinical trial, the research was conducted at the Physiotherapy department of G D Goenka University in Gurugram, Haryana, India, spanning 8 months from April to December 2023. All procedures adhered strictly to ethical standards and followed the guidelines outlined in the Helsinki Declaration of 2013. Informed consent was obtained from all participants, and their rights were fully acknowledged, with documentation properly archived. Independent ethics committee approval was granted by Waves Women Empowerment Trust (IEC.01/ WWE/01/2023/01). The study was registered with the clinical trial registry-India under CTRI/2023/03/050505.

Sample size calculation

The sample size was determined using G-Power 3.1.9.4 Software with a significance level of 5%, power (1-beta) of 95%, number of group-two, and no. of measurements- three. The estimated sample size was 78. Factoring in a 10% dropout rate, the final sample size was set at 86 individuals.

Inclusion and exclusion criteria

This study includes participants aged 20 to 50 yr. with chronic neck pain, at least one latent MTrP in the upper trapezius muscle, worsening neck pain with resistance movements, no history of fractures or dislocations, elicitation of a local twitch response during palpation, and experiencing the typical referred pain pattern from MTrPs upon compression (8,9). Exclusion criteria involve red flags for serious illnesses, specific shoulder pain with structural origins, language comprehension limitations (English or Hindi), history of traumatic shoulder issues or cognitive impairments, diagnosis of cervical radiculopathy or myelopathy by a primary care physician, and recent myofascial pain therapy within the past month (8-10).

Study procedure

In this study, 86 individuals with MTrPs in the upper trapezius muscle participated, comprising 33 males and 53 females. The sample allocation employed a systematic random sampling method. The recruitment and allocation process details can be found in figure 1. The participants were evenly distributed between two groups. Both groups underwent a six-session treatment regimen over a two-week period. The study centered on evaluating the PPT associated with TrPs in the upper trapezius muscle, with a focus on the neck pain disability index as an outcome measure. The diagnosis of TrPs was made based on specific criteria (10,11), such as regional pain complaints, referred pain, palpable taut band, spot tenderness, and restricted range of motion.

The study protocol involved the experimental group receiving MET and AHPPTSU, while the control group received MET and HPPTSU. The treatment regimen consisted of six sessions conducted over two consecutive weeks (on the 1st, 3rd, 5th, 7th, 9th, and 11th days). Each session included palpation and marking of the MTrPs in the upper trapezius to identify the treatment region. Participants in both groups received specific interventions, and to avoid potential interference effects, they did not receive any other forms of treatment or medication.

MET treatment

In this study MET was used for improving muscle function, joint mobility, and reducing musculoskeletal pain and dysfunction. Both participant groups underwent the MET as outlined by Chaitow. In this procedure, the participants were positioned supine on a therapy table, with the practitioner at the head end of the table. In cases where the restriction was identified on the right side, the practitioner would passively

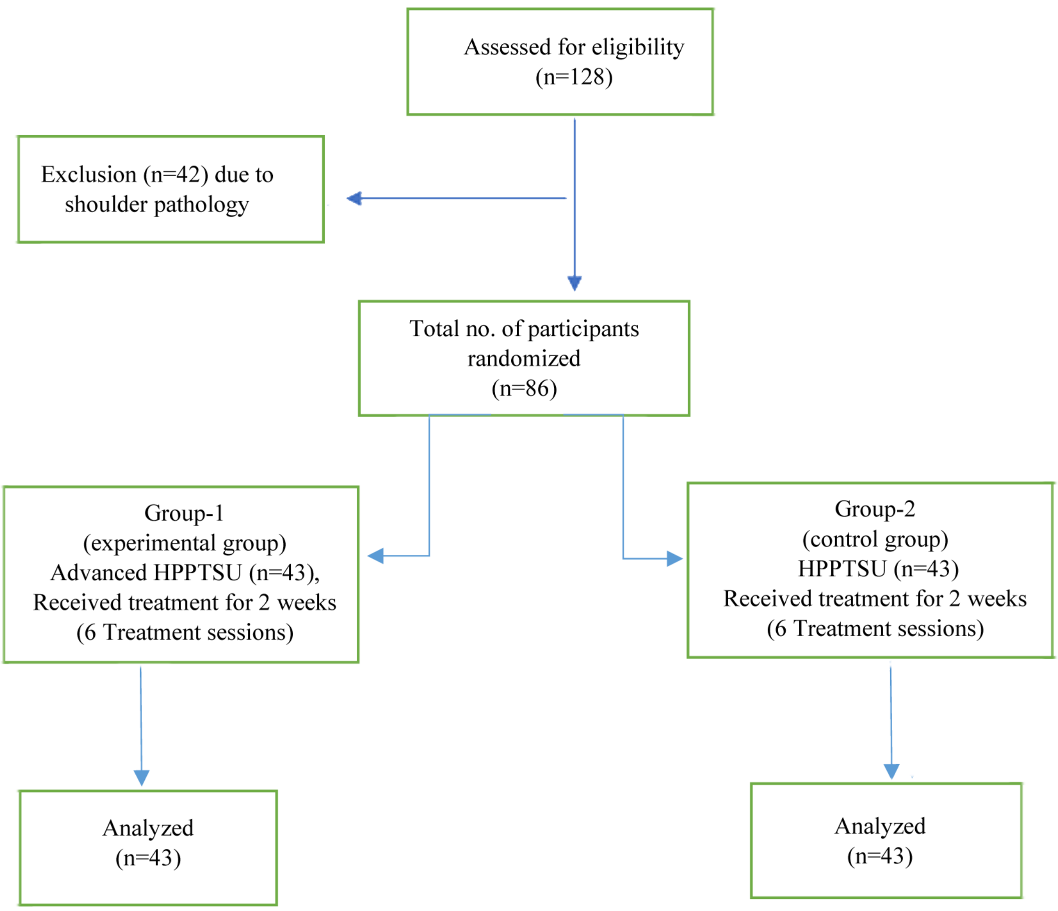

Figure 1. Randomized group assignment and trial progression.

flex the participant's head and neck to approximately 45 degrees until feeling resistance, effectively immobilizing the mid and lower cervical segments. The head was then rotated right until reaching a point of restriction.

The participant was guided to apply a mild force against the practitioner's hand (turning left) with about 40% of their maximum strength for a duration of 7 to 10 seconds. This was succeeded by a brief relaxation period of 2 to 3 seconds. Subsequently, the practitioner gently stretched the participant's neck to the identified limit or until the participant felt a comfortable stretch, maintaining this position for 30 seconds (Figure 2). After the stretch, the participant was allowed a brief rest in a neutral neck position for roughly 10 seconds. This entire sequence was repeated three times. During the final relaxation stage, the participant was advised to engage in deep breathing to enhance relaxation (11-14).

AHPPTSU

The US therapy utilized the Digisonic-2s apparatus, known for its adherence to international standards and quality. The AHPPTUS approach required increased interaction between participants and the therapist compared to the conventional US technique. In this method, the transducer was placed on TrPs and kept stationary with a continuous waveform during each session. The intensity was gradually increased from 0.5 W/cm^2 until the patient verbally reported feeling pain (the pain threshold). The therapist maintained this intensity level for 4 to 5 seconds before moving the US transducer in a circular motion with slight pressure for 15 seconds while keeping the intensity constant. Patients were regularly asked about any significant pain or unusual sensations experienced during AHPPTUS. The intensity varied between 0.5 and 1.5 W/cm^2 (15). Experimental group underwent the described procedure nine times.

HPPTSU

In the second method, the transducer was placed directly on the MTrP and maintained in a stationary position, with a continuous waveform recorded during each session. The intensity started at 0.5 W/cm^2 and gradually increased until reaching the pain threshold, at which point the patient indicated that the pain was no longer tolerable. The therapist maintained the intensity at that level for 4 to 5 seconds, followed by a reduction to half of that intensity for a 15-second duration in a static position. This sequence was repeated three times. The total application time for the HPPTUS technique was less than 5 *Min*, and the intensity ranged from 0.5 W/cm^2 to 1.5 W/cm^2. Throughout the treatment, patients were instructed to continuously report their pain levels.

Outcome measure

This study involved initial evaluations at baseline, followed by further assessments after three sessions (and at the conclusion of the treatment, to determine PPT and degrees of disability). The researchers

Table 1. Characteristics of demographic and clinical nature in both study groups

Variable	Mean	Std. devi.	Std. error	95% Confidence Interval		df	F	p-value
				Lower bound	Upper bound			
Initial PPT (kg/cm^2)	2.012	0.789	0.085	1.844	2.18			
PPT after 3rd session	3.488	0.85	0.077	3.335	3.642	1	184.4	<0.001
PPT after 6th session	6.744	1.48	0.085	6.574	6.914			
Initial disability index %	39.209	2.169	0.224	38.763	39.656			
Disability index % after 3rd session	27.477	3.622	0.28	26.919	28.034	1	208.64	<0.001
Disability index % after 6th session	12.244	3.34	0.178	11.89	12.598			

Table 2. Clinical characteristics of the two groups

Groups	Variable	Mean	Std. devi.	Std. error	95% Confidence Interval		df	F	p-value
					Lower bound	Upper bound			
Experimental group	Initial PPT (*kg/cm²*)	2.14	0.744	0.118	1.901	2.378	2	603.66	<0.001
	PPT after 3rd session	3.953	0.722	0.11	3.731	4.176			
	PPT after 6th session	8	0.723	0.11	7.777	8.223			
Control group	Initial PPT (*kg/cm²*)	1.884	0.793	0.121	1.64	2.128	2	251.71	<0.001
	PPT after 3rd session	3.023	0.706	0.108	2.806	3.241			
	PPT after 6th session	5.488	0.855	0.13	5.225	5.752			
Experimental group	Initial disability index %	39.86	2.48	0.379	39.096	40.625	2	1569	<0.001
	Disability index % after 3rd session	24.953	2.75	0.421	24.104	25.803			
	Disability index % after 6th session	9.349	1.39	0.213	8.919	9.778			
Control group	Initial disability index %	38.558	1.57	0.241	38.072	39.044	2	1398	<0.001
	Disability index % after 3rd session	30	2.42	0.371	29.252	30.748			
	Disability index % after 6th session	15.14	1.87	0.285	14.563	15.716			

utilized the pressure algometer "Force Gauge Model" manufactured by Baseline Instruments, located in New York, USA. This instrument employs a pressure transducer probe to accurately determine the minimum force or pressure required to elicit pain or discomfort in individuals. To measure the PPT, participants were positioned face down, and an algometer was applied to their MTrPs. The pressure was steadily increased at a rate of 1 $kg/cm^2/sec$, and the procedure was stopped when the participant indicated a transition from discomfort to actual pain. The maximum pressure applied at this point was recorded. For analysis, the average of two consecutive measurements was used (7).

The Neck Pain Disability Index (NPDI) is a tool used to assess disability and function related to neck pain. It consists of a questionnaire with 10 items, each contributing to a total score of 50. This index helps evaluate the impact of neck pain and its associated symptoms on daily life. This survey encompasses four subjective domains (pain severity, presence of headaches, ability to concentrate, and sleep quality), four domains pertaining to everyday activities, and two additional optional domains (self-care and reading ability). Items are rated on a 0-5 scale, where 0 signifies no pain and 5 denotes extreme pain. A cumulative score of 50 represents the highest level of neck-related disability, with higher scores indicating greater impairment (6). This approach provided an in-depth analysis of cervical spine mobility and the impact of TrPs on disability levels. These findings hold considerable importance for the discipline,

Figure 2. Application of muscle energy technique on upper trapezius muscle.

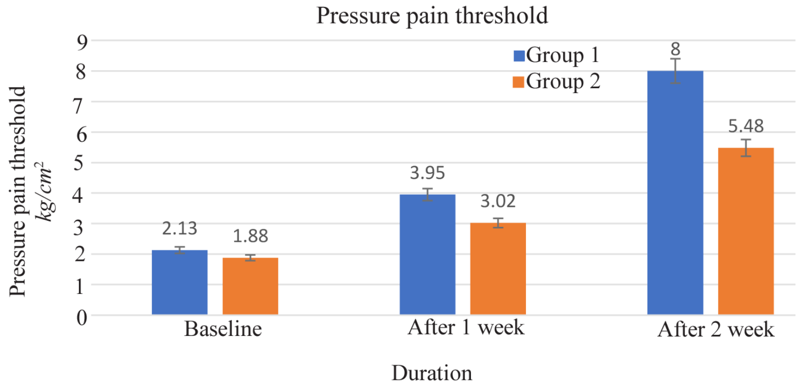

Figure 3. Improvement in Pressure Pain Threshold (PPT) after 2 weeks of intervention.

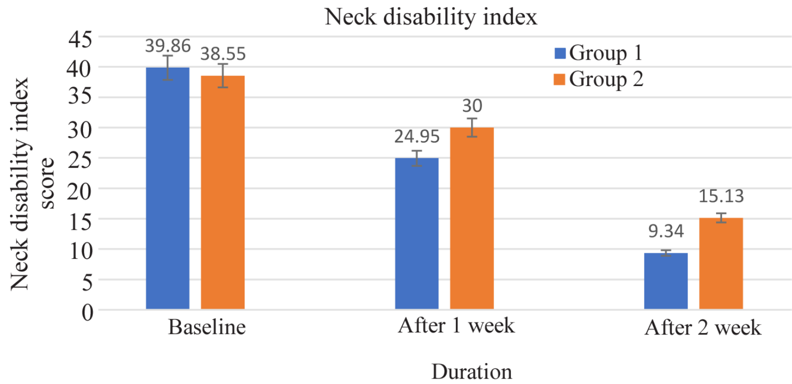

Figure 4. Improvement in Neck Pain Disability Index (NPDI) after 2 weeks of intervention.

enhancing comprehension and possibly directing improved treatment strategies for those afflicted with MTrPs. This could lead to enhanced life quality and better overall health for these individuals.

Data analysis

Data analysis was done for all the participants, SPSS Statistics 25.0 software was employed for conducting statistical analyses. A significance level (alpha) of $p<0.05$ was established for determining statistical significance. Repeated measure Analysis of variance was utilized to assess and compare variables such as PPT and neck pain disability index. Also, normality of the data distribution was checked using Shapiro Wilk test.

Results

In experimental group, which included 17 males and 26 females, the participants had a mean age of 32.37±5.73 yr. In control group, which comprised 16 males and 27 females, the mean age was 33.55±5.71 yr. The p-value for the gender distribution between the two groups is 0.770, which is not significant. The Shapiro-Wilk normality test was performed on all participants in each group for every variable. The findings revealed no significant differences, indicating comparability between groups for both variables and data was normally distributed. During the baseline assessment, there were no significant differences observed in PPT values (p=0.134) and disability percentages demonstrated no statistically significant disparities at the baseline evaluation (p=0.069) (Table 1).

Following a two-week intervention period, statistically significant differences were observed in PPT (p=0.001) and disability (p=0.001). Repeated measure ANOVA demonstrated a noteworthy difference in comparisons between the baseline and measurements at 1 week (5th day), and 2 week (11th day). The corresponding data depicting these changes was detailed in table 2 (Figures 3 and 4).

Discussion

The objective of this study is to investigate and assess the effectiveness of AHPPTSU and MET in altering pain thresholds and enhancing functional outcomes in individuals with MTrPs.

In group comparison, the PPT and disability showed that the experimental group experienced a greater increase in pain threshold than the control group. Data of the present study suggest that higher times of applications of HPPTUS is necessary to treat TrPs as evidenced by increased PPT in experimental group compared with control group. Previous studies have extensively compared different treatment protocols for managing MTrPs (16-19,29). However, there remains a gap in the literature concerning the specific comparison and correlation of two distinct HPPTUS approaches and their effects on MTrPs. This study aims to fill this gap by examining the efficacy and outcomes of these two HPPTUS techniques in addressing MTrPs.

This study is significant as it contributes a novel perspective to the existing literature. A previous study investigated the use of HPPTUS on MTrPs, demonstrating positive outcomes (10). The results of the current study are in accordance with these findings, highlighting the advantageous effects of AHPPTSU in improving PPTs and reducing pain levels.

In a study conducted by Gam AN *et al*, it was observed that ultrasound showed no discernible difference compared to sham ultrasound (21). Another study conducted on the same subject reported statistically significant improvements in pain and function following the administration of ultrasound therapy. The findings suggested that ultrasound therapy was effective in alleviating pain and improving functional outcomes. This underscores the potential of ultrasound therapy as a viable treatment modality for addressing musculoskeletal conditions (22). The application of ultrasound has been a subject of debate within the scientific community. The results of the current study indicate that the utilization of AHPPTSU on a TrP significantly influences an individual's PPT and function. These findings align with previous research, emphasizing the efficacy of high-power pain threshold static ultrasound (19).

The results further reveal that the experimental group receiving AHPPTUS experienced a more substantial reduction in PPT and disability compared to the control group. Previous research has demonstrated that HPPTUS exhibits similar efficacy to conventional ultrasound, extracorporeal shock wave therapy, and other HPPTUS modalities in the management of TrPs (4,5,11,14). However, the majority of these studies have primarily investigated the immediate effects of these interventions. Further investigation into the long-term effects and comparative effectiveness of these treatments could provide valuable insights into their clinical utility and optimal use in managing TrPs (19). However, this investigation suggests that a higher intensity of HPPTUS applications is necessary to effectively address TrPs, leading to an increased PPT and function by reducing disability in the experimental group.

In this study, AHPPTSU was employed over a two-week period to target active MTrPs. Study findings align with previous research conducted by Yushin *et al* (19). It is essential to highlight that while Yushin *et al*'s study demonstrated similar effects on latent TrPs, this study specifically concentrated on active TrPs. It is also noteworthy that separate studies conducted by Hariharan *et al* (18). and Haytham *et al* (23). utilized distinct methodologies and administered varying doses of HPPTUS, contributing to the diverse range of therapeutic approaches in this field.

One potential underlying mechanism involves the enhancement of the pain threshold in the central nervous system due to recurrent pain exposure. Previous neuroimaging investigations have shown a progressive reduction in pain perception following repeated noxious stimuli, a phenomenon known as habituation or pain adaptation. These studies have provided evidence that repeated exposure to painful stimuli alters brain activity and raises the pain threshold. This adaptation to pain serves as a protective strategy against recurring painful episodes (4,5,19). As a result, the HPPTUS technique might increase sensitivity to pain due to habituation to pain (24,25). Another possible mechanism for HPPTUS is its potential to cause damage to muscle tissue and subsequent regeneration. Previous research has suggested that ultrasound stimulation can change cell membrane permeability and surface morphology (26,27). This study proposes that the application of high-intensity ultrasound promotes the proliferation of muscle cells through both mechanical and thermal effects (25,27). However, the proper administration of HPPTUS, along with sufficient healing intervals, may help disrupt the positive feedback cycle described by the energy crisis hypothesis and promote the regeneration of muscle tissue containing TrPs. Moreover, high-intensity ultrasound could have an immediate effect on reducing the conduction of pain signals in TrPs. It has been reported that intense ultrasound waves can decrease the amplitude of the evoked compound action potential associated with its thermal impact (28,29).

The application of AHPPTUS techniques yielded no reported adverse effects among any of the participants, indicating a favorable safety profile. Notably, the study's findings elucidated significant improvements in PPT and overall pain-related disability. These results underscore the potential efficacy and safety of AHPPTUS in mitigating pain and enhancing functional outcomes, suggesting promising avenues for clinical application and further investigation.

Limitation of the study

The current study did not incorporate an evaluation of Range of Motion (ROM) in the neck area, a factor that might have offered further understanding of the treatments' impact. Moreover, the duration of the study was limited to two weeks, without subsequent monitoring to determine the enduring effects of the treatments. For a more comprehensive analysis of these interventions in future research, it is advisable to extend the observation period and incorporate a wider array of outcome measures. These may include assessments of neck ROM, quantification of pain levels, and evaluation of sleep quality. Additionally, electromyography can be employed for a detailed analysis of muscle activity.

Conclusion

The findings of this research indicate that increasing the frequency of HPPTUS applications, as as used in experimental group, leads to more effective TrP management. This is evident from notable improvements in PPT, reduced disability, and enhanced function. These results provide valuable insights into a practical approach for TrP treatment, opening doors to further exploration in this promising field. A higher frequency of HPPTUS applications can significantly enhance TrP management, offering a potentially more effective treatment option for patients and clinicians to consider.

Acknowledgement

We extend our sincere appreciation to all the individuals who participated in this research study. Their willingness to be part of this investigation has been instrumental to its success. Additionally, we would like to express our gratitude to the Independent Ethics Committee with DHR Registration No.: EC/NEW/IND/2021/1807 and CDSCO Registration No.: ECR/358/Indt/DL/2022 for granting approval for this study. We also acknowledge the Clinical Trial Registry-India for registering this study with CTRI/2023/03/050505.

Conflict of Interest

There was no conflict of interest in this manuscript.

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