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Acute effect of full time office work in real environment on postural actions and lumbar range of motion

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ABSTRACT

Introduction: Prolonged sitting is often proposed as a risk factor for low back pain development. The purpose of this study was to evaluate the acute effect of full time office work on sensorimotor trunk functions.

Methods: Seventeen healthy office workers participated in the study. Maximal lumbar flexion range of motion, anticipatory postural adjustments and postural reflex reactions were tested before and after full time office work in a real life environment.

Results: There were longer onset latencies of postural reflexive reactions and decreased response amplitudes of anticipatory postural adjustments after full time office work, but these were significant only for the obliquus externus abdominis muscle. No changes in lumbar range of motion was found.

Conclusion: To our knowledge this is the first study that evaluates the effect of full time office work on postural actions and lumbar RoM. We found an absence of normal human circadian flexibility in the lumbar spine and some changes in postural actions. We propose that active trunk stiffness increase to compensate for decreased passive stiffness after prolonged seated work. Further studies are needed to confirm this assumption.

1. Introduction

The prevalence of low back pain (LBP) in western society is high. Epidemiological studies show that every day between 12 and 33% of the adult population suffers from LBP, while the lifetime prevalence is up to 84% (Walker, 2000). Although the condition is not life threatening, it has detrimental effects on the perceived quality of life, especially if the pain is chronic. Moreover, it presents a considerable social and economic burden (Hemmila, 2002). While the etiology of LBP is very complex and multi-factorial, the majority of professionals agree that biomechanical factors play a crucial role.

In occupational studies, special attention is given to prolonged and repeated trunk flexion. There is a growing body of studies focusing on sitting exposures, since sitting is a very common working position in modern jobs. Even when sitting upright, the lumbar spine is in semi-flexed position (Endo et al., 2012). Prolonged (non)occupational sitting is often proposed as a risk factor for LBP development. Although the majority of epidemiological studies do not support a causal relationship (Chen et al., 2009; Kwon et al., 2011; Roffey et al., 2010), prolonged sitting is a common aggravating factor for LBP sufferers (Astfalck et al., 2010; O'Keeffe et al., 2013; O'Sullivan et al., 2010). Furthermore, several potentially harmful mechanisms of prolonged sitting with (semi)flexion of the lumbar spine have been studied extensively over the past decades.

Following trunk flexion, creep deformation of the intervertebral discs (Adams et al., 1996) and posterior ligaments (McGill and Brown, 1992), results in decreased passive stiffness of the spine. The magnitude of the effects depends on duration of exposure (and rest), type of loading (creep loading or stress-relaxation, static or cyclic loading), load magnitude (e.g. flexion angle, flexion rate, external load), temperature and ligamentous material characteristics (Solomonow, 2009).

In parallel with creep deformation, several alternations in neuromuscular control were found. Sánchez-Zuriaga et al. (2010) showed, that one hour of supported sitting with 70% of lumbar flexion induces significantly longer latencies of postural reflex reactions in some paraspinal muscles. Moreover, there is a gain in the amplitudes of reflexive reactions, which increases with flexion angle exposure (Bazrgari et al., 2011; Hendershot et al., 2011). It was also shown that creep deformation of the viscoelastic tissues results in an acutely compromised kinesthetic sense of the trunk (Dolan and Green, 2006) and balance in sitting on an unstable surface (Hendershot et al., 2013).

The previously discussed studies used relatively short-term exposure

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to (semi) flexion of the lumbar spine. To our knowledge, there are no studies where long-term exposure, e.g. several hours, has been examined. The aim of our study was to assess the effect of full time office work in a real environment on sensorimotor trunk functions. Studies shows that office workers often slouch their backs while working (Mork and Westgaard, 2009; Morl and Bradl, 2013). According to a study by Morl and Bradl (2013), office workers sit around 30% of their working time with their lumbar spine near full flexion, which may induce creep of the passive tissues. Thus, we hypothesized that full time office work induces an increase in lumbar flexion range of motion due to creep deformation and alternations in postural actions.

2. Methods

2.1. Participants

Seventeen (9 males and 8 female; 42.2 ± 9.4 years, 176 ± 8 cm, 76.5 ± 14.5 kg) healthy office workers (Port of Koper, Slovenia) volunteered for the study. Inclusion criteria was absence of LBP episode during the past 12 months (VAS > 3) and minimum 3 years at the current workplace. The study was conducted in line with Helsinki declaration and Oviedo Convention - approved by the National Medical Ethics Committee (approval number: SI-107/01112). All participants signed an informed consent statement prior to the experiment.

2.2. Study design

Each participant was tested two times in the same day - prior to and after his/her working time. Participants underwent a short warm up (20 times alternating (i.e., left–right) high knee lifts, 20 times alternating single leg dead lifts without additional weight, 10 squats, and 10 inclined pushups) prior testing sessions. Measurement devices were positioned on standardized body locations for both visits. In this report we are focusing on the following datasets: (i) lumbar flexion range of motion (RoM), trunk muscle responses (ii) of anticipatory postural adjustments (APA) and (iii) of postural reflexive reactions (PRR).

2.3. Measurement devices

All measurements were carried out using a custom developed diagnostic system (TNC system by S2P, Science to Practice, Ltd., Ljubljana, Slovenia). Among other sub-components the TNC system includes: (i) axial inertial measurement units (IMU) for RoM measurements, (ii) unit for quick arm rise with electromyography (EMG) for APAs measurement and (iii) unit for sudden arm loading with EMG for PRRs measurement. EMG signals were 1500-times amplified (INA121UA, Texas Instruments, USA; input resistance 1 TΩ) and captured via an analog-digital card (NI USB-6343, National Instruments Inc., Texas, USA) with a frequency of 4000 Hz. An anti-aliasing analog filter was implemented using a low-pass filter with a bandwidth of 1 kHz. Signal acquisition and processing was done by custom software (Labview, National Instruments Inc., Texas, USA). All signals were displayed in real time and stored in a personal computer for further analysis.

2.4. Measurement of lumbar RoM

For maximal lumbar flexion RoM measurement IMUs were attached with tape to the pre-degreased skin over the sacrum (S1) and the first lumbar vertebrae (L1). The starting position was a normal upright posture. A researcher than guided the participant to maximal flex the torso and neck (Fig. 1a) for 2–3 s and then return back to normal upright position (3 repetitions were performed).

2.5. Measurement of postural actions

We measured muscle activation using the bipolar setup of surface EMG pairs of electrodes (2r = 10 mm, center-to-center distance = 20 mm, zinc cup electrodes filled with Ten20 conductive paste (Weaver & Company, USA)). A pair of electrodes were embedded in a thin plastic plate enabling good fixation to the body using two-sided adhesive tape. After skin preparation (shaving and cleaning with alcohol), the electrodes were placed on the left side of the body over the multifidus muscles at level L5 (note that EMG signal might also be attributed to longissimus muscle (Stokes et al., 2003)), erector spinae at level L1, obliquus externus abdominis, obliquus internus abdominis, and deltoideus muscles as in previous studies (for details see: Cholewicki et al., 2005; Radebold et al., 2000; Voglar and Sarabon, 2014); summing up to 5 pairs of EMG electrodes in total. An 5 × 5 cm square self-adhesive electrode (STIMEX, Pierenkemper GmbH, Wetzlar, Germany) was placed over the great femur trochanter as the ground electrode. To prevent mechanical artefacts in the EMG signals, electrodes and cables were additionally fixed to the skin using stick tape and elastic nets.

APAs were measured during the quick arm rise maneuver in standing position (Fig. 1b). The participant stood relaxed with feet parallel at hip width and holding a stick (300 g) in his/her hands positioned relaxed in front of the hips. The participant was asked to quickly rise his/her hands (90° shoulders flexion) following a sound signal that appeared at random timing (8–12 s). Two sets of 10 repetitions (1-min rest between sets) were performed (Voglar and Sarabon, 2014).

PRRs were measured using sudden unexpected loading applied to the participant's hands (Fig. 1c). Participant stood relaxed with feet parallel at hip width and 90° flexion in elbows, hands facing up and slightly touching the stick. The mechanism randomly (every 8–12 s) released the stick which fell into the participant's hands. An 8-kg (~9.1% body mass) stick for men and 5-kg (~7.8% body mass) for women was used. Two sets of 10 repetitions (1-min rest between sets) were performed (Voglar and Sarabon, 2014).

2.6. Evaluation of data and statistical analysis

For lumbar flexion RoM evaluation, we calculated the spatial orientation of the IMUs and angles between them, using the Madgwick filter (Madgwick, 2010). The difference between data from lumbar angle in relaxed standing position and in maximal flexion of the back was calculated. An average of three repetitions was taken to further statistical analysis.

In case of APAs' and PRRs' analysis, the EMG signals were filtered (Butterworth band-pass, 3–500 Hz, level 2, zero phase shift) and smoothed (moving window root-mean-square, 20-ms window), followed by a linear envelope calculation (Butterworth 10 Hz low-pass filter, level 2, zero phase shift) (for details see: Voglar and Sarabon, 2014). The onset of muscle activation was determined on only band-pass filtered signals, using a custom developed algorithm (Panjan, 2015) with the criterion of two standard deviations change in EMG activity (reference 50-ms window prior to the arm movement). Latencies of APAs were calculated as the time difference between the onset of the deltoid muscle's activation and the onset of the individual trunk muscle's activation. The latencies of PRRs were calculated in reference to the time of load release. Additionally, we calculated the average EMG amplitude in the 50-ms window from the muscle's activation onset.

Descriptive statistics were calculated (mean, standard error). Normality was tested using the Shapiro-Wilk test. The pairwise two-tailed *t*-test was applied to test differences between pre work and post work values. Statistical significance was set at $p < .05$.