Journal of Bodywork & Movement Therapies (2016) 20, 235–242

Available online at www.sciencedirect.com

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journal homepage: www.elsevier.com/jbmt

ORIGINAL RESEARCH

Effect of static neck flexion in cervical flexion-relaxation phenomenon in healthy males and females

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Received 15 February 2015; received in revised form 23 June 2015; accepted 22 July 2015

KEYWORDS
Flexion-relaxation phenomenon;
Neck pain;
Cervical spine;
Electromyography

Summary *Introduction:* Neck pain is a common musculoskeletal disorder, especially among skilled workers who must keep their necks in a flexed position frequently during the day. The present study investigated changes in cervical flexion-relaxation phenomenon parameters after sustained neck flexion.
Methods: The participants were 40 healthy subjects grouped by gender (20 females, 20 males). They were exposed to static neck flexion at the full angle of cervical flexion for 10 min. Each subject underwent three trials of cervical flexion and re-extension before and after this period. Differences in onset and cessation angle of flexion-relaxation phenomenon, maximum neck flexion angle, amplitude of neck muscle activation and flexion-relaxation ratio were evaluated.
Results: The maximum neck flexion angle significantly increased after sustained flexion. The onset of flexion-relaxation was significantly delayed during flexion, but cessation angle remained unchanged. Myoelectric activity of the cervical erector spinae muscles increased significantly after maintaining flexion, especially in female subjects. The flexion-relaxation ratio also decreased significantly.
Conclusion: It was concluded that 10 min of static flexion results in a delay in flexion-relaxation phenomenon and a shortened silence period. Also the cervical erector spinae muscles are

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http://dx.doi.org/10.1016/j.jbmt.2015.07.039

required to be active longer and generate more activity. These neuromuscular changes may be a risk factor for neck pain.

Introduction

Neck pain is a common health problem among adults and may require medical attention and the cause an economic burden by absence from work (Cagnie et al., 2007; Fejer et al., 2006). Neck pain is multifactorial in nature and has risk factors that can be categorized as physical, psychosocial, and individual (Andersen et al., 2003; Ariens et al., 2002, 2000). Of the factors at risk for neck pain, work-related physical factors play a more important role (Ariens et al., 2001). Previous studies have shown that neck pain is positively correlated with holding the neck in a flexed posture for a prolonged period of time which can cause static loading of the musculoskeletal structures (Andersen et al., 2003; Ariens et al., 2001, 2002; Cagnie et al., 2007; Eltayeb et al., 2009; Mayer et al., 2012; Palmer and Smedley, 2007; Reesink et al., 2007; Wærsted et al., 2010). Evidence shows that working with the cervical spine in flexion may increase the risk of neck pain (Côté et al., 2008; Ranasinghe et al., 2011; Sim et al., 2006). Various occupations are dominated by a static flexed posture of the cervical spine; dentists, agricultural, industrial and construction workers and sewing machine operators, are high risk groups for developing work-related neck pain (Diaz-Caballero et al., 2010; Finsen, 1999; Kaergaard and Andersen, 2000; Mäkela et al., 1991; Palmer et al., 2001). Neck flexion is also related to sick leave from work caused by neck pain (Ariens et al., 2002). It should be mentioned that prolonged neck flexion is commonly measured by questionnaires based on self-reporting (Cagnie et al., 2007; Eltayeb et al., 2009; Ranasinghe et al., 2011; Reesink et al., 2007; Sim et al., 2006). Therefore, interpretation of prolonged time may be different for each person, and this variable cannot be taken to have a single objective meaning (Sim et al., 2006). Neck pain may disrupt the lives of individuals experiencing it; thus, it is essential to understand the alterations in cervical spine neuromuscular behavior following exposure to flexion to develop prevention strategies.

Time- and rate-dependent mechanical behavior of cadaver cervical spine ligaments (Ivancic et al., 2007; Troyer and Puttlitz, 2011), intervertebral discs (Nuckley et al., 2005) and bone (Shim et al., 2005) were measured in vitro under different loading conditions. But time-related physiological and biomechanical changes in healthy human cervical spine viscoelastic tissues under constant loading have been poorly understood to date. It is commonly accepted that static flexion in the lumbar spine is a major risk factor for low back disorders (Adams and Dolan, 1996; Kumar, 2001; Solomonow, 2004; Solomonow et al., 2003a, 2003b). Studies suggest that creep caused by repetitive or prolonged flexion can produce more laxity in the lumbar spine and impair spinal stability (Little and Khalsa, 2005; Olson et al., 2004; Solomonow, 2004; Solomonow et al., 2003a, 2003b; Troyer and Puttlitz, 2011). Spinal stability is achieved by the highly coordinated interaction of the subsystems having active, passive and neural components (Panjabi, 1992). The viscoelastic behavior of passive tissues of the spine provides passive stiffness. Baseline and reflexive muscle activation are considered as components of Active stiffness. Active neuromuscular systems can compensate for reductions in passive stiffness (Hendershot et al., 2011). Viscoelastic changes in the passive lumbar spine tissues and their effect on other components of spinal stabilization have been studied during static flexion to understand the mechanisms of injury (Bazrgari et al., 2011; Rogers and Granata, 2006; Shin and Mirka, 2007; Solomonow, 2004; Solomonow et al., 2003a, 2003b). Performance of spinal flexion is associated with the flexion-relaxation phenomenon (FRP). FRP is indicative of the transfer of the load-supporting role from active muscles to the passive tissues of the spine (Callaghan and Dunk, 2002; Colloca and Hinrichs, 2005; Descarreaux et al., 2008; Floyd and Silver, 1955; McGill and Brown, 1992). The occurrence of creep or stress relaxation of spinal tissues in the lower back can be distinguished by quantifying the full flexion angle and investigating the parameters of the FRP (such as the onset and cessation angles) after a period of static flexion (Adams and Dolan, 1996; McGill and Brown, 1992; Shin and Mirka, 2007; Solomonow et al., 2003a; Toosizadeh and Nussbaum, 2013). The FRP onset angle is the angle at which the erector spinae (ES) muscles become silent during flexion and the cessation angle is the angle at which muscle activity resumes (Shin et al., 2009). Studies have shown the delayed onset of FRP following static flexion of the lumbar spine may indicate decreased stiffness of spinal passive tissues and result in compensation of the active component of the neuromuscular system (Shin and Mirka, 2007; Solomonow et al., 2003a). Research results also indicate gender-related differences; females are more likely to develop lumbar creep than males over the same duration of lumbar static flexion (McGill and Brown, 1992; Solomonow et al., 2003a).

As in the lumbar spine, cervical ES muscles also display myoelectric silence during neck flexion. This phenomenon was first reported in the cervical spine using a pulley with a needle electrode (Pauly, 1966). Since then, a number of studies have investigated this phenomenon and the factors influencing it (Airaksinen et al., 2005; Burnett et al., 2009; Meyer et al., 1993; Pialasse et al., 2009, 2010). Two studies compared FRP parameters in patients with chronic neck pain and healthy controls. They reported differences between groups in the FRP parameters such as flexion-relaxation ratio (FRR), onset and cessation angle and muscular activity (Maroufi et al., 2013; Murphy et al., 2010). FRR is an index used to monitor changes in FRP (Mak et al., 2010) and is a reliable marker of altered