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Research Article

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Musculoskeletal Ultrasound to Identify Changes in Obliquus Capitis Inferior Muscle & Position of Atlas After a Manual Stretch

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Abstract

Introduction: *Cervicogenic headache (CGH) is a prevalent condition caused by a disorder of the cervical spine that is commonly accompanied by neck pain and headaches. There is limited research regarding interventions benefiting CGH long-term. Interventions geared toward the suboccipital musculature may be used to improve CGH symptoms due to their anatomical connection to the cervical spine.*

Purpose: *To determine if an isolated manual stretch of the obliquus capitis inferior will create a change in muscle diameter and length and position of atlas relative to axis.*

Methods: *This quasi-experimental study used a single group of 36 subjects. Pre- and post-test measurements of the muscle diameter and length of the obliquus capitis inferior and the distance between atlas and axis were obtained using musculoskeletal ultrasound before and after our manual stretching intervention.*

Results: *The results showed a significant increase in both measures, indicating increased length of the right Obliquus Capitis Inferior and the distance between the transverse process of C1 and spinous process of C2 after the manual stretch was applied. The average width of the right Obliquus Capitis Inferior was found to be 1.01 cm prior to applying the manual stretch and 1.99 cm after applying the manual stretch, demonstrating an increase in the width of the R OCI pre- and post-stretch.*

Conclusion: *The results of this study indicate that the application of a manual static stretch held for 2x30 seconds will produce and immediate and significant increases in muscle length and width of the right Obliquus Capitis Inferior. Further research should be conducted to establish validated stretching parameters targeting the suboccipital muscles and further examine the effects of these muscles on CGH symptoms.*

Keywords: Musculoskeletal Ultrasound, Stretching, Upper Cervical Spine, Atlas Position

Introduction

Cervicogenic headache (CGH) is defined as a headache caused by a disorder of the cervical spine that is commonly accompanied by neck pain [1]. It is estimated that up to 20% of those who experience headache also experience CGH symptoms [3]. There is a lack of consensus on the exact etiology of CGH; however, proposed underlying contributors have been identified as postural abnormalities, alterations in the cervical spine, and soft tissue connections [2,3]. The suboccipital muscles, including the obliquus capitis inferior, have also been implicated as a possible cause of CGH manifestation due to their anatomical connection to the cervical spine [2,3].

There are various interventions currently in use to treat CGH, but the evidence is lacking for their success in minimizing symptoms long term [4]. Research has indicated that alterations of the muscle tone and tightness of the suboccipital muscles may be involved in producing CGH symptoms [2,3,19]. Stretching as a form of conservative treatment has been shown to be effective in reducing headache frequency and intensity as well as improving cervical posture, tone, and stiffness [5,6]. There is sufficient evidence to support an increase in flexibility and elongation of muscle with static stretches held for 10 to 30 seconds for two to four repetitions [7]. Stretching has also been shown to be effective in temporarily decreasing muscle stiffness due to the increase in cytoplasmic calcium that occurs during muscle lengthening and the subsequent opening of the stretch-activated calcium channels [21].

Musculoskeletal ultrasound (MSK US) imaging is becoming more widely used amongst clinicians and researchers due to its low-cost and portability [8,9]. This imaging modality provides real-time images of the positions of bony landmarks and various tissues in their contracted or relaxed states and can be used to calculate changes in muscle diameter and length [8,9]. Research has shown that MSK US is an accurate and reliable method of imaging with moderate to good sensitivity and specificity, comparable to the gold standard MRI, that requires relatively minimal training to perform accurately [10,11].

Based on what is known about stretching and the anatomical connection to CGH, the purpose of our research is to determine if a manual stretch of the obliquus capitis inferior will create short-term changes in the muscle diameter and length and alter the position of atlas demonstrated with MSK US imaging.

Methods

Study Design

This quasi-experimental study was performed using a single group of 36 subjects between the ages of 18 to 65 years old. They underwent measurements before and after manual stretching intervention of the right OCI muscle for changes in muscle diameter and length and position of atlas relative to axis. A pre-test measurement of the muscle diameter and length of the obliquus capitis inferior using MSK US was obtained along with the distance between the spinous process of axis and the transverse process of atlas, followed by our manual stretching intervention and a post-test measurement was completed using the same measurement protocol.

Subjects

A power analysis was conducted using G*power with a power of 0.8, effect size of 0.5, and alpha of .05 which yielded 34 participants as our target population size. Our subjects consisted of a convenience sample of available students and staff of Marieb College of Health and Human Services at Florida Gulf Coast University (FGCU). After obtaining approval from the FGCU Institutional Review Board (IRB), subjects were recruited during the summer and spring of 2023 with flyers and emails. Any college student or staff member at Florida Gulf Coast University who was 18 to 65 years old was allowed to participate. Subjects were excluded from our research if they were non-English readers, had a history of cervical spine surgery, or if they had any contraindications to manual stretching, including hypermobility or open wounds in the area being stretched.

The IRB at FGCU granted approval for this research in March of 2023, with a protocol ID # 2023-31, to ensure the study would not compromise the rights, privacy, and welfare of our subjects. Subjects were required to read and sign an informed consent form that outlined the purpose of the study, methods of data collection, and the potential risk and benefits of participation in the study. Participants were assigned a subject number to be used during data collection to protect their identity.

Procedure

Each subject received an intake form that included demographic information including age and gender. Subjects were seated in a chair and assumed a forward bent position with their head supported on a table (see Figure 1). The first examiner located the subjects' obliquus capitis inferior by palpating the muscle's bony landmarks on the posterior neck, the transverse process of atlas and the spinous process of axis, and applied US gel to the area (see Figure 1). A GE LOGIQ ultrasound with a curved probe was utilized to obtain a baseline measurement of the muscle diameter and length and the distance between the spinous process of axis and the transverse process of atlas. Since the transverse process of atlas is difficult to locate through palpation, the doppler function was used to visualize the vertebral artery, which provided a consistent landmark to use in locating the transverse process of atlas (see Figure 1).

The second examiner performed the manual stretch on the subject by holding the C2 spinous process in right rotation and providing a rotational stretch to the neck by turning the head to the left until movement was felt in the spinous process of C2 while maintaining a neutral spine, indicating end range motion of the targeted right obliquus capitis inferior (see Figure 2). The stretch was held for 30 seconds for two repetitions, with a 30 second pause between stretches, based on the current research [7]. Immediately after the intervention, the first examiner then repeated the initial measurements of muscle diameter and length and distance between atlas and axis

Figure 1: Image on the top left-subject positioning for ultrasound measurement. Image on the bottom left-screenshot of R OCI measurements with Doppler function. Image on the left - examiner 1 performing ultrasound measurement of R OCI.

Figure 2: Examiner 2 performing manual stretch to R OCI. Image on the left - posterior view. Image on the right - anterior view.

Data Analysis

Data was analyzed using IBM SPSS version 28, using descriptive and comparative statistics. Descriptive statistics were utilized for the demographic data of our subjects to find the mean, standard deviation, and minimum and maximum values. The dependent variables, muscle diameter and length of the obliquus capitis inferior and the distance between the spinous process of axis and the transverse process of atlas, were measured in centimeters. The Shapiro-Wilk test was utilized to evaluate for normal distribution of the results, as shown in Table 2. Level of significance was set to □ <.05 to determine the difference between measures. The measures of length and distance had significance values of P<.05, demonstrating that the data was normally distributed, while the conditions of width were not normally distributed with significance values of P>.05. Parametric data was analyzed using a paired t-test and non-parametric data was analyzed using the Friedman's test.

Results

The general demographics of the subjects can be found in Table 1. Of the 36 participants, 20 (55.56%) were female and 16 (44.44%) were male. The mean age among subjects was 26.28 years (SD 5.558). The results of the paired t-test for pre- and post-length and pre- and post-distance of the right OCI are shown in Tables 3 and 4. There was a significant increase (P<.001) in length of the R OCI after performing the manual stretch compared to the length of the R OCI at baseline. There was also a significant increase

(P<.001) in the distance between the transverse process of C1 and the spinous process of C2 on the right side after the manual stretch was performed. Additionally, a statistically significant increase (P<.001) in the width of the R OCI was found in the post-manual stretch measures when compared to the pre-manual stretch measures as demonstrated in Table 5. The average width measures of the R OCI was found to be 1.01 prior to the manual stretch while the average width of the R OCI was 1.99 after administration of the manual stretch.

	N	Range	Minimum	Maximum	Mean	Std. Deviation
Gender*	36	1	1	2	1.56	.504
Age (years)	36	23	22	45	26.28	5.558

* Gender was analyzed using Male as 1 and Female as 2.

Table 1: General demographics of the subject's gender and age.

	Shapiro-Wilk		
	Statistic	df	Sig.
Pre-Length (cm)	.952	36	.125
Post-Length (cm)	.941	36	.054
Pre-Width (cm)	.884	36	.001
Post-Width (cm)	.834	36	<.001
Pre-Distance (cm)	.956	36	.158
Post-Distance (cm)	.945	36	.074
*. This is a lower bound of the true significance.			

Table 2: Shapiro-Wilk test for normality of the R OCI pre- and post- manual stretch.

One-Sample Test (OCI Length)							
	Test Value=0						
	t	df	Significance		Mean Difference	95% Confidence Interval of the Difference	
			One-Sided p	Two-Sided p		Lower	Upper
Pre-Length (cm)	49.910	35	<.001	<.001	5.76139	5.5270	5.9957
Post-Length (cm)	47.164	35	<.001	<.001	5.89583	5.6421	6.1496

Table 3: Results of paired t-test for length of R OCI.

One-Sample Test (Distance between C1 and C2)							
	Test Value=0						
	t	df	Significance		Mean Difference	95% Confidence Interval of the Difference	
			One-Sided p	Two-Sided p		Lower	Upper
Pre-Distance (cm)	44.499	35	<.001	<.001	6.02694	5.7520	6.3019
Post-Distance (cm)	43.367	35	<.001	<.001	6.13583	5.8486	6.4231

Table 4: Results of paired t-test for distance between C1 and C2.

Friedman Test	
N	36
Chi-Square	35.000
df	1
Asymp. Sig.	<.001

Table 5: Friedman Test for width of R OCI.

	Mean
Pre-Width (cm)	1.01
Post-Width (cm)	1.99

Table 6: Mean pre- and post-width measures of R OCI.

Discussion

The aim of this study was to investigate the effects of a manual stretch applied to the obliquus capitis inferior muscle on its length and diameter, as well as the distance between the spinous process of C2 and the transverse process of C1. The manual stretch was provided to the subjects' right OCI muscle and held for 30 seconds for two repetitions. Our results indicated that the intervention was effective in producing a significant change in muscle length and diameter and position of atlas relative to axis. This manual stretch produced significant increases in muscle length–thereby also increasing the distance between the muscle's attachment points–and muscle width. While there is literature to support the use of stretching exercises targeting neck, shoulder, and upper limb musculature to improve headache symptoms [5], this study aimed to isolate and stretch the obliquus capitis inferior muscle, which has been implicated in CGH etiology due to its anatomical connection to the cervical spine [2,3]. At the time of this study, minimal research had been performed to examine the acute effects of a static stretch on muscle properties including length and width.

Our findings on muscle length correlate with Page [7], who demonstrated that stretching increases the length of the musculotendinous unit which therefore increases the distance between muscle attachment points. McNair et al. [26] investigated the effects of static hold contractions and continuous passive motion on muscle stiffness and force relaxation of the ankle plantar flexors. One of their conditions was holding end-range dorsiflexion for 2 x 30 seconds with a 10 second rest in between repetitions [26]. This study demonstrated that static hold under this condition did not significantly affect muscle stiffness [26]. This is in contrast to our study, in which we utilized the 2x30 second parameters and did find a significant increase in muscle length, however, we allotted 30 seconds of rest between repetitions. It can be theorized that longer rest intervals may improve the muscles response to a static stretch.

Additionally, Bouvier et al. [27] aimed to investigate the acute effects of static stretching with parameters of 5x30 second holds on fascicle length and musculotendinous junction elongation in the rectus femoris and triceps surae muscles utilizing ultrasonography. Increases in fascicle length for both muscles and elongation of the musculotendinous junction in the rectus femoris muscle were observed [27]. While parameters varied from our study to that of Bouvier et al. [27], the acute increase in fascicle length lends support to our observation of acutely increased muscle length following a static stretch of the targeted muscle.

This study also showed a statistically significant increase in muscle width following a static manual stretch to the targeted muscle. Evidence suggests that stretching provides mechanical and metabolic stimuli to muscle and produces cellular biomarkers that are important for muscle growth, thereby potentially increasing muscle width overall [28]. Furthermore, acute stretching may trigger mechanisms that relate to muscle hypertrophy, such as insulin-like and myogenic growth factors, stretch-activated channels, and protein synthesis [28]. Based on these findings, it can be assumed that the same principles might explain the finding of increased muscle width in this study.

Simpson et al. [29] conducted a study to measure the effects of stretch training on the fascicle length, pennation angles, and muscle thickness of the lateral and medial gastrocnemius muscles using ultrasonography. Muscle thickness was measured as the perpendicular distance of the widest part of the muscle between the parallel upper and lower borders for both muscles, which was the same principle utilized to measure muscle thickness of the OCI in the present study [29]. After 6 weeks of static, passive stretching of the gastrocnemius, muscle thickness showed a statistically significant increase, suggesting that increased muscle thickness coupled with increased fascicle length may be indicative of hypertrophic adaptation, as fascicle length is correlated to muscle size [29]. Based on these results, along with our findings of increased muscle width in the R OCI, it can be hypothesized that passive stretching induces short term muscle hypertrophy, therefore increasing muscle width.

MSK US has been shown to be a successful tool in evaluating anatomical structures, including those of the cervical spine [8]. Ashir et al. [30] explained that ultrasound B-mode images can help with estimation of muscle thickness and length, which was the aim of our current study. The use of MSK US allowed for real-time comparison of muscle composition of the R OCI prior to our manual static stretch and immediately after. The accuracy and reliability of this imaging method has been proven to be adequate in prior research, especially when proper training had been performed, which proves that this method was appropriate for the current study [10,11].

Limitations

It should be noted that this study presents with several limitations that may have impacted our results. Participants of this study ranged in age from 23 years old to 45 years old, with a mean age of 26.28 years, therefore the response to our manual stretch is unknown for populations outside of this age range. Additionally, the MSK ultrasound experience of the examiner who performed OCI muscle measurements was somewhat limited. Although the examiner practiced using the MSK ultrasound machine for a minimum of 10 hours as recommended by Mouratev et al. [11], practice was only performed on the same individual, which made navigating variabilities in subject anatomy difficult and may have impacted the accuracy of measurements of the OCI muscle.

Furthermore, there may have been differences in the intensity of force applied during the manual stretch, impacting the post-stretch measurements in muscle length and diameter due to a lack of an established stretching protocol for the OCI muscle. Finally, the ability of each subject to maintain a neutral spine during ultrasound measurements may have been affected due to the use of a non-adjustable chair and fixed table height. This may have resulted in varying spinal positions, such as cervical spine flexion or extension, while US measurements were taken, altering the visualization and subsequent measurements of the OCI.

Conclusion

The objective of this study was to determine if a manual static stretch isolating the OCI muscle would produce short-term changes in muscle length, diameter, and the distance between the spinous process of C2 and the transverse process of C1 as visualized and measured using MSK US imaging. Our data demonstrates significant increases in muscle length, subsequently increasing the distance between the muscle's attachment points, and muscle diameter following the manual static stretch held for 2x30". While there are previously identified clinical correlations of the OCI muscle with CGH symptoms, this study is novel in its attempt to isolate the OCI muscle and implement a manual static stretch. This study will allow other researchers to continue to investigate the effects of the OCI muscle, in addition to the other suboccipital musculature, on CGH symptoms. In addition, it identifies a need to establish and validate stretching protocols that target the suboccipital muscles to decrease symptoms associated with CGH.

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