Relationship between Active Cervical Range of Motion and Flexion–Relaxation Ratio in Asymptomatic Computer Workers

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Abstract A high prevalence and incidence of neck and shoulder pain is present in the working population, especially sedentary workers. Recent findings have indicated that the flexion-relaxation (FR) ratio in the cervical erector spinae (CES) muscles might be a significant criteria of neuromuscular impairment and function. Additionally, the active cervical range of motion (ROM) is frequently used for discriminating between individuals with pain and those who are asymptomatic. The purpose of the present study was to examine the relationship between the active cervical ROM and the FR ratio in a sample of regular visual display terminal (VDT) workers. In total, 20 asymptomatic male VDT workers were recruited. Active cervical ROM was measured by a cervical ROM (CROM) instrument. Surface electromyography (EMG) was used to collect myoelectrical signals from the CES muscles, and the FR ratio was calculated for statistical analysis. Pearson correlation coefficients were used to quantify the linear relationship between the active cervical ROM and the FR ratio. The values obtained for the FR ratio in the right CES muscles correlated significantly with the active cervical ROM measured in flexion (r = 0.73, p < 0.01), left lateral flexion (r = 0.64, p < 0.01), and left rotation (r = 0.60, p < 0.01). Flexion (r = 0.74, p < 0.01) and right lateral flexion (r = 0.61, p < 0.01) positively correlated with the left FR ratio. Extension and right rotation showed either a very weak or no correlation with the mean value of the right and left FR ratio. Our findings suggested that the cervical FR ratio had a positive correlation with cervical movements, and that changes of the activation patterns in CES demonstrated as cervical FR ratio are associated with reduction of the cervical range of motion including flexion and lateral flexion. In addition, muscular dysfunction of the CES could occur in regular computer workers prior to occurrence of pain; this means that the FR ratio could be used to evaluate the potential risk of neck discomfort in computer workers. J Physiol Anthropol 30(5): 203–207, 2011 http://www.jstage.jst.go.jp/browse/jpa2 [DOI: 10.2114/jpa2.30.203]

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Introduction

A high prevalence and incidence of neck and shoulder pain is present in the working population, especially sedentary workers (Braun, 1991; NIOSH, 1997). According to the NIOSH report, working groups with high levels of static contraction, prolonged static loads, or extreme working postures involving the neck/shoulder muscles are exposed to an increased risk for neck/shoulder musculoskeletal disorders (NIOSH, 1997). Although various factors are related to neck and shoulder pain, representative causes include reduced range of movement and abnormal activation patterns of para-cervical muscles (Szeto et al., 2005a; Yoo and An, 2009). During computer work, the cervical erector spinae (CES) muscle is important for efficient activation and support for the task being performed (Szeto et al., 2005a). Johnston et al. (2008) also reported that pain-related activation of the CES muscles could not be relaxed, even after the arm task. Therefore, CES is one of the cases of frequently damaged musculature due to abnormal posture such as maintaining a forward head.

The flexion–relaxation (FR) phenomenon, a normal pattern in muscle activation, originates from the lumbar region and is defined as an electrical silence response in the erector spinae muscles during a full forward-bending trunk posture (Floyd and Silver, 1951). The causes of this phenomenon were seen as transferring extensor moment from superficial erector spinae to passive paraspinal structures or deep muscle such as quadrates lumborum (Andersson et al., 1996; Colloca and Hinrichs,
Subjects

This study was performed on 20 asymptomatic male VDT workers aged 23.6±2.0 years (mean±SD); their heights and weights were 173±1.3 cm and 71.5±5.2 kg, respectively. Their usual VDT working hours were 6.5±1.7 h/d. The inclusion criterion was regular VDT workers who used the computer in a seated posture during their work hours. The exclusion criterion was a history of upper or lower extremity injuries/diseases that could affect VDT work. All participants provided written informed consent according to a protocol approved by Inje University Faculty of Health Science Human Ethics Committee.

Methods

Set-up and measurement

The ROM in the neck area was measured using a cervical ROM (CROM) instrument (Performance Attainment Associates, St. Paul, MN). The CROM instrument was able to measure the sagittal, coronal, and transverse ROM movements performed by the cervical spine, and included two inclinometers and one compass goniometer (Fig. 1). Two inclinometers measured flexion-extension in the sagittal plane and lateral flexion in the coronal plane. The compass goniometer measured the rotational movements in the transverse plane, which was connected with magnetic fittings. Using a patented mainframe, which was positioned according to the nose bridge and the ears, the CROM instrument eliminated location errors, initial head position errors, and tracking errors. The CROM instrument was positioned using anatomical landmarks with the inclinometers zeroed to the instrument frame, thus eliminating initial head position and location errors. It positioned easily and securely, like a pair of sunglasses.

Each participant was asked to sit on a standard chair with a backrest and maintain a neutral spinal alignment as perceived by the experienced physiotherapist. This posture was defined as anterior rotation of pelvis for a neutral lumbar lordosis and relaxation of thorax with an upright head posture. With participants in this erect sitting posture, the active cervical ROM in the sagittal, coronal, and transverse planes was measured with the CROM instrument. During the measurement, the trunk was fixed in an initial posture ensured by the therapist, and each subject was asked to move the head until the feeling of muscle tightness or pain occurred. Three trials were performed with 60-s intervals between the tests. The trial which included the substitute motion in the trunk was excluded and re-tested.
After measuring the cervical active ROM, electromyographic (EMG) data were obtained for analyzing the FR ratio. EMG data were obtained by using a BIOPAC system (MP150 acquisition system unit, Acknowledge™ software and surface EMG electrodes). EMG signals were amplified, band-pass filtered through 10–500 Hz, and sampled at 1000 Hz. The skin was prepared for EMG measurement by cleaning the electrode site with alcohol, shaving it, and lightly abrading the skin with fine sandpaper. Surface electrodes were placed on both sides of the CES muscles, 2 cm lateral to the C4 spinous process (Murphy et al., 2010).

To measure the FR ratio, subjects were asked to perform a standardized cervical flexion-extension movement in three phases: (1) flexion phase, complete cervical flexion for 5 s, (2) relaxation phase, static period in complete cervical flexion held for 5 s, and (3) extension phase, extension to return to the initial position for 5 s. Each subject was asked to bend his head slowly, approximating his chin to the manubrium, and then to maintain this position until asked to return to a neutral position. Durations of the three phases were controlled by a sound signal generated from a metronome. Three trials of the experiment were conducted with 60-s intervals, and each subject was given 5 min of practice time for acclimatizing to the movement and speed before the measurement. The FR ratio was calculated by dividing the maximal muscle activation during the 5 s of re-extension phase by average activation during the 5 s of relaxation phase (Fig. 2). Both measured values of the active cervical ROMs and FR ratios through the three trials in each test were calculated as mean values for statistical analysis.

Statistical analyses
To quantify the statistical linear relationship between the active cervical ROM measurements and the cervical FR ratio, Pearson correlation coefficients were used. An a priori α level was set at 0.01 for the determination of statistical significance.

Results
The average values of the active cervical ROM were 59.2 ± 12.9° for flexion, 68.4 ± 8.0° for extension, 42.7 ± 8.0° for right lateral flexion, 46.6 ± 10.1° for left lateral flexion, 64.5 ± 10.3° for right rotation, and 69.3 ± 7.9° for left rotation. The FR ratios of each cervical area were 2.60 ± 1.11 for the right side and 2.54 ± 1.08 for the left (Table 1). The FR ratios in the right CES muscles were significantly correlated with the active cervical ROM measured in flexion (r = 0.73, p < 0.01), left lateral flexion (r = 0.64, p < 0.01), and left rotation (r = 0.60, p < 0.01; Table 2). Flexion (r = 0.74, p < 0.01) and right lateral flexion (r = 0.61, p < 0.01) positively correlated with the left FR ratio (Table 3). Extension and right rotation showed either a very weak or no correlation with the mean value of the right and left FR ratios (Tables 2, 3).

Discussion
This study compared the FR ratio of both sides of the CES muscles with the active cervical ROM in a sample of asymptomatic regular computer workers. Because the goal of the present study was to investigate the relationship between FR ratio in CES muscles and active cervical movements, we could not include symptomatic subjects where there was the
possibility of muscular dysfunction with upper trapezius or soft tissue degeneration. Youdas et al. (1992) investigated that normal range of cervical motion in 337 asymptomatic participants. Our result of the cervical ROM shows little difference from that of the previous work, considering age and gender and including the normal range of each of active cervical ROM.

According to previous work, Blater and Bongers (2002) have suggested that duration of computer usage of more than 6 h per day was highly associated with musculoskeletal symptoms including the limitation of range of motion. Although subjects were recruited as asymptomatic participants, therefore, we expected that they had potential risk for musculoskeletal dysfunction, considering their usual work hours. It was not possible to assess these potential factors by estimating the FR phenomenon, because the FR phenomenon is shown as qualitative criteria represented as presence or absence. Instead, the FR ratio could be expressed as a numerical value and become a sensitive marker for measuring neuromuscular changes associated with even mild discomfort (Murphy et al., 2010).

The data support the notion that the ratio obtained by dividing the maximal muscle activation during the re-extension phase by activation during the relaxation phase was associated with the cervical active ROM. The magnitude of neck flexion positively correlated with both sides of the FR ratio. Despite use of a different part of the human body, this is consistent with a previous study showing that the FR ratio was significantly correlated with pain-related fear and active flexion movements in the lumbar region (Alschuler et al., 2009; Mayer et al., 2009). Interestingly, our results showed a positive relationship between each side of the FR ratio and the opposite side of lateral flexion. A possible explanation is the absence of a relaxation response in the contralateral CES muscles during lateral flexion. However, the cause cannot be determined, likely because our protocol did not include a procedure for measuring muscle activation during CROM instrument measurements or a normalization procedure for muscle activation. The right FR ratio was positively correlated with cervical rotation in the contralateral direction. However, this phenomenon did not occur on the left side of the FR ratio.

Although lateral flexion and rotation movement were closely associated in the cervical area (Bogduk and Mercer, 2000), cervical rotation occurred in a wider region in the cervical spine than did lateral flexion and required combined activity between the musculature of the ipsilateral and contralateral sides (Kendall et al., 2005). We believe that the subjects participating in the present study were all right-handed, which also influenced the directional difference in the FR ratio.

Palasse et al. (2009) determined the index in the presence or absence of a cervical FR phenomenon as the value of the FR ratio, which is more than 40%, indicating a value of 2.5. Our study showed a conflicting result compared with this study because the mean value of the FR ratio was 2.60±1.11 for the right and 2.54±1.08 for the left. Using the index from previous work, our result showed that 12 of the 20 participants had an absence of the FR phenomenon. We believe that the features of the experimental group (the regular VDT workers) might have influenced our results. Prolonged computer tasks require a static posture of the upper body, and the musculature of the cervical area becomes overloaded from supporting the head (Minga et al., 2004). Although subjects were in the pain-free population, participants may develop increased muscular tension and habitually shortened muscle length on a daily basis, which might be the cause of averagely decreased FR ratios, compared with previous work.

This is the first study to investigate the relationship between the cervical FR ratio and the active cervical ROM in computer workers. Our findings suggest that changes of the activation patterns in CES demonstrated as cervical FR ratio are associated with reduction of the cervical range of motion including flexion and lateral flexion. Although the correlation coefficients are not sufficiently high, this is because the nature of our participants was that of a pain-free population. We believe that this correlation would be represented more obviously within a symptomatic population. In considering the result of the FR ratios obtained from the subjects, we expected that muscular dysfunction of the CES could occur in computer workers prior to occurrence of pain, which means the FR ratio could be used to evaluate the potential risk of neck discomfort in computer workers.

However, the present study had certain limitations to be considered in future research. Our results cannot be generalized because of the small number of subjects, and we did not include measurements of trapezius muscle activity, which could play a significant role in the assessment of the cervical area (Sommerich et al., 2000). Future research should consider these limitations and proceed as composite studies, assessing the trapezius to more objectively examine the relationship between active cervical ROM and muscular dysfunction.

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