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THE EFFECTS OF MASSAGE WITH PLAI ESSENTIAL OIL AND STATIC STRETCHING ON SEVERITY OF PAIN, NECK MOVEMENT, CRANIOVERTEBRAL ANGLE IN OFFICE WORKERS WITH CHRONIC NECK PAIN

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ABSTRACT

Chronic neck pain is a common disorder in office workers. Massage with plai essential oil and static stretching has been found to improve pain severity and neck function in patients with neck pain. However, there is no evidence about the effectiveness of plai essential oil massage compared to static stretching. This study aimed to compare massage with plai essential oil to static stretching on pain level, pressure pain threshold (PPT), range of motion (ROM) of the neck, and craniovertebral angles (CVA) in office workers with chronic neck pain. The subjects were 48 females with chronic neck pain, ages 30-45 years old. They were divided into three groups: group 1 (n=16) was massage with plai essential oil (MASS), group 2 (n=16) was static stretching (SS) and group 3 (n=16) was the control. Each group participated 3 times a week for a total of 4 weeks, all subjects were assessed on neck pain level, PPT, ROM of the neck, and CVA before and after the 4th week of interventions. A one-way repeated ANOVA was used to determine the differences among the three groups.

After four weeks of interventions, all variables of the MASS and SS groups improved significantly. Moreover, the pain of the MASS group decreased significantly more than the SS group. The ROM of the neck in lateral flexion of the SS group increased significantly more than the MASS group. Both techniques were useful for improving pain and function of the neck. Thus, combining both interventions should be investigated further.

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INTRODUCTION

Neck pain is a common orthopedic and muscular problem in office workers. *According to a survey of musculoskeletal symptoms in office workers,* a prevalence of neck and shoulder pain was found of up to 42 percent, with lower back being second most prevalent representing 34 percent[1], while in another study, German and British office workers had incidence of neck pain of 55 percent and 58 percent respectively[2]. Females had almost twice the prevalence of neck pain than males, while those aged 30 and over were 2.61 times more likely to have neck pain than those who were younger[3].

Studies have reported that sitting with poor posture for a long time will cause poor head posture. Subsequently, the neck muscles fatigue and can spasm, causing neck pain[4,5]. Green[6] reported that sitting and working incorrectly on a computer for a long time can increase cervical lordosis, and both shoulders are wrapped to the front (rounded shoulders), which if the head is held forward for a long time, will result in constant neck contraction, leading to deep cervical flexor muscle weakness and increased weight on the neck and spine, resulting in neck pain[7,8]. Harrison and his team[4] reported that people with chronic neck pain were associated with bad posture, with the head and neck forward and bent down. In addition, sitting for long periods can result in upper-crossed syndrome[9]. The previous study suggested that decreased CVA and cervical flexion range were predictive factors for the occurrence of pain in the cervical region. The decreased CVA causes flexing of the cervical vertebrae in a forward position, which if maintained for a long time, increases the load in the extension muscle (by increasing the external moment arm) and its surrounding connective tissues. Constant stress on the extension muscle and connective tissue in the craniocervical area leads to an imbalance in the neck that induces pain[10].

There are many non-invasive treatment techniques such as anti-inflammatory drugs, muscle relaxants, and pain relievers, as well as physical therapy; modality, acupressure, manipulation, mobilization, massage therapy, exercise therapy, stretching, ergonomic advice, and home exercises for further recovery. Hoving et al.,[11] found that manual therapy including massage, mobilization techniques involving low-velocity passive movements within the limit of joint movement, and coordination or stabilization techniques significantly reduced neck pain more effectively than medication. Manual therapy was more cost-effective than physical therapy or treatment by a general practitioner with regards to both direct and indirect costs after a 1-year follow-up[12].

Massage therapy is one of the most popular ways to treat neck and shoulder pain using techniques such as effleurage, petrissage, and tapping (percussion)[13]. However, massage efficiency for neck pain is still uncertain. A systematic review found moderate evidence for massage therapy improving pain in patients with neck pain, compared with inactive therapies. Presupposing that massage therapy is at least immediately effective and safe, it might be preliminarily recommended as a complementary and alternative treatment for patients with neck pain[14]. A pilot study is needed to determine the optimal massage characteristics, e.g., frequency, duration, number of sessions, and massage techniques, and establish the most suitable treatment to be used in subsequent larger trials that examine massage as either a standalone treatment or part of a

multimodal intervention. For multimodal interventions, factorial designs are needed to determine the relative contribution of massage[15]. Although massage therapy may provide immediate effects for neck and shoulder pain, there is no evidence to suggest that massage therapy is effective in improving functional status[16].

Substances extracted from different herbal plants can be combined with massage to provide a more significant effect. Plai, scientifically named "Zingiber cassumunar Roxb", is one of the most popular Thai herbs used to relieve pain and reduce inflammation. A previous study found that plai cream containing 14 percent plai oil can reduce pain and inflammation[17,18,19]. Plai oil also decreased muscle tension and improved the restricted range of motion in myofascial pain syndrome, so it can be used as a topical application for muscle pain[20]. One study showed that massage with plai essential oil could decrease pain levels, and increase pressure pain threshold (PPT) and the range of motion of the neck (ROM), however, it was not significantly different from massage with the base oil [21]. While, Sopha Leesiriwattanagul et al.,[22] showed that plai oil massage and traditional massage were not different. Sukrom Cheechareoan et al.,[23] reported that plai cream is effective in reducing the pain of muscle tears. It was no different from the placebo during the 2-week measurement period. However, it was found that the treatment by a massage with plai essential oil tended to decrease the pain scores, moreover, there was an increase in PPT and ROM of the neck better than a massage with base oil[24.]

Static stretching is the most common for decreasing tension and improving flexibility in certain muscle-joint areas. In static stretching, you hold a stretch of a particular muscle or muscle group for a period of time[25]. Paul and Thenmozhi[26] reported that static stretching is more effective than dynamic stretching in improving pain and functional disability in patients with mechanical neck pain.

Both stretching exercise and manual therapy considerably decreased neck pain and disability in women with non-specific neck pain. The difference in effectiveness between the 2 treatments was minor. Low-cost stretching exercises can be recommended in the first instance as an appropriate therapy intervention to relieve pain, at least in the short term. In addition to reducing pain, active neck strengthening and stretching exercises have also improved neck function[27]. A systematic review showed that pain and function in chronic neck pain improved consistently at all follow-up time points. None of the manual therapies used alone or in combination was superior to the others. In the long term, exercises alone or combined with manual therapies were superior to manual therapies used alone[28]. Previous studies have reported that deep friction massage and static stretching are equally effective in reducing nonspecific neck pain in terms of alleviating pain and improving ranges of neck movement. However, deep friction massage shows superior effects on the Neck Disability Index (NDI)[29].

There is no evidence in the literature about the efficacy of massage with plai essential oil in comparison with static stretching exercises on pain level, pressure pain threshold (PPT), range of motion (ROM) of the neck, and craniovertebral angle (CVA) in chronic neck pain. Therefore, this study is designed to compare the effect of massage with plai essential oil to static stretching on decreasing pain and increasing PPT, ROM of the neck, and CVA in chronic neck pain.

MATERIALS AND METHODS

Participants

This study was based on a previous study[21], which calculated the sample with G*Power 3.1.9.2 in calculating estimates based on the use of ANOVA: repeated–measures within-between interaction statistics, with a power of 0.95, an effect size of 0.80 and an alpha level of 0.05, a total of 48 females with chronic neck muscle pain were recruited in this study.

Afterward, the participants were randomly assigned to three groups: group 1 was massage with plai essential oil (MASS), group 2 was static stretching (SS) and group 3 was the control. Each group consisted of 16 people (table 1). Random assignment was done via a computer-generated random allocation number by an investigator who was not involved in the study.

The inclusion criteria were female office workers with chronic neck muscle pain for at least 3 months, aged between 30-45 years, a moderate pain score (scale of 4-6 from pain level 0-10), myofascial pain syndrome (scale of 4-5 from pain level 0-5)[30], worked on a computer at least 4 hours/day[31], office work experience of at least five years[32], had been examined and diagnosed by an ophthalmologist to see if their eyesight was normal or if their eyeglasses were appropriate for their eyesight, a body mass index (BMI) between 18.0-24.9 kg/m^2, and limitation of neck movement.

Those who had neurological disorders, women menstruating, pregnancy, or a history of spine, hip, or lower limb surgery or severe neck pain (pain scale 7-10), or received treatment for up to 7 days before participating were excluded.

Before participating in the study, all participants were informed about the scope and procedures of the study. All individuals were provided with written informed consent before participating in the study. This research was approved by the Kasetsart University Human Research Ethics committee (KUREC-HS63/009).

Procedure

In the present study, *the MASS group,* Swedish massages with plai essential oil (100% natural plai rhizome extracted from USDA Organic, ECO Certificate, and SOIL Association Organic Standard) was performed to the neck-upper back muscles, while in the prone position and the chest muscles while in the supine position, with the force and rhythm of the massage adjusted to the comfort level of the subject for 20 minutes, 3 times a week for a total of 4 weeks in a room temperature set at 25 °C., quiet, no noise, and always the same room. The musculature was the same musculature that was stretched. Massage techniques included deep stroking, kneading, pulling, wringing, compression, and sliding techniques. The participants were given massages by massage therapists with more than 10 years of experience. The reliability of the same measurer (intra-tester reliability) was 80 percent or more.

For *the SS group,* active static stretching was performed by slightly stretching the muscle to the point of warm sensation (with slight discomfort) and holding that position without pain with rest for 10 seconds between each stretch. Each muscle stretch was repeated 10 times; two cycles of stretching were performed at 20-second intervals. Stretching was performed for the neck-upper back (towards flexion-extensor muscles, ipsilateral flexion, and rotation-scalene, toward the lateral flexion-upper part of trapezius, and static sternocleidomastoid stretch[33,34] and chest muscles (one-sided unilateral-pectoral minor, and pectoralis muscle stretch)[34,35] about 3 times per week, for a total of 4 consecutive weeks. The researcher was responsible for administering the static stretching protocol and correctly demonstrating all exercise techniques to the participants. Participants followed the researcher's procedures. While the participants of the *Control group* maintained their normal physical activities (but not more than 2 days/week) and they did not receive any intervention. The Control group participants visited the clinic 2 times before and after the study. Control group participants were given treatment after the study ended.

Outcome Measurements

The protocol consisted of measuring the PPT, neck pain level, ROM of the neck movement, and CVA before the start and after the 4th week of intervention.

1) PPT and pain level

PPT was measured using a digital algometer (Commander Algometer, JTECH, Inc, Italy) in a comfortable supine lying position. The examiner palpated and pinpointed the location of the sore pressure point by making a symbol on the study participants' body, which located the sore pressure point on the transparent sheet where the shoulder, neck, and head at the back were divided into 4 parts and the spinous of the 7th vertebrae (C_7) was a reference point.

Compression pressure was gradually increased at the rate of approximately 1 kg per second perpendicularly onto the muscle tissue. The participants were asked to say “pain” when they experienced an increase in pain intensity and the examiner stopped the compression. The average value of 2 repetitive measurements with an interval of 30 seconds was collected for data analysis. After a pause of 30 seconds, the next measurement was taken. A single measurement was made at each site. The physiotherapist was not blinded to the groups[36].

The measurement was performed at each site in each test session. Pressure pain measurements were performed before and at the end of the 4 weeks intervention period, and they were repeated by the same experienced physiotherapist, who had been trained in algometry. Participants perceived neck pain was assessed by the visual analog scale (VAS) with a scale of 0-10.

2) ROM of the neck movement

The ROM of the neck movement was measured using the goniometer before and after the intervention. The measurements were conducted while the participants performed flexion, extension, lateral flexion, and

rotation movements on the left and right sides of the neck. The participants were asked to look forward in a comfortable sitting position for the performance of the measurements. The initial position of each movement was set at an angle of 0 degrees. The measuring of each direction once at a time by a physiotherapist who had been tested for 80 percent or more accuracy (intra-reliability).

3) CVA

The participants were attached to two reflective markers on the skin: the tragus of the ear and the spinous process of the 7th cervical vertebra (C_7)[37]. The CVA was measured as the angle that correlated between the line drawn from the right tragus of the ear and the C_7 markers angled to the horizontal line[37,38,39,40,41].

Kinovea Motion Angle Measuring Program (version 0.8.15) was used to measure the CVA[37]. The digital camera (Sony digital camera LCS-U11, shooting resolution of 640×840 pixels and speed at 70 frames per second) was placed parallel to the ground, 2 meters away from the participants[42] in a perpendicular direction to the right side of the participants to shoot in a lateral view and set the camera up from the floor to equal the level of the 7th cervical vertebra (C_7). The participants sat upright on the chair (without backrests and armrests) where the height could be adjusted, with the height of the chair sitting at a level where the hip joints and knee joints are bent at an angle of 90. The participants were asked to put both feet on the ground and place their hands on the thighs while relaxing the back. The participants conducted a single experiment.

STATISTICAL ANALYSIS

General information such as age, weight, and height by descriptive statistics was used. The pain level, PPT, the angle of neck movement, and the CVA were tested for the distribution of the data by Shapiro-Will test statistics, which showed that the data was distributed normally. For the analysis of the before-and-after results of each intervention, a paired t-test was performed to determine their effects on pain levels, PPT, the angles of neck movement, and the CVA. A one-way repeated ANOVA was used to determine the differences in pain levels, PPT, the angles of neck movement, and the CVA among the three groups. An F-test was calculated to check for interactions between groups. The Tukey method was used for the post-hoc analysis and the significance level was set at α=0.05.

RESULTS

The results of this study showed there were no differences in the general characteristics including age, weight, and height in both groups as shown in Table 1.

Table 1 General characteristics of the participants in massage with plai essential oil (MASS), static stretching (SS), and control groups

Characteristic	Control (n=16)	MASS (n=16)	SS (n=16)
Age (years)	33.42 ± 4.36	34.05 ± 4.50	35.23 ± 5.45
Weight (kg)	53.64 ± 5.65	54.75 ± 5.59	53.75 ± 5.43
Height (cm)	157.80 ± 4.53	158.16 ± 4.07	158.61 ± 4.85
Body Mass Index (kg/m^2)	21.56 ± 4.30	21.90 ± 3.08	21.48 ± 3.84

Values are means ± SE, n = 48

There were no differences between groups in the pre-test of all variables. When comparing pain levels, PPT, ROM of the neck movement, and CVA, before and after the treatment in each group, the control group was not significantly different, while in the MASS and SS groups, there was a significant difference in all outcomes after treatment. In the MASS and SS groups, the pain levels decreased, and the PPT, ROM of the neck movement, and CVA increased significantly after the 4-week interventions ($p < 0.05$) (Table 2).

Table 2 Comparison between pre-and post-test in Control, MASS, and SS groups

Group	Pre-test	Post-test	*p*-value
Control (n=16)			
Pain level (score)	5.63 ± 1.03	5.50 ± 0.82	0.708
Rt. PPT (kg)	38.72 ± 4.70	37.91 ± 5.32	0.514
Lt. PPT (kg)	37.01 ± 3.99	36.95 ± 3.25	0.957
Neck flexion (degree)	29.94 ± 4.36	30.63 ± 5.67	0.460
Neck extension (degree)	34.38 ± 4.37	35.50 ± 4.00	0.236
Rt. neck lateral flexion (degree)	31.19 ± 3.83	31.50 ± 1.05	0.690
Lt. neck lateral flexion (degree)	30.25 ± 3.24	30.75 ± 3.15	0.617
Rt. neck rotation (degree)	53.56 ± 4.96	56.19 ± 5.74	0.062
Lt. neck rotation (degree)	53.56 ± 5.94	53.44 ± 6.84	0.908
CVA (degree)	41.88 ± 3.16	42.13 ± 1.96	0.708
MASS (n=16)			
Pain level (score)	5.44 ± 0.73	1.44 ± 0.81	0.000*
Rt. PPT (kg)	38.80 ± 5.53	45.03 ± 5.53	0.000*

Lt. PPT (kg)	37.85 ± 4.39	43.84 ± 4.76	0.000*
Neck flexion (degree)	29.50 ± 4.47	39.19 ± 3.89	0.000*
Neck extension (degree)	35.44 ± 4.05	43.06 ± 3.89	0.000*
Rt. neck lateral flexion (degree)	31.31 ± 2.33	39.06 ± 3.64	0.000*
Lt. neck lateral flexion (degree)	30.44 ± 1.86	39.69 ± 2.70	0.000*
Rt. neck rotation (degree)	54.38 ± 4.43	63.75 ± 4.28	0.000*
Lt. neck rotation (degree)	52.69 ± 4.99	61.88 ± 4.03	0.000*
CVA (degree)	41.63 ± 3.01	45.44 ± 3.09	0.001*
SS (n=16)			
Pain level (score)	5.56 ± 0.81	2.13 ± 1.09	0.000*
Rt. PPT (kg)	38.05 ± 5.05	42.02 ± 4.25	0.001*
Lt. PPT (kg)	36.70 ± 3.59	40.75 ± 4.66	0.000*
Neck flexion (degree)	29.88 ± 4.99	41.88 ± 5.70	0.000*
Neck extension (degree)	35.13 ± 4.77	45.25 ± 5.12	0.000*
Rt. neck lateral flexion (degree)	31.75 ± 2.38	42.44 ± 2.09	0.000*
Lt. neck lateral flexion (degree)	30.06 ± 2.76	43.88 ± 5.24	0.000*
Rt. neck rotation (degree)	54.25 ± 4.58	62.50 ± 4.08	0.000*
Lt. neck rotation (degree)	53.38 ± 6.41	61.31 ± 4.73	0.000*
CVA (degree)	41.75 ± 3.24	47.13 ± 4.24	0.000*

Values are means ± SE, n = 48

MASS, massage with plai essential oil; SS, static stretching; PPT, pressure pain threshold;

Rt., right; Lt., left; CVA, craniovertebral angle.

* A significant difference from the pre-test value ($p < 0.05$).

In addition, the comparison of variables after the experiment between each group found a statistical significance between both interventions and the control group for pain level, PPT, ROM of the neck movements in flexion, extension, lateral flexion, rotation, and CVA (* $p < 0.05$, ** $p < 0.01$, *** $p < 0.000$). All of the variables of the intervention groups improved more than the control group. The pain of the MASS group decreased more than the SS group significantly ($p < 0.05$). The ROM of the neck movements in lateral flexion of the SS group increased more than the MASS group significantly ($p < 0.01$) (Table 3).

Table 3 Comparison of variation among control, MASS, and SS groups after 4 weeks of intervention.

Variable	Control (n=16)	MASS (n=16)	SS (n=16)	*F* (*p*-value)
Pain level (score)	5.50 ± 0.82	1.44 ± 0.81***,#	2.13 ± 1.09***	90.32 (.000)
Rt. PPT (kg)	37.91 ± 5.32	45.03 ± 5.53***	42.02 ± 4.25*	4.87 (.001)
Lt. PPT (kg)	36.95 ± 3.25	43.84 ± 4.76***	40.75 ± 4.66*	4.82 (.000)
Neck flexion (degree)	30.63 ± 5.67	39.19 ± 3.89***	41.88 ± 5.70***	20.78 (.000)
Neck extension (degree)	35.50 ± 4.00	43.06 ± 3.89***	45.25 ± 5.12***	21.91 (.000)
Rt. neck lateral flexion (degree)	31.50 ± 1.05	39.06 ± 3.64***	42.44 ± 2.09***,##	42.87 (.000)
Lt. neck lateral flexion (degree)	30.75 ± 3.15	39.69 ± 2.70***	43.88 ± 5.24***,##	48.29 (.000)
Rt. neck rotation (degree)	56.19 ± 5.74	63.75 ± 4.28***	62.50 ± 4.08**	11.61 (.000)
Lt. neck rotation (degree)	53.44 ± 6.84	61.88 ± 4.03***	61.31 ± 4.73***	12.51 (.000)
CVA (degree)	42.13 ± 1.96	45.44 ± 3.09**	47.13 ± 4.24***	9.88 (.000)

Values are means ± SE, n = 48

MASS, massage with plai essential oil; SS, static stretching; PPT, pressure pain threshold;

Rt., right; Lt., left; CVA, craniovertebral angle.

* $p < 0.05$, ** $p < 0.01$, *** $p < 0.000$ (Comparison between control and MASS group, and comparison between control and SS group)

# $p < 0.05$, ## $p < 0.01$ (Comparison between MASS and SS group)

DISCUSSION

In the present study, pain level decreased significantly, and PPT, ROM of the neck movement, and the CVA increased significantly after 4 weeks of interventions. All of the variables of the intervention groups were improved more than the control group. The pain of the MASS group decreased significantly more than the SS group. The ROM of the neck movements in lateral flexion of the SS group increased significantly more than the MASS group. The pain level was significantly reduced and increased in PPT, ROM of the neck movement, and the CVA with the MASS. This may be due to the pressure and technique of Swedish massage to stimulate large nerve fibers. This inhibits the transmission of nerves, feeling pain in the spinal cord area. This causes the pain door to be closed, as well as increased pain tolerance and pressure levels, in line with the gate control theory. Massage delivered to soft and connective tissues may induce local biochemical changes that modulate local blood circulation, improve muscle flexibility, intensify the movement of lymph, and loosen adherent connective tissue, which may alternately improve the reuptake of local nociceptive and inflammatory mediators. These local effects may subsequently influence neural activity at the spinal cord segmental level, thereby modulating the activities of subcortical nuclei that influence pain perception[43,44]. Massage can create mechanical pressure which is expected to increase muscle consistency as a result, the range of motion of the joint is increased,

stiffness is decreased, and active stiffness is decreased. Mechanical pressure may improve blood flow by increasing arterial pressure as well as increasing the temperature of the muscles from rubbing depending on the massage technique. Moreover, massage can reduce the tension of the neck-upper back and chest muscles so the neck has more significant movement in different directions. The mechanical pressure expected by the muscles increases or decreases the excitability of the nervous system. Previous studies have found that massage and proper pressure reduced tissue adhesion of connective tissue, which causes muscle tendons and muscles to be stretched, resulting in the relaxation of muscles and ligaments and the movement of joints increased[45,46,47]. Another study also found that massage provided immediate or short-term effectiveness in pain and tenderness. Further study is needed to assess the long-term effects of treatment[48].

In addition, the massage with plai essential oil reduced pain levels and increased the PPT, ROM of the neck movement, and the CVA, possibly due to the effect of the composition of plai essential oil. A past study reported that the composition of plai essential oil containing the substance (E)-4-(3',4'; Dimethoxyphenyl), But-3-en-l-ol, or substance D, reduces pain[49,21]. These compounds have an anti-inflammatory effect of reducing the activities of COX-2, lipoxygenase, inducible nitric oxide synthase, and inflammatory cytokines[50]. Similarly, Jeenapongsa et al., reported that the mechanism of action of 14% Plai cream on pain reduction was likely related to the anti-inflammatory pathways including cyclooxygenase and lipoxygenase pathways. A previous study conducted to determine the effect of (E)-1-(3,4-dimethoxyphenyl) butadiene (DMPBD), a phenylbutanoid that is the active ingredient of Plai, on anti-inflammatory effect using both in vivo and in vitro models. The study found that DMPBD could dose-dependently inhibit inflammation of rat ears which were induced by ethyl phenylpropiolate (EPP), arachidonic acid (AA), and 12-O-tetradecanoylphorbol 13-acetate (TPA)[51]. Manimmanokorn et al., 2016 showed the positive effect of 14% Plai in healthy volunteers who were forced to get muscle soreness which was relatively less severe than muscle strain[52].

The previous study showed that plai essential oil decreased significantly the visual analog scales and increased significantly the pressure threshold after applying plai oil on their shoulder and neck for 6 days in participants with myofascial pain syndrome. Moreover, the angle of neck flexion and extension also increased within 3 days of application[20]. Massage therapy can produce a relaxation response (RR) that creates a calm state and enhances the ability to rest, qualities that are so essential for healing to occur. In addition, the RR elicits physiological changes, including lower blood pressure and heart rate, decreased oxygen consumption and muscle tension, and lower levels of cortisol and noradrenaline[53].

The essential oil molecules are so minute that when they are applied to the skin, the molecule passes through the dermis, into the capillaries, and into the bloodstream. Absorption also occurs through the hair follicles and sweat ducts. Both rates of circulation and the warmth of the skin increase blood flow to the surface, therefore increasing the skin's ability to absorb the oil. Other research found lavender oil (*Lavendula angustifolia* Mill, Labiatae) and bergamot (*Citrus bergamia* Risso, Rutaceae) to be effective in treating depression and anxiety[54,55]. The results of two trials involving 32 patients with non-specific subacute cervical pain and 61 patients with lumbar pain, respectively, suggest that eight sessions of manual acupressure with lavender oil can significantly reduce pain and improve spine mobility[56]. All essential oils, regardless of the plant they are extracted from, should be carefully administered when topically applied, and any contact with irritated or damaged skin must be avoided. When externally applied, essential oils should be adequately diluted at a concentration of 1.5%–3.0% in a carrier oil[57]. However, little research about plai essential oil has been conducted.

In addition, we also found a significant decrease in pain level and an increase in PPT, ROM of the neck movement, and the CVA with the SS, due to the stretching reduced the stiffness of the muscle-tendon unit as adaptations of the proprioceptive system occurred[58]. The majority of current research shows that when acute stretches cause a noticeable increase in a joint's range of motion, the person can experience either inhibition of the motor nerves, overlengthening of the muscle sarcomeres, or increased length and compliance of the muscle's tendons. As the sarcomere contracts, the area of overlap between the thick and thin myofilaments increases when muscles are stretched, and this area of overlap decreases, allowing the muscle fiber to elongate. Additional stretching places force on the surrounding connective tissue. As the tension increases, the collagen fibers in the connective tissue align themselves along the same line of force as the tension. It may help to realign any disorganized fibers in the direction of the tension. This realignment may be what helps to rehabilitate scarred tissue or tightness of muscles back to health. The viscoelastic properties of muscle exhibit several phenomena when an external load is applied. When tissues are held at a constant length, the force at that length gradually declines and is described as the "stress relaxation" response. When tissues are held at a constant force, the tissue deformation continues until approaching a new length and is termed "creep". Creep might be another explanation for the immediate increased range of motion after static stretching. The musculotendinous unit also produces a variation in the load-deformation relationship between loading and unloading curves. The area between the loading and unloading curves is termed "hysteresis" and represents the energy loss as heat due to internal damping. When the muscle is stretched, so is the muscle spindle. The

muscle spindle records the change in length of the muscle and how fast this change occurs. It then sends signals to the spine, which then conveys this information to the brain. Initially, this information triggers the stretch reflex, which attempts to resist the change in muscle length by causing the stretched muscle to contract. The more sudden the change in muscle length, the stronger the muscle contractions will be. This basic function of the muscle spindle helps to maintain muscle tone and to protect the body from injury. Another neural component, the Golgi tendon organ (GTO), goes into action and takes power over the muscle spindle. When muscles contract, they produce tension at the point where the muscle is connected to the tendon. This is where the Golgi tendon organ is located. The Golgi tendon organ then records the change in tension, and the rate of change of the tension, and sends signals to the spine to convey this information. When this tension exceeds a certain threshold, it triggers the lengthening reaction, which inhibits the muscle's contraction and instead causes it to relax and lengthen. The lengthening reaction is possible only because the signaling of the Golgi tendon organ to the spinal cord is powerful enough to overcome the signaling of the muscle spindles telling the muscle to contract. The reasons for holding a stretch for a prolonged period are to allow the lengthening reaction to occur, thus helping the stretched muscles to relax and the muscle spindle becomes accustomed to the new length and reduces its signaling. Gradually, stretch receptors are trained to allow greater lengthening of the muscles[59]. Interestingly, the increase in ROM may not be caused by increased length or decreased tension of the muscle; rather, the subject may simply have an increased tolerance to stretching[60]. The stretching-induced increases range of motion of joints, viscoelastic deformation, neutral adaption, mechanical factors, and changes in muscle's contractile properties. Effects of stretching decrease viscosity and increases stretch tolerance, the effect of stretching over 3 to 4 weeks appears to affect only stretch tolerance[25]. Mechanical tension would stimulate free nerve endings sensitive to mechanical stimuli. These stimuli, transmitted by afferent pathways with a larger caliber and greater conduction velocity than nociceptive afferent pathways, would reach the posterior horn of the medulla first, in the substantia gelatinosa, generating presynaptic inhibition, a mechanism known as the gate control theory. Stimulated by the nervous impulse from mechanoreceptors, the substantia gelatinosa would modulate the synaptic transmission of nerve impulses between peripheral and central afferent fibers, acting as a gate system and reducing the passage of painful stimuli. Stretching could also elongate nerve fibers, reducing fibrosis and adhesion between the surrounding connective tissue and neural tissues, allowing better intrafascicular gliding and pumping/flushing of intraneural fluid, facilitating axoplasmic flow, minimizing the deposition of chemical sensitizers, resulting in pain relief. These neurophysiological mechanisms could explain how stretching exercises would reduce pain

Both static and dynamic stretching appear equally effective at improving ROM acutely or overtime with training[61]. Interestingly, static stretching is the most common approach for rehabilitation, where a specific position is held with the muscle on tension to a point of a stretching sensation and repeated. Static stretching can reduce or prevent injury, and decrease subsequent muscle soreness [25]. Mechanically, static stretching causes a decrease in the musculotendinous unit (MTU) stiffness[62]. However, some previous studies reported static stretching decreased performance, while others reported no change or an increase in performance[60]. Bae et al.,[63] reported that static stretching using a load on fascia lata affected pain relief and flexibility increases in patients with low back pain. In contrast, it found that dynamic stretching treatment gave more optimum effects than static stretching to increase spine ROM[64]. Paul et al. reported that static stretching is more effective than dynamic stretching in improving pain and functional disability in patients with mechanical neck pain. The reduction in the pain following static stretching can be explained based on the inhibitory effect of GTO, which causes a dampening effect on the motor neuronal discharges, thereby causing relaxation of the musculotendinous unit by resulting in its resting length and Pacinian corpuscle modification. These reflexes will allow relaxation in musculotendinous unit tension and decreased pain perception[65]. Another study reported that static stretching and dynamic stretching were found to be equally effective in pain relief and improvement in range of motion in chronic neck pain patients[66].

The pain of the MASS group decreased significantly more than the SS group because the massage with plai essential oil is a kind of passive treatment that participants had to lie down on a comfortable bed and relax their bodies. During the massage, they had no movement of joints actively and no muscle exertion. The researcher used suitable pressure on their skin and muscle so participants felt better. A previous study suggested that petrissage massage could reduce soreness and maintain swelling and knee range of motion after plyometric exercise, compared to stretching or resting[67].

The ROM of the neck movements in lateral flexion of the SS group increased significantly more than the MASS group due to the static stretching being the active treatment in which participants had to exert muscle actively and tried to move cervical joints and muscles around gently. So, active static stretching was more effective in a range of motion. The main effects of static stretching on flexibility are related to the viscoelasticity of the tendon and the relaxation of the actin-myosin complex, resulting in a temporary lengthening of muscles and tendons[68]. A previous study reported that massage increased only ankle dorsiflexion range of motion while stretching significantly increased all lower extremity range of motion measurements, so, the effectiveness of massage on the range of motion is still not clear[69]. The study demonstrated a significant positive effect of static

stretching and massage on flexibility but it found no significant differences between static stretching and massage[70]. The current study suggests that adding stretching to the standard procedures may be more effective than the standard procedure alone at improving cervical extension, right rotation, and lateral flexion active range of motion, but not pain and disability[71].

Both interventions offer different benefits for the body, while both also have weaknesses. Massage with plai oil requires an experienced therapist, as it is difficult for a participant to do it by themselves. Active static stretching may also require the opposing muscles to have sufficient strength to move the joint while stretching. The present study showed that massage with plai essential oil could reduce pain better than active static stretching, while active static stretching was a greater improvement in some ranges of motion of the neck than a massage with plai essential oil. It may be better to improve both pain level and neck movement if we combine both interventions. Stretching exercises and massage applied to the sternocleidomastoid muscle, together with conventional physiotherapy, can reduce pain and disability, and increase ROM and endurance in individuals with chronic neck pain compared to physiotherapy alone[72]. A previous study showed that combined static stretching and massage increased flexibility greater than static stretching alone in university athletes[73].

There are limitations in this study that could be addressed in future research. First, we could not control the force and motion of movement when participants performed active static stretching. Second, the results have only reported short-term effects.

CONCLUSION

The MASS and SS can decrease pain levels, and increase PPT, ROM of the neck movement, and CVA as well. However, a massage with plai essential oil was better to decrease pain than the active static stretching but the active static stretching improved the ROM of the neck in lateral flexion more than a massage with plai essential oil. Thus, further study needs to investigate the effect of combining two techniques on pain and neck movement or motion variables in chronic neck pain.

CONFLICTS OF INTEREST

The authors declare no conflict of interest

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