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Flexion–relaxation ratio in computer workers with and without chronic neck pain

Carina Ferreira Pinheiro [a,b,1], Marina Foresti dos Santos [a,c,1], Thais Cristina Chaves [a,b,d,*,1]

[a] Ribeirão Preto Medical School, University of São Paulo, Ribeirão Preto, São Paulo, Brazil
[b] Post Graduation Program in Rehabilitation and Functional Performance, University of São Paulo, Ribeirão Preto, São Paulo, Brazil
[c] Undergraduate Program in Physical Therapy, University of São Paulo, Ribeirão Preto, São Paulo, Brazil
[d] Department of Neuroscience and Behavioral Sciences, University of São Paulo, Ribeirão Preto, São Paulo, Brazil

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ABSTRACT

This study evaluated the flexion–relaxation phenomenon (FRP) and flexion–relaxation ratios (FR-ratios) using surface electromyography (sEMG) of the cervical extensor muscles of computer workers with and without chronic neck pain, as well as of healthy subjects who were not computer users. This study comprised 60 subjects 20–45 years of age, of which 20 were computer workers with chronic neck pain (CPG), 20 were computer workers without neck pain (NPG), and 20 were control individuals who do not use computers for work and use them less than 4 h/day for other purposes (CG). FRP and FR-ratios were analyzed using sEMG of the cervical extensors. Analysis of FR-ratios showed smaller values in the semispinalis capitis muscles of the two groups of workers compared to the control group. The reference FR-ratio (flexion relaxation ratio [FRR], defined as the maximum activity in 1 s of the re-extension/full flexion sEMG activity) was significantly higher in the computer workers with neck pain compared to the CG (CPG: 3.10, 95% confidence interval [CI95%] 2.50–3.70; NPG: 2.33, CI95% 1.93–2.74; CG: 1.99, CI95% 1.81–2.17; $p < 0.001$). The FR-ratios and FRR of sEMG in this study suggested that computer use could increase recruitment of the semispinalis capitis during neck extension (concentric and eccentric phases), which could explain our results. These results also suggest that the FR-ratios of the semispinalis may be a potential functional predictive neuromuscular marker of asymptomatic neck musculoskeletal disorders since even asymptomatic computer workers showed altered values. On the other hand, the FRR values of the semispinalis capitis demonstrated a good discriminative ability to detect neck pain, and such results suggested that each FR-ratio could have a different application.

1. Introduction

Neck pain is a common musculoskeletal complaint reported by workers using computers (Sillanpää et al., 2003; Wahlström, 2005; Klussmann et al., 2008; Janwantanakul et al., 2008; Brandt et al., 2014), with a reported prevalence of between 55% and 69% (Oha et al., 2014). Despite a history and diagnostic examinations suggesting potential causes, the pathophysiology of neck pain is unclear in the majority of cases. For this reason, it is classified as non-specific (Maroufi et al., 2013), with multifactorial etiology involving individual, physical, and psychosocial factors such as gender, age, incorrect posture while working, and high work demands (Cagnie et al., 2007; Côté et al., 2004; Paksaichol et al., 2015).

Patients with neck pain often present with altered neck flexor muscle activity (increased electromyographic [EMG] activity of the superficial neck flexor muscles and reduced activation of the deep cervical flexors – longus capitis and longus colli) (Falla et al., 2004b) as well as reduced surface electromyographic (sEMG) activity in the cervical erector spinae muscles (CES) compared to asymptomatic volunteers (Maroufi et al., 2013).

Neck pain in workers using computers for extended periods has been associated with sitting posture (Cagnie et al., 2007), awkward working position, and repetitive manual tasks (Paksaichol et al., 2012). Muscle pain may originate from overload of low-threshold muscle fibers during work that requires continuous, low-level muscle activity (Strøm et al., 2009). Computer-using office workers with neck pain also have higher activity levels in their upper trapezius and CES muscles during computer work (Szeto et al.,

* Corresponding author at: Ribeirão Preto Medical School, University of São Paulo, Ribeirão Preto, São Paulo, Brazil.
E-mail addresses: carinafp@hotmail.com (C.F. Pinheiro), marinafsfisio@hotmail.com (M.F.d. Santos), chavestc@fmrp.usp.br (T.C. Chaves).
[1] These authors contributed equally to this work.

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2005). Moreover, Johnston et al. (2008) showed that CES activity "relaxed at a slower rate" in study participants who experienced neck pain and who used computers during work compared to the rate of decline in non-working controls and computer users who did not experience neck pain, following a visually controlled simple repetitive manual task, suggesting a disturbance in CES muscle activation among participants with neck pain.

The flexion–relaxation phenomenon (FRP) is a method used to evaluate altered muscle recruitment patterns in the CES muscles. FRP is characterized by the absence of EMG signals from the extensor muscles during maximum anterior cervical flexion (Solomonow et al., 2003; Burnett et al., 2009; Murphy et al., 2010; Pialasse et al., 2010). Recent studies have reported FRP in most individuals without neck pain (95% and 85%, respectively) (Pialasse et al., 2009; Maroufi et al., 2013). However, only some studies have reported a lack or delayed FRP during full cervical flexion in subjects with neck pain, which could be used to differentiate subjects with neck pain from asymptomatic subjects (Airaksinen et al., 2005; Maroufi et al., 2013).

Flexion–relaxation ratios (FR-ratios) are used to quantify the FRP, and several methods have been described in the literature (Burnett et al., 2009). One of the most commonly used FR-ratio methods is the flexion relaxation ratio (FRR), which measures the maximum activity during 1 s of re-extension/mean activity during the total flexion phase (Maroufi et al., 2013; Nimbarte et al., 2014; Zabihhosseinian et al., 2015). Previous studies demonstrated lower FRRs in volunteers with neck pain compared to the control group (Murphy et al., 2010; Maroufi et al., 2013; Zabihhosseinian et al., 2015).

Although the relationship between prolonged computer use and neck pain has been described in the literature, to the best of our knowledge, there are no reports about the occurrence of the FRP and FR-ratios in computer workers with and without neck pain (Yoo et al., 2011; Yoo, 2014). Yoo et al. (2011) proposed that FRR could be used to calculate the potential risk of neck discomfort in computer workers and suggested that CES muscle disorders could occur in asymptomatic computer workers prior to the occurrence of pain (Yoo et al., 2011). Thus, early identification of FRP and FRR alterations in asymptomatic computer workers may help identify subclinical levels of musculoskeletal disorders and the need for preventive interventions among these workers. This could be implemented by systematic and periodic assessments of workers in the workplace with sEMG and controlling clinical symptoms. Furthermore, workplace interventions and ergonomic training could be employed for workers with FRP and FRR changes in order to avoid the onset of neck pain.

The hypothesis of this study was that computer workers have altered cervical extensor activity during the cervical flexion–relaxation test, and that this alteration would be more severe in workers with chronic neck pain compared to a control group and asymptomatic computer workers. This study used sEMG to evaluate the occurrence of the FRP and measured FR-ratios in the cervical spine extensor muscles of computer workers with and without chronic neck pain as well as in healthy subjects who were not computer users.

2. Methods

2.1. Sample

This study included 60 participants, 30 male and 30 female, between 20 and 45 years of age; they were divided into three groups: 20 computer workers with chronic neck pain (CPG), 20 computer workers without neck pain (NPG), and 20 individuals who were not computer users and who did not have neck pain (CG). Table 1 presents their anthropometric and clinical characteristics. Sample size calculations showed the need for a minimum number of 17 subjects per group ($\beta = 0.95$, $\alpha = 0.05$, effect size of 0.6). GPower version 3.0.10 (University of Kiel, Germany) was used for this analysis, based on a variable FRR (FRR for the CPG: 2.22 ± 0.7 and for CG: 4.88 ± 1.4: Maroufi et al., 2013).

Inclusion criteria for the CPG were: neck pain for at least 3 months (Hoy et al., 2010), at least mild neck-related disability according to the Neck Disability Index (NDI), pain intensity of at least three on a numerical pain intensity scale from 0 to 10 on most days (Lau et al., 2010), and working at the same job/position for at least 12 months.

The NPG included workers with no neck pain in the last year and no score on the NDI. The control group (CG) included individuals with no history of neck pain in the last year but reported using a computer for less than 4 h per day (Sonne et al., 2012).

Individuals were excluded from this study if they had other acute or chronic pain disorders, whether musculoskeletal or not, as well as systemic degenerative diseases that involved multiple joints, cervical whiplash syndrome and other traumatic conditions, congenital deformities of the upper limbs and spine, history of spine surgery, vision or hearing impairment, and cognitive deficits.

The ethics committee on research involving humans (Clinical Hospital of the College of Medicine of Ribeirão Preto at the University of São Paulo – HCRP Process No. 4492/2013) approved this project. All volunteers signed a free and informed consent form.

2.2. Neck Disabilityy Index (NDI)

Neck pain disability was evaluated using NDI (Vernon and Mior, 1991; Vernon, 2008), which classifies subjects according to the following scores: 0–8% (0–4 points) = no disability; 10–28% (5–14 points) = mild disability; 30–48% (15–24 points) = moderate disability; 50–68% (25–35 points) = severe disability; 72% or more points (36 points or more) = complete disability. A version adapted to Brazilian Portuguese subjects (Cook et al., 2006) was used.

2.3. Instrumentation

Trigno™ Wireless EMG (20–450 Hz, CMRR of 80 dB, input impedance 1015 Ω, Delsys Inc., Boston, USA) equipment with 16 channels and parallel bar-active surface electrodes were used for data collection. The signals were digitized with a sampling frequency of 2 kHz, with a 16-bit resolution A/D system and simultaneous signal sampling.

The data were collected with active differential simple electrodes (two bars of Ag–AgCl – 10 × 1 × 1 mm), with a 10-mm interelectrode distance, 300× gain, fixed to the skin with proper Delsys adhesive sensor interface, and an overall channel noise of <0.75 μV. The skin was prepared for electrode placement by shaving (if necessary) and cleaning with 70% alcohol pads to reduce impedance; pairs of bipolar Ag/AgCl electrodes were then placed bilaterally, parallel to muscle fibers, with a minimum distance of 20 mm between the centers of different electrodes, on the following points:

- Semispinalis capitis: 2 cm below the occipital bone and lateral to the C2 spinous process (Sommerich et al., 2000).
- Splenius capitis: palpable muscle belly region 7 cm lateral to the C4 spinous process (Sommerich et al., 2000).
- Upper trapezius: lateral to the midpoint of the imaginary line formed by the posterior point of the acromion and the C7 spinous process (Burnett et al., 2007).

Other studies that have assessed cervical FRP have used just one point on the posterior region of the neck (2 cm lateral to the C4 spinous process) for sEMG assessment of the CES muscles. This study