Original Article

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Impact of Two Different High-power Pain Threshold Static Ultrasound Techniques on Myofascial Trigger Points: A Pilot Study

Physiotherapy Section

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ABSTRACT

Introduction: Myofascial Pain Syndrome (MPS) is a challenging musculoskeletal condition with a prevalence of upto 30% in certain populations seeking medical care. It is characterised by Trigger Points (TrPs) in muscle fibres, leading to spontaneous pain, referred pain, muscle tension, and restricted Range of Motion (ROM). The integrated TrP hypothesis proposes that an energy crisis triggers TrPs through calcium release, prolonged muscle activity, and localised ischaemia. Vasoactive substances sensitise nociceptors and perpetuate the cycle. High-power Pain Threshold Ultrasound (HPPTUS-9), a novel Ultrasound (US) therapy, shows promise in reducing pain from active TrPs. The present study investigates the effects of HPPTUS-9 on Pressure Pain Threshold (PPT), subjective pain intensity, lateral flexion ROM, and disability in MPS patients.

Aim: To determine the impact of two different HPPTUS techniques on MTrPs.

Materials and Methods: A randomised clinical trial was conducted using a two-way mixed analysis of variance at the Department of Physiotherapy, GD Goenka University in Gurugram, Haryana, India, over a four-month period from April 2023 to August 2023. A total of 16 individuals with TrPs in the upper trapezius muscle, comprising seven males and nine females, were included. They were equally divided into two groups: the HPPTUS-9 group 1 and the HPPTUS group 2. Both groups received treatments over a six-session period spanning two weeks. The primary outcome measure was the PPT, which evaluated the pain threshold of TrPs in the upper trapezius muscle. The secondary outcome measures included ROM, Neck Pain Disability Index (NPDI), and subjective pressure pain intensity. Statistical analysis was conducted using paired t-tests.

Results: Between-group analysis revealed that participants who underwent nine applications of HPPTUS experienced a significantly greater increase in PPT (p=0.001) and ROM (p=0.001) compared to the other group at the end of the two-week intervention. Additionally, both groups demonstrated a significant decrease in pain (p=0.002) within their respective treatments. Notably, no adverse effects were reported in either group.

Conclusion: The present study demonstrates that nine applications of HPPTUS led to significant improvements in PPT and ROM compared to the alternative treatment group. Both groups showed a notable reduction in pain during their respective interventions. Importantly, no adverse effects were reported in either group throughout the two-week study period. These findings suggest that HPPTUS has the potential to be an effective and safe treatment option for addressing pain and mobility issues.

Keywords: Ischaemia, Myofascial pain syndrome, Neck pain disability index, Upper trapezius, Visual analogue scale

INTRODUCTION

Cervical discomfort ranks as the fourth leading cause of disability, with an annual occurrence rate of over 30%. Globally, approximately 70% of individuals will experience neck discomfort at some point, with a prevalence of 19.5% in Spain, more common among women than men [1,2]. While most cases of acute neck pain resolve on their own, up to 50% of individuals may continue to experience discomfort or recurrent pain despite treatment [2-4]. Furthermore, the onset of neck pain is associated with factors such as occupational demands, psychological stress, and feelings of depression [1]. Jobs that involve prolonged stillness and repetitive upper limb movements are more prone to neck discomfort [5].

There is a suggestion that Myofascial Trigger Points (MTrPs) may contribute to pain in individuals with mechanical neck pain. Consequently, certain studies incorporate MTrP therapy as part of the treatment strategy for these patients [6,7]. MTrPs are highly prevalent in individuals with myofascial pain, particularly in the upper trapezius muscle (93.75%). Active MTrPs are more common on the right-side (82.1%) than the left-side (79%) [4]. The upper trapezius muscle is susceptible to MTrP development due to continuous engagement and micro-trauma [7].

MTrPs are highly sensitive areas within tense muscles that often cause referred pain. The diagnosis of Myofascial Pain Syndrome (MPS) usually involves identifying one or more TrPs [8,9]. MTrPs can be classified into two clinical types: active and latent. Active MTrPs cause spontaneous or movement-related pain, while latent MTrPs do not exhibit symptoms but can trigger pain under pressure [5,9]. MTrPs can lead to muscle weakness, limited Range of Motion (ROM), and typically elicit a local twitch response that replicates the patient's symptoms by inducing pain [9,10]. The convergence of these symptoms can significantly impact an individual's overall quality of life, emotional well-being, and overall health [5].

Various treatments have been employed over time to address active TrPs. Non invasive methods like laser, Ultrasound (US), magnetic, and manual therapies have been extensively studied [11]. Among these approaches, US therapy has received academic attention due to its ability to penetrate superficial tissues [10,12]. Earlier studies have suggested that direct deep tissue stimulation through US therapy can rapidly alleviate pain from active TrPs [11,13]. Consequently, a rigorous and high-quality randomised controlled study is warranted.

A new technique called HPPTUS has been developed to address this issue. It involves applying continuous US waves until the patient experiences uncomfortable referred pain, at which point the therapist continues with circular movements at the same

intensity or reduces it by 50% [14-16]. A prior study demonstrated that three sessions of HPPTUS treatment (HPPTUS-3) were more effective than the conventional approach in reducing pain caused by active TrPs [15].

The present study aimed to test the hypothesis by evaluating Pressure Pain Threshold (PPT), pain intensity, Lateral Flexion Range of Motion (LFROM), and disability at baseline, after the third and sixth treatments using different HPPTUS applications. Previous research has confirmed the reliability and validity of these measurement methods, particularly PPT, in earlier studies [17,18]. Preliminary findings from a prior study indicated that three HPPTUS treatments per session were well-tolerated but insufficient to reduce the level of TrPs [15]. Therefore, the current study aimed to apply a higher dosage of HPPTUS, specifically nine times per session (HPPTUS-9). One initial study showed that subjecting individuals to repeated painful stimuli over nine applications can alter brain activity and elevate the pain threshold, prompting an exploration of the potential impacts of these changes [15].

MATERIALS AND METHODS

A randomised clinical trial was conducted using a two-way mixed analysis of variance. The study took place at the Physiotherapy Department of GD Goenka University in Gurugram, Haryana, India, over a four-month period from April 2023 to August 2023. The procedures implemented in the study adhered strictly to ethical standards and the guidelines of the Helsinki Declaration of 2013. Institutional approval was obtained from Waves Women Empowerment Trust (IEC.01/ WWE/01/2023/01), and the study was registered at the clinical trial registry-India CTRI/2023/03/050505.

Inclusion criteria: The study included individuals aged 20 to 50 experiencing neck pain for over three months, with atleast one latent Myofascial Trigger Point (MTrP) in the upper trapezius muscle. Other criteria included neck pain worsening with resistance movements, absence of fractures or dislocations, eliciting a local twitch response during palpation, and experiencing the typical referred pain pattern from MTrPs upon compression.

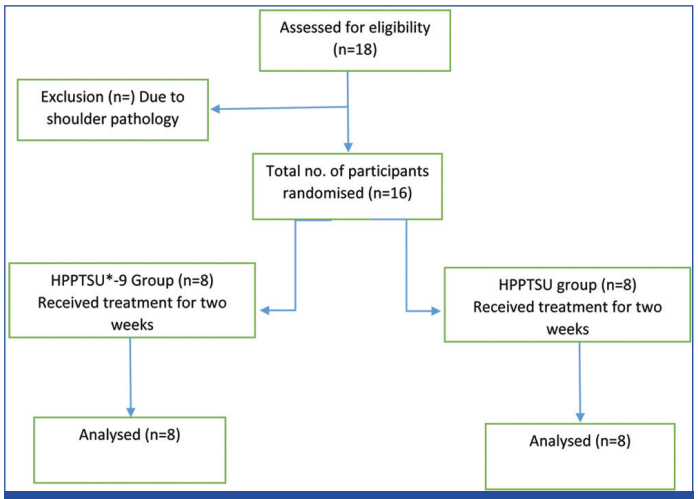
Exclusion criteria: Exclusion criteria encompassed the presence of red flags indicating serious illnesses, specific shoulder pain with structural or pathophysiological origins, age below 18 years, language comprehension limitations (English or Hindi), a history of traumatic shoulder issues or cognitive impairments, a diagnosis of cervical radiculopathy or myelopathy by a primary care physician, and recent myofascial pain therapy within the past month prior to the study.

Sample size calculation: The sample size for the present pilot study was determined to be 134 individuals, considering a significance level of 5% and a power of 95%, along with a 10% dropout rate. The primary study's sample size was set at 1,122 individuals, making the pilot study's sample size deliberately set at 12% (16) of the primary study's sample size.

Study Procedure

The study included a total of 16 individuals (seven males and nine females) with myofascial trigger points in the upper trapezius muscle. They were equally divided into two groups: the HPPTUS group and the HPPTUS-9 group. Both groups underwent treatments over a six-session period spanning two weeks. The primary outcome measure was the Pain Pressure Threshold (PPT) to evaluate the pain threshold of trigger points in the upper trapezius muscle.

Secondary outcome measures included ROM, Neck Pain and Disability Index (NPDI), and subjective pressure pain intensity. The recruitment and allocation process is depicted in [Table/Fig-1]. A systematic random sampling method was used for the allocation of the sample. The treatment protocol involved the application of two different types of US therapies. The US apparatus used for treatment was the Digisonic-2s, which met international standards and quality. The HPPTUS approach necessitated greater interaction between participants and the therapist compared to the conventional US technique. In this method, the transducer was positioned on the trigger points and maintained in a stationary position with a continuous waveform. The intensity was gradually increased until the patient 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 for 15 seconds while keeping the intensity constant. The intensity ranged from 0.5 to 1.5 W/cm^2. The procedure was repeated nine times in the HPPTUS-9 group.



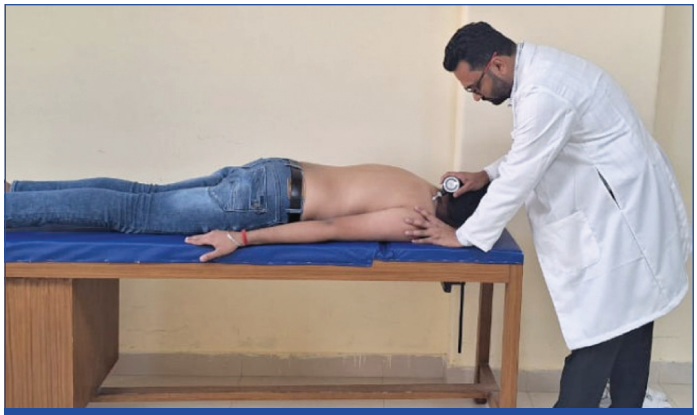
[Table/Fig-1]: Group randomisation and progression through the trial.
*HPPTUS: High-power pain threshold ultrasound

In the second method, the transducer was placed directly on the trigger point and kept static, with a continuous waveform during each session. The intensity was gradually increased to the pain threshold level at which the patient reported that the pain was no longer tolerable. The therapist kept the intensity at that level for 4 to 5 seconds, after which the intensity was reduced to half that level for a 15-second duration. This procedure was repeated three times. The application time for the HPPTUS technique was less than five minutes, and the intensity varied from 0.5 to 1.5 W/cm^2. Patients were asked to continuously report their pain level during the treatment.

The study employed distinct measurements to assess participants' improvement, including the PPT, Visual Analogue Scale (VAS), lateral flexion Range of Motion (ROM) of the cervical spine, and the Neck Pain Disability Index (NPDI).

Outcome measures:

1. **Pressure Pain Threshold (PPT):** The algometer was positioned on the myofascial trigger points (MTrPs) while the individuals lay down [Table/Fig-2]. When discomfort turned to pain, they alerted the therapist, and the pressure was stopped. The maximum pressure applied was noted. Pressure was increased at a rate of 1 kg/cm^2/sec until discomfort, monitored by an algometer. The average of two consecutive readings was used for analysis [17].
2. **Visual Analogue Scale (VAS):** The VAS is a frequently employed tool for assessing outcomes or determining a health utility index. It consists of a straight line that is 10 centimetres long, with labels at both ends denoting the scale. Patients are requested to mark a point on this line between the labels "no pain" and "pain as severe as possible" to indicate the intensity



[Table/Fig-2]: Assessment of Pressure Pain Threshold (PPT) using algometry.

of their pain. The total score can vary from 0 to 100 mm, depending on the placement of the mark [19].

3. **Lateral Flexion Range of Motion (ROM) of the cervical spine:** This measurement quantifies the degree of lateral movement that the cervical spine can achieve. A reduced ROM indicates limited flexibility and can be indicative of musculoskeletal issues [20].
4. **Neck Pain Disability Index (NPDI):** The NPDI assessment comprises a 10-item questionnaire with a total of 50 points, which evaluates the influence of neck pain and related symptoms on different daily activities. Among these, four elements are subjective (pain intensity, headache, concentration, and sleep), four pertain to daily tasks, and two are optional (personal care and reading). A score of 0 implies no discomfort, while a score of 5 signifies severe pain for a single component. The highest achievable score for all components is 50, with higher scores indicating a more significant level of neck impairment [21].

This comprehensive approach provided valuable insights into participants' cervical spine mobility and the impact of myofascial trigger points (MTrPs) on disability. The findings contribute to advancing knowledge in the field and may guide targeted interventions for individuals with MTrPs, enhancing their overall well-being and quality of life.

STATISTICAL ANALYSIS

Statistical analysis was performed using Statistical Package for Social Sciences (SPSS) Statistics 25.0. The level of significance, or alpha level, was set at a p-value <0.05 to be considered statistically significant. Two-way mixed analysis of variance was used to compare the Pressure Pain Threshold (PPT), Neck Pain Disability Index (NDI), Range of Motion (ROM), and Visual Analogue Scale (VAS), taking into account the normality of the data. Within-group analysis was conducted using paired t-tests for PPT, NDI, ROM, and VAS.

RESULTS

At the baseline assessment, no significant differences were observed in the PPT values (p=0.57), and the lateral flexion ROM similarly demonstrated no significant variance at baseline (p=0.89). Furthermore, the visual analogue scores and disability percentages also exhibited no statistically significant disparities at the baseline evaluation (p=0.51 and p=0.33, respectively) [Table/Fig-3].

After one week of intervention, notable differences were observed between the experimental and control groups in various outcome measures. Specifically, there were significant differences in PPT (p=0.03), ROM (p=0.006), and Disability (p=0.001). However, it is worth mentioning that the Visual Analogue Scale (VAS) did not show any significant difference after three treatment sessions (p=0.57).

	Group 1: HPPTUS-9 (N=8)	Group 2: HPPTUS (N=8)	p-value
Gender % Women	62.5 % (5)	62.5 % (5)	1.00
Gender % Men	37.5 % (3)	37.5 % (3)	1.00
Age (years)	32.75±5.95	34.87±4.61	0.73
Initial PPT (kg/cm^2)	2.25±0.79	2±0.79	0.57
Initial LFROM (°)	14±4.71	14±5.14	0.89
Initial VAS	8.25 ±0.89	7.87±0.87	0.51
Initial disability index %	39.87±2.72	38.5±1.50	0.33
PPT after 3rd session	4±0.70	3±1.19	0.03
LFROM after 3rd session	35±2.27	28±2.69	0.006
VAS after 3rd session	6.87±0.77	7±0.70	0.57
Disability index % after 3rd session	25.5±2.84	27.5±3.67	0.001
PPT after 6th session	8±0.70	5.5±0.86	0.001
LFROM after 6th session	43.5±3.16	34.25±2.39	0.001
VAS after 6th session	2.5±0.86	4.5±0.86	0.002
Disability index % after 6th session	9.37±1.41	15.12±1.84	0.001

[Table/Fig-3]: Demographic and clinical characteristics of the two groups.

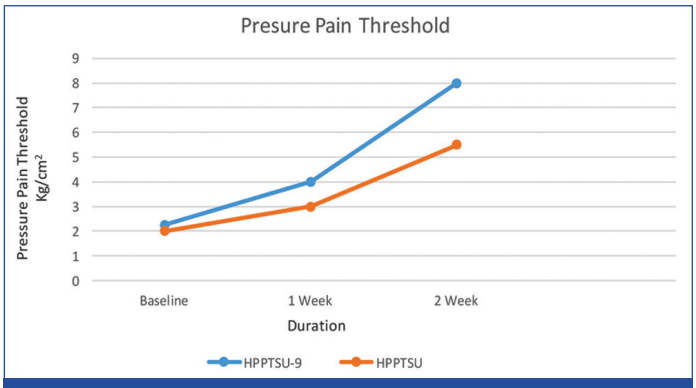
After a two-week intervention period, statistically significant variances were found in PPT (p=0.001), ROM (p=0.001), and Disability (p=0.001). It is worth noting that the VAS also displayed a significant difference after three treatment sessions (p=0.002).

The paired t-test was employed for within-group analysis, and it revealed a significant difference when the baseline was compared with the measurements taken after one week and after two weeks. The data illustrating these variations were presented in [Table/Fig-4].

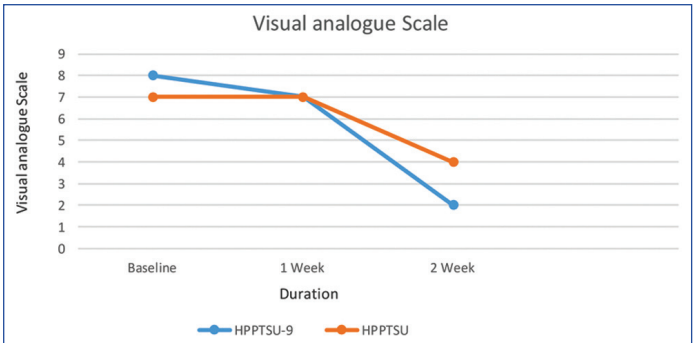
Groups	Baseline	After 6th treatment session	p-value
Group-1			
PPT	2.25±0.79	8±0.70	0.001
LFROM	14±4.71	43.5±3.16	0.001
VAS	8.25 ±0.89	2.5±0.86	0.001
Disability index %	39.87±2.72	9.37±1.41	0.001
Group-2			
PPT	2±0.79	5.5±0.86	0.001
LFROM	14±5.14	34.25±2.39	0.001
VAS	7.87±0.87	4.5±0.86	0.001
Disability Index %	38.5±1.50	15.12±1.84	0.001

[Table/Fig-4]: Clinical characteristics of the two groups.

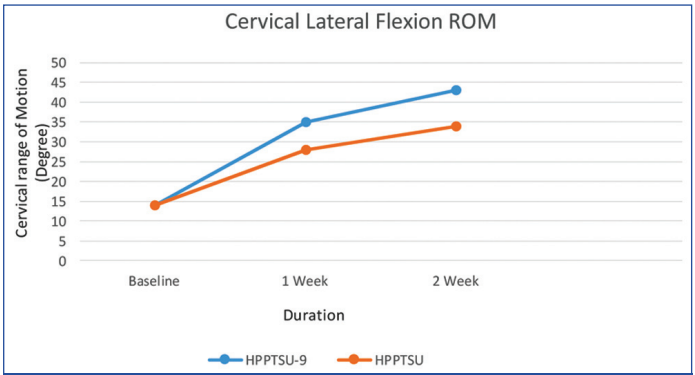
Moreover, it is worth highlighting that none of the participants reported any adverse effects following the application of the HPPTUS techniques. Overall, the study findings suggested that both groups experienced positive changes in pain perception, neck mobility, and overall pain-related disability [Table/Fig-5-8].



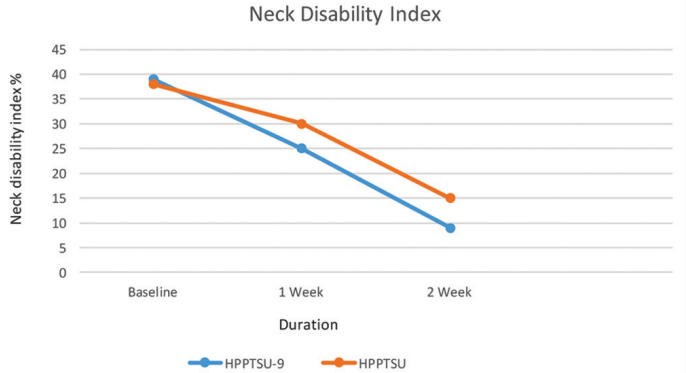
[Table/Fig-5]: Comparisons of the Pressure Pain Threshold (PPT).



[Table/Fig-6]: Comparisons of the Visual Analogue Scale (VAS) score.



[Table/Fig-7]: Comparisons of the Lateral Flexion Range of Motion (ROM).



[Table/Fig-8]: Comparisons of the disability percentage.

DISCUSSION

The present study aimed to investigate the efficacy of two different HPPTUS techniques on Myofascial Trigger Points (MTrPs). Previous research studies [2,3,6,15,22] have compared different treatment protocols for MTrPs, but none have explored the relationship between these two different HPPTUS techniques on MTrPs. Therefore, the present study is unique and contributes to the existing literature.

One study examined the effect of a HPPTUS technique on MTrPs and found positive results [15]. These findings were consistent with the results of the present study and supported the influence of the HPPTUS technique in improving PPT and pain.

In a study conducted by Gam AN et al., it was found that US did not show any difference compared to sham US [23]. However, another study reported significant improvements in pain and function with the application of US therapy [24]. The use of US was therefore controversial in the literature. The results of the present study suggested that HPPT static US on MTrPs had a significant effect on an individual's PPT and pain. These findings align with other research studies that indicate the effectiveness of HPPT static US [15,16].

The results indicated that the group that received HPPTUS-9 experienced a more significant reduction in PPT and subjective pain intensity compared to the HPPTUS group. In previous studies, HPPTUS was found to be comparable to conventional US, extracorporeal shock wave therapy, and other HPPTUS techniques in the treatment of MTrPs. Most of these studies observed the immediate effects of these treatments [Table/Fig-9] [13,15,23,25]. However, this investigation revealed that a higher frequency of HPPTUS applications was necessary to effectively address MTrPs, leading to an increased PPT and ROM in the HPPTUS-9 group.

In the present study, the authors utilised HPPTSU-9 over a two-week period to target active MTrPs. The present study findings were consistent with prior research conducted by Kim Y et al., [15]. However, it is crucial to emphasise that Kim Y et al.'s study demonstrated similar effects on latent MTrPs, while the

S. No.	Author's name and year	Place of study	Number of subjects	Intervention given	Parameters assessed	Conclusion
1	2013- Hari HR and Singh AK, [13]	M M University, Ambala Haryana, India	N1-15 and N2-15	N1- HPPT static ultrasound with transverse friction massage and stretching of upper trapezius muscle fibre N2- Transverse friction massage and stretching of upper trapezius muscle fibre	Range of Motion by Goniometer Disability % -Neck Disability Index (NDI) questionnaire	N1- Showed Significant difference between pre and post values of VAS, PPT, ROM
2	2014- Kim Y et al., [15]	Korea University, Seoul, South Korea	N1=8, N2=8 and N3=8	N1-HPPT Static US -5 N2-HPPT Static US -9 N3 received continuous US for 5 min with an intensity of 1.0 W/cm^2 and a duty cycle of 100%	Pressure pain tolerance by Algometer Pain-Visual analogue scale	HPPTSU-9 Group showed a significant difference than other groups
3	1998- Gam AN et al., [23]	University of Copenhagen, Lyngholmvej, Vanløse, Denmark	N1-18, N2-22 and N3-18	N1-Ultrasound, massage and exercise, N2-Sham-ultrasound, massage and exercise N3-Control group	Pain- Visual Analogue Scale	Ultrasound gives no pain reduction, but apparently massage and exercisereduces the number and intensity of MTrP
4	2021- Elhafez HM et al., [25]	Modern University for Information and Technology, Cairo, Egypt	N1-20, N2-20 and N3-20	N1-Extracorporeal shock wave plus neck stretching and strengthening exercise and N2- HPPTUS plus neck stretching, strengthening exercise, N3-Neck stretching, strengthening exercise	Functional disability by Arabic Neck Disability Index and Pressure Pain Threshold (PPT) by pressure Algometer	Extracorporeal shock wave therapy had significant improvement when compared to HPPT Static ultrasound
5	2023- Anand Kumar Singh and Kamran Ali (Present study)	G.D. Goenka University, Haryana India	N1-8 and N2-8	N1-High Power Pain Threshold Static Ultrasound-9 N2-High Power Pain Threshold Static Ultrasound	PPT by Algometer ROM by Goniometer Disability % -Neck Disability Index (NDI) questionnaire Pain by visual analogue scale	N1- Showed Significant difference between pre and post values of PPT, VAS, ROM and Disability %

[Table/Fig-9]: Similar studies and their findings [13,15,23,25].

present investigation specifically focused on active MTrPs [15]. Additionally, it is worth noting that separate studies conducted by Hari HR and Singh AK, and Elhafez HM et al., employed distinct methodologies and administered varying doses of HPPTSU, thus contributing to the diverse range of therapeutic approaches in this field. Similar studies have been tabulated in [Table/Fig-9] [13,15,23,25].

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 revealed 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 elevates the pain threshold. This adaptation to pain serves as a protective strategy against recurring painful episodes [15].

Consequently, the HPPTUS technique could heighten pain sensitivity as a result of pain habituation [26,27]. Another plausible mechanism for HPPTUS is its potential to induce muscle tissue damage and subsequent regeneration. Notably, the groups subjected to HPPTUS did not display any reduction in PPT or tolerance for up to two days following the intervention. Previous research has suggested that US stimulation can alter cell membrane permeability and surface morphology [28,29]. We hypothesise that the application of HPPTUS promotes the proliferation of muscular cells through both mechanical and thermal effects [27,29]. However, the correct administration of HPPTUS, coupled with adequate healing intervals, may aid in disrupting the positive feedback cycle described by the energy crisis hypothesis and promoting the regeneration of muscle tissue harbouring MTrPs.

Furthermore, HPPTUS could have an immediate effect on reducing the conduction of pain signals in MTrPs. It has been reported that intense US waves can diminish the amplitude of the evoked compound action potential associated with its thermal impact [30,31].

Limitation(s)

The study has several limitations. Firstly, it lacks a follow-up beyond the initial 2-week period, leaving the long-term effects unexplored. Additionally, the sample size is relatively small, attributed to the pilot study nature of the research. Employing blinding techniques can be considered to mitigate potential bias effects.

CONCLUSION(S)

The present research has revealed that increasing the frequency of HPPTUS applications, as demonstrated in group-1 HPPTUS-9, results in more effective TrP management. This is evident from the notable improvements in PPT, pain relief, reduced disability, and enhanced ROM. These findings offer valuable insights into a practical approach for TrP treatment and open the doors to further exploration in this promising field. A higher frequency of HPPTUS applications can significantly improve TrP management, providing a potentially more effective treatment option for patients and clinicians to consider.

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