ANALYSIS OF NECK MUSCLES RECRUITMENT USING ULTRASONOGRAPHY: A PRELIMINARY INVESTIGATION

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The purpose of this study was to investigate the recruitment pattern of the neck muscles during the Craniocervical Flexion Test (CCFT) using ultrasound measurement. Ten subjects performed the CCFT and ultrasound changes in thickness from resting values during the test were obtained for deep cervical flexors (DCF) and sternocleidomastoid (SCM) muscles. The most significant changes found in DCF thickness were between phases 1 and phases 4 ($p<0.001$), and 5 ($p= <0.001$). For SCM, differences were most significant between phases 1 and 3 ($p<0.001$), 4 ($p<0.001$), and 5 ($p<0.001$); and between phase 2, 4 ($p<0.001$) and 5 ($p<0.001$).The present study confirms the evidence that the CCFT challenges the cervical spine and that DCF activity is increased during this maneuver demonstrating its role in controlling and stabilizing the neck.

KEY WORDS: ultrasonography, neck flexors, craniocervical flexion test.

INTRODUCTION:

Contact sports such as soccer and football are popular around the world and the incidence of head and neck injuries in these type of modalities are high (Menhert *et al.*, 2005). Junge *et al.* (2006) investigated the incidence of injuries in different team sports during the 2004 Olympic Games and found that 24 % of 377 injuries reported involved the head or the neck, being over 50 % in sports like water polo. Mechanical trauma can affect cervical structures resulting in a painful, chronic and disabling condition that challenges management (Sterling *et al*, 2003). Due to the great prevalence of neck pain from traumatic origin, knowledge of its prognostic factors and effective management are important to reduce pain, disability, and the associated health care costs (Borghouts *et al.*, 1999). Mechanical stability of the cervical spine, provided primarily by the surrounding muscles (Panjabi *et al.*, 1998), is necessary so athletes can perform sports maneuvers that involve the head-neck complex (Bauer *et al.*, 2001). Altered patterns of neck flexors synergy are known to be present in individuals with neck pain developed after a trauma (Sterling *et al.*, 2003). Less activity of the deep cervical flexors (DFC) muscles is seen in subjects suffering from cervical pain in comparison to asymptomatic ones (Falla, Jull & Hodges, 2004). Ultrasonography is a well established method to evaluate muscle architectural variables associated with activity such as changes in muscle thickness, fiber pennation and muscle fascicle length (McMeeken *et al*, 2004). It is a valuable and alternative instrument for the assessment of muscle recruitment, since it is a non invasive technique, with no occurrence of cross-talk of adjacent muscles and with acceptable reliability for the assessment of deep muscles recruitment (Hodges *et al*, 2003). Although it is traditionally being used to visualize lumbar spine muscles, it has been used for neck muscles visualization (Kristjansson, 2004). However, no study has investigated the pattern of recruitment of the DFC muscle using ultrasonography. Therefore, the aim of this study was to investigate the recruitment pattern of the neck muscles, particularly DFC, using ultrasound measurement of muscle activity in asymptomatic subjects.

METHOD:

Data Collection: 10 subjects (4 female, 6 male), mean age 26 (SD=6, 7) years, with no history of cervical pain volunteered for this experiment. Subjects were included in the study if they were free from neck or upper limb complaints and had no history of musculoskeletal or neurological conditions affecting the neck. All subjects consented to participate in this study. Ultrasound (US) recordings of DCF and sternocleidomastoideous (SCM) were made unilaterally, on the right side, using the Siemens Sonoline SL-1 Ultra Sound. The positioning of the instrument was developed for this experiment, since no previous study investigating ultrasound activity of cervical flexors could be identified. A 7.5 MHz transducer was positioned longitudinally in the anterior neck, in parallel with trachea's orientation and approximately 5 cm from its midline. In this position, the ultrasound allowed proper visualization of these muscles, right carotid artery and the vertebral lamina (figure 1).

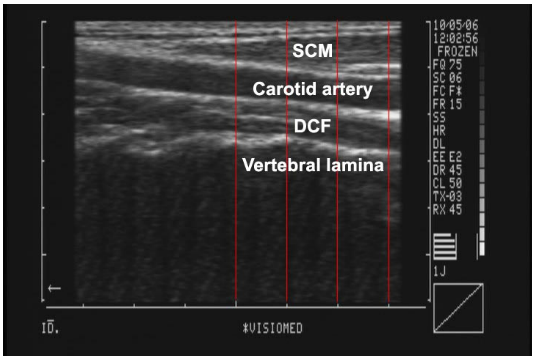

Figure 1: US image: Location of measurements for DCF and SCM are indicated by red lines

Subjects were positioned in supine lying with the knees bent and their arms crossed in their chests. The head and the neck were placed in a standardized way so the subject's forehead and chin were horizontal and in a midposition. The Pressure Biofeedback Unit- PBU, (Chattanooga Group, Hixon,TN) was placed suboccipitally and inflated to a 20 mm Hg baseline pressure. This unit is a sensitive apparatus to record increases in pressure with cervical nodding and is a reliable tool to discriminate chronic neck pain individuals from asymptomatic ones, using the Craniocervical Flexion Test (CCFT), described by Jull *et al.* (1999). Feedback of pressure level was provided *via* a manometer visible to the subject.
During the CCFT, subjects were instructed to perform a nodding movement, representing the craniocervical flexion, in five incremental levels, from 22 to 30 mm Hg. In each stage, subjects performed the action and hold the target pressure for 10 seconds, with a 2 minutes rest between trials. Ultrasound images were recorded at baseline phase and at the end of each successive stage. To guarantee the accuracy of the performance during the test, the examiner taught the movement passively to each subject. Neck retraction or a visual increase in superficial muscles tenderness was verbally discouraged.
Data Analysis: Two repetitions of the CCFT were performed and the test that had the best images recorded was considered for data analysis. US data were measured with "Distance Software". A grid was placed over each image and measures of muscle thickness of DCF and SCM were made at sites 1, 2 and 3 cm to the right of the midline. Cursors were placed on the superficial and deep boundaries of SCM and the outlines of the DCF were identified superiorly by carotid boundaries and inferiorly by the echogenic vertebral lamina. The average of the 3 measurements to all images for each muscle was calculated. Changes in thickness during the CCFT were expressed as a proportion of muscle thickness at rest. Means and 95% confidence intervals of measures were considered for descriptive analysis. Statistical analysis of US data was performed using an analysis of variance (ANOVA) with between factors being muscles and within factors being the test phases. Duncan's Post hoc testing was also performed when main factors were obtained. Significance was accepted at the 5% level ($p \leq 0.05$).

RESULTS:

Descriptive analysis revealed an increase in DCF and SCM recruitment with each progressive phase of the test (figure 2). No significant differences were found between DCF and SCM changes in thickness. The ANOVA analysis only showed a significant effect between CCFT phases ($p<0.001$), as seen on table 1. For DCF, Post Hoc analysis indicated that the comparisons that were significantly different were between phases 1 and phases 3 (p=0.003) 4 (p<0.001) and 5 (p= <0.001), and also between phases 2 and 4 (p= 0.035) and 5 (p= 0.003). For SCM, the comparisons that were significantly different were between phase 1 and phases 3 (p<0.001), 4 (p<0.001) and 5 (p<0.001), between phases 2 and 3 (p=0.03); phase 4 (p<0.001) and 5 (p<0.001) and finally, between phases 3 and 5 (p= 0.003).

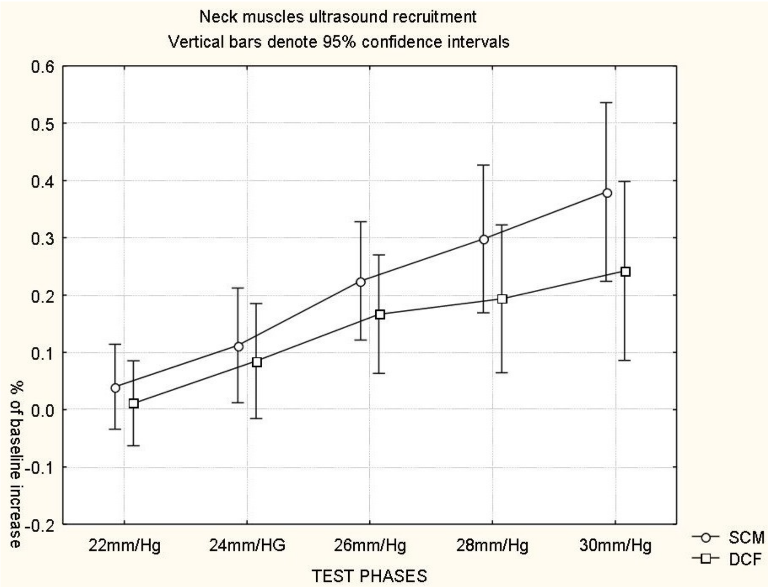

Figure 2: Mean and 95% confidence interval change in thickness in DCF and SCM at CCFT Phases.

Table 1 Main effects off ANOVA between DCF and SCM and CCFT phases

	Degrees of Freedom	F	P
Muscles	1	1,16726	0,294229
Test Phases	4	24,07052	0,000000*
Test Phases X Muscles	4	1,08834	0,368825

* p< 0.05

DISCUSSION:

Changes in thickness seen in ultrasound imaging are associated with changes in muscle recruitment (Hodges *et al.*, 2003) and therefore, US was used in this study to investigate whether changes in pressure during the CCFT were associated with changes in DCF and SCM thickness. A progressive increase in the recruitment of DCF at different levels of pressure achievement was observed; however, it was not significant among all of the target pressures. We hypothesize that since the DCF consist of a thinner muscle belly, compared to SCM and to other muscles around the spine, changes in thickness are more subtle and, therefore, more difficult to detect between each of the cranio-cervical movement phases. Since no previous data related to US measurement of these muscles was found in literature, we were not able to provide any comparison between our findings and other US data. Still, the present findings reinforce the evidence that the CCFT recruits deep and superficial neck flexors (Falla *et al.*, 2003). Even though no differences between SCM and DCF recruitment were found, there was a tendency towards a greater increase in muscle thickness for SCM than for DCF on the last 3 phases of the test. A potential limitation of the method used in this experiment is that since SCM has a greater muscle belly than DCF, its increasingly contraction potentially produces compression of carotid artery and deep muscles belly and it could reduce the ability of the ultrasound to identify increases in DCF thickness.

It is known that CCFT can discriminate chronic cervical pain individuals from asymptomatic ones (Jull, 2000). Individuals who suffer from neck pain have impaired performance of the test, with less amplitude of DFC electromyography activity and significantly higher EMG amplitude of superficial muscles compared with controls (Falla, Jull & Hodges, 2004). It

seems that there is a specific effect of neck trauma on muscle function (Jull, 2000) and that pain can cause alterations and significant deficits in fine motor control of the spine (Falla *et al*., 2007). Because of that, our hypothesis is that ultrasound measurements during the CCFT would be sensitive to detect DCF dysfunction in athletes who had suffered neck injuries in sports, developing chronic pain in the segment and that these subjects would have smaller increases in DFC thickness along the test, compared to asymptomatic subjects.
Further research will be performed to verify this protocol reliability and, more important, if it is able to discriminate subjects with and without history of neck injury. These studies are currently being developed by our group.

CONCLUSION:

The present study reinforces the evidence that the Craniocervical Flexion Test changes DCF recruitment; however ultrasonography did not show significant changes in recruitment of these muscles between each phase of the test. The protocol developed in this study appears to have potential clinical application in sports rehabilitation, both in assessment and rehabilitation of neck related dysfunctions, which are so common in athletes of several modalities. Further research is required to investigate its reliability and discriminatory validity.

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Acknowledgement:

Authors would like thank Dr. David James Magee for his support.