Clinical Biomechanics 33 (2016) 98–102

Contents lists available at ScienceDirect

Clinical Biomechanics

journal homepage: www.elsevier.com/locate/clinbiomech

Decreased neck muscle strength in patients with the loss of cervical lordosis

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ARTICLE INFO

Article history:
Received 18 November 2015
Accepted 19 February 2016

Keywords:
Cervical lordosis
Neck muscles
Cervical spine
Biomechanics

ABSTRACT

Background: The loss of cervical lordosis is associated with some negative clinical outcomes. No previous study has examined cervical muscle strength, specifically in patients with the loss of cervical lordosis. This study aims to investigate whether there is weakness of the cervical muscles or an imbalance between cervical flexor and extensor muscle strength in patients with the loss of cervical lordosis compared with healthy controls matched by age, gender, body mass index (BMI), and employment status.
Methods: Thirty-two patients with the loss of cervical lordosis (23 F, 9 M) and 31 healthy volunteers (23 F, 8 M) were included in the study. Maximal isometric neck extension and flexion strength, and the strength ratio between extension and flexion were used as evaluation parameters. All measurements were conducted by a blinded assessor using a digital force gauge. The participants were positioned on a chair in a neutral cervical position and without the trunk inclined during measurements.
Findings: Maximal isometric neck extension and flexion strength values were significantly lower in the patients versus healthy controls ($P < 0.001$ and $P = 0.040$, respectively). The mean (SD) values of the extension/flexion ratio were 1.21 (0.34) in the patients and 1.46 ± 0.33 in the controls ($P = 0.004$).
Interpretation: According to our results, patients with the loss of cervical lordosis have reduced neck muscle strength, especially in the extensors. These findings may be beneficial for optimizing cervical exercise prescriptions.

1. Introduction

Anatomically, there is a natural lordotic curvature in the cervical spine (Fig. 1a). This natural lordosis is believed to be an ideal posture in terms of biomechanical principles. The loss of cervical lordosis (Fig. 1b) causes disrupted biomechanics in the cervical spine because the axial load is shifted anteriorly as lordosis is lost, and thus, the increased compressive forces can trigger a progressive degenerative process resulting in cervical kyphosis (Fig. 1c) (Ferrara, 2012; Harrison et al., 2001; Tan et al., 2015). In addition, the loss of cervical lordosis is associated with neck, upper thoracic, and shoulder pain, as well as tension and cervicogenic headaches and poorer health-related quality of life outcomes (McAviney et al., 2005; Morningstar et al., 2003; Tan et al., 2015).

A decreased cervical lordosis may result from muscular spasms, trauma, congenital defects, muscular dystrophies, amyotrophic lateral sclerosis, ankylosing spondylitis, tumor, infection, or surgical complications (Beltsios et al., 2013; Lee et al., 2013; Xiaolong et al., 2011). However, the exact etiology and mechanisms remain unclear in a great majority of cases. According to Panjabi et al. (1998) the mechanical stability of the cervical spine is provided by the neck musculature (80%) rather than the osseoligamentous system (20%). Therefore, weakness of the cervical muscles may bring about the mechanical instability of cervical spine, contributing to the loss of cervical lordosis. Additionally, it has been found that proprioceptive balance activities and a balanced co-contraction between agonistic and antagonistic muscles contribute to maintaining spinal stability (Beinert et al., 2015; Cheng et al., 2008), and altered co-contraction of cervical muscles has been shown in young adults with chronic neck pain (Cheng et al., 2014). Furthermore, it has been reported that the strength ratio between reciprocal muscle groups within a limb plays an important role in articular stabilization, and an abnormal ratio can increase the risk of injury (Baumhauer et al., 1995; Knapik et al., 1991; Stafford and Grana, 1984). Similarly, the existence of an imbalance between neck extension and flexion strength may have an important negative effect on the stabilization of the cervical spine.

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http://dx.doi.org/10.1016/j.clinbiomech.2016.02.014
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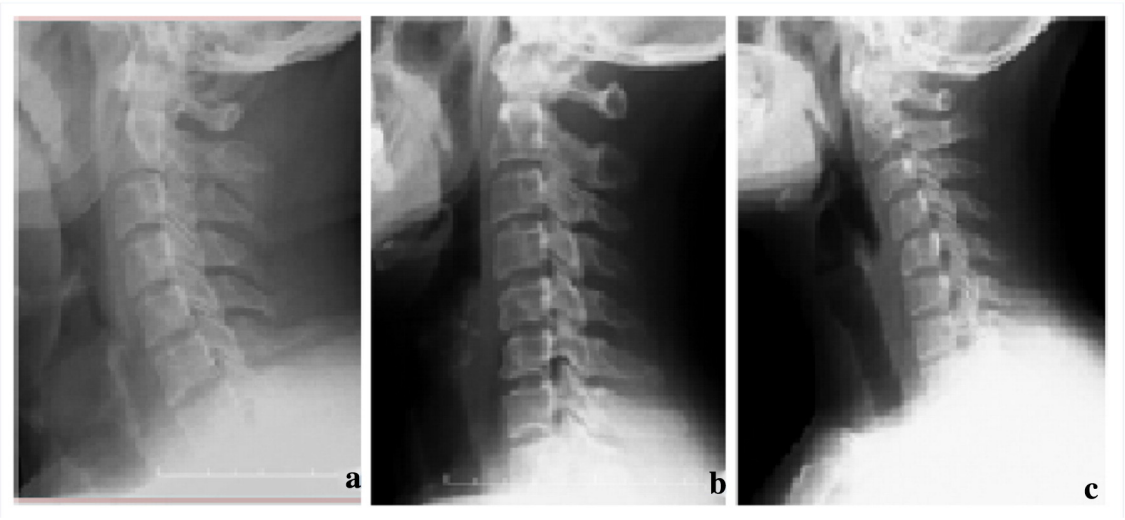

Fig. 1. a, Normal cervical lordosis; b, the loss of cervical lordosis; c, cervical kyphosis.

Although many studies have examined neck strength in both patients with nonspecific neck pain and healthy subjects (Cagnie et al., 2007; Chiu and Sing, 2002; de Koning et al., 2008; Salo et al., 2006), there is currently no known study that has examined neck muscle strength in the loss of cervical lordosis. Thus, more specific data on the topic are needed. In this study we aimed to determine whether there is a weakness of the cervical muscles or an imbalance between cervical flexion and extension strength in patients with the loss of cervical lordosis.

2. Methods

The research protocol was approved by the local ethics committee. Thirty-two patients [23 F, 9 M; mean (SD) age 25.0 (5.9) years] with the loss of cervical lordosis were enrolled between March 2015 and September 2015 from among patients who were admitted to the Department of Physical Medicine and Rehabilitation Outpatient Clinic at Yuzuncu Yil University Hospital. Thirty-one healthy controls matched for age, gender, body mass index (BMI), and employment status [23 F, 8 M; mean (SD) age 23.87 (4.92) years] were recruited from the staff of the same hospital and the patients' relatives with a strictly normal medical record and with normal cervical lordosis (Table 1). All participants gave written consent prior to participation in the study.

Cervical lordosis was assessed on lateral cervical radiographs according to the posterior tangent technique (Erkan et al., 2010). The total curvature of the cervical spine, which is the angle between the posterior wall of the C2 and C7 vertebral bodies (Erkan et al., 2010; Grob et al., 2007), was measured. It has been reported that the posterior tangent technique has a good intra- and inter-observer reliability, with a smaller standard error of measurement than four-line Cobb methods (Harrison et al., 2000). However, the literature yields no standard values for the definition of a normal cervical lordosis. As defined by Grob et al. (2007), we considered the loss of cervical lordosis or straightness of the total curvature as $+4°$ to $-4°$, and lordotic and kyphotic as <-4 and $>+4$, respectively.

Table 1
Demographic findings of controls and patients.

	Healthy controls (n = 31)	The loss of cervical lordosis (n = 32)	P value
Age (years)	23.87 (4.92)	25.0 (5.9)	0.412
Gender (F/M)	23/8	23/9	0.660
Weight (kg)	60.13 (8.08)	59.91 (7.73)	0.911
Height (m)	1.64 (0.8)	1.62 (0.05)	0.196
BMI (kg/m^2)	22.31 (2.16)	22.90 (3.13)	0.388
Lordosis angle (°)	−13.09 (6.08)	−0.62 (2.99)	<0.001
Employment status			0.974
Housewife	8	9	
University student	9	11	
Liberal profession	5	5	
Health personnel	5	4	
Others	4	3	

Data expressed as mean (standard deviation) or number; F/M, female/male; BMI, body mass index.

The medical history and physical examination findings of all participants was recorded to assess each participant's eligibility. Participants with any of the following conditions were excluded from the study: exercise or drug therapy acting on muscular tone and strength (e.g., phenyramidol, steroids, thyroxine); hypo- or hyperthyroidism; underweight (BMI < 18.5 kg/m^2) or obesity (BMI ≥ 30 kg/m^2); neuromuscular diseases such as cervical disk hernia, fibromyalgia, myofascial pain syndrome, and muscular dystrophies; scoliosis; rheumatic diseases such as ankylosing spondylitis and rheumatoid arthritis; and a history of cervical spine trauma. In addition, because an increased psychologic distress and a higher level of current pain tend to show increased inhibition of muscle activity, thus leading to submaximal performance (Verbunt et al., 2005), individuals with psychiatric issues such as depression and anxiety and patients with severe pain were excluded. Moreover, taking into account the potential inhibition of muscle activity due to pain, all patients were given acetaminophen (500 mg, p.o.) one hour before the measurements.

Maximal isometric neck flexion and extension strength were measured by the same assessor, who was blinded to the participant's group. The measurements were performed twice and the highest value was used. Our measurement system consists of a digital force gauge (Digital Force Gauge, Model: SH-200, SHAHE) placed into a fixed frame, which was calibrated with standard masses (5, 10, and 15 kg). During the measurements, the participants were positioned on a chair, with hips and knees at 90° flexion and in a neutral cervical position, without the trunk inclined (Fig. 2).

Statistical analyses were performed using the Statistical Package for Social Sciences for Windows version 15.0 (SPSS Inc., Chicago, IL, USA) software program. The descriptive statistics were presented as the mean (standard deviation) for continuous variables and as the number of the cases for the categorical variables. Before performing the statistical analysis, the normality of the distribution of continuous variables was determined with a one-sample Kolmogorov–Smirnov test. The Independent Samples Test was used to compare the means of two