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Effect of Magnesium Sulfate Iontophoresis on Suboccipital Trigger Points in Patients with Tension-Type Headache

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Abstract

Background and purpose: Tension-type headache (TTH) development is linked to the presence of myofascial trigger points (TrPs) and muscular tenderness. These TrPs, when in an active state within the muscles of the head and neck, can manifest as referred pain that is perceived in the head.

Objective: The current study was conducted to investigate the effect of magnesium sulphate (MgSO4) iontophoresis on suboccipital TrPs in TTH patients.

Methods: This study was conducted on forty patients (30 females and 10 males) with a clinical diagnosis of TTH and active myofascial TrPs on the occipital muscles bilaterally. The participants' ages varied between 30 and 45 years. They were randomly divided into two groups of equal size: the study group (GA) and the control group (GB). **Group A (study group)** underwent MgSO4 iontophoresis on the occipital muscles along with conventional physical therapy biweekly for four weeks. **Group B (control group)** underwent a placebo iontophoresis (without medication) along with conventional physical therapy biweekly for four weeks. Each patient in both groups was evaluated by visual analogue scale(VAS) to assess pain, Digital Electronic Pressure Algometer to assess pressure pain threshold(PPT)and headache disability index(HDI)to assess the headache impact on daily living before and after a four-week treatment period.

Results: The present study demonstrated a statistically significant reduction in the mean scores of VAS and HDI, alongside a significant increase in the mean scores of PPT in the study group in comparison to the control group after treatment.

Conclusion: Magnesium sulfate iontophoresis has a significant effect in improvement of VAS, PPT, and HDI in patients suffering from TTH due to suboccipital TrPs.

Key words: Tension-type headache, magnesium sulfate, Iontophoresis, trigger points, sub-occipital muscle.

Introduction:

Tension-type headache (TTH) represents the predominant primary headache kind in the adult population, posing significant health and socioeconomic challenges. Persistent headaches can evolve into chronic conditions, severely affecting patients' lives in various dimensions such as emotional well-being, daily work, and overall life tasks **(1).**

Observations indicate that the myofascial tissue in the suboccipital region exhibits tenderness in individuals experiencing TTH, correlating directly with the headaches' frequency and severity. Myofascial trigger points (TrPs) within the suboccipital muscles could contribute to or exacerbate the severity of TTH **(2).**

Physical therapy stands out as a primary approach for managing TTH, with a focus on the suboccipital region. Exploring physical therapy methods targeted at the suboccipital area in TTH treatment could offer innovative insights for managing this kind of headache, leading to more precise medical interventions that could enhance patient outcomes **(3).**

Iontophoresis is a non-invasive method employed to enhance ion penetration across skin layers. By utilizing controlled voltage and/or charge in an electrolytic solution, this technique involves two electrodes, the anode (positive electrode) and cathode (negative electrode), connected to the skin. Technological progress in microprocessor and microcontroller systems has led to the development of smaller, more cost-effective electrotherapy devices tailored for iontophoresis applications **(4)**.

Magnesium sulfate (MgSO4) is utilized for its muscle-relaxing, vasodilating, and pain-relieving properties. Research has shown its potential in managing conditions like deltoid bursitis, neuritis, and myalgias. Its capability to permeate intact skin effectively increases serum magnesium levels, with transdermal absorption increasing proportionally with the concentration of the solution and the area of skin exposed. When combined with iontophoresis, MgSO4's benefits are further enhanced, making it a more potent treatment option **(5).**

This study was structured to assess the impact of magnesium sulphate iontophoresis on suboccipital trigger points in patients with tension-type headache.

Materials and methods:

Design of the study

This is a single-blind, randomized controlled trial executed from May to December 2022 at the physical therapy Department of police academy Hospital. All procedures were performed in alignment with the Declaration of Helsinki.

Subjects

This study included 40 subjects (30 females and 10 males), ranging in age from 30 to 45 years, patients were diagnosed as having tension-type headache and active myofascial TrPs on the suboccipital muscles bilaterally. Institutional approval for informed consent was obtained before the collection of data.

The inclusion criteria encompassed patients who were diagnosed as having tension-type headache and active myofascial TrPs on the suboccipital muscles bilaterally. Patients' age ranged from 30-45 years and their body mass index (BMI) was<35.The diagnostic criteria for TTH were derived from the guidelines established by the Headache Classification Committee of the International Headache Society (HIS, 2018). In accordance with these criteria, the headache episodes must exhibit at least two of the following features: presenting on average 15 days monthly over a period exceeding three months (totaling 180 days annually), a tightening or pressing (non-

pulsatile) sensation in nature, being located bilaterally, not worsened by routine physical activities, mild to moderate severity, patients should exhibit the presence of, at most, one condition among phonophobia, photophobia, or mild nausea, and they must not have moderate to severe nausea or any vomiting. The exclusion criteria includea history of cancer, previous surgeries on the neck and head, severe psychiatric conditions (major depression), uncontrolled hypertension, another primary/secondary headache, headaches accompanied by elevated body temperature, neck stiffness, skin rash, visual disturbances, or marked dizziness, systemic degenerative conditions like lupus erythematosus and rheumatoid arthritis, and the concurrent diagnosis of fibromyalgia syndrome.

A single trained investigator examined all patients and collect all data to eliminate inter- investigator error. The subjects who full filled the inclusion criteria were randomly assigned to either Group A (study group) or Group B (control group) through a secure system involving opaque sealed envelopes.

Interventions

The subjects in the study group underwent MgSO4 iontophoresis on the occipital muscles using a device known as Unify Guidance E device, Serial number: 72880; coupled with conventional physical therapy, including active range of motion exercises, stretching of sub occipital muscle and strengthening exercises for neck muscles. A concentration of 100 mg/cm^2 of MgSO4 was administered to the active positive electrode via a syringe. This electrode was positioned precisely on the identified area containing the sensitive MTrPs. The dispersive electrode was positioned on the skin, a 6-inch distance from the active electrode, towards a more distal direction. The chosen dosage on the device was set at 75 mA/min. Based on each participant's comfort level, the intensity of the current was incrementally adjusted, varying between 2 and 4 mA. The device was designed to automatically determine the necessary duration to administer the selected dosage. This treatment protocol was conducted twice weekly over a period of four weeks **(6).**The subjects in the control group underwent the same physical therapy program plus Placebo magnesium sulphate iontophoresis (without medication),repeated twice weekly over a four-week period.

Outcome measures

The evaluation of outcome measures took place both prior to and following the treatment program.

For pain intensity assessment, the visual analogue scale (VAS) is recognized for its validity and reliability **(7)**. It is composed of a 10-centimeter line, length, with its ends delineated on paper and patients were given instructions to choose a position along the line that accurately described their existing pain intensity, with 0 demonstrating no pain and 10 demonstrating excruciating discomfort. Before the intervention and during each follow- up, a visual analogue scale was administered. Each patient was instructed to score the pain before and after treatment program **(8).**

The evaluation of the pressure pain threshold (PPT) was carried out with the Digital Electronic Pressure Algometer (Wagner Instruments, FDX, Greenwich, CT), recognized for its validity and reliability in measuring tenderness at active MTrP**(9).**

The tip of the transducer probe was placed directly against the MTrP at a 90-degree angle. The pressure was consistently applied and slowly increased until the participant signaled the onset of pain, which determined the PPT value **(6).**

To evaluate how headaches affect daily life, the Headache Disability Index (HDI) was employed. This index comprises 25 items that gauge the influence of headaches on everyday tasks. Each item was assigned a score, with the overall scores ranging from

0 to 100. Based on these scores, headache disability was categorized into: 10% to 28% indicating mild impact; 30% to 48% signifying moderate impact; 50% to 68% reflecting severe impact; and 72% or above denoting complete impact. The validity and reliability of the HDI in its Persian version has been established for evaluating headache disabilities in Persian-speaking populations **(10).**

Sample size determination

Sample size was determined using G*POWER statistical software (version 3.1.9.2; Franz Faul, Universitat Kiel, Germany) in accordance with pain pressure threshold (PPT) data derived from the previous study **(6)** who reported a significant effect of magnesium sulphate iontophoresis compared with direct current on TrPs. The study indicated that each group would need 17 participants to achieve the necessary sample size. These calculations were based on a significance level of 0.05, a statistical power of 80%, an effect size of 1.01, and an allocation ratio of 1 for group N2 to group N1. To compensate for drop out, the group sizes were increased to 20 members each.

Data analysis

Subject characteristics between groups were analyzed using an unpaired t-test. Data normality was examined using the Shapiro-Wilk test. Additionally, Levene's test was used to examine the homogeneity of variances between the groups. Mixed MANOVA was performed to assess the treatment effect on VAS, HDI, and PPT. Post-hoc testing incorporating the Bonferroni correction was performed for further multiple comparisons. The level of significance for all statistical tests was set at $p < 0.05$. All statistical analysis was conducted through the statistical package for social studies (SPSS) version 25 for windows (IBM SPSS, Chicago, IL, USA).

RESULTS

Subject characteristics:

Table (1) shows the subject characteristics of study and control groups. No significant differences were observed between the groups in terms of age, weight, height, BMI, and distribution by sex ($p > 0.05$).

Table 1.Subject characteristics.

	Study group	Control group	p-value
	Mean ± SD	Mean ± SD	
Age (years)	38.90± 3.16	39.55 ± 3.96	0.57
Weight (kg)	81.15 ± 8.59	81.95 ± 6.23	0.73
Height (cm)	166.40 ± 9.99	167.25 ± 5.64	0.74
BMI (kg/m²)	29.49 ± 3.93	29.34 ± 2.45	0.88
Sex, n (%)			
Female	16 (80%)	14 (70%)	0.46
Male	4 (20%)	6 (30%)	

SD, standard deviation; MD, mean difference; p-value, level of significance.

To explore the treatment effects on VAS, HDI, and PPT, Mixed MANOVA analysis indicated a significant interaction effect between treatment and time ($F = 32.26$, $p = 0.001$). Significant main effects were also observed for treatment ($F = 6.54$, $p = 0.01$) and time ($F = 288.58$, $p = 0.001$).

Within group comparison: There was a significant decrease of the mean values VAS and HDI and a significant increase of the mean values PPT in both groups post treatment compared with that pre treatment ($p < 0.001$). The change percent in VAS, HDI, right PPT, and left PPT of study group was 59.60, 41.60, 38.46 and 42.10% respectively and that in control group was 37.83, 11.34, 20.37 and 18.61%respectively **(Table 2).**

Comparing groups before treatment showed insignificant differences ($p > 0.05$). After treatment, VAS and HDI significantly decreased ($p < 0.001$), while PPT increased significantly ($p < 0.01$), with the study group showing greater improvement **(Table 2).**

Table2. Mean VAS, HDI and PPT pre and post treatment of study and control groups:

	Pre treatment	**Post treatment**			
	Mean±SD	**Mean±SD**	**MD**	**% of change**	**p value**
VAS					
Study group	7.55 ± 0.82	3.05 ± 1.39	4.5	59.60	0.001
Control group	7.40 ± 1.14	4.60 ± 1.14	2.8	37.83	0.001
MD	0.15	-1.55			
	p = 0.63	***p = 0.001***			
HDI					
Study group	29.20 ± 1.60	17.05 ± 6.70	12.15	41.60	0.001
Control group	28.65 ± 1.92	25.40 ± 5.51	3.25	11.34	0.001
MD	0.55	-8.35			
	p = 0.33	***p = 0.001***			
RightPPT(kg)					
Study group	2.21 ± 0.58	3.06 ± 0.47	-0.85	38.46	0.001
Control group	2.16 ± 0.48	2.60 ± 0.57	-0.44	20.37	0.001
MD	0.05	0.45			
	p = 0.75	***p = 0.009***			
Left PPT (kg)					
Study group	2.28 ± 0.62	3.24 ± 0.67	-0.96	42.10	0.001
Control group	2.31 ± 0.55	2.74 ± 0.56	-0.43	18.61	0.001
MD	-0.03	0.50			
	p = 0.87	***p = 0.01***			

SD, Standard deviation; MD, Mean difference;p value, Probability value.

Discussion:

This study was conducted to determine the effect of MgSO4 iontophoresis on suboccipital TrPs in TTH patients.

The results revealed a significant decrease in VAS and HDI mean values and a significant increase in PPT mean values in both groups post treatment, with the study group showing greater improvement.

The study group experienced a 59.60% improvement in VAS scores, contrasting with a 37.83% increase in the control group. Right PPT and left PPT had changes of

38.46% and 42.10%, respectively, in the study group, while the control group exhibited changes of 20.37% and 18.61%, respectively, post treatment.

These findings come in agreement with **Brown et al., (11)** who evaluated the influence of MgSO4 infusion on the necessary dosage of anesthesia and the intensity of post-surgical pain. They demonstrated that administering MgSO4 to patients markedly decreased the need for intra operative analgesics and neuromuscular blockers. Additionally, there was a notable reduction in post-surgical pain and the consumption of opioid pain relievers.

The possible explanation for improvement in pain is that Magnesium functions as an inhibitor of N-methyl-D-aspartate (NMDA), thereby regulating the entry of calcium into neurons. Studies have demonstrated that magnesium is effective in reducing the excitability of peripheral nerves **(12).**

The underlying biological mechanisms, particularly its capacity to act as an antagonist to NMDA receptors and block calcium channels, are notably promising. This is especially true in instances of extended nociceptive input from chronic inflammation, which may lead to increased NMDA receptor numbers (hyperalgesia), thereby lowering the threshold of stimuli required for pain initiation **(13).**

In the present study, there was improvement in HDI post treatment; HDI values improved by 41.60% in the study group, in contrast to an 11.34% improvement in the control group.

The results correspond with the research conducted by **Pérez-Llanes et al., (14),** which examined the impact of sub-occipital muscle inhibition plus interferential therapy on alleviating pain and disability in TTH patients. Findings showed enhancements in reported pain levels, disability associated with headache, and the overall effect of headache. These observations bolster our hypothesis, proposing that the concurrent use of sub-occipital inhibition and interferential current may exhibit enhanced efficacy compared to traditional treatments in reducing pain and disability among TTH patients over a short period.

Likewise, **Falsiroli Maistrello et al.,(15)**observed enhancements in reported pain levels, the impact of headaches, and disability following four-week therapy utilizing sub-occipital muscle inhibition alongside an osteopathic technique for cervical manipulation.

Concerning the link between the sub-occipital muscle and headaches, **Jianget al., (16)** carried out a two-year longitudinal study on the myodural bridge. This bridge represents a thick fibrous tissue linking the suboccipital muscle to the spinal dura mater in humans. They conducted a surgical procedure to release this structure in a patient suffering from chronic headaches, which led to a significant alleviation of the symptoms. These findings highlight the association between the suboccipital muscle and headaches.

One possible explanation for improvement of HDI could be increased muscle elasticity and extensibility coupled with a more comprehensive restoration of muscle functionality. The therapy not only has the potential to address TrPs but also to enhance local blood flow and boost proprioception. Additionally, treating the suboccipital area might influence the flow rate of cerebrospinal fluid (CSF). The applied mechanical pressure on the sub-occipital region could affect the CSF dynamics, as the myodural bridge directly links muscles to the dura mater **(17).**

Liet al., (18) proposed a theory connecting the myodural bridge to CSF circulation. They hypothesized that abnormalities such as swelling and inflammation within the sub-occipital muscle alter its traction on the dura mater, affecting the "pumping action" where head movements cause the muscle to pull on the dura mater

via the myodural bridge. Such alteration could impact the subarachnoid space volume, creating negative pressure that acts similarly to a pump, influencing CSF dynamics.
In essence, the existence of the myodural bridge might elucidate how treating the suboccipital muscles alleviates myofascial TrPs, eases fascial restrictions, and diminishes central sensitivity. Alternatively, this could be attributed to its impact on the circulation of CSF.
Conversely, some studies indicate that MgSO4 does not lead to a decrease in the need for post-surgical pain relievers. For example**, Helanderet al., (19)** demonstrated that the CSF levels of magnesium remained unchanged following IV delivery of MgSO4, which did not influence post-surgical pain. Conversely, they observed a reverse correlation between the total consumption of post-surgical analgesics and the magnesium levels in the CSF. Their findings led to the conclusion that while the concentration of magnesium in the CSF impacts post-surgical pain, the administration of magnesium via IV during the perioperative period does not provide analgesic benefits.Moreover, **Abdolrazaghnejad et al., (20)** indicated that intraoperative infusion of MgSO4 failed to decrease the need for analgesics.

Study limitations
A potential limitation of our research is the limited number of participants, which, despite its size, was considered adequate because of the utilized experimental framework and the statistical methods employed for drawing conclusions. Additionally, the absence of a post-treatment patient follow-up to assess the long-lasting impacts of the therapy could impact the study findings. Nonetheless, this study could contribute to future investigations aimed at enhancing pain management strategies for individuals suffering from tension-type headaches.

Conclusion:

From the present findings, itcan be concluded that Magnesium sulfate iontophoresis significantly improves pain levels and alleviates disability associated with headaches in patients suffering from tension-type headaches due to suboccipital trigger points.

Recommendations:

We recommend application of the study on larger number of patients, repeating it with diverse age categories and analyze the long-lasting influences of MgSO4.

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Conflict of interest:
The authors declare that there is no conflict of interests.

Ethical approval:
This study protocol was accepted before commencement by the Research Ethics Committee of the Faculty of Physical Therapy, Cairo University (2022)(No: P.T.REC/012/003944).

Consent:
Prior to the commencement of the study, all participants provided their signed consent following a comprehensive explanation of the treatment methodologies.

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