Journal of Bodywork & Movement Therapies xxx (2016) 1–4

Contents lists available at ScienceDirect

Journal of Bodywork & Movement Therapies

journal homepage: www.elsevier.com/jbmt

Correlation between cervical flexor muscle thickness and craniocervical flexion torque in healthy subjects

Hiroshi Ishida[*], Tadanobu Suehiro, Susumu Watanabe

Department of Rehabilitation, Faculty of Health Science and Technology, Kawasaki University of Medical Welfare, 288, Matsushima, Kurashiki City, 701-0193, Japan

ARTICLE INFO

Article history:
Received 20 March 2016
Received in revised form
12 October 2016
Accepted 16 October 2016

ABSTRACT

The purpose of this study was to clarify the relationship between the size of the cervical flexor muscles and craniocervical (CC) flexion torque.

Thirty-eight healthy men participated in this study. Thickness of the deep cervical flexor (DCF) and sternocleidomastoid (SM) muscles were measured using ultrasonography. Maximal isometric CC flexion torque was measured using dynamometry. The DCF and SM muscle thickness and CC flexion torque were normalized relative to body weight. Correlations between normalized muscle thickness and normalized CC flexion torque were determined.

A significant positive correlation was observed between normalized DCF muscle thickness and normalized CC flexion torque ($r = 0.361$, $P = 0.028$), whereas there was no significant correlation between normalized SM muscle thickness and normalized CC flexion torque ($r = 0.233$, $P = 0.166$).

DCF muscle thickness appears to have potential clinical application in the performance of CC flexion.

1. Introduction

Cervical muscles play an important role in maintaining mechanical stability (Panjabi et al., 1998). Although all cervical muscles contribute toward supporting the cervical spine, the deep cervical flexor (DCF) muscles (longus capitis and longus colli) have particularly demonstrated changes in motor control (changes in the timing and activity levels) in people with neck pain disorders (Jull et al., 2009; Falla et al., 2012). In addition, the DCF muscle has been shown to be smaller in size in subjects with chronic neck pain compared to that in healthy controls (Javanshir et al., 2011b).

Recently, researchers quantified DCF muscle size using ultrasonography (US) (Cagnie et al., 2009; Javanshir et al., 2010, 2011a, 2011b; Ishida et al., 2015a, b, Ishida et al., 2016a), an inexpensive assessment tool for monitoring the DCF in a clinical setting compared to magnetic resonance imaging and a computed tomographic scan (Javanshir et al., 2010). Muscle size may serve as an indirect measurement of force-generating capacity, as demonstrated in the case of cervical extensor muscles (Mayoux-Benhamou et al., 1989). However, no study has investigated the relationship between an objective size measurement and force-generating function of the DCF muscles, which depends on subjective voluntary effort.

The longus capitis arises from the anterior tubercles of the transverse processes of the mid-to-lower cervical vertebrae and inserts into the basilar part of the occipital bone (Neumann, 2010). The longus colli consists of multiple fascicles that closely adhere to the anterior surfaces of the upper 3 thoracic and all cervical vertebrae (Neumann, 2010). Clinically, the longus capitis and longus colli are investigated as one entity, as in the craniocervical (CC) flexion test (Jull, 1997; O'Leary et al., 2007), despite the differences in their anatomical actions (the primary anatomical action of the longus capitis is flexion of the CC junction, whereas that of the longus colli is flexion of the cervical region) (Neumann, 2010). It is difficult to assess the strength of the longus capitis and the longus colli muscles separately, because flexion of the cervical region is necessary for flexion of the CC junction. In this study, the sternocleidomastoid (SM) muscle size was measured as a control, because contracting bilaterally with the cervical spine in the neutral position, it serves as a flexor of the lower cervical spine and an extensor of the upper cervical spine (Neumann, 2010). The purpose of this study was to clarify the correlation between the size of the DCF and SM muscles and

---

[*] Corresponding author.
E-mail address: ishida@mw.kawasaki-m.ac.jp (H. Ishida).

http://dx.doi.org/10.1016/j.jbmt.2016.10.004

Please cite this article in press as: Ishida, H., et al., Correlation between cervical flexor muscle thickness and craniocervical flexion torque in healthy subjects, Journal of Bodywork & Movement Therapies (2016), http://dx.doi.org/10.1016/j.jbmt.2016.10.004

CC flexion strength.

2. Methods

2.1. Participants

The subjects were recruited from physical therapy students at the Kawasaki University of Medical Welfare via advertisements. Those who experienced neck pain in the previous year, those with a history of neurological or orthopedic disorders involving the neck, and those who had undergone specific neck muscle training in the previous year were excluded. Thirty-eight male volunteers participated, and all participants were included in this study. Their age, height, and weight (mean ± standard deviation) were 20.9 ± 0.9 years, 170.5 ± 4.9 cm, and 61.1 ± 7.3 kg, respectively. The protocol for this study was approved by the Ethics Committee of the Kawasaki University of Medical Welfare. The subjects provided written informed consent prior to study participation.

2.2. US measurements

One investigator was responsible for collecting US. The experimenter had 5 years of experience in musculoskeletal ultrasound. Unilateral (right-sided) US was performed using the Aloka SSD-3500SX (Aloka Co. Ltd., Tokyo, Japan) with a 10-MHz linear array transducer. B-mode US of the DCF muscles was performed at rest using a protocol developed by Ishida et al. (2015a). The subjects were positioned in supine with the head and neck in mid-position, which was defined as the forehead and chin aligned parallel to a horizontal line. The center of the middle phalanx of the subject's index finger was placed at the laryngeal prominence, with the index and middle fingers of the left hand held together. The measurement level was defined as 1.5-finger breadths (subject's) below the laryngeal prominence of the thyroid cartilage. The diagonal dimension of the DCF muscles was measured as the length between the anterolateral (muscular fasciae) and posteromedial (vertebral body) boundaries of the extension line from the carotid artery to the nearest muscular fasciae of the DCF muscles (Fig. 1). US was performed on the SM at the same level as that of the DCF muscles. A recent study indicated that the inward pressure of the transducer during US decreased the thickness of the superficial muscles (Ishida and Watanabe, 2012, 2014; Ishida et al., 2016b). The transducer was held using the minimum pressure required to obtain a clear image. The anterior-posterior dimension of the SM was measured as the length between the anterior and posterior muscular fasciae. During the US recordings, each subject was positioned in supine with both arms alongside the body, and 2 images were obtained in the relaxed state. Mean values of the 2 images were used for analysis.

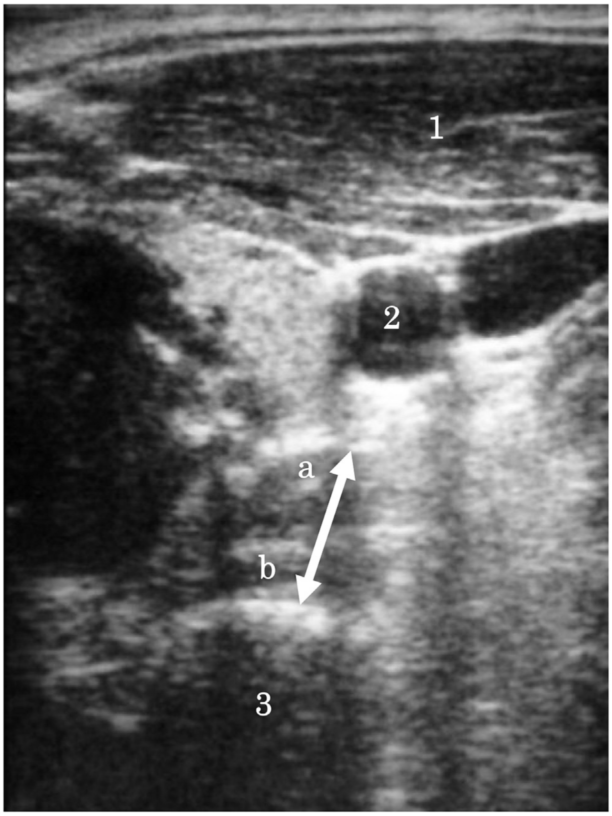

Fig. 1. Standard image used for measurement of the deep cervical flexor muscles. 1: Sternocleidomastoid muscle 2: Carotid artery 3: Vertebral body a⇔b: Diagonal dimension of the deep cervical flexor muscles.

2.3. Dynamometry measurements

A second investigator was responsible for collecting the CC flexion torque. The CC flexion torque was measured using a dynamometry (NS-1410; Nissin Kikai Co., Ltd., Okayama, Japan). The primary feature of this device is an axis and lever arm system that measures the torque of the CC flexor muscle group at the cranium-C1 axis of rotation (Fig. 2). The cranium-C1 axis of rotation during motion in the sagittal plane is at the mastoid process, varying from the anterior mastoid process to an area slightly dorsal and cranial to the mastoid process (Harms-Ringdahl et al., 1986; van Mameren et al., 1992). The concha of the ear, a depression immediately posterior to the bony external acoustic meatus, was chosen as the landmark to which the dynamometry axis was aligned (O'Leary et al., 2005). The dynamometry has an adjustable axis, which permits alignment to the subject's cranium-C1 axis of rotation landmark. The resistance arm of the dynamometry consists of 2 metal arms at a right angle. One is the lever arm that extends from the axis to a length such that the lever arm sits 1-finger breadth (subject's) dorsal to the inferior border of the subject's mandible. This resultant lever arm length is adjustable to accommodate different-sized individuals. In addition, the dynamometry axis was adjustable so that it could be freely rotated to the appropriate point in the CC flexion angle and then locked at the load cell deflection arm, allowing the torque to be measured with the head and neck in mid-position, which was defined as the subject's forehead and chin being aligned parallel to a horizontal line. CC flexion exerted by the subject was resisted at the mandible by the lever arm of the dynamometry. The force exerted by the mandible on the lever arm was transferred, producing a torque at the dynamometry axis, which was locked at the load cell deflection arm of the dynamometry. This torque deflected a load cell (LMB-A-200N, Kyowa Electronic Instruments Co., Ltd., Tokyo, Japan), causing a change in voltage. The voltage change was amplified using a sensor interface (PCD400A, Kyowa Electronic Instruments Co., Ltd., Tokyo, Japan) and transmitted to a personal computer equipped with a dynamic control software (DCS100A, Kyowa Electronic Instruments Co., Ltd., Tokyo, Japan) calibrated to convert the amplified voltage to the corresponding force measurement (in newton). The data were recorded at 1 kHz. A visual display was set up in the subject's view. When the subject exerted CC flexion effort against the dynamometry lever arm, a numerical value of the visual feedback was displayed on the screen, increasing or decreasing in accordance with force production. All subjects were provided with standard instructions and were familiarized with the testing procedure immediately before the trial. The subjects were instructed to nod

Please cite this article in press as: Ishida, H., et al., Correlation between cervical flexor muscle thickness and craniocervical flexion torque in healthy subjects, Journal of Bodywork & Movement Therapies (2016), http://dx.doi.org/10.1016/j.jbmt.2016.10.004