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Effects of Alpha Neck on Neck Pain, Pressure Pain, Muscle Tone, Muscle Fatigue, Infrared Body Heat, Stress and Satisfaction

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This study aimed to assess the effects of the Alpha Neck devise with and without heat on neck pain, pressure pain, muscle tone, muscle fatigue, muscle temperature, and stress in subjects with chronic neck pain. It is a one-way repeated design conducted on two days with twenty-four subjects (12 men, 12 women) with chronic neck pain. During the first day experiment, subjects received the Alpha Neck session without heat for 10min and on the second-day same procedure but with heat application. Current neck pain, pressure pain threshold, neck disability, muscle tone, fatigue, the temperature of neck extensors, perceived stress, and satisfaction were evaluated before and after the sessions. Neck pain and a disability score significantly reduced after experiments regardless of heat application ($p<0.05$). Moreover, in terms of pressure pain, a significant change was only observed after the second experiment with heat application ($p<0.05$). We observed no significant difference after both experiments in muscle tone($p>0.05$), and only the second experiment showed a significant improvement in muscle temperature. For the muscle fatigue, each experiment showed significant improvement with a higher decrease after the second experiment. Participants expressed their satisfaction using the Alpha Neck with heat application, and it resulted in decreasing stress. These results suggested that Alpha Neck with heat application for a maximum 10min/sessions might be a useful self and low-cost management device for people with chronic neck pain.

***Keywords*:** chronic neck pain; alpha neck; pressure pain; muscle fatigue, muscle tone

Introduction

Recently with the increase of society's industrialization and fast development of technology, the prevalence of people suffering from chronic neck pain keeps continuing to increase. Chronic neck pain is considered as a familiar musculoskeletal problem and the most vulnerable population is especially the working-age population [1]. Among the population at high risk, the most reported cases are office workers, students with excessive smartphone and computer use [2]. Neck pain is the sensation of pain perceived in the back region of the neck from the superior nuchal line until the first spinous process varying from a simple aching to a diverse degree regardless of radiation to other parts of the body [3]. Generally, pain can be resolved within days or less than 12 weeks, and it is classified as acute neck pain. However, in some cases, people report neck pain exceeding 3 months which is defined as chronic neck pain [4].

Many conditions can cause chronic neck pain such as degenerative cervical disc disease, traumatic neck injury (whiplash), cervical radiculopathy, etc. The most known mechanism causing chronic neck pain is the abnormal posture conducted in daily life or sleeping in an unwieldy position [5]. [6] demonstrated that maintaining an abnormal posture for a long period of time leads to increased stress on the neck and shoulder muscles resulting by increasing muscle stiffness and weakness [6]. Many previous studies on deep neck muscle thickness, muscle size, electromyography (EMG), and cross-section area on patients with chronic neck pain showed weakness and atrophy of deep neck extensor muscles [7;8;9]. In addition to pain and muscle weakness, in some cases of chronic neck pain, patients present trigger points on the surface around the neck, limitation of some movement and normal range of motion, present also fatigue during their activities of daily living [10]. This structural dysfunction appears to be the main cause of neck and shoulder muscle imbalance known as an upper-cross syndrome and the reason for the repeated neck pain.

Common musculoskeletal dysfunction, chronic neck pain treatment, and management involve all health care providers with various medications, laboratory imaging, physical modalities, therapeutic interventions, acupuncture, chiropractic, and education programs adapted for patients [11]. Physical therapists have been used diverse treatment techniques as massage, manipulation, mobilization, physical modalities (TENS, ultrasound, infrared, heat/cold, cervical traction, etc.). According to the guideline, manual therapy and TENS are recommended treatment methods and are effective for reducing pain in patients with chronic neck pain [12]. All those listed treatment techniques are administrated principally to release muscle tension, reduce muscle stress, stiffness resulting in pain reduction and muscle balance. Although the previously mentioned treatment techniques are mostly conducted in clinical with therapist supervision. However chronic neck pain treatment guideline highlights the use of effective low-cost self-treatment that should be easily accessible at the home of frequent use [13]. Moreover, studies have affirmed that self-treatment/home interventions are not only beneficial for reducing pain but also thoroughly advantageable in terms of reducing health care expenses [14]. Otherwise, there is a considerable and immediate need for a low-cost, effective chronic neck pain self-treatment technique of device that can be used for all ranges of ages.

The Alpha Neck device is easily portable with a small size, lightweight, thermo-acupressure, potentially effective, and beneficial self-treatment device for chronic neck pain patients. It is designed based on three distinct massage styles: Shiatsu, Thai, and Hot-Stone with an ideal curvature to support the neck while providing low-frequency electrical pulses through the skin and surrounding the pain site. With three (3) different degree of intensity, electrical pulses are transmitted to deep skin to reduce the pain signals, relax muscles through a consistent heat massage which accelerate blood circulation. With just one button of turning on-off and the same button to change the degree of the electrical pulse, it is very comfortable, safe, and easy to use. Additionally, it runs with a built-in battery of large capacity that supports over 10 times use (15min/time) and has automatic power-off protection for more than 10 minutes for safety and saving energy.

Therefore, the purpose of this study is to evaluate the effectiveness and efficacity of the Alpha neck on people with chronic neck pain in the treatment of neck chronic pain, pressure pain, muscle tone, muscle fatigue, and stress.

Study hypotheses

Primary hypothesis: There would be imminent improvements in chronic neck pain and pressure pain reduction after both experiments. However, changes would be more distinguished after the Alpha Neck heat application compared to the control experiment without heat application.

Secondary hypothesis: There would be a remarkable improvement in muscle fatigue, muscle tone, and perceived stress in the experiment study compared to the control study.

Participants and Methods

Study design

This study was a one-way repeated measures design, conducted at the Sunmoon University's Physical Therapy Research Lab assessing the effectiveness of the Alpha neck reducing chronic pain, pressure pain, muscle tone, and stress of subjects with chronic neck pain. The experiment procedure was conducted in conformity with the ethical principles and was approved by the Sunmoon University Institutional Review Board with the registry number SM-202104-030-2. Prior to their enrollment in the present study, all participants provided written informed consent.

Sample calculation

Table 1. Demographic characteristics of subjects

Variables	Mean ± SD	Min - Max	*P*
Age (years)	23.50 ± 2.10	20 ± 32	0.016
Height (cm)	167.88 ± 9.99	150 ± 189	0.539
Weight (kg)	66.88 ± 13.25	47 ± 90	0.622

SD: standard deviation, Min: minimum, Max: maximum

The sample size was calculated using the computer software G-power (Heinrich-Heine-University Düsseldorf, version 3.1.9.7, Düsseldorf, Germany). In the present study, the effect size was set to 0.2 (Smaller effect size), and the alpha level was 0.05. Based on these values, 23 participants were needed to achieve 95% of power. However, to avoid bias according to participants' gender, a total of 12 men and 12 women were recruited and a total of 24 participants we included.

Participants

We recruited 24 volunteers (12 men, 12 women) between the age of 20 and 50 who reported chronic neck pain and filled our study's inclusion criteria. The inclusion criteria were men and women aged between 20-50 years reporting chronic mechanical neck pain (≥ 12 weeks), those who complain of pain with non-traumatic neck pain (≥ 12 weeks) at least days a week. Exclusion criteria included those who have a history of cervical disc disease, those with whiplash injury due to a traffic accident within the last 3 months, a history of previous traumatic spinal cord injury and injuries to the neck or upper back above T6 level, those with thoracic outlet syndrome, or neurological symptoms such as sensory abnormalities and those who have contraindications to physical therapy modalities such as heat therapy.

Instruments

In the present study, all the outcomes were assessed by the same examiner. The primary outcomes were pain score and neck disability, assessed by the widely known visual analog scale (VAS), Neck Disability Index (NDI), and the short-form McGill Pain Questionnaire (Korean version, KSF-MPQ). The visual analog scale is a patient's self-pain report which requests to indicate the perceived pain comprise from 0 to 10, and a higher score indicates greater pain intensity. The NDI is one of the most used and most reliable tools for self-evaluation of neck disability in subjects with neck pain (15). It includes 10 items reporting the effect of pain on various activities of daily living. Widely used for evaluating the quality and intensity of the pain, the Short Form of the McGill Pain Questionnaire (SF-MPQ) was translated into many languages such as the Korean version (KSF-MPQ) with excellent reliability and validity (16).

The secondary outcome was the pressure pain threshold which was assessed by the Baseline digital Algometer. The Algometer is an instrument designed to assess specific tender points and pressure pain applied directly to the contact of the skin. In the present study, the pressure pain threshold was measured on the deep neck extensor around the area of the levator scapular and splenius capitis in both sides (left, right) in the same way as in a previous study (17). The pressure applied was gently increased until the subjects manifest verbal or gestural pain.

Muscle proprieties was the third outcome, and it includes muscle tone and muscle fatigue. The muscle tone was measured using the MyotonPro which has a moderate to excellent inter-rater and interrater reliability (intraclass correlation coefficients: 0.50-0.95) (17). The MyotonPro is a reliable hand-held tool used to measure five (5) muscle proprieties related to muscle health conditions that are muscle tone, muscle stiffness, muscle elasticity, stress relaxation time, and the ratio of deformation and relaxation time (creep) (18). It works by creating a mechanical impulse directly on the skin of the testing muscle. The muscle tone was measured as frequency (Hz) describing muscle state in absence of any voluntary contraction, muscle stiffness as newtons/meter (N/m) describing muscle resistance to contraction or outside force, elasticity that is the ability to regain its normal form after a condition change, stress relaxation time as meter/second (ms) describing time for a muscle to recover his initial form after proprieties change and creep expressing gradual elongation of tissue over time. The measurement position was the same as the algometer measurement.

The muscle fatigue was assessed by surface electromyography (Smart Wireless EMG Analysis Solution) and the change of neck temperature using IRIS-XP Infrared Imaging System – Medicore. The Smart Wireless EMG Analysis Solution is composed of a two (2) channels MoTive-Rs device with Bluetooth included and the MoTive-Rs software (research mode). The MoTive-Rs's particularity is to have real-time biofeedback and automatic data filtering technology. However, in the present study, the biofeedback screen was hidden to avoid bias during the experiment process. IRIS-XP Infrared Imaging System is a medical infrared thermograph system with an infrared camera unit visualizing the pain in colored images by detecting the infrared ray from the human body and having the ability to save the real-time temperature of patients. In the present study, the imaging was focused on the backside of the neck targeting neck extensor muscles.

Regarding subjects' stress, it was assessed through the classic stress assessment instrument Perceived Stress Scale (PSS). The PSS consists of 10 items questions about the current level of perceived stress and each question has a five-point Likert scale (range 0–4) with higher scores indicating higher perceived stress (19). Satisfaction about the use of the Alpha Neck device was conducted by The Client Satisfaction Questionnaire (CSQ) which is an 8-item measure. The questions were chosen based on the utilization of device protocol and a previous study (20).

<Figure 1. *A. Digital Algometer - Measurement position*, B. *MyotonPro - Measurement position* >

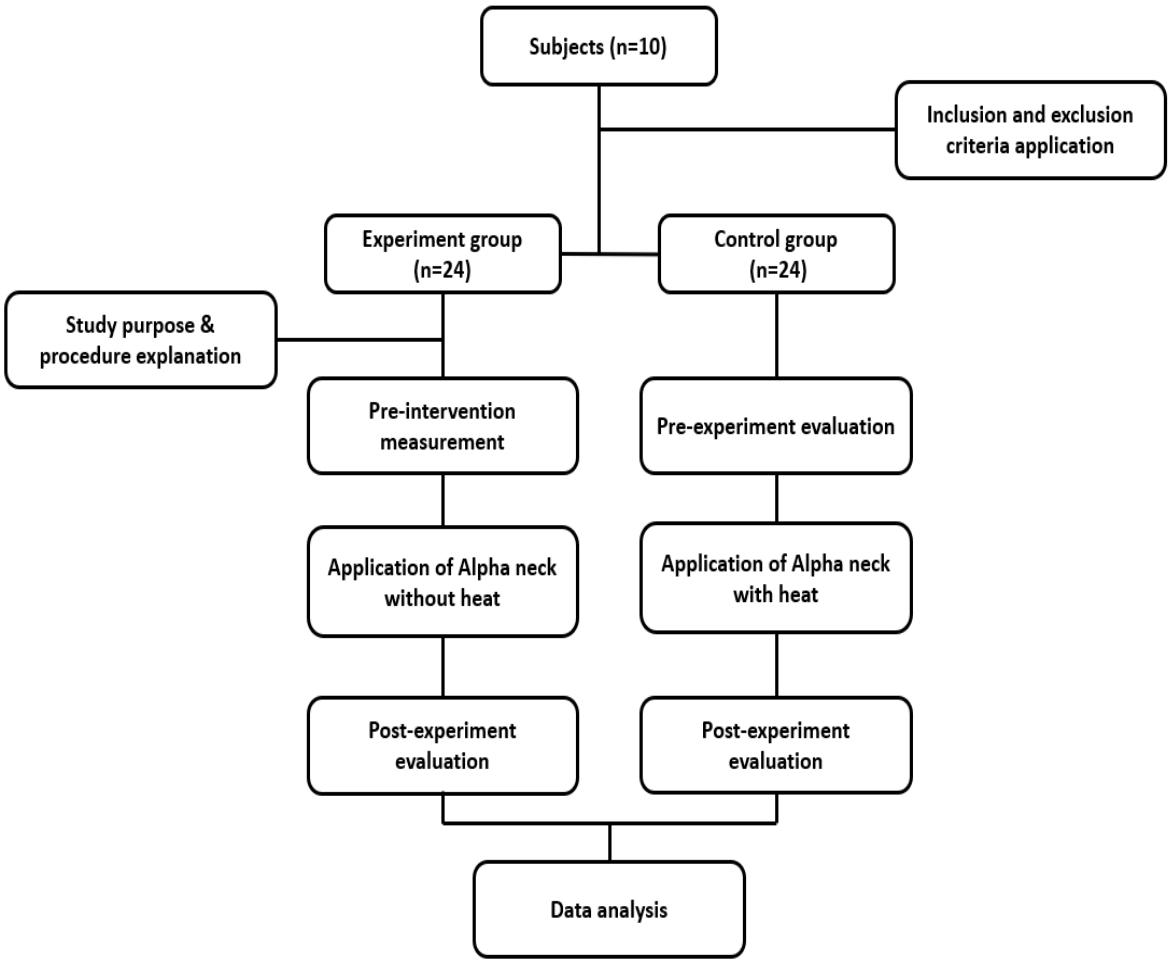
<Figure 2. A. *Smart Wireless EMG Analysis Solution*

B. Measurement position, IRIS-XP Infrared Imaging System – Medicore B. Measurement shape >

Procedure

The experiment was conducted on two (2) separate days for around 90min for each participant. The procedure was almost the same during both days with a difference of absence of Alpha neck heat on the first day contrary to the second day. According to participants' availability, a maximum of two (2) participants were scheduled for each session time. On the first day, prior to the experiment, a brief interview was done in order to obtain participants' general information, and a short explanation was given by examiners about each measurement's procedure and each scale/questionary item. Participants were asked to fill up the PSS, KSF-MPQ, NDI form and describe their pain level through the printed-out VAS form. After that, the infrared image of the neck extensor muscles showing neck pain regions was taken from about 1m of distance. then, the participants were asked to side down on a chair

and the assessment of muscle proprieties through MyotonPro and pressure pain threshold through Algometer was performed. Next was the EMG electrodes were placed on the splenius capitis (between C3-C6) with channel 1 on the right channel 2 on left. Participants were asked to lie on the massage bed in a supine position (facing the top), placing their heads in the bed headrest hole to perform isometric neck extension. The EMG signal of the splenius capitis was measured for 5min with repeated 5sec of neck extension (with the headrest hole as fix resistance) and 20 sec of rest. After the EMG was recorded and the electrodes removed, the Alpha Neck device was placed under the neck (without heat for the 1st day and with heat on the 2nd day) for 10min. Finally, the experiment was concluded by a post-experiment evaluation that was performed in the following order: Neck infrared imaging, Algometer testing, MyotonPro testing, EMG recording, fulling up PSS, NDI, KSF-MPQ, and client satisfaction questionnaire. Figure 3 shows the measurement procedure.



<Figure 3. Measurement procedure>

Statistical analysis

All statistical analyses were performed using SPSS for windows version 26.0 (IBM-SPSS Inc, Chicago, USA) and data were tested for normality using the Kolmogorov-Smirnov test. Descriptive statistics were used to assess general characteristics, paired sample t-test was conducted to compare changes within-group, and an independent t-test for the between-group test. Bonferroni was used for the post hoc test and all results were presented as means and standard deviations. A $p < 0.05$ was set up to indicate statistical significance.

Result

Pain intensity

The pain intensity was assessed before and after the experiments and as shown below (Table 2) there was a significant decrease in pain intensity in both the control experiment (p=0.021) and the intervention experiment (p=0.001). However, as shown in (Table 3), during the independent t-test, there was not a significant difference between the two (p=0,477).

Neck Disability

Regardless of the application of the Alpha Neck heat, the NDI and KSF-MPQ score impressively decreased resulting in a reduction of neck disability. The control experiment revealed significant improvement in NDI and KSF-MPQ, (both p=0.000) and the intervention experiment NDI (p=0.000) KSF-MPQ (p=0.002). However, the between experiment test did not show a significant difference between the two (2) experiments.

Table 2. Changes in pain intensity - neck disability & pressure pain threshold – Within test

Outcome	Test group		Pre-test	Post-test	t	*p*
VAS	Control		3.45 ± 2.20	2.70 ± 2.19	2.480*	0.021
	Intervention		3.12 ± 1.91	2.08 ± 1.88	3.824*	0.001
NDI	Control		6.54 ± 5.31	3.75 ± 3.91	5.252*	0.000
	Intervention		5.54 ± 3.90	2.33 ± 3.22	5.441*	0.000
KSF-MPQ	Control		10.62 ± 9.19	7.58 ± 8.31	4.190*	0.000
	Intervention		8.37 ± 8.06	5.41 ± 7.99	3.515*	0.002
PPT	Control	Rt	5.22 ± 1.38	5.29 ± 1.55	-0.320	0.752
		Lt	4.97 ± 1.49	5.20 ± 1.47	-1.014	0.321
	Intervention	Rt	5.17 ± 1.41	5.89 ± 1.88	-3.648*	0.001
		Lt	4.85 ± 1.72	5.62 ± 2.03	-4.635*	0.000

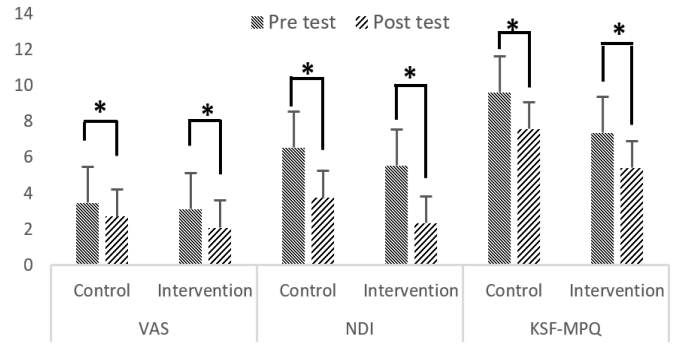
*p<0.05, mean ± standard deviation, VAS: visual analog scale, NDI: neck disability index, KSF-MPQ: Korean version of short-form McGill Pain Questionnaire, Rt: right, Lt: left, PPT: pressure pain threshold

Table 3. Changes in pain intensity - neck disability & pressure pain threshold– Between test

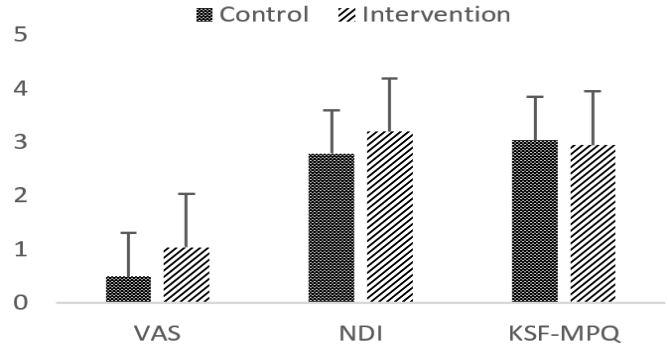
Outcome		Control	Intervention	t	*p*
VAS		0.75 ± 1.48	1.04 ± 1.33	-0.717	0.477
NDI		2.79 ± 2.60	3.20 ± 2.88	-0.525	0.602
KSF-MPQ		3.04 ± 3.55	2.95 ± 4.12	0.075	0.941
PPT	Rt	-0.06 ± 0.96	-0.72 ± 0.97	2.368	0.22
	Lt	-0.22 ± 1.06	-0.77 ± 0.81	2.007	0.51

*p<0.05, mean ± standard deviation, VAS: visual analog scale, NDI: neck disability index, KSF-MPQ: Korean version of short-form McGill Pain Questionnaire, Rt: right, Lt: left, PPT: pressure pain threshold

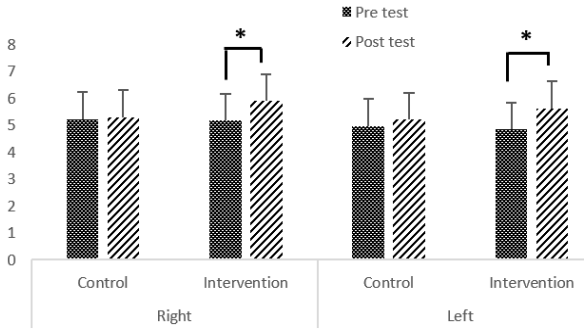
The pressure pain threshold was not improved on the first day with the absence of Alpha Neck heat on both the right and left side of the neck extensor muscles (p>0.05). However, a significant improvement was observed on both sides right (p=0.001) ad left (p=0.000) during the second day after the Alpha Neck heat application (Table 2). Despite that, the independent sample t-test did not show a significant difference between the two (2) experiments (Table 3).



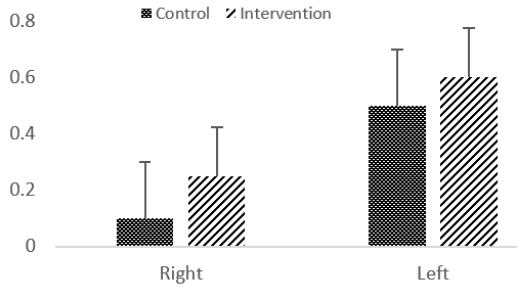
[Figure 4] VAS, NDI, KSF-MPQ within group



[Figure 5] VAS, NDI, KSF-MPQ Between group



[Figure 6] Pressure pain threshold within group



[Figure 7] Pressure pain threshold Between group

Muscle Proprieties

First, the muscle tone, stiffness, elasticity, relaxation time, and ratio did not show any significant improvement during both experiments with and without heat application ($p>0.05$). Without any major change in the above factors, the comparison between the two (2) experiments resulted in a non-significant difference as shown below in (Table 4).

Second, the changes in neck muscle fatigue were observed through RMS peak value and average value, and the results are presented in (Table 5). Although the first experiment with the absence of heat showed significant improvement only in RMS average value (right & left) contrary to the second experiment with alpha neck heat application that presented improvement in both RMS peak and average value (right & left) ($p < 0.05$). A significant difference was found between experiments ($p<0.05$) except the RMS average value on the left side ($p>0.05$).

The comparison of the muscle temperature after the control experiment as shown in (Table 5) did not show a significant change ($p>0.05$). Though, the neck muscle temperature significantly increased after the application of heat during the intervention experiment ($p<0.005$). Moreover, the independent sample t-test showed a significant difference between the two (2) experiments ($p<0.05$).

Stress and satisfaction

The analysis of perceived stress revealed no statistical improvement after the first experiment ($p>0.05$), but a considerable decrease of stress was observed after the second experiment ($p<0.05$). We did not observe a significant difference between both experiments ($p=0.081$). In terms of the satisfaction after the use of the Alpha Neck, participants only appreciated the heat feeling and expressed their satisfaction.

Table 4. Changes in muscle proprieties – Within test

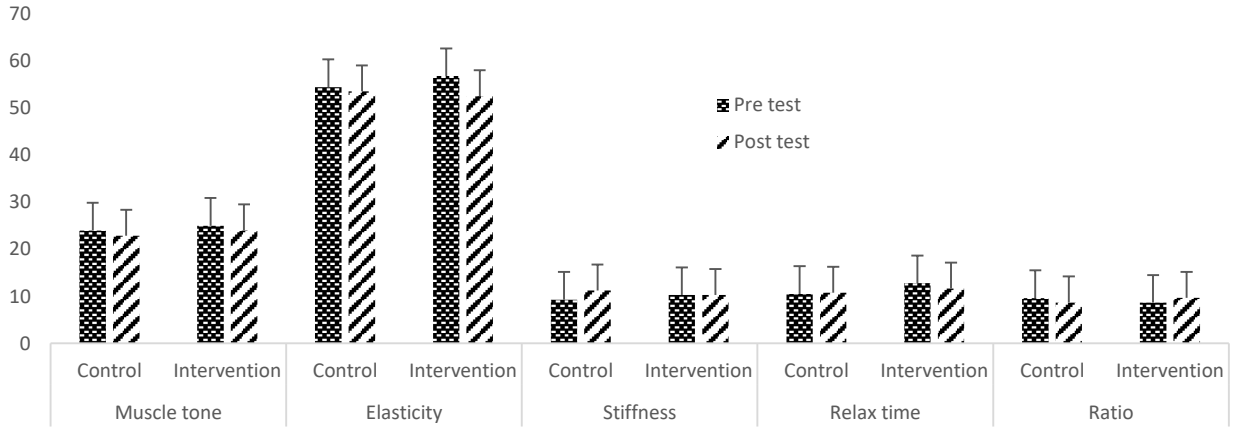
			Pre-test	Post-test	t	*p*
Muscle tone (Hz)	Control	Right	23.71 ± 3.33	23.30 ± 3.63	0.692	0.496
		Left	24.80 ± 4.22	24.50 ± 4.86	0.414	0.683
	Intervention	Right	24.00 ± 2.99	22.85 ± 3.92	1.794	0.860
		Left	25.06 ± 6.05	23.92 ± 4.68	1.808	0.840
Elasticity (log)	Control	Rt	512.08 ± 113.59	473.63 ± 123.96	1.767	0.900
		Left	514.58 ± 133.82	517.00 ± 133.43	-0.108	0.915
	Intervention	Right	490.04 ± 92.69	482.62 ± 90.25	0.415	0.682
		Left	496.87 ± 137.06	508.25 ± 136.03	-0.685	0.500
Stiffness (N/m)	Control	Right	1.27 ± 0.23	1.28 ± 0.20	-0.287	0.777
		Left	1.30 ± 0.19	1.25 ± 0.21	1.154	0.261
	Intervention	Right	1.30 ± 0.19	1.25 ± 0.21	1.154	0.261
		Left	1.48 ± 0.37	1.38 ± 0.19	1.506	0.146
Relaxation time (ms)	Control	Right	10.30 ± 2.45	10.65 ± 2.37	-0.742	0.466
		Left	10.23 ± 2.46	10.22 ± 2.53	0.009	0.993
	Intervention	Right	10.30 ± 1.71	10.77 ± 2.10	-1.272	0.216
		Left	10.08 ± 2.97	10.73 ± 2.53	-1.716	0.100
Ratio (De)	Control	Right	0.65 ± 0.13	0.66 ± 0.13	-0.390	0.700
		Left	0.65 ± 0.13	0.64 ± 0.13	0.201	0.842
	Intervention	Right	0.65 ± 0.10	0.69 ± 0.12	-1.534	0.139
		Left	0.66 ± 0.13	0.68 ± 0.14	-1.169	0.254

*p<0.05, mean ± standard deviation, Hz: hertz, log: logarithm, N/m: newtons per meter, ms: meters per second De: Deborah number

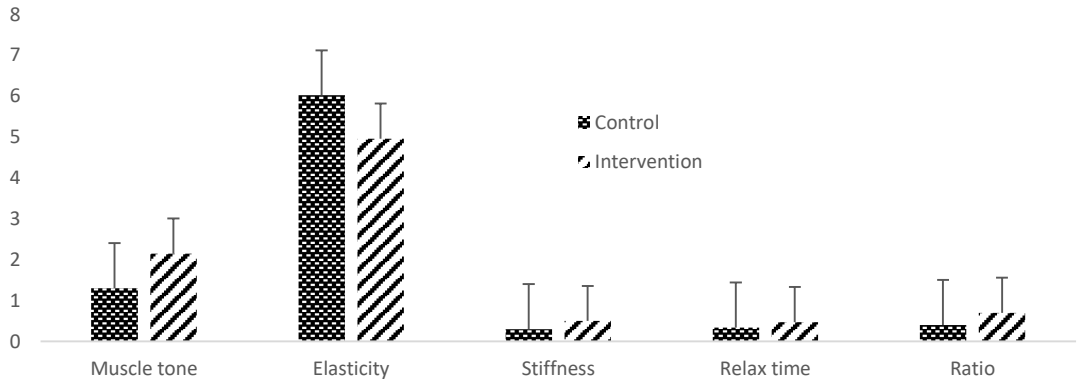
Table 5. Changes in muscle proprieties – Between test

		Control	Intervention	t	*p*
Muscle tone (Hz)	Right	0.40 ± 2.89	1.15 ± 3.14	-0.852	0.399
	Left	0.29 ± 3.47	1.14 ± 3.09	1.894	0.376
Elasticity (log)	Right	38.45 ± 106.61	7.41 ± 87.47	1.103	0.276
	Left	-2.41 ± 109.59	-11.37 ± 81.32	0.322	0.749
Stiffness (N/m)	Right	-0.00 ± 0.09	0.05 ± 0.21	-1.169	0.248
	Left	0.07 ± 0.33	0.10 ± 0.32	1.767	0.748
Relaxation time (ms)	Right	-0.34 ± 2.28	-0.47 ± 1.81	0.210	0.835
	Left	0.00 ± 2.18	-0.64 ± 1.84	1.113	0.272
Ratio (De)	Right	-0.01 ± 0.14	-0.36 ± 0.11	0.678	0.501
	Left	0.00 ± 0.12	-0.26 ± 0.14	0.934	0.355

*p<0.05, mean ± standard deviation, Hz: hertz, log: logarithm, N/m: newtons per meter, ms: meters per second De: Deborah number



[Figure 8] Muscle proprieties within group



[Figure 9] Muscle proprieties between group

Table 6. Changes in muscle fatigue and temperature – Within test

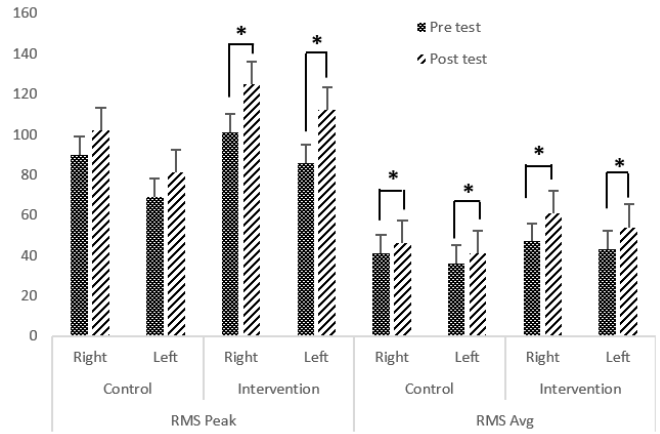
			Pre-test	Post-test	t	*p*
RMS Peak value	Control	Right	90.64 ± 57.06	102.29 ± 64.38	-2.131	0.44
		Left	69.16 ± 41.75	81.77 ± 48.64	-2.122	0.45
	Intervention	Right	101.41 ± 58.25	144.13 ± 89.76	-4.121*	0.000
		Left	86.10 ± 55.70	129.46 ± 90.32	-4.854*	0.000
RMS Avg value	Control	Right	41.56 ± 20.90	46.85 ± 25.51	-2.603*	0.016
		Left	36.19 ± 17.94	41.22 ± 19.40	-2.485*	0.021
	Intervention	Right	47.13 ± 23.86	61.49 ± 31.88	-4.323*	0.000
		Left	43.35 ± 26.54	54.31 ± 35.41	-3.471*	0.002
Temperature	Control	-	32.97 ± 3.22	33.71 ± 2.19	-1.164	0.256
	Intervention	-	33.53 ± 2.10	37.60 ± 1.98	-11.719*	0.000
PSS	Control	-	15.00 ± 6.20	15.00 ± 6.52	0.000	1.000
	Intervention	-	17.58 ± 6.41	15.16 ± 7.58	2.143*	0.043

*p<0.05, mean ± standard deviation, RMS: root-mean-square, Avg: average, PSS: perceived stress scale

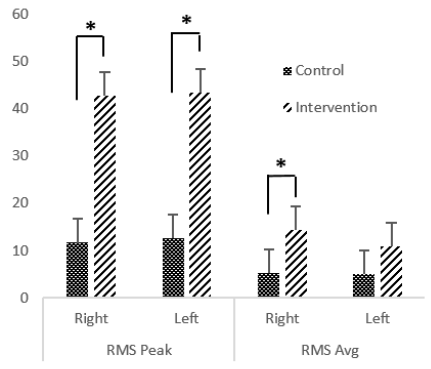
Table 7. Changes in muscle fatigue and temperature – Between test

		Control	Intervention	t	*p*
RMS Peak value	Right	-11.65 ± 26.77	-42.72 ± 43.11	2.999*	0.004
	Left	-12.61 ± 29.12	-43.36 ± 51.54	2.544*	0.014
RMS Avg value	Right	-5.28 ± 9.94	-14.36 ± 16.27	2.333*	0.024
	Left	-5.02 ± 9.90	-10.95 ± 15.46	1.581	0.121
Temperature	-	-0.73 ± 3.10	-4.06 ± 1.70	4.610*	0.000
PSS	-	2.41 ± 5.52	0.00 ± 3.67	1.785	0.081

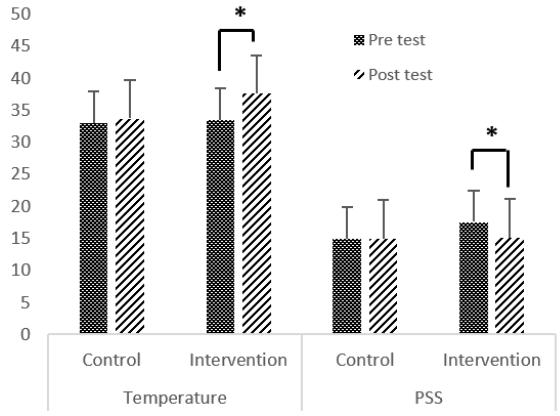
*p<0.05, mean ± standard deviation, RMS: root-mean-square, Avg: average, PSS: perceived stress scale



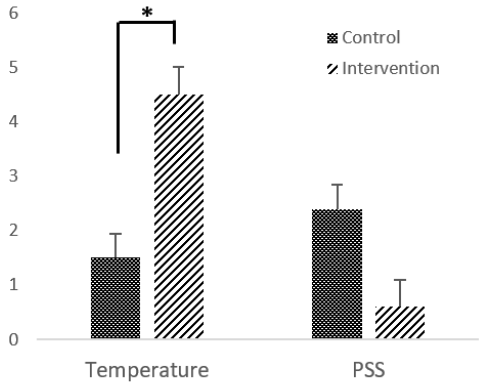
[Figure 10] Muscle fatigue within group



[Figure 11] Muscle fatigue Between group



[Figure 12] Temperature & PSS within group



[Figure 13] Temperature & PSS Between group

Discussion

The present study was a one-way repeated measure, short-term trial aimed to assess the effectiveness of the Alpha Neck devise with and without application of heat on chronic neck pain, pressure pain threshold, muscle tone, muscle fatigue, temperature, and stress in people with neck pain (< 12 weeks). Impressively, one of our main findings was that Alpha Neck with and without heat application led both to an improvement of pain and disability due to pain in people with chronic neck pain.

Chronic neck pain is highly related to the malalignment of the cervical curve with an increase of head forward shift. Reword, a loose of normal lordosis leads to increase neck pain. However, as mentioned in many previous studies, ideal cervical lordosis support such as a well-designed pillow is reported to have a positive effect on reducing pain intensity in people with neck pain (21,22,23). That can be a major reference explaining the findings of our study. The Alpha Neck device even without heat application has reduced VAS score in participants as it provides an ideal curve surface disposition supporting the neck area. Additionally, lying on a supine position, associated with gravity and the head weight applying a downward force conducting to increase stability around the muscles, facilitate proper muscle balance on both side of the cervical spine resulting in increasing pain threshold. However, the application of heat was statistically superior($p=0.001$) to the experiment without heat ($p=0.021$). This result can be explained by the fact that Alpha Neck heat application provides a combination of Shiatsu and Thai massage with a stone hot technology.

Originated respectively from Japan and Thailand, Shiatsu and Thai massage are both manual therapy techniques consisting of applying pressure on some particular points of the body as a means to activate the body's self-healing function (24,25). Shiatsu and Thai massage are distinctly reported effective in terms of stabling balance on vital energy resulting in the increase of blood circulation, increasing neurotransmitters leading to relieve pain (24). In addition, heat stimulation also promotes the elevation of chemical activity resulting in dilatation of blood vessels and increasing blood flow and metabolism. It was reported in a previous study to be an important factor in increasing the afferent nociceptor fiber's (C-fiber) activity and inhibits the nociceptive stimuli resulting in alleviation of pain (26). Besides, in another study regarding the use of heat as thermotherapy for chronic neck pain, Nadler, Scott F., et al on their trial confirmed his effectiveness for short-term pain relief (27). These affirmations support the findings of the present study conducted in a very short period of time applying a combination of Shiatsu-Thai and heat through the Alpha Neck on neck extensor muscles.

Moreover, in the present study, we found a significant improvement in neck disability with NDI and KSF-MPQ ($p<0.05$) regardless of heat application as well as the VAS result. The Neck Disability Index (NDI) is a patient direct-report questionnaire composed of items indicating how much neck pain affects daily life. Furthermore, KSF-MPQ indicates three separate variables of the pain such as sensory, emotional, and cognitive. Thus, the decrease of NDI and KSF-MPQ is specifically connected to the relief of the pain intensity as they are strongly correlated. This affirmation can be supported by several previous studies referring the similar results (28, 29).

Increases in pressure pain threshold were only found after the heat application during the second experiment, indicating a decrease in pain sensitivity. In contrast, no improvement was observed after the control test without heat application ($p>0.05$). These results demonstrate that the Alpha Neck without heat's benefit is limited for supporting neck curve, decreasing pain, and the disability-related but it is not effective for reducing pressure pain threshold. However, the application of heat on the neck extensor muscles (splenius capitis, levator scapula) induces the relief of the pressure pain threshold. As shown in (Table 6,7) muscle temperature was highly increased after the heat application and seems to be related to the increase of the pressure pain threshold. Since the application of heat occasions an increase in superficial tissue temperature, it stimulates the release of chemical mediators which result in vasodilation and enhances blood flow and muscle relaxation. The same mechanism has been shown in a previous study explaining the influence of heat application on reducing pressure pain threshold in patients reporting nonspecific neck pain (30).

Regarding the changes in muscle tone and muscle proprieties in general, no significant improvement was observed after both experiments. As repletely mentioned, the application of heat directly to the surface of the skin may influence muscle proprieties by causing the dilatation of blood vessels, bringing more blood to the stimulated area, and leading to their extensibility and relaxation. Several previous studies demonstrated that connective tissues become more extensible and muscle viscoelasticity increases as the

temperature increases (31, 32). Shin, Ho-Jin, et al. on their trial applied thermotherapy for 30min on neck extensors (splenius capitis, levator scapula) and shoulder muscle (upper trapezius) additionally associated with stabilization exercise during 10 sessions. They affirmed a reduction of neck muscle tone, stiffness, and increase of elasticity. They also showed a correlation between high neck-shoulder muscle tone and stiffness with forwarding head position which is associated with elevated tone of trapezius muscle as well. Nonetheless, the discrepancy of these affirmations and the results of our study may be attributable to two (2) major factors which are heat application location and the experiment duration. The Alpha Neck heat application area (45mm of width) is limited to the center part of the upper and middle cervical which can poorly reach the shoulder and affect the trapezius muscle tone and stiffness. Besides, the present study was a short-term experiment conducted for 10 min of heat application which seems to be insufficient to have a direct effect on neck extensor proprieties.

Investigating the effect of Alpha Neck with and without heat application on muscle fatigue revealed a steady decrease after both experiments but more importantly after the heat application. However, a previous study evaluating the effect of muscle fatigue by heat and cold reported a not significant improvement in muscle strength and fatigue that immersion of 8 minutes in hot water (48 °C) (33). That study did not mention any particular musculoskeletal pain on involved participants, the study method was based on immersion and the experiment location was the arm. Those parameters can explain the contradiction of the result with our present study. More recently, however, Roots, Hamish, et al. in their study on muscle fatigue at various temperatures reported that the application of heat that increases muscle tissue temperature induces the decrease of muscle fatigue (34). Muscle fatigue can be associated with various physiological factors such as high use of glycogen after an exercise or during the maintenance of a certain position for a long period. Thus, a decrease of muscle fatigue by increasing muscle tissue temperature can be explained by the fact that heat works as an accelerator for the resynthesis of the glycogen which is used as the main energy substrate.

The last outcomes of this study were the change of stress and satisfaction after the use of the Alpha Neck devise. Only the experiment after the application of heat has a positive change and statistically significant improvement in both stress and satisfaction scores. Participants affirmed a release of anxiety and relaxation after the application of heat. They reported their satisfaction with the heat intensity (42°C), the C- the shape of the device, and some felt comfort and asleep during the experience.

In the process of carrying out the present study, some limitations were noticed. First, all the results are based on an assessment of the Alpha Neck with and without application of heat conducted only after one (1) session of 10min. Previous authors supported the fact that heat therapy might be more effective when performed for the long term (28). Thus, a long period of the experiment is necessaire for an exhaustive understanding of the effect of the use of the Alpha Neck device on chronic neck pain patients for its clinical purpose. Second, five (5) of the eight (8) measurements conducted in this study relied on a valid and reliable self-report questionnaire. However, we should undertake the fact that those data were subjective, and participants may not provide a total objective response. Henceforth, further research is needed to establish sufficient evidence regarding these results and look over the long-term effectiveness of the Alpha Neck device.

Conclusion

In summary, this study investigated the effect of Alpha neck with and without heat application in chronic neck patients. The main conclusion drawn from the current study is that the use of the Alpha Neck device with heat application reduces pain, disability related to pain, pressure pain threshold, muscle fatigue, and perceived stress. Though, a short-term intervention was not sufficient for a positive change in muscle tone, stiffness, and muscle elasticity. In addition, the application of the Alpha Neck without heat does not have a positive effect on pressure pain threshold, muscle proprieties, muscle fatigue, and even perceived stress. Furthermore, it can be considered as a good neck lordosis curve supporter which can also have an effect on pain relief and related neck disability. The use of Alpha Neck with heat application can be suggested as a home self-management for chronic neck pain.

Conflicts of Interest

The authors declare that there is no conflict of interest regarding the publication of this paper.

Institutional Review Board Statement

The study was conducted in accordance with the Declaration of Helsinki and approved by the Institutional Review Board of Sunmoon University (SM-202104-029-2)

Informed Consent Statement

Informed consent was obtained from all subjects involved in the study. Written informed consent has been obtained from the patient(s) to publish this paper.

Data Availability Statement

The data used to support the findings of this study are available from the corresponding author upon request.

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