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Can neck exercises enhance the activation of the semispinalis cervicis relative to the splenius capitis at specific spinal levels?

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ABSTRACT

The deep cervical extensor, semispinalis cervicis, displays changes in behaviour and structure in people with chronic neck pain yet there is limited knowledge on how activation of this muscle can be emphasized during training. Using intramuscular electromyography (EMG), this study investigated the activity of the deep semispinalis cervicis and the superficial splenius capitis muscle at two spinal levels (C2 and C5) in ten healthy volunteers during a series of neck exercises: 1. Traction and compression, 2. Resistance applied in either flexion or extension at the occiput, at the level of the vertebral arch of C1 and of C4, and 3. Maintaining the neck in neutral while inclined on the elbows, with and without resistance at C4. The ratio between semispinalis cervicis and the splenius capitis EMG amplitude was quantified as an indication of whether the exercise could emphasize the activation of the semispinalis cervicis muscle relative to the splenius capitis. Manual resistance applied in extension over the vertebral arch emphasized the activation of the semispinalis cervicis relative to the splenius capitis at the spinal level directly caudal to the site of resistance (ratio: 2.0 ± 1.1 measured at C5 with resistance at C4 and 2.1 ± 1.2 measured at C2 with resistance at C1). This study confirmed the possibility of emphasizing the activation of the semispinalis cervicis relative to the splenius capitis which may be relevant for targeted exercise interventions for this deep extensor muscle. Further studies are required to investigate the clinical efficacy of these exercises for people with neck pain.

1. Introduction

Exercise is an effective treatment for people with chronic neck pain (Miller et al., 2010). Several neck exercises have been shown to alleviate pain including motor control training (Jull et al., 2002; Falla et al., 2013) and resistance training (Bronfort et al., 2001; Ylinen et al., 2003) probably by facilitating endogenous analgesia via different mechanisms (Bialosky et al., 2009). Furthermore, exercise may have positive psychological effects including reduced pain castastrophizing (Slepian et al., 2014). Therefore various training approaches are appropriate for pain management.

In contrast to the similar effects on clinical symptoms, neuromuscular changes in response to training are typically specific to the mode of exercise performed. For instance, craniocervical flexion exercise, designed to emphasise the activation of the deep cervical flexors and minimise activation of the superficial flexors (Jull et al., 2008; Falla et al., 2012) enhances the activation of the deep cervical flexors (Jull et al., 2009) which are often less activated in patients with neck pain (Falla et al., 2004). Moreover, this exercise reduces the activation of the sternocleidomastoid muscle (Jull et al., 2009) which is often overactive in association with reduced deep cervical flexor activity (Falla et al., 2004; O'Leary et al., 2011b). Enhanced activation of the deep cervical flexor muscles was not achieved with general resistance training of the neck (Falla et al., 2007a; Jull et al., 2009), despite comparable changes in pain.

The deep cervical extensor muscle, semispinalis cervicis, may also display reduced activation in people with neck pain (Schomacher et al., 2012b, 2013; Schomacher and Falla, 2013).

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Moreover, studies have shown higher levels of superficial extensor muscle activation in people with neck pain including that of the splenius capitis (e.g. Lindstrom et al., 2011). Training of the deep spinal muscles is generally considered to be an important component of a multimodal intervention for low back (Hodges et al., 2013) and neck pain (Jull et al., 2008). Yet there is limited knowledge on how the activation of the deep semispinalis cervicis can be facilitated with training whilst minimising the activation of the splenius capitis muscle, that is, an exercise analogous to craniocervcal flexion exercise used to emphasize the activation of the deep cervical flexor muscles relative to the superficial flexors.

A recent study showed that the activity of the semispinalis cervicis recorded at the level of C3 can be enhanced relative to the splenius capitis in patients with chronic neck pain by applying localized resistance over the vertebral arch of C2 compared to resistance applied at the head and over C5 (Schomacher et al., 2012c). However, measurements were performed at one spinal level only (C3), and given that synaptic input is distributed independently and non-uniformly to different fascicles of the semispinalis cervicis (Schomacher et al., 2012a), it is necessary to consider whether the activity of the semispinalis cervical can be enhanced relative to the splenius capitis at different spinal levels.

Emphasizing the activation of muscles at selected spinal levels may be clinically relevant since movement dysfunction is often observed at single segments. For example, the physiological limits of extension are often exceeded in the lower cervical spine during whiplash trauma (Bogduk and Yoganandan, 2001) causing facet joint injuries most frequently in C5–C6 and C6–C7 segments (Pearson et al., 2004). Furthermore, people with traumatic onset of neck pain have an increased prevalence of combined rotational and translational hypermobility in the segments C3–4 to C5–6 (Kristjansson et al., 2003). In addition, reduced cross sectional area was noted for the semispinalis cervicis muscle at the spinal levels of C3, C5 and C6 levels in people following a whiplash injury (Elliott et al., 2008). Considering possible changes in semispinalis cervicis activation and structure in people with neck pain, targeted exercise interventions to enhance the activation of the semispinalis cervicis muscles may be relevant.

In this descriptive and exploratory study we evaluate the activation of the semispinalis cervicis and splenius capitis muscles at two spinal levels (C2, C5) in healthy volunteers during various neck exercises. The aim was to evaluate whether neck exercise could enhance the activation of the semispinalis cervicis relative to the splenius capitis muscle thus the ratio between the amplitude of activity of the semispinalis cervicis and the splenius capitis muscle was calculated and compared across exercises.

2. Methods

2.1. Participants

Ten healthy volunteers (3 men and 7 women; age, mean ± SD: 30.7 ± 7.4 years; height: 170.0 ± 8.8 cm; weight: 67.6 ± 24.8 kg) were recruited from the University Medical Center Göttingen, Germany, via e-mail and advertisements on the university's notice board. The experiment was conducted at the Laboratory for Spinal Pain Research, Center for Anesthesiology, Emergency and Intensive Care Medicine, University Hospital Göttingen, Germany.

Subjects were included if they were aged between 18 and 50 years and free of any neck pain. Subjects were excluded if they had any complaints of neurological symptoms, a history of cervical spine surgery, any known risk of infection following needle insertion or of coagulation disorders, and if they were taking medications which could affect coagulation, such as aspirin.

Ethical approval for the study was granted by the ethics committee of the medical faculty of the Georg-August-University, Göttingen, Germany (21/2/14). All procedures were conducted according to the Declaration of Helsinki. All subjects provided informed consent.

2.2. Electromyography

Intramuscular EMG was acquired from the semispinalis cervicis and splenius capitis muscles at the level of the 2nd and 5th spinous processes on the right side (Fig. 1). Teflon-coated stainless steel fine wire electrodes (diameter: 0.1 mm) were inserted in each muscle using a prefabricated 27-gauge hypodermic needle with a single wire inside (SEI EMG s.r.l., Cittadella, Italy). Approximately 3–4 mm of insulation was removed from the tip of the wire to obtain an interference EMG signal, which was acquired in referenced monopolar mode. Needle insertion was guided by ultrasound (Lee et al., 2007) (LS 128, Telemed, Vilnius, Lithuania) with a linear transducer (HL9.0/40) set between 8 and 9 MHz. Ultrasound is a reliable tool to visualize the neck muscles (Kristjansson, 2004; Stokes et al., 2007).

Subjects were lying prone with the head in a slightly flexed position. The ultrasound transducer was placed transversally lateral to the spinous processes of C2 and C5 to image the extensor muscles. The identification of the echogenic (bright, reflective) laminae and the spinous process are the main bony landmarks for locating the cervical extensors which are separated by echogenic fascia layers (Stokes et al., 2007). The deep cervical artery was visualized with Doppler sonography prior to needle insertion. It lies in the fascia separating semispinalis capitis from semispinalis cervicis muscle. Following an exploratory scan of the muscles and the artery, the spinous process of the second cervical vertebrae was located by palpation as the first bony landmark caudal to the occiput. Similarly, the spinous process of the fifth cervical vertebrae

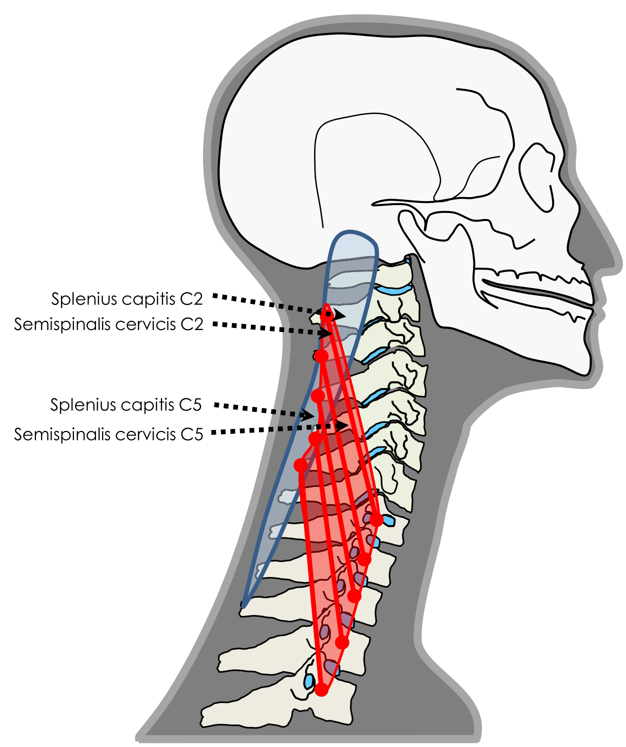

Fig. 1. Illustration of the electrode locations in the semsispinalis cervicis and splenius capitis muscles at the level of the 2nd and 5th cervical vertebrae (C2 and C5 respectively).