Efficacy of Pulsed Ultrasonic Therapy Combined with Manual Therapy on Pain, Sleep Quality and Neck Disability in Patients with Chronic Tension-Type Headaches

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Abstract
Tension-type headache is the most common headache type worldwide with significant socio-economic and psychological impacts on the affected persons. This study examined the therapeutic efficacy of pulsed ultrasonic therapy combined with manual therapy (MT) in the management of chronic tension-type headache (CTTH) symptoms of pain, sleep disorders and neck disability. Twelve patients (11F, 1M) aged 36 to 72 years, diagnosed with CTTH and presented with its symptoms were managed with physiotherapy techniques (pulsed ultrasonic therapy [frequency = 1 MHz, intensity = 1.5 Wcm^{-2}, mark-to-space ratio = 2:8], manual stretching and kneading massage). All participants were treated daily for four consecutive days in the first week and thrice weekly during the second week making a total of seven treatment sessions per participant. Outcome measures including the Numeric Pain Rating Scale, the Pittsburgh Sleep Quality Index and the Neck Disability Index were used to assess participants' pain severity, sleep quality and how pain affected the performance of their daily activities respectively. Data obtained were subjected to descriptive and inferential statistical analyses with significance level set at 0.05. The paired samples t-test was used to test the efficacy of the interventions. Results showed a significant difference between participants' pre- and post-treatment pain severity ($p < 0.05$), sleep quality ($p < 0.05$) and performance of daily activities ($p < 0.05$). This shows that a combination of pulsed ultrasound and MT was effective in the management of patients with CTTH. Healthcare professionals, especially physicians and GPs, should employ this non-pharmacological option in the management of CTTH patients by timely referral in order to improve their quality of life.

Keywords: *Chronic Tension-Type Headache; Pulsed Ultrasound; Manual Therapy.*

Introduction
Tension-type headache (TTH) is reported to be the most common type of primary headaches accounting for about 90% of all headaches (Yu & Han, 2015). It is said that almost every other person might have had a TTH at one point or the other (Stovner *et al.*, 2007). Tension-type headaches have no definitive cause (Yu & Han, 2015) despite the assertion that they could be associated with muscle contraction and stress (Martin, 2016; Fernández-de-Las-Peñas, Cuadrado & Pareja, 2006). There are reports of its progression to chronic forms accounting for 0.5 to 4.8% of the world's population (Yu & Han, 2015). Chronic tension type headache (CTTH) is the occurrence of TTH at a frequency of ≥15 days per month for at least three months with typical presentation of

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bilateral affectation, tightening in quality, mild to moderate intensity lasting hours to days or might be unremitting (Yu & Han, 2015). Chronic tension type headaches have a significant impact on the affected individual's physical emotional, mental, and social well-being (Yu & Han, 2015; Martin, 2016; Fernández-de-Las-Peñas *et al*., 2018). The disorder has been shown to occur across the different age categories. Even childhood tension-type headache (TTH), which has not received much research attention, is significant as children with frequent episodic TTH may be at increased risk of CTTH; TTH is also as prevalent as migraine in children and adolescents (Antilla, 2004).

The mechanism underpinning CTTH is reported to be diverse ranging from central to peripheral, genetic, and psychological factors (Yu & Han, 2015). However, hyperactivity of the pericranial muscle giving rise to tenderness and generalized pressure pain hypersensitivity are said to be the most prominent findings in CTTH (Schmidt-Hansen, Svensson, Bendtsen, Graven-Nielsen & Bach, 2007; Yu & Han, 2015). Pain and tightness that accompany CTTH are associated with changes in sleep patterns and functional activities limitations in the sufferers (Chowdhurry, 2012). Sleep disturbance (ie, difficulty falling or staying asleep) has been identified as a risk factor for developing chronic headaches. Insomnia symptoms are a frequent complaint among both TTH and migraine sufferers (Ong, Stepanski & Gramling, 2009).

Reports from the literature have suggested that there is a bidirectional relationship between headache pain and sleep disturbance among young adults with TTH especially those who do not seek treatment and also women with headache are known to report significantly higher ratings of pain interfering with their sleep (Ong *et al.*, 2009). Sleep disorders are interrelated with medical and psychiatric illness (Tibbitts, 2008). Insomnia is a highly prevalent condition and carries a significant burden in terms of functional impairment, health care costs, and increased risk for depression (Morin, Belleville, Belanger & Ivers, 2011). A variety of therapeutic strategies including pharmacological, physiotherapy, psychological and acupuncture have, generally, been used in the management of CTTH. However, the therapeutic efficacy of the non-steroidal anti-inflammatory drugs and tricyclic antidepressants, which are the most commonly used first-line therapeutic agents for this condition, has remained incomplete and the few controlled studies available have not established their efficacy.

Manual therapy (MT) is a non-surgical type of conservative management that includes different skilled hands/fingers-on techniques directed to the patient's body (spine and extremities) to assess, diagnose, and treat a variety of symptoms and conditions (Clar, Tsertsvadze, Court, Hundt & Sutcliffee, 2014). MT is a passive, skilled movement applied by clinicians that directly or indirectly targets a variety of anatomical structures or systems, which is utilised with the intent to create beneficial changes in some aspects of the patient pain experience (Bishop *et al*., 2015).

Therapeutic ultrasound is a physiotherapeutic treatment procedure with a mechanism which involves sound waves mechanically oscillating the molecules of a given tissue, setting up a chain reaction with the adjacent molecules (Gulick, 2008). It is one of the most widely used physical modalities in clinical practice for rehabilitation and has a number of uses including the treatment of musculoskeletal disorders such as pain,

muscle spasm, joint contracture, and tissue injury (Morishita *et al*., 2014) as well as tissue stiffness arising from trigger points (Draper, Mahaffey, Kaiser, Eggett & Jarmin, 2010). Therapeutic ultrasound is, therefore, recognised as a major therapeutic method in treating musculoskeletal disorders (Morishita *et al*., 2014) and neurological damages (Oke & Dada, 2004). A few studies have examined the benefits of non-pharmacological therapies such as ultrasound therapy and manual therapy either as a single modality or combined in reducing migraine attacks. There is, however, a dearth of literature on the efficacy of physiotherapy techniques in CTTH management. This study, therefore, examined the impact of therapeutic ultrasound combined with manual therapy on pain, sleep quality and neck disability among patients with CTTH.

Methods

This study was a quasi-experimental (time series) study conducted on adult patients suffering from chronic tension-type headache who were referred by their primary physicians for physiotherapy. The participants had been seen by their physicians for diagnosis and had been initially placed on medications but with transient and unremarkable relief. Participants were recruited using a convenient sampling technique. The inclusion criteria were age greater than 18 years, the occurrence of TTH at a frequency of ≥15 days per month for at least three months with the typical presentation of bilateral affectation, tightening in quality, mild to moderate intensity lasting hours to days or might be unremitting. Participants with acute presentation of TTH, presence of any medical conditions such as high blood pressure, head injury, cerebrovascular accident, cardiovascular impairment, intake of central acting drugs such as anti-depressants, history of mental disorder, and cigarette smoking were excluded from the study. Twelve adult patients (11females, 1male) with age ranging between 36 and 72 years who had been diagnosed with chronic tension-type headaches between March 2016 and August 2017 by their physicians participated in this study. The treatment approach was explained to the patients and informed consent obtained. Participants were advised to abstain from medications and other forms of management within the period and even four weeks after the last treatment session.

All participants were treated daily for four consecutive days in the first week and three times a week during the second week, making a total of seven treatment sessions per participant. First, manual therapy was administered before the application of pulsed ultrasound. Manual therapy consisted of transverse oscillatory pressure to the transverse processes of C1-C3 vertebrae with patient lying in prone position and the forehead resting on their hands, manual traction to the upper cervical spine with patient in supine lying, stretching exercises to the trapezius and sternocleidomastoid muscles, sub-occipital release directed to the occipital part of the occipitofrontalis muscles, myofascial release to the upper trapezius and sternocleidomastoid muscle, finger kneading to the chin, mastoid process, and forehead.

Pulsed ultrasound was delivered with a therapeutic ultrasound machine (Megasonic [Model 212K] Electromedicarin, Spain). Patients were positioned in side side-lying on a couch with heads resting on a pillow. The treatment was administered on the

sternocleidomastoid, upper trapezius, and inferior occiput on both sides of the neck at a frequency of 1 MHz, intensity of 1.5 Wcm^{-2} and a mark-to-space ratio of 2:8.

Outcome measures included a 10-point Numerical Pain Rating scale used to assess headache severity, the Pittsburgh Sleep Questionnaire Index used to assess sleep quality, and the Neck Disability Index (NDI) scale for evaluating how headaches affected participants' performance of daily activities.

Data analysis

Data were analysed using descriptive and inferential statistics. The paired samples t-test was used to compare outcome measures before and after the interventions.

Results

The participants' physical characteristics as well as their mean headache intensity, sleep quality and neck disability scores are presented in Table 1.

Table 1: *Participants' demographic and baseline clinical variables*

Variables	Mean±SD
Age (yrs)	59.81±9.78
Weight (kg)	64.95±6.17
Height (m)	1.65±0.03
Pre NPR	7.54±0.52
Pre PSQI	7.81±0.75
Pre NDI	52.86±10.43

Abbreviations: Pre NPR = Pre-treatment Numerical Pain Rating; Pre NDI = Pre-treatment Neck Disability Index score; Pre PSQI = Pre-treatment Pittsburgh Sleep Quality Index score.

Table 2 shows the comparison of the outcomes before and after the two weeks of intervention. Significant improvement ($p < 0.05$) was obtained for headache severity, sleep quality, and neck disability over time.

Table 2: *Comparison of pre- and post-intervention clinical variables*

Variables	Pre-treatment Mean±SD	Post-treatment Mean±SD	t	*p*
NPR	7.54±0.52	2.18±0.40	26.39	<0.05
NDI	52.86±10.43	13.04±1.38	11.78	<0.05
PSQI	7.81±0.75	3.54±0.52	18.024	<0.05

*Significant $p \leq 0.05$
p values are for the paired samples t-test

NPR = Numerical Pain Rating, NDI = Neck Disability Index score, PSQI = Pittsburgh Sleep Quality Index score.

Discussion

The outcome of this study has revealed the efficacy of pulsed ultrasonic therapy combined with manual therapy on twelve patients with chronic tension-type headaches. Reports of previous studies have suggested that patients with TTH receiving manual

therapies showed better progress than those receiving conventional treatment or placebo (Lozano López, Mesa Jiménez, de la Hoz Aizpurúa, Pareja Grande & Fernández de Las Peñas, 2016). Research findings have revealed that soft tissue techniques are effective in reducing associated psychological symptoms of anxiety and depression levels in patients with TTH (Espı´-Lo´pez, Lo´pez-Bueno, Vicente-Herrero & Martinez-Arnau, 2016).

Majority of the participants in this study were females. This is consistent with the trend observed in the literature. Previous studies have reported higher female to male ratios in CTTH (Russell, Levi, Benth & Fenger, 2006; Yu & Han, 2015). Also, the mean age of participants in this study was 59 years. This differs from the assertion of Russell *et al*. (2006) that the prevalence of frequent episodic TTH increased slightly in men until age 39 then it declined. This assertion was based on a study population with age ranged 12-41 years in contrast with the current study whose participants' were aged greater than 18 years. On the other hand, our findings corroborate those of previous studies in which participants aged >18 years were recruited (Queiroz *et al*., 2009; Ferrante *et al*., 2013). However, ours was a quasi-experimental study with a limited sample size despite using convenient sampling and as such the mean age of 59 cannot be generalised to the entire population.

The study outcome recorded a significant reduction in headache severity and neck disability among the participants. This observation is in agreement with previous literature report that manual therapy is efficacious in the management of CTTH (Chaibi & Russell, 2014). Previous studies have also revealed the benefits of therapeutic ultrasound on soft tissues tension release and reduction of muscle stiffness resulting in increased active range of motion (Bellew, Michlovitz & Nolan, 2016; Morishita *et al*., 2014). Sleep disturbances (i.e. difficulty falling or staying asleep) has been identified as a risk factor for developing headaches (Ong *et al.*, 2009). Insomnia is believed to carry a significant burden in terms of functional impairment, health care costs, and increased risk of depression (Morin *et al.*, 2011).

The effect of combined therapy, ultrasound and interferential current, has been previously examined and reported to be effective on pain and sleep among patients with fibromyalgia (Almeida, Roizenblatt, Benedito-Silva & Tufik, 2003). The combined use of connective tissue manipulation and ultrasound therapy has been reported to help improve pain intensity, complaints of non-restorative sleep, and impact on functional activities in patients with fibromyalgia (Citak-Karakaya, Akbayrak, Demirturk, Ekici & Bakar, 2006).

The outcome of the present study revealed that there was an improvement in sleep quality of the participants following the intervention and even at follow up. The efficacy of soft tissue manipulation in the form of massage in improving sleep quality in postpartum women with sleep disorders (Ko & Lee, 2014), and in improving sleep quality and pattern among patients with chronic cardiac failure (Sable, Sivabalan & Shetti, 2017) have been documented. Massage technique has been reported to be an effective manoeuvre for relieving pain among migraineurs (Haque *et al*., 2012).

There appears to be little established evidence on the efficacy of ultrasound therapy alone or combined with other physical modalities in neck disability arising from tension-type tension headache. However, its effects in improving neck disability and relieving pain in conditions such as cervical spondylosis when used in combination with TENS and exercises have been reported (Soysal & Aslan, 2013). The thermal impact of ultrasound when used alone over latent trigger points was shown to decrease tissue stiffness on upper trapezius muscle in cervical spondylosis (Draper *et al.*, 2010). Ultrasound alone was also found effective in improving stretch pain and range of motion (Morishita *et al.,* 2014).

The uniqueness of our study is that manual therapy was coupled with pulsed ultrasound therapy. A previous parallel study by Gonçalves *et al*. (2012) showed that pulsed ultrasound combined with manual therapy was effective in reducing migraine attacks. The choice of ultrasound as an adjunct therapy to manual therapy is based on the premise that ultrasound decreases soft tissue inflammation, increases tissue extensibility, enhances scar tissue remodelling, increases soft tissue healing, and decreases pain (Daniel & Martinez, 2010).

A randomised clinical trial has revealed the effectiveness of multi-modal manual therapy, which included mobilisation of the cervical spine, isometric training of neck flexors, and posture correction resulting in 50% or greater reduction in headache days of patients with CTTH (Castien, Blankestein, van der Windt, Heymans & Dekker, 2013).

Pulsing the ultrasound beam reduces the rate of heating while allowing the same peak intensity to be used thereby reducing the risk of mechanical damage to tissues in addition to enhancing acoustic streaming and micro-massage effects (Robertson, Ward, Low & Reed, 2006). These effects could culminate in the gross reduction of muscular tension with a corresponding improvement in neural supplies to muscles of the scalp and neck thereby resulting in a reduction in headache severity and neck disability.

Finally, this study found significant improvement in the sleep quality of participants with CTTH. This is not unexpected as previous studies have shown that there is a direct relationship between sleep problems and headache frequencies and severity (Houle *et al.*, 2012; Fernández-de-Las-Peñas *et al.*, 2018). This is buttressed by the assertion that insomnia is considered a risk factor for higher headache frequency, particularly in TTH and migraine (Tran & Spierings, 2013). Thus, our finding of a gross reduction in headache severity should reflect an improvement in sleep quality of participants as was rightly observed.

Conclusion

The outcome of this study has therefore posited that physiotherapy techniques mainly in the form of pulsed ultrasonic therapy and manual therapy are effective in alleviating pain and disability and improving sleep quality in patients with chronic tension-type headache. Health care professionals especially physiotherapists and physicians who manage patients with tension-type headache should recognise the efficacy of non-pharmacological methods (in particular, physiotherapy) and administer them.

Appropriate referrals should be made in order to improve the quality of care for affected patients.

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