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MUSCLE PHYSIOLOGY: BRIEF REPORT

The variation of the strength of neck extensor muscles and semispinalis capitis muscle size with head and neck position

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Summary Semispinalis capitis muscle (SECM) is a massive and long cervico-thoracic muscle which functions as a main head and neck extensor muscle. The aim of this study was to detect the effect of head and neck positions on the strength of neck extensor muscles and size of SECM in healthy subjects. Thirty healthy women students voluntarily participated in this study. An ultrasonography apparatus (Hitachi EUB 525) and a system of tension-meter were used to scan the right SECM at the level of third cervical spine and to measure the strength of neck extensor muscles at three head and neck positions. Neck extensor muscles were stronger in neutral than flexion or than extension positions while the size of SECM was larger in extension than neutral or than flexion position. The force generation capacity of the main neck extensor muscle was lower at two head and neck flexion and extension positions than neutral position.

Introduction

The strength of a group of neck muscles varies according to the joint range of motion. By using an isometric muscle strength test Vasavada et al. reported that the strength of neck extensor muscles were the strongest while head and neck were in neutral position. The authors concluded that the force generation capacity of neck extensor muscles was not constantly maintained during the entire cervical range of motion (Vasavada et al., 1998). The function of an individual muscle may also be varied during an entire range of motion accordingly. Ultrasonography has been

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Table 1 The mean, standard deviation and range of the maximum strength of neck extensor muscles, anterior—posterior dimension (APD), lateral dimension (LD) and the size of semispinalis capitis muscle (APD*LD) in three cervical neutral, flexion and extension positions.

Neck position	MVC (N)	APD (mm)	LD (mm)	Size (mm^2)
Neutral	45.61 ± 116.05	4.58 ± 2.31	33.06 ± 5.69	152.41 ± 36.57
	44.14—256.04	2.60—16.50	17.90—44.73	89.70—289.08
Flexion	42.83 ± 108.20	4.78 ± 0.72	30.3 ± 3.38	143.27 ± 24.22
	43.45—210.42	3.65—6.60	23.95—36.15	91.01—183.00
Extension	38.35 ± 83.48	6.31 ± 1.32	31.93 ± 3.82	201.36 ± 50.45
	30.41—16.34	3.90—10.03	25.05—41.00	123.83—361.04

recommended to study the function of a single small muscle even located in deep layers (Rezasoltani et al., 2002; Lee et al., 2009; Javanshir et al., 2011).

In an ultrasonography study, Wantanabe et al. measured the thickness of the lumbar extensor muscles when subjects were in different positions of the lumbar spine (standing neutral, flexion and extension) (Watanabe et al., 2004). The authors reported that muscles thickness was the largest in the lumber extension position and the smallest at in the lumbar flexion position. McGill et al. combined two methods of muscle strength test and muscle ultrasonography and revealed that the force generation capacity and the dimension of erector spinae muscles decreased when subjects were in a lumbar flexion position (McGill et al., 2000).

The strength related neck muscle size in different ranges of head and neck position have not yet been reported. The study of the function of the neck semispinalis capitis muscle (SECM) is very important since it acts as a prime mover and main head and neck extensor muscle. The aim of this study was to detect the effect of head and neck positions on the strength of neck extensor muscles and size of SECM in healthy subjects.

Methods

Thirty healthy female students (age 18—24 years old) voluntarily participated in this study. They were informed about the aim and experimental aspects of the research prior to the study. The study protocol was approved by the Ethical Committee of Shahid Beheshti University of Medical Sciences.

A real time ultrasonography device (Hitachi EUB 525, Japan) with the frequency of 7.5 MHz linear array probe was applied in this study. The subjects were asked to sit relaxed, on a chair without back support. Hands were on the thighs, feet on the floor and the spine was kept in a neutral position. Ultrasonography was performed at the right side of third cervical spine.

The lateral dimension (LD) and the antero—posterior dimension (APD) of SECM were measured to calculate the size of the muscle as APD multiplied by LD. (Rezasoltani et al., 1998). Two scans were taken from right SECM in each of three neck positions (neutral, flexion and extension) and on each scan the mean of two APD and two LD measurements were computed for data analysis.

A digital tension-meter was used to determine the strength of neck extensor muscles while the subjects sat on a chair with the hands on their thighs, the thorax and pelvis were fastened tightly at the level of the spine of the scapula and the iliac crest. Knees were straight and feet on a stand 15 cm in height.

The strap of the tension-meter was put around the head so that force could be applied against the occipital bone. In order to warm up, subjects performed 2—3 sub-maximal neck muscle contractions prior to the test. They were instructed to perform three maximum voluntary contractions (MVCs) in each of three positions of neutral, flexion and extension. The maximum value from 3 attempts in each position was selected for the strength of the neck extensor muscles in that position.

The inter-testers reliability of both muscle ultrasonography and muscle strength test was performed by two examiners in 10 subjects at the same times on two separate days.

Statistical analysis

To estimate the repeatability of the measurements taken by two examiners, the ICC (Intra-class coefficient correlation) was computed from repeated measurement of ANOVA. A one-way analysis of variance was used to compare any difference in variables of muscles strength and muscle size among positions of neutral, flexion and extension. The statistical analysis was performed using the SPSS statistical software program for Windows.

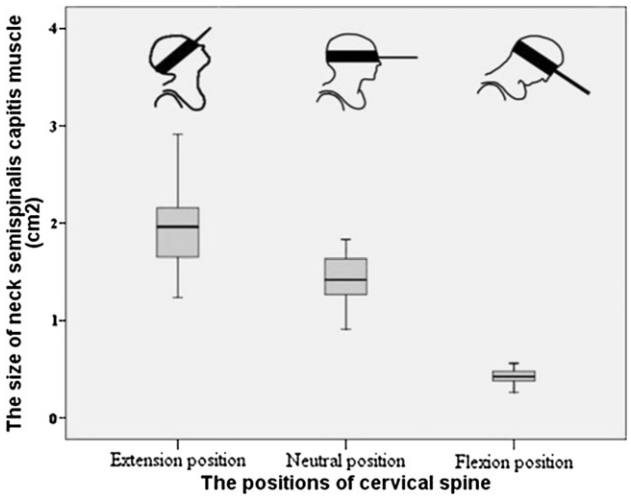

Figure 1 The size of neck semispinalis capitis muscle (cm^2) in three different neck positions.

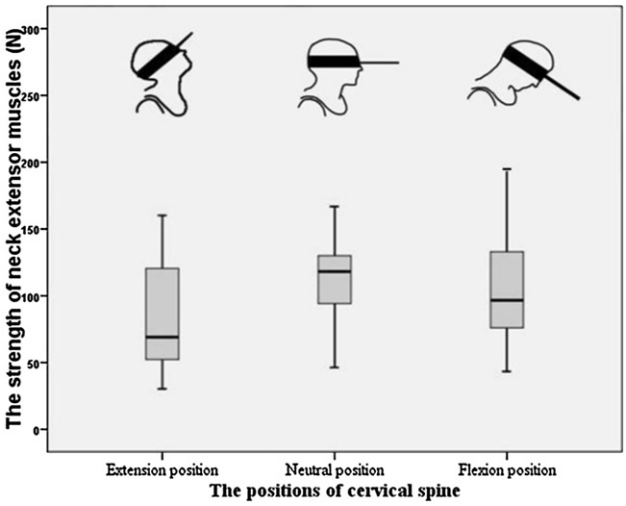

Figure 2 The strength of neck extensor muscles (N) in three different neck positions.

Results

The index of inter-testers reliability for SECM size measurement was $0.88 < ICC < 0.98$ and for muscle strength measurements it was $0.75 < ICC < 0.90$ in all three positions. The size of SECM was significantly smaller in flexion than extension ($p < 0.001$) (Fig. 1). The maximum isometric strength of neck extensor muscles was significantly different between extension and flexion positions and also between extension and neutral positions ($p < 0.05$) (Table 1). Indicating that, neck extensor muscles were stronger in neutral than flexion than extension positions (Fig. 2).

Conclusion

The size and the strength of a muscle may linearly be associated with the joint range of motion (Vasavada et al., 1998; McGill et al., 2000; Watanabe et al., 2004). The authors of two earlier studies stated that lumbar flexion caused a reduction in dimensions of erector spinae muscles (McGill et al., 2000; Watanabe et al., 2004). In our study, the size of SECM was larger in extension than that of flexion position. The difference may be related to the variation of SECM length from extension to flexion. SECM has an especial complexity of attachments by which the fascial length of the muscle changes during the entire head and neck range of motion (Vasavada et al., 1998). On the other hand, neck muscle extensors were stronger in flexion than extension, indicating that the size of SECM was not a good predictor for muscle strength in these two positions. It has been revealed that SECM in it's neutral anatomical position may provide a proper muscle length and suitable position for maximum muscle performance (Garces et al., 2002). In a computer-graphic model of the cervical muscles study Vasavada et al., 1998 indicated that total strength capacity of neck extensor muscles decreased in head and neck flexion and extension. In this study we measured SECM size since it provides a long lever arm and functions as a prime mover & main cervical extensor muscle (Vasavada et al., 1998; Elliott et al., 2010). It originates from the skull and courses down to the lower cervical (C3—C7) and upper thoracic vertebrae (T1—T6). In a tissue velocity ultrasound imaging study to investigating the tissue motion of the dorsal neck muscle, SECM exhibited a higher rate of deformation during cervical extension than the other neck extensor muscles (Peolsson et al., 2010).

In studies of the association between muscle strength and muscle size, a significant statistical correlation has been reported between two variables (Ikai and Fukunaga, 1968; Rezasoltani et al., 2002). In our previous study, we found a significant correlation between SECM size and the strength of neck extensor muscles in athletes when subjects' head and neck were in a neutral position. In the present study, no significant correlation was found between the strength of neck extensor muscles and the size of SECM in three neutral, flexion and extension positions. This disassociation may be because of different distribution of fat and contractile component of SECM between athletes and non-athletes (Kawakami, 2005) and/or due to the system by which muscle strength was measured. To measure the strength of a group of muscles by tensiometer, the angle of joints may not be maintained exactly at the same degree as if using a load cell.

The strength of neck the extensor muscle was physiologically related to the size and the length of the SECM. To measure the strength of the neck extensor muscles in the extension position, care should be taken to keep the craniocervical junction in a neutrally oriented position to avoid the contraction of long neck flexor muscles. Sterno-cleido-mastoid muscles are considered as head and neck long flexor muscles when bilaterally contracted. With full head and neck extension, they provide a proper line of action to extend the craniocervical joint. Further studies may be required to evaluate the size and the strength of neck extensor muscles in patients with work related neck pain.

Conflict of interest statement

The Authors certify that there is no actual or potential conflict of interest in relation to this article.

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