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Effects of aging on mechanical properties of sternocleidomastoid and trapezius muscles during transition from lying to sitting position—A cross-sectional study

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ABSTRACT

Aim: The aim of this study was to analyze the effects of aging on the viscoelastic properties of the upper trapezius (UT) and the sternocleidomastoid (SCM) muscle during transition from lying to sitting position.
Materials and methods: The study included 39 older (mean age 67 ± 5.9 years) and 36 younger (21.1 ± 1.8 years) women. Tone, stiffness and elasticity of the UT and the SCM were measured by means of myotonometry (MyotonPRO) in lying and then, in sitting position. The results were compared using two-way analysis of variance.
Results: Irrespective of the position, older women presented with significantly higher muscle tone, stiffness and elasticity than younger subjects ($P < 0.05$). In both groups, the transition from lying to sitting position resulted in a decrease ($P < 0.05$) in the tone and stiffness, but not the elasticity ($P > 0.05$) of the SCM, and stimulated an increase in the tone, stiffness and elasticity of the UT ($P < 0.05$). The degree of changes in both study groups was similar, except from the absolute value of the UT elasticity, significantly higher increase in older women than in younger subjects ($P < 0.05$).
Conclusion: Age contributes to an increase in the stiffness and tone of the UT and the SCM, as well as to a decrease in the elasticity of these muscles in female subjects. In contrast, age exerts only a slight effect on the mechanical properties of both muscles during transition from lying to sitting position.

1. Introduction

Musculoskeletal pain is one of the most common causes of discomfort in cervical spine during aging (Leveille, Fried, & Guralnik, 2002). Older people are more likely to sufferer from muscular pain than younger persons (Lautenbacher, Kunz, Strate, Nielsen, & Arendt-Nielsen, 2005). Moreover, older subjects feel pain more intensely (Marini et al., 2012). Tension headache was shown to be the most common type of headache experienced by older persons (Schwaiger et al., 2009). Available evidence suggests that the sternocleidomastoid (SCM) muscle and the upper trapezius (UT) muscle are major contributors to tension headache (Bendtsen, Ashina, Moore, & Steiner, 2016; Fernández-de-Las-Peñas, Alonso-Blanco, Cuadrado, Gerwin, & Pareja, 2006; Fernández-de-Las-Peñas, Ge, Arendt-Nielsen, Cuadrado, & Pareja, 2007).

Maintaining static position of the head during sitting is associated with increased strain of cervical spine (Moroney, Schultz, & Miller, 1988). Sitting was shown to be associated with greater tension and stiffness of the cervical extensors, including the upper trapezius (UT), than lying in supine position (Viir et al., 2007). Older persons tend to lean the head forward in relation to the trunk in sagittal plane when sitting, which is referred to as forward head posture (FHP) (Park et al., 2014; Yukawa, Kato, Suda, Yamagata, & Ueta, 2012). FHP increases moment arm of the cervical extensors to counteract the moment of inertia created by the head's weight (Neumann, 2002). FHP usually results in shortening of the cervical extensors, including the UT, frequently without corresponding changes in the cervical flexors, e.g. the sternocleidomastoid (SCM) (Fernández-de-las-Peñas, Cleland, & Dommerholt, 2015). FHP is also associated with reduced electromyographic activity of individual cervical muscles, e.g. the SCM, during

Abbreviations: FHP, forward head posture; UT, upper trapezius; SCM, sternocleidomastoid.

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protraction and retraction of the neck (Lee, Han, Cheon, Park, & Yong, 2015), and with greater activity of the UT, which increases the likelihood of neck and shoulder discomfort (Szeto, Straker, & Raine, 2002).

Aging is associated with structural remodeling of myofascial tissue, which results in an increase in its stiffness and tone, and in a concomitant decrease in its elasticity (Agyapong-Badua, Warnera, Dinesh, & Stokes, 2016). The aim of this study was to analyze the effects of aging on the viscoelastic properties of the UT and the SCM during transition from lying to sitting position. We expected an age-related increase in the tone and stiffness of both muscles, and a decrease in their elasticity, in both sitting and lying position. Based on published evidence documenting an age-related increase in the prevalence of FHP during sitting, we also expected that during transition from lying to sitting, older subjects may show a relatively greater increase in the UT tone and stiffness, as well as a relatively greater decrease in these parameters for the SCM.

2. Material and methods

2.1. Design

A cross-sectional study conducted in Poznan municipality included volunteers from local community. Mechanical properties of the analyzed muscles were determined over a 5-day period at the university laboratory. The protocol of the study was granted approval from the Institutional Review Board at the Poznan University of Medical Sciences (decision no. 449/14), and written informed consent to participate was sought from each study subject at the time of enrollment.

2.2. Participants

The study included 75 adult women from two age categories: younger (age <30 years, n = 36) and older postmenopausal women (age >60 years, n = 39). The sample size was determined on the basis of previous research on validity and reliability (Myoton, Chuang, Wu, & Lin, 2012; Leonard et al., 2003; Pruyn, Watsford, & Murphy, 2015). The inclusion criteria of the study were: good health, lack of neck and shoulder pain over past 6 months, and no history of regular physical exercise over past two years. The exclusion criteria were: neurological deficits, visible motor dysfunctions, acute or chronic pain syndromes involving the neck and/or shoulders, history of thoracic surgeries and surgical procedures in the shoulder girdle and cervical spine.

2.3. Procedure

Viscoelastic parameters were determined in a mid-length of muscle belly, using MyotonPRO® device (Myoton AS, Tallinn, Estonia). First, the measurements were taken with subject lying in supine position on an examination table, with arms along the trunk, externally rotated shoulders, extended elbows and supinated wrists. Prior to examination, the subjects spent ca. 6 min in supine position. The UT was examined first, followed by the SCM. The measurements were taken on the right side of the body, and then on the left side. The UT was identified as a triangle in the neck area, reaching mid-length between the most outward part of the acromion on each side and C7 spinous process. The measurement was taken in a point providing optimal access to the muscle tissue. The SCM was examined mid-length between its attachments to the sternum and to the mastoid process of the temporal bone where the two heads fused together. Then, the same measurements were repeated in sitting position. The subjects were seated in a natural position on a chair with a backrest, with their hands lying on their knees; they were asked to focus their attention on a text displayed on the computer screen for approximately 2 min. Then, the measurements were taken following the same protocol as described above. During each measurement, the device's probe (3 mm in diameter) was applied vertically to the skin surface with a constant preload (0.18 N). The oscillations of underlying tissues were evoked by delivering 10 brief (15-ms) mechanical impulses at low force (0.4 N) and 1-Hz frequency. Two consecutive measurements were taken at each site in each position, and the mean result was subjected to analysis. Device-induced natural damped oscillations of the tissues were recorded with an accelerometer included in the MyotonPRO® set. This part of the study was conducted by an investigator who had an adequate experience in taking measurements with MyotonPRO® device, blinded to characteristics of the study subjects.

2.4. Outcome measures

Muscle stiffness [N/m] expressed as the resistance of tissue to an external mechanical impulse, and muscle tension (tone) defined as the maximum frequency [Hz] of soft tissue oscillation, computed from the signal spectrum by Fast Fourier Transform, were calculated using previously established formulas (Gavronski, Veraksits, Vasar, & Maaroos, 2007). The higher the measured values, the greater the stiffness and tension of the examined muscle. Also elasticity, defined as the ability of the muscle to restore its superficial shape and to dissipate mechanical energy after being deformed, was measured. Elasticity was calculated as the magnitude of decrement (after logarithmic transformation, expressed in arbitrary units) in the amplitude of the second natural tissue oscillation in relation to the first oscillation evoked in response to the single external mechanical impulse. The lower the value of the logarithmic decrement, the smaller the mechanical energy dissipation and the higher the elasticity of the muscle (Gavronski et al., 2007).

2.5. Statistical methods

Since no statistically significant differences were found between the measurements taken on the right and left side of the body in subjects from both study groups, bilateral results were pooled and analyzed together. Two-way analysis of variance was conducted to determine the effects of subjects' age (factor 1: younger vs. older) and body position (factor 2: lying vs. sitting) on the characteristics of both muscles. As the two groups differed in terms of their BMI values, this variable was included as a covariate in an ANCOVA model. Also the significance of intergroup differences in a relative change in the measurements taken after transition from lying to sitting position (delta) was analyzed. Intergroup comparisons of descriptive characteristics (age, body weight, body height and BMI) were carried out with Mann-Whitney *U* test for non-parametric data, or with Student *t*-test for parametric data. The threshold of statistical significance for all tests was set at $P < 0.05$.

Table 1
Demographic and anthropometric characteristics of the study subjects.

	Younger women	Older women
Age (years)	21.1 ± 1.8	67 ± 5.9*
Body weight (kg)	58.7 ± 6.6	64.5 ± 8.1*
Body height (cm)	164.3 ± 5.5	157.6 ± 6.1*
BMI (kg/m²)	22.1 ± 2.2	26 ± 2.8*

* Statistically significant difference, $P < 0.05$.