Effect of suboccipital release versus instrument-assisted soft tissue mobilization on tension-type headache: a randomized controlled trial

Efecto de la liberación suboccipital versus movilización de tejidos blandos asistida por instrumentos en la cefalea tensional: un ensayo controlado aleatorio

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Abstract

Background: Tension-type headache is the most common form of primary headache disorder associated with increased muscle tension. This study aimed to compare the effects of suboccipital release and instrument-assisted soft tissue mobilization (IASTM) on tension-type headache. Methods: Fifty-six females with tension-type headache aged 20-40 years, with a body mass index ranging from 18.5 to 24.9, were randomly assigned to three groups. Group A (control) (n=18) received conventional physical therapy, including hot pack and exercise program. Group B (experimental) (n=19) received suboccipital release in addition to conventional physical therapy and Group C (experimental) (n=19) received IASTM in addition to conventional physical therapy. Outcome measures included pain intensity assessed by the Numeric Rating Scale, pressure pain threshold measured using a pressure algometer, headache-related impact assessed by the Headache Impact Test, cervical functional disability assessed by the Neck Disability Index, and headache frequency measured as the number of headache days per week. Measurements were recorded at baseline and after four weeks of treatment.
Results: MANOVA showed that Groups B and C had significantly better outcomes than Group A across all measures ($p < 0.001$). No significant differences were found between Groups B and C in pain intensity, pressure pain threshold, impact of headache, and headache frequency. However, Group C showed greater improvement in neck functional ability compared with Group B ($p = 0.001$).
Conclusion: Both suboccipital release and IASTM were associated with improvements in pain intensity, pressure pain threshold, impact of headache, and headache frequency in women with tension-type headache. IASTM showed greater improvement in neck functional ability.

Keywords

Tension-type headache; suboccipital release; instrument-assisted soft tissue mobilization; physiotherapy; manual therapy.

Resumen

Antecedentes: La cefalea tensional es la forma más común de trastorno primario de cefalea asociado con un aumento de la tensión muscular. Este estudio tuvo como objetivo comparar los efectos de la liberación suboccipital y la movilización de tejidos blandos asistida por instrumentos (IASTM) en la cefalea tensional.
Métodos: Cincuenta y seis mujeres con cefalea tensional de 20 - 40 años, con un índice de masa corporal que oscilaba entre 18,5 y 24,9, fueron asignadas al azar a tres grupos. El Grupo A (control) (n=18) recibió fisioterapia convencional, incluida compresa caliente y programa de ejercicios. El Grupo B (experimental) (n=19) recibió liberación suboccipital además de fisioterapia convencional y el Grupo C (experimental) (n=19) recibió IASTM además de fisioterapia convencional. Las medidas de resultado incluyeron la intensidad del dolor evaluada mediante la Escala de Calificación Numérica, el umbral del dolor por presión medido con un algómetro de presión, el impacto relacionado con el dolor de cabeza evaluado mediante la Prueba de Impacto del Dolor de Cabeza, la discapacidad funcional cervical evaluada mediante el Índice de Discapacidad del Cuello y la frecuencia del dolor de cabeza medida como el número de días de dolor de cabeza por semana. Las mediciones se registraron al inicio del estudio y después de cuatro semanas de tratamiento.
Resultados: MANOVA mostró que los Grupos B y C tuvieron resultados significativamente mejores que el Grupo A en todas las medidas ($p < 0,001$). No se encontraron diferencias significativas entre los Grupos B y C en la intensidad del dolor, el umbral del dolor por presión, el impacto del dolor de cabeza y la frecuencia del dolor de cabeza. Sin embargo, el Grupo C mostró una mayor mejora en la capacidad funcional del cuello en comparación con el Grupo B ($p = 0,001$).
Conclusión: Tanto la liberación suboccipital como la IASTM se asociaron con mejoras en la intensidad del dolor, el umbral del dolor por presión, el impacto del dolor de cabeza y la frecuencia del dolor de cabeza en mujeres con cefalea tensional. IASTM mostró una mayor mejora en la capacidad funcional del cuello.

Palabras clave

Cefalea tensional; liberación suboccipital; movilización de tejidos blandos asistida por instrumentos; fisioterapia; terapia manual.

Introduction

Tension-type headache (TTH) is the most common form of primary headache disorder. It is commonly described as mild to moderate, non-pulsating, band-like pain that is not aggravated by routine physical activity and is generally not accompanied by nausea or vomiting (Arslan & Hatık, 2026). The reported lifetime prevalence of TTH ranges from 30% to 78%, highlighting its importance as a widespread public health concern. It affects individuals across different age groups and socioeconomic backgrounds, with epidemiological data showing a higher frequency among females than males. Although TTH is often considered less disabling than other headache disorders, it can still negatively affect daily activities, attention, occupational performance, and overall quality of life, particularly in individuals with frequent or persistent episodes (Xu et al., 2025; Raggi, 2026; Ruiz-Francol & Arjona-Padilla, 2026).

The pathophysiology of TTH has been closely linked to myofascial trigger points (MTrPs) in the cranio-cervical region. These trigger points can reproduce referred pain patterns similar to TTH and are associated with increased sensitivity to pressure (Karadaş et al., 2013; Do et al., 2018). The most common muscles that contain these MTrPs include the sternocleidomastoid, suboccipital, trapezius, and the posterior cervical paraspinals, all of which may contribute to both pain and functional limitations. These findings highlight the important role of the cranio-cervical region in the development and persistence of TTH symptoms (Fernández-de-Las-Peñas et al., 2023).

The suboccipital muscle complex plays an important role in cervical stability, proprioception, and postural control. These deep muscles contain a high density of muscle spindles, which make them particularly sensitive to positional changes and mechanical loading.Dysfunction in this region can contribute to altered neuromuscular control and the persistence of TTH symptoms (Safran & Kaya, 2025).

Suboccipital release (SOR) is a manual therapy technique commonly used to reduce muscle tension and improve function in the cranio-cervical region. It is often applied to address dysfunction related to MTrPs, particularly in the suboccipital muscles. The technique involves gentle, sustained pressure applied to this area, which helps to promote muscle relaxation and to reduce neuromuscular sensitivity. It may also support local circulation and contribute to improvements in pain and functional outcomes (Rowlands & Brown, 2022).

Instrument-assisted soft tissue mobilization (IASTM) is a widely used technique for identifying and treating soft tissue dysfunction using specialized instruments (Stuber, 2023). It improves mechanical efficiency and allows deeper tissue penetration with minimal effort. Previous studies suggest that IASTM may promote fibroblast activity, collagen remodeling, and the breakdown of fibrotic adhesions, which may improve tissue mobility and function. Its analgesic effect has also been linked to controlled microtrauma and a localized hyperemic response that may contribute to pain reduction (Agarwal et al., 2024).

Although both SOR and IASTM have shown beneficial effects in the management of musculoskeletal pain, there is still limited evidence directly comparing their effects on MTrPs and clinical outcomes in individuals with TTH. In addition, previous literature supports the use of combined therapeutic approaches in the management of TTH, which may influence treatment outcomes (Pan et al., 2025). However, most available studies have examined these techniques separately rather than providing direct comparative evidence in TTH populations. Therefore, the present study aimed to compare the effects of SOR and IASTM, when combined with conventional physical therapy, on pain intensity, pressure pain threshold, impact of headache, neck disability, and headache frequency in women with tension-type headache.

Method

Study design

This study was a randomized controlled trial with repeated measures and a pretest-posttest experimental design conducted at the outpatient clinic of the National Institute of Neuromotor System, Giza, Egypt, from December 2024 to May 2025. Prior to commencement, ethical clearance was obtained from the Institutional Review Board of the Faculty of Physical Therapy at Cairo University, Egypt (NO: P.T. REC/012/005419). The research adhered to the principles outlined in the Declaration of Helsinki concerning research involving human participants. Furthermore, the trial protocol was prospectively registered on the ClinicalTrials.gov database (NCT06703385).

Participants

Fifty-six females with TTH between the ages of 20-40 years with body mass index from 18.5 to 24.9 participated in this study (Yontar & Ozgan, 2024; Liu et al., 2025). Female participants were specifically selected to minimize variability and improve sample homogeneity, as TTH is more commonly reported in women (Zhang et al., 2026). A power analysis was conducted to determine the required sample size. The initial calculation indicated that a minimum of 35 participants were required. To account for a potential dropout rate of 20%, an additional seven participants were added, resulting in a total sample size of 42 participants, with 14 participants allocated to each group. The calculation was informed by NRS values reported by Agarwal et al. (2024) and was based on an interaction effect F-test for a mixed design including between- and within-subject factors. Power analysis was performed using G*Power software (version 3.0.10), assuming an effect size of 0.7, three groups and two measurement points, a significance level of α = 0.05, and a desired statistical power of 95%. Although the minimum required sample size was 42 participants, a total of 60 participants were initially recruited to account for potential dropouts and maintain adequate statistical power. During the study, four participants were lost to follow-up, resulting in 56 participants who completed the study and were included in the final analysis.

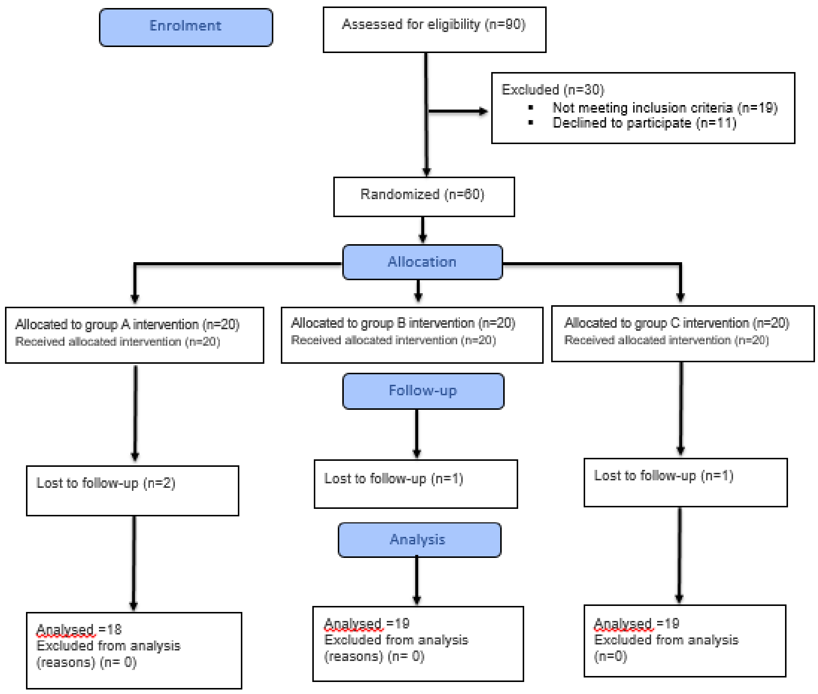
Patients were allowed to participate in the study if they met the following requirements: diagnosis of frequent episodic TTH according to the International Classification of Headache Disorders, 3rd edition (ICHD-3) of the International Headache Society (IHS) (Headache Classification Committee of the International Headache Society, 2018), 1) Participants had bilateral headaches of mild-to-moderate intensity, which lasted 30 minutes to 7 days. 2) The quality of pain was determined as non-pulsating and constricting and not aggravated by daily activities like climbing stairs. In addition, the clinical image ruled out nausea and vomiting, but single cases of photophobia or phonophobia were acceptable. 3) Patients had active trigger points in the suboccipital muscle and upper trapezius muscle (Ghanbari et al., 2012). 4) The verification of MTrPs using the diagnostic framework of Simons and Travell, which included the presence of palpable nodules in a taut band, pain at rest, referred sensation patterns, limited range of motion, local twitch response, and a positive jump sign (Simons & Travell, 1999).

They were excluded from the study if they exhibited one of the following criteria: 1) Patients with severe psychological disorders (major depression), 2) Any recent surgery in cervical region, 3) Females who are pregnant or lactating (Karakus et al., 2025), 4) Fibromyalgia, 5) Rheumatologic, hormonal, or neurological disorders (Monti-Ballano et al., 2024),6) History of cancer (Son et al., 2024), 7) Headaches associated with high fever, stiff neck, or rash, visual problems or profound dizziness (Satpute et al., 2021).

Randomization

Participants were divided into three groups. Group A (control) (n=18) received conventional physical therapy (CPT), which included hot packs, range of motion exercises, stretching, and isometric strengthening exercises for the cervical muscles (Fernández-de-Las-Peñas et al., 2023). Group B (experimental) (n=19) received suboccipital release (SOR) in addition to the same CPT program, while Group C (experimental) (n=19) received instrument-assisted soft tissue mobilization (IASTM) along with the same CPT program. The assignment of participants to the groups was carried out using a computer-generated randomization method. To reduce the risk of selection bias, allocation was concealed using sealed, opaque envelopes. Each participant was asked to select one envelope containing their group assignment; therefore, the allocation was not known in advance. Due to the nature of the interventions, it was not feasible to blind either the participants or the therapist. In addition, all outcome assessments were performed by the same therapist who delivered the intervention; therefore, assessor blinding was not implemented, which may have introduced a potential risk of measurement bias. The study flow is presented in Figure 1.

Figure 1. CONSORT Flow Diagram



Measurement Procedures

All outcome measures were recorded before the start of the treatment and again after four weeks. The same assessment procedures were applied to all participants to maintain consistency. Assessments were carried out by the same therapist who delivered the treatment; therefore, blinding was not feasible.

1) Weight and Height Scale

Weight and height were measured using the OMEGA RGZ-200 Mechanical Dial Weighing Scale (Brand: Generic, Made in China). This scale features a maximum weight capacity of 200 kg and includes an integrated height bar. The scale operates with a mechanical dial for precise weight measurements and does not require batteries (Greenwood et al., 2011).

2) Numerical Rating Scale

It was used as the primary measure of headache intensity. Subjects were asked to place a value that was associated with their present level of symptoms, with 0 (no pain) and 10 (the worst imaginable pain). The NRS was chosen due to the fact that it is a well-developed, stable and valid approach to evaluation of pain (Cleland et al., 2008).

3) Pressure Algometer

Pressure Pain Threshold (PPT) is described as the lowest level of mechanical pressure that induces pain (Vanderweenet et al., 1996). An algometer “Push-pull force gauge FEI” (Baseline instruments, White Plains, New York, USA) with a 1-cm2 contact area was used to measure PPT .The device was used perpendicular to the MTrPs in suboccipital and trapezius muscles and pressure was increased at a constant rate of 1 kg/cm2/s, three consecutive measurements were taken at each site and the mean value was used for analysis. This is a well-documented method of assessing MTrPs sensitivity because of its reliability and validity (Trueba-Perdomo et al., 2021).

4) Headache Impact Test (HIT-6)

It has a total score range of 36-78, which makes it a strong measure of disability caused by headache. The questionnaire consists of six items that are rated from 6 to 13. These items test how pain interferes with daily life such as work, education, home situation and leisure time. Higher total scores indicate functional impairment (Haywood et al., 2021; Ragab et al., 2023).

5) Neck Disability Index (NDI) (Arabic version)

It was used to measure cervical function disability because it is a valid and reliable tool. It is based on ten different domains with six response levels rated between 0 and 5. As a result, the cumulative index reaches a limit of 50 points. The respondents were asked to select the statement that best described their present state, with higher scores associated with severe functional disability (Shaheen et al., 2013).

6) Frequency of Headache

Headache frequency was assessed as the number of headache days per week. At baseline, participants were asked to report the number of days they experienced a headache during the week preceding the start of the intervention. The same procedure was repeated at the post-intervention assessment, where participants reported the number of headache days during the week following completion of the intervention. This measure was recorded as 'headache days/week'. Higher values indicating more frequent headache episodes (Castien et al., 2011).

Treatment Procedures

All interventions were applied by a physiotherapist with clinical experience, ensuring consistency in treatment application across all participants.

Suboccipital Release Technique

The therapist was positioned at the head of the bed as the patient took a supine position. The method included putting the finger pads of the therapist on the suboccipital area (particularly C2) and applying constant pressure until the feeling of tissue relaxation or melting took place. In order to avoid the oculomotor effect on cervical tone, the participants were advised to close their eyes. The duration of each application was 4 -5 minutes for only one set per session, and it was given three times per week for one month. The technique was applied using consistent hand positioning and sustained pressure until tissue relaxation was perceived, following a standardized clinical approach (Aggarwal et al., 2022).

Instrument -Assistive Soft Mobilization Technique

The participants were positioned comfortably in sitting position, and an emollient (Vaseline) was applied to the cervical region to facilitate instrument gliding. The M2T blade was applied to the cervical area to identify areas of soft tissue restriction within the upper trapezius and suboccipital muscles. Treatment was performed using the convex edge of the instrument at an angle of approximately 45°, with gentle longitudinal strokes. As the instrument passed over areas of tissue restriction, vibration in tissue texture were identified through tactile feedback. The stroking technique was continued for approximately 5 minutes until a reduction in tissue restriction was perceived. The treatment was administered three times per week for four weeks. The IASTM technique was performed using a standardized protocol in terms of stroke direction, angle, and duration to ensure consistency across participants (Purbia, 2023).

Conventional Physical Therapy

Each group received CPT that addressed MTrPs in TTH, three times a week over four weeks. The process included the application of:

A) Hot Packs:

For the application of hot packs, the patient was seated upright in a chair with good lumbar support, ensuring that the treatment area is easily accessible. The hot pack was placed over the back of the neck, with a towel or cloth between the hot pack and the skin to avoid burns. The patient remained in this position for 10–15 minutes during treatment (Cramer et al., 2012).

B) Active Range of Motion exercise:

The patient was seated upright on a sturdy chair, with the head in neutral alignment with the spine and the shoulders relaxed. The patient was then instructed to actively move the neck through extension, flexion, rotation, and lateral flexion in both directions, performing one set of 10 repetitions in each direction (Freimann et al., 2015).

C) Stretching exercise:

Upper trapezius: The patient was seated with the head in a neutral position. The therapist gently tilted the patient's head toward one shoulder (lateral flexion), using one hand to support the head and the other to apply gentle pressure to increase the stretch. The stretch was held for 15–20 seconds and then repeated it three times (Battecha et al., 2021).

Suboccipital muscles: The patient was seated with the head relaxed and in a neutral alignment. The therapist placed their fingers or palms just below the base of the skull, applying gentle pressure to guide the head into flexion. The stretch was held for 15–20 seconds, with the therapist applying a gentle, controlled stretch to avoid discomfort. The stretch was repeated three times (Vyas et al., 2023).

D) Isometric contractions:

The patient was seated with a neutral head position and relaxed shoulders. The therapist applied manual resistance in different directions (flexion, extension, lateral flexion, and rotation), while the patient contracted the neck muscles for 10–15 seconds without moving the head, and this was repeated five times (Battecha et al., 2021).

Statistical Analysis

Statistical calculations were performed with the help of the IBM SPSS software (Version 25; Chicago, IL, USA). In order to test the assumptions of parametric testing, data distribution was tested using the Shapiro-Wilk test and test of equality of variances was done using Levene's test. ANOVA was used for baseline demographic comparisons. The main analysis involved a mixed-design MANOVA, to examine the main effects of treatment and time, as well as their interaction on dependent variables; NDI, headache frequency, HIT-6, PPT, and NRS. To test the post-hoc multiple comparisons, the Bonferroni adjustment was used. The alpha value was set at $p < 0.05$.

Results

Demographic characteristics of patients in all groups

There were no significant differences between the groups in age, weight, height, and body mass index (BMI) as shown in Table 1.

Table 1. Baseline demographic characteristics of participants diagnosed with TTH

Sample characteristic	Group A (N= 18)	Group B (N= 19)	Group C (N= 19)	P value
Age (years)	32.06 ± 5.87	33.84 ± 6.16	34.37 ± 5.85	0.47
Weight (kg)	64.94 ± 6.35	64.47 ± 8.29	65.66 ± 5.74	0.87
Height (cm)	164.44 ± 3.54	164.11 ± 6.08	163.26 ± 7.94	0.83
BMI (kg/m^2)	23.91 ± 1.61	23.72 ± 1.80	23.85 ± 1.62	0.94

Group A, CPT; Group B, SOR plus CPT; Group C, IASTM plus CPT
Data are presented as mean ± SD, and compared using ANOVA test. Bold denotes two-sided statistical significance; ANOVA, analysis of variance; BMI, body mass index; CPT, conventional physical therapy; IASTM, instrument-assisted soft tissue mobilization; SD, standard deviation; SOR, suboccipital release; TTH; tension-type headache

Effect of treatment on NRS, PPT, HIT-6, Headache frequency, and NDI

Mixed MANOVA revealed that there was a significant interaction between treatment and time ($F = 38.07$, $P < 0.001$, $\eta 2 = 0.87$), a significant main effect of time ($F = 764.74$, $P < 0.001$, $\eta 2 = 0.99$), and a significant main effect of treatment ($F = 11.67$, $P < 0.001$, $\eta 2 = 0.67$).

Within-group comparison

There were significant decreases in NRS, HIT-6 score, headache frequency, and NDI in the three groups post-treatment compared to pre-treatment (P < 0.001). Additionally, we observed a significant increase in PPT of the upper trapezius and suboccipital muscles in the three groups post-treatment compared to pre-treatment (P < 0.001) (Table 2).

Between-group comparison

There were significant decreases in NRS, HIT-6, headache frequency, and NDI in group B and group C compared to group A (P < 0.001). Moreover, a significant increase in PPT of the upper trapezius and suboccipital muscles in group B and group C compared to group A (P < 0.001) was observed. There were no significant differences in NRS, PPT, HIT-6, and headache frequency between group B and group C. However, there was a significant decrease in NDI in group C compared to group B (P < 0.001) (Table 3).

Table 2. Pre- and post-TTH treatment within-group assessment of pain intensity level, PPT, impact of headache, headache frequency and neck functional ability

Assessment	Group A (N= 18)	Group B (N= 19)	Group C (N= 19)
Pain intensity level using NRS			
Pre-treatment	7.00 ± 0.97	6.84 ± 1.17	6.79 ± 0.92
Post-treatment	4.61 ± 0.92	1.42 ± 0.77	1.05 ± 0.71
MD (95% CI)	2.39 (1.96: 2.82)	5.42 (5.00: 5.84)	5.74 (5.31: 6.16)
P-Value	P < 0.001	P < 0.001	P < 0.001
PPT of right upper trapezius (kg)			
Pre-treatment	1.28 ± 0.41	1.33 ± 0.40	1.27 ± 0.40
Post-treatment	1.73 ± 0.33	3.31 ± 0.44	3.39 ± 0.44
MD (95% CI)	-0.45 (-0.55: -0.33)	-1.98 (-2.09: -1.88)	-2.11 (-2.22: -2.01)
P-Value	P < 0.001	P < 0.001	P < 0.001
PPT of left upper trapezius (kg)			
Pre-treatment	1.39 ± 0.33	1.29 ± 0.39	1.32 ± 0.34
Post-treatment	1.83 ± 0.29	3.29 ± 0.34	3.45 ± 0.36
MD (95% CI)	-0.44 (-0.56: -0.32)	-2 (-2.11: -1.88)	-2.13 (-2.25: -2.02)
P-Value	P < 0.001	P < 0.001	P < 0.001
PPT of right suboccipital (kg)			
Pre-treatment	1.26 ± 0.30	1.34 ± 0.27	1.30 ± 0.37
Post-treatment	1.69 ± 0.25	3.39 ± 0.33	3.49 ± 0.39
MD (95% CI)	-0.43 (-0.55: -0.31)	-2.05 (-2.17: -1.94)	-2.19 (-2.31: -2.08)
P-Value	P < 0.001	P < 0.001	P < 0.001
PPT of left suboccipital (kg)			
Pre-treatment	1.38 ± 0.33	1.29 ± 0.32	1.41 ± 0.33
Post-treatment	1.87 ± 0.30	3.33 ± 0.30	3.47 ± 0.41
MD (95% CI)	-0.49 (-0.61: -0.36)	-2.04 (-2.15: -1.91)	-2.06 (-2.19: -1.95)
P-Value	P < 0.001	P < 0.001	P < 0.001
Impact of headache using HIT-6			
Pre-treatment	63.11 ± 2.68	63.68 ± 3.33	62.47 ± 3.89
Post-treatment	58.72 ± 2.42	39.26 ± 3.54	38.95 ± 2.61
MD (95% CI)	4.39 (2.50: 6.28)	24.42 (22.58: 26.26)	23.52 (21.69: 25.37)
P-Value	P < 0.001	P < 0.001	P < 0.001
Headache frequency (number of headache days per week)			
Pre-treatment	4.61 ± 0.70	4.32 ± 0.75	4.42 ± 0.61
Post-treatment	2.89 ± 0.58	1.05 ± 0.71	0.95 ± 0.52
MD (95% CI)	1.72 (1.31: 2.13)	3.27 (2.86: 3.66)	3.47 (3.07: 3.87)
P-Value	P < 0.001	P < 0.001	P < 0.001
Neck functional ability using NDI			
Pre-treatment	20.22 ± 1.70	21.26 ± 2.79	21.32 ± 1.67
Post-treatment	15.44 ± 1.69	10.37 ± 2.71	6.47 ± 1.93
MD (95% CI)	4.78 (3.96: 5.59)	10.89 (10.10: 11.69)	14.85 (14.05: 15.64)
P-Value	P < 0.001	P < 0.001	P < 0.001

Group A, CPT; Group B, SOR plus CPT; Group C, IASTM plus CPT
Data are presented as mean ± SD, and compared using a mixed MANOVA test. Bold denotes two-sided statistical significance; CI, confidence interval; CPT, conventional physical therapy; HIT-6, headache impact test–6; IASTM, instrument-assisted soft tissue mobilization; MANOVA, multivariate analysis of variance; MD, mean difference; NDI, neck disability index; NRS, Numerical Rating Scale; PPT, pressure pain threshold; SD, standard deviation; SOR, suboccipital release; TTH; tension-type headache

Table 3. Between-group comparison after TTH treatment.

Outcome	Group A vs B		Group A vs C		Group B vs C	P value	η2
	MD (95% CI)	P value	MD (95% CI)	P value	MD (95% CI)		
NRS	3.19 (2.56: 3.82)	< 0.001	3.56 (2.92: 4.19)	< 0.001	0.37 (-0.26: 0.99)	0.33	0.81
PPT (kg)							
Right upper trapezius	-1.58 (-1.90: -1.26)	< 0.001	-1.66 (-1.99: -1.35)	< 0.001	-0.08 (-0.40: 0.23)	0.79	0.79
Left upper trapezius	-1.46 (-1.72: -1.19)	< 0.001	-1.62 (-1.88: -1.35)	< 0.001	-0.16 (-0.42: 0.10)	0.29	0.83
Right suboccipital	-1.7 (-1.96: -1.44)	< 0.001	-1.8 (-2.07: -1.54)	< 0.001	-0.1 (-0.36: 0.15)	0.59	0.87
Left suboccipital	-1.46 (-1.73: -1.19)	< 0.001	-1.6 (-1.88: -1.34)	< 0.001	-0.14 (-0.41: 0.12)	0.38	0.82
HIT-6	19.46 (17.15: 21.77)	< 0.001	19.77 (17.47: 22.08)	< 0.001	0.31 (-1.96: 2.59)	0.94	0.91
Headache frequency	1.84 (1.38: 2.29)	< 0.001	1.94 (1.48: 2.40)	< 0.001	0.1 (-0.35: 0.56)	0.84	0.71
NDI	5.07 (3.36: 6.79)	< 0.001	8.97 (7.26: 10.69)	< 0.001	3.9 (2.20: 5.59)	< 0.001	0.76

Group A, CPT; Group B, SOR plus CPT; Group C, IASTM plus CPT
Data are compared using a mixed MANOVA test. Bold denotes two-sided statistical significance.; CI, confidence interval; CPT, conventional physical therapy; HIT-6, headache impact test–6; IASTM, instrument-assisted soft tissue mobilization; MANOVA, multivariate analysis of variance; MD, mean difference; η2, partial eta squared, NDI, neck disability index; NRS, Numerical Rating Scale; PPT, pressure pain threshold; SOR, suboccipital release; TTH; tension-type headache.

Discussion

This study aimed to compare the effects of SOR and IASTM in the management of TTH. The study's findings showed that there were no significant differences between Groups B and C regarding pain intensity, pressure pain threshold, impact of headache and headache frequency. Furthermore, Group C exhibited an additional significant improvement in neck functional ability compared to Group B.

The level of improvement observed over the four-week period may be considered relatively high. This may be explained by the combined effect of the interventions, as all groups received conventional physiotherapy in addition to the specific techniques applied. Furthermore, early improvements are commonly observed during the initial phase of treatment. The relatively large effect sizes reported in this study may also be attributed to multiple factors, including the combined nature of the interventions, the use of sensitive outcome measures, and the relatively short duration of the intervention.

The pathophysiology of TTH has been closely associated with MTrPs, particularly in the craniocervical region. These trigger points can reproduce referred pain patterns similar to TTH and are linked to increased pressure sensitivity. The suboccipital and upper trapezius muscles are among the most frequently involved, contributing to both pain and functional limitations (Fernández-de-Las-Peñas et al., 2006). This supports the role of both peripheral and central mechanisms in the development and persistence of TTH symptoms (Do et al., 2018).

The therapeutic effects of SOR may be explained by its influence on both muscular and neural components. The suboccipital muscles are anatomically connected to the dura mater through myodural bridges, and increased tension in this region may contribute to pain generation. SOR may reduce this tension, improve local circulation, and promote relaxation, thereby reducing nociceptive input and improving cervical mobility (Patra et al., 2021). Similarly, IASTM has been shown to improve soft tissue extensibility and reduce fascial restrictions through mechanical stimulation. It may induce controlled microtrauma, leading to a localized hyperemic response that enhances tissue healing and contributes to pain reduction. In addition, IASTM may stimulate mechanoreceptors and modulate nociceptive input, thereby improving functional outcomes. These proposed mechanisms are based on evidence from previous studies and should be interpreted with caution, as they were not directly measured in the present study (Zheng et al., 2020; Ikeda & Isaka, 2024; Maras et al., 2024).

In addition, accumulating evidence indicates that manual therapy may exert its effects not only through local mechanical changes in soft tissues but also through broader neurophysiological mechanisms related to pain modulation. These mechanisms may involve alterations in nociceptive input at the peripheral level, as well as modulation of central pain processing within the central nervous system. In particular, manual therapy has been proposed to influence descending inhibitory pathways, which play a key role in reducing pain perception. Furthermore, they may contribute to reducing both peripheral and central sensitization, thereby lowering responsiveness to painful stimuli. Such neurophysiological responses may help explain the observed reductions in pain intensity and improvements in functional outcomes. Recent high-level evidence, including systematic and umbrella reviews, supports the role of manual therapy in modulating pain sensitization mechanisms and improving clinical outcomes in musculoskeletal conditions (Martínez-Pozas et al., 2023). These mechanisms may provide a possible explanation for the observed findings.

Furthermore, the present findings may be interpreted within the broader context of multimodal physiotherapy approaches for TTH. It has been suggested that combining manual therapy with therapeutic exercise may produce synergistic effects through both mechanical and neurophysiological pathways. From a neurophysiological perspective, manual therapy may alter afferent nociceptive input at the peripheral level and influence spinal and supraspinal processing, thereby contributing to pain inhibition. In parallel, therapeutic exercise may enhance neuromuscular control, improve proprioceptive feedback, and promote adaptive changes in motor function. The interaction between these mechanisms may facilitate more effective pain modulation and contribute to sustained improvements in functional outcomes. Such integrative effects may help explain the magnitude of clinical improvements observed in the present study (Martin Perez et al., 2021; Repiso-Guardeño et al., 2023).

The findings of the present study are consistent with previous research investigating the effects of SOR in patients with TTH. Previous studies have suggested that SOR may contribute to symptom improvement through its influence on muscle relaxation and reduction of soft tissue tension in the suboccipital and upper cervical regions (Kim et al., 2016). These effects may help reduce nociceptive input and improve cervical mobility, which aligns with the improvements observed in pain intensity and functional outcomes in the present study.

Supporting this, a systematic review by Maistrello et al. (2018) reported that manual myofascial interventions are associated with reductions in muscle hypertonicity, improvements in regional blood flow, and modulation of nociceptive processing. These changes may contribute to reductions in pain intensity and headache-related symptoms. Similarly, Pérez-Llanes et al. (2022) suggested that combining suboccipital techniques with other therapeutic approaches may enhance analgesic effects through improved soft tissue function and modulation of pain pathways.

In agreement with these findings, Venugopal et al. (2024) reported that SOR and soft tissue techniques are effective in reducing headache-related disability and pain intensity. The observed improvements may be attributed to the direct mechanical influence of SOR on suboccipital musculature, which may reduce muscle tension and modulate afferent input, thereby contributing to pain relief and functional improvement.

The reduction in pain intensity observed in the IASTM group may be attributed to its effects on pain modulation. It has been suggested that IASTM may influence nociceptive processing through stimulation of mechanoreceptors and modulation of afferent input, contributing to pain inhibition. These effects may help explain the improvements observed in pain-related outcomes in the present study, including NRS and PPT (Gulick, 2018).

The improvement in PPT observed in the present study is supported by previous evidence on the effects of IASTM on active MTrPs. Emshi et al. (2021) found that IASTM was effective in improving PPT, pain, and functional outcomes in patients with active trigger points in the upper trapezius. In addition, a recent systematic review and meta-analysis reported beneficial effects of IASTM on pain, disability, and PPT, further supporting its clinical value (Lin et al., 2025).

In the present study, although both intervention groups demonstrated similar improvements across most outcome measures, the IASTM group demonstrated significantly lower NDI scores. This may be explained by the mechanical effects of IASTM on soft tissue structures, particularly its ability to improve tissue mobility and reduce mechanical restrictions, thereby facilitating better cervical function. In contrast, SOR primarily targets muscle relaxation and pain reduction, with a more limited influence on functional performance (Kim et al., 2016; Kim et al., 2017).

In agreement with these results, Ramadan et al. (2023) demonstrated that IASTM produced superior improvements compared to pressure-algometry release and sham ultrasound, including reductions in headache frequency, increased PPT, and improvements in cervical posture. Despite these consistent findings, a previous study by Gulick (2014) reported no significant differences between IASTM and conventional treatment in improving PPT. This discrepancy may be attributed to variations in treatment dosage, intervention duration, and protocol design, as well as differences in participant characteristics.

The improvements observed across all groups may be partially attributed to CPT, which includes stretching, strengthening, and heat therapy. These components may collectively contribute to reducing muscle tension, improving soft tissue flexibility, and enhancing neuromuscular control, thereby supporting pain reduction and functional improvement (Aggarwal et al., 2022).

Previous studies have suggested that stretching and strengthening exercises may help reduce muscle hypertonicity, improve circulation, and enhance cervical mobility, which may contribute to reductions in pain intensity and disability (Cho, 2019; Simons, 2002). Additionally, strengthening exercises may improve muscle stability and support functional recovery following soft tissue interventions (Hammer, 2008).

Heat therapy may also play a supportive role by increasing local blood flow, enhancing tissue elasticity, and promoting relaxation, which may further contribute to pain relief (Malanga et al., 2015). Overall, the combined application of these interventions may produce greater clinical improvements compared to isolated approaches, as supported by previous findings demonstrating the effectiveness of multimodal physiotherapy programs in reducing pain and functional disability in patients with tension-type headache (Javaid et al., 2022).

This study has some limitations that should be considered. First, the sample included only female participants, which may limit the generalizability of the findings. Second, the absence of a sham intervention and the inability to blind participants and therapists may have introduced some degree of bias and made it difficult to distinguish between specific and non-specific treatment effects. Additionally, all groups received a similar conventional physiotherapy program, making it difficult to isolate the independent effects of each intervention. Finally, the relatively short duration of the study and the lack of long-term follow-up limit conclusions regarding the sustainability of the treatment effects. Future studies with larger and more diverse samples and longer follow-up periods are recommended.

Conclusions

Based on the findings of this study, both suboccipital release and instrument-assisted soft tissue mobilization were associated with improvements in pain intensity, pressure pain threshold, headache frequency, headache impact, and neck function in women with tension-type headache. The results also suggest that IASTM may have a greater effect on improving neck function. These findings may have clinical relevance for guiding the selection of manual therapy techniques as part of a multimodal physiotherapy approach. However, these findings should be interpreted with caution due to certain limitations in the study design, including the absence of a sham control and the short duration of follow-up. Additional well-designed studies are needed to confirm these results and to better understand their long-term clinical implications.

Ethics approval and consent to participate

Participants were thoroughly informed about the intervention and evaluation procedures, and informed consent was obtained. Ethical approval was obtained from the Research Ethics Committee of the Faculty of Physical Therapy (No: P.T. REC/012/005419, dated 10/9/2024).

Authors' contributions

All authors discussed and selected the idea, performed the research, gathered data, and organized it. N.G.S. and A.A. were responsible for clinical assessment and statistical analysis. R.R.M. assisted in writing the original draft and reviewed the final draft. N.A.A. and N.A.I. reviewed and approved the final draft. All authors have critically reviewed and approved the final draft and are responsible for the content and the similarity index of the manuscript.

Availability of data and materials

The datasets generated or analyzed during the current study are available from the corresponding author upon reasonable request.

Competing interests

The authors declare no competing interests.

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