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Lumbar posture and muscular activity while sitting during office work

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ABSTRACT

Purpose: Field study, cross-sectional study to measure the posture and sEMG of the lumbar spine during office work for a better understanding of the lumbar spine within such conditions.
Scope: There is high incidence of low back pain in office workers. Currently there is little information about lumbar posture and the activity of lumbar muscles during extended office work.
Methods: Thirteen volunteers were examined for around 2 h of their normal office work. Typical tasks were documented and synchronised to a portable long term measuring device for sEMG and posture examination. The correlation of lumbar spine posture and sEMG was tested statistically.
Results: The majority of time spent in office work was sedentary (82%). Only 5% of the measured time was undertaken in erect body position (standing or walking). The sEMG of the lumbar muscles under investigation was task dependent. A strong relation to lumbar spine posture was found within each task. The more the lumbar spine was flexed, the less there was activation of lumbar muscles ($P < .01$). Periods of very low or no activation of lumbar muscles accounted for about 30% of relaxed sitting postures.
Conclusion: Because of very low activation of lumbar muscles while sitting, the load is transmitted by passive structures like ligaments and intervertebral discs. Due to the viscoelasticity of passive structures and low activation of lumbar muscles, the lumbar spine may incline into de-conditioning. This may be a reason for low back pain.

1. Introduction

Office work and sitting at a desk for longer periods is common for people in western civilisation. Orthopaedists and physical therapists assume de-conditioning of the trunk and lumbar spine structures due to long-term sitting without longer active periods of standing, walking or running. This de-conditioning may be a reason for low back pain and accelerated degeneration of lumbar spine structures. Looking at the incidence of low back pain and the inability to work because of low back pain in office workers confirms this assumption (Burdorf et al., 1993; Hemingway et al., 1997; Janwantanakul et al., 2008; Juul-Kristensen and Jensen, 2005; Juul-Kristensen et al., 2004; Riihimäki et al., 1989, 1994; Spyropoulos et al., 2007; Törner et al., 1991; Videman and Battie, 1999). In summary, there is high prevalence of low back pain in office workers with the risk of getting low back pain comparable to more demanding work. However, there is currently little information available about the behaviour of the lumbar spine over long periods because of a lack of adequate measurement devices. In laboratory settings, no coherence of lumbar flexion angle and lumbar muscle activity was found (O'Sullivan et al., 2006; Callaghan and Dunk, 2002). One study documents different movement patterns of the lumbar spine during sitting for low back pain developers and asymptomatic subjects (Dunk and Callaghan, 2010). Only one field study measured global angles of trunk and thighs and correlated these posture measurements to the activation of lumbar muscles (Mork and Westgaard, 2009). They did not show clear correlations ($-.44 < r < .80$) because the measurements used for trunk posture are not precise enough.

The load on lumbar discs while sitting is not to be underestimated and is greater than in erect positions like standing or reclined (Nachemson, 1966). Newer studies support this data on the whole (Wilke et al., 2001). Further, the flexion–relaxation phenomenon is present in flexed postures of the trunk, so there is no active muscular support or stabilisation while resting in such positions (Schultz et al., 1985; Sihvonen et al., 1988). This means activation of the lumbar muscles is not required in such body positions and it would seem that this is comparable to the situation in sedentary work. Most studies on the flexion–relaxation phenomenon only show global angles for trunk inclination. For the lumbar spine, however, it is assumed that the curvature (lordosis, flat or kyphosis) is the main impacting factor on activating the lumbar muscles. There have been no studies providing this information as yet.

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Low back pain patients show atrophy of lumbar muscles (Hadar et al., 1983; Cooper et al., 1992; Hides et al., 1994; Danneels et al., 2000; Barker et al., 2004; de-las Peñas et al., 2008). Since physical inactivity and a lack of activation of muscles are reasons for atrophy (Hayashi et al., 1992; Salminen et al., 1993; Bloomfield, 1997; Hodges et al., 2006; Hides et al., 2007; Hyun et al., 2007; Belavý et al., 2008) de-conditioning or atrophy of lumbar muscles can be assumed due to long periods of sedentary work without active leisure.

Physical changes are not only present in the muscles. Passive structures like ligaments or intervertebral discs are characterised by viscoelasticity. This means that (also low) cyclic but long-lasting loading leads to the creep of discs or ligaments (Solomonow et al., 1998; Adams and Dolan, 1996). The main function of passive structures, which is to guide the kinematics of a joint, decreases because of the decrease in stiffness (Solomonow et al., 1998; Adams and Dolan, 1996). Moreover, ligaments have neural connections to muscles and are mechanical receptors for critical situations (Solomonow et al., 1987; Johansson et al., 1991). Due to the creep of the passive structures, the mechanism that triggers reflexes decreases and finally disappears (Solomonow et al., 1999, 2003). It should be noted that recovery of ligaments takes more than 8 h of total rest (Gedalia et al., 1999).

Both changes (de-conditioning of lumbar muscles and creep of passive structures) may be characterised as detuning of the lumbar spine. For example, an important reflex is triggered too late and within a wrong joint-angle and the adynamic muscle is not able to protect the joint.

With this in mind, the purpose of this paper was to measure the normal behaviour of the lumbar spine during two hours of office work. Healthy subjects were investigated. The lumbar posture and sEMG of lumbar muscles were recorded. As a more precise measure for lumbar posture (than pelvic angle and trunk angle), the curvature of lumbar spine was deduced. The aim of this paper is to investigate the coherence between lumbar curvature and lumbar muscle activity. The results may provide the first impetus for further discussion on whether sedentary work is disadvantageous or unhealthy.

2. Materials and methods

2.1. Subjects and procedure

Thirteen subjects (8 ♀; 5 ♂) were recruited from an insurance company ($n = 4$), a software development company ($n = 2$) and a health care company ($n = 7$). All the subjects were investigated while undertaking their normal sedentary work at a desk (Table 1). Inclusion criteria was no period of acute low back pain during the 12 months before measurement. Exclusion criteria were acute low back pain, acute pain or injury of lower extremities, deformation of the spine and known protrusion or prolapse of an intervertebral disc.

Before work, the subjects were equipped with a small and portable measuring device. At the start of data collection, a calibration procedure lasting approximately 1–2 min was carried out (see Section 2.2).

Table 1
Age, body height, and body weight as mean (standard deviation) for all investigated subjects.

Gender (*n*)	Age (years)	Body height (cm)	Body weight (kg)
Female (8)	36.0 (7.0)	168 (3.2)	61.8 (6.1)
Male (5)	41.2 (11.7)	182 (4.2)	81.2 (8.4)

All the subjects were investigated for a minimum of 2 h. During the measurement, different tasks were manually marked by the researcher and written online to the data file for later identification. The observed tasks were standing, walking, unsupported sitting, supported sitting on backrest of the chair, long-lasting periods of keyboard use and telephoning. Each subject performed each of these tasks at least once, as triggered by the work to be done. The backrest of the chair did not affect the positions of the EMG-electrodes and motion sensors. None of the subjects reported restrictions from the measuring device. All other office-typical tasks and periods in which the subjects could not be viewed by the researcher were summarised using the "miscellaneous" marker (Table 2).

All the subjects were volunteers and gave written informed consent under the terms of the Declaration of Helsinki. The experimental protocol was reviewed and approved by the local ethics commission.

2.2. Measurements

Using the PS11-UD measuring device (Thumedi, Jahnsbach, Germany) the posture of the lumbar spine, the sEMG of selected lumbar muscles and the cardiogram (for identification within EMG signals) were measured synchronously. It is possible to measure and collect bipolar sEMG and posture data for up to 8 h with this device. Lumbar posture was monitored by three gravity-based sensors. The selected lumbar muscles were the longissimus muscle at lumbar level 1 and the multifidus muscle at lumbar level 4 bilaterally.

The motion sensors (size: $24 \times 24 \times 10$ mm) were applied on the lumbar spine at level L5, L3 and L1 using hypoallergenic double-sided adhesive tape. Each motion sensor measures spatial orientation with an accuracy of 0.1° within the field of gravity (e.g. inclination from vertical axis) and is comparable to devices described in the literature (Aminian and Najafi, 2004). The angular difference between the sensors in the sagittal plane was calculated as a measure of the lumbar spine curvature (Mörl and Blickhan, 2006).

Abrasive lotion was used for skin preparation for bipolar sEMG and ECG measurements. Where there was pronounced growth of hair at the application position, the subjects were shaved prior to skin preparation. After this the skin was fumigated and dried. The electrodes used were Ag/AgCl-electrodes (H93SG, Tyco Healthcare, Germany) with a circular uptake area of 10 mm and an inter-electrode distance of 25 mm. The electrode positions of the four investigated muscles were in line with the recommendations of SENIAM (Hermens et al., 1999).

Before data collection a calibration procedure was carried out for identification and elimination of the ECG signal from EMG signals, for spinal posture offset-adjustment and for normalisation of the EMG. The first step of calibration was to measure the raw ECG signal on each EMG channel while the subject sat relaxed and supported by the back of the chair. While occurrence of the ECG signal (detected by ECG channel) during data collection, the device eliminates the main part of crosstalk by subtracting the ECG signal from the sEMG signal for each single EMG channel (Mörl et al., 2010).

The second step of calibration was to eliminate the angular offset for lateral bending and axial rotation of the spine (not discussed in this paper) due to inaccurate sensor application. The normal shape of the lordosis in standing position was not offset-adjusted and was given in normal angular positions.

The golden standard for EMG normalisation are records during maximum voluntary contractions (MVC). These measurements are laborious and depend on the subject's motivation. MVC measurements are nearly impossible at the workplace, especially for lumbar spine muscles. A special normalisation posture was therefore undertaken by the subjects during the third step of the calibration