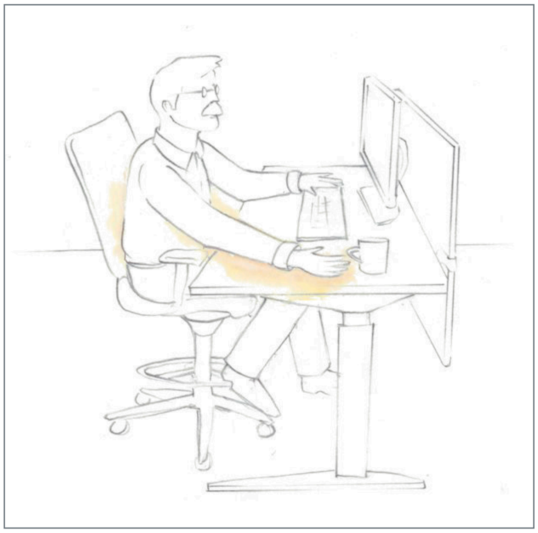

Body movements, postural changes, and load handling activities during the course of a workday impose compressive stresses on the spine's intervertebral discs. When these stresses become too great, the discs lose fluid, causing them to shrink. The result of this shrinkage is loss of body height and flexibility. Several studies have investigated the effect of body posture on spinal loading with one reporting that subjects showed 40 to 175 percent greater disc pressures while seated, compared to standing. This paper reports the results of a study that investigated the effect of sit-stand schedules on spinal shrinkage in office employees working on video display terminals. A user-adjustable sit-stand workstation was utilized to implement two different sit-stand schedules. Findings revealed that all video display terminal operators with sit-stand workstations experienced gradual spinal shrinkage throughout the workday but those who stood up for longer, infrequent breaks reduced spinal shrinkage as compared to standing for frequent, shorter breaks.

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Effects of Sit-Stand Schedule on Spinal Shrinkage in VDT Operators

by: Rajendra D. Paul and Martin G. Helander, Ph.D.

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Body movements, postural changes, and load handling activities during the course of a workday impose compressive stresses on the intervertebral discs. When the compressive stresses become greater than the interstitial osmotic pressure of the disc, fluid flows out of the disc until a new equilibrium between the two opposing pressures is established. Loss of fluid makes the discs shrink (Adams and Hutton, 1983) and overall stature is reduced by about 1 percent diurnally (Tyrell et. al., 1985). Reduction in stature is a reliable measure of spinal compression since almost all the body height loss during the day is due to gradual spinal compression (Forssberg, 1899 cited in Eklund, 1986). Several studies have investigated the effect of body posture on spinal loading (Nachemson and Elfstrom, 1970; Andersson and Ortengren, 1974; Nachemson, 1975; Occhipinti et. al., 1985). Nachemson (1975) reported 40 to 175 percent greater disc pressures in various sitting postures, compared to standing erect. The other studies noted several factors that reduce compressive stresses in the lower back, such as a reclined torso with a greater hip joint angle, the use of a lumbar support, and support for the upper limbs.

Helander and Quance (1990) investigated the effect of different standing rest schedules on spinal shrinkage. During a four-hour session, subjects sat and typed for a total of three hours and 20 minutes and took rest breaks for the remaining 40 minutes. During the rest breaks, subjects either walked or stood up. The four rest break conditions were eight equidistant breaks of 5 minutes, four breaks of 10 minutes, two breaks of 20 minutes, and a single break of 40 minutes at the end of the work session. After the four-hour session, the longer but fewer standing rest breaks, i.e. 20 and 40 minutes, caused significantly less shrinkage than shorter but frequent breaks.

In a study on sit-stand work, Michel and Helander (1994) compared spinal shrinkage with sit-stand and conventional chairs in subjects with and without back problems. The study found that use of a sit-stand chair for VDT work produced less height loss than a conventional chair. The subjects with herniated discs lost more height than subjects with healthy discs. Also a positive correlation between height loss and age was observed with the sit-stand chair.

The objective of this study was to investigate the effect of sit-stand schedules on spinal shrinkage in office employees working on VDTs. A user-adjustable sit-stand workstation was used to implement two different sit-stand schedules.

EXPERIMENTAL METHOD

Subjects

Thirteen VDT operators, ten healthy and three unhealthy, participated in this study. The unhealthy subjects were medically diagnosed with spinal disorders. Two had herniated discs and one had scoliosis. The demographic characteristics of the subjects are shown in Table 1. The subjects used computers to carry out their job duties.

Apparatus

The changes in stature were measured using a stadiometer developed at the University of Nottingham (Corlett and Eklund, 1986) and used by Helander and Quance (1990), Michael and Helander (1994), and Paul and Helander (1995). This device can constrain a standing posture so that it can be reproduced fairly consistently for measurement of height. The apparatus uses a linear transducer and is sensitive enough to detect 0.1mm change in stature. Stature is measured between the plantar aspect of the feet and a marked spot on the cranial vertex. The procedure described in Helander and Quance (1990) was followed.

Table 1. Average values and standard deviations of demographic characteristics of test subjects.

Group	Age (years)	Height (cm)	Weight (kg)
1. Healthy:			
a. 30 minute Sessions	36.50 (7.9)	172.9 (10.7)	67.9 (8.8)
b. 15 minute Sessions	31.75 (3.9)	164.5 (11.6)	65.5 (14.9)
2. Unhealthy 15 minute	48.00 (12.1)	164.6 (8.0)	68.2 (12.4)

Foreman and Linge (1989) found that soft tissue under the heels flattens under the body weight and recommended that a subject should stand for at least two minutes on the stadiometer platform before recording stature measurements. In this study, the subjects stood on the stadiometer platform for two minutes before the first reading was taken. Also, each reading was replicated six times to assure reliable results.

Tyrell et al. (1985) noted that the rate of spinal shrinkage is very high soon after rising in the morning, and about 50 percent of the shrinkage occurs during the first hour after waking. Consequently, it is crucial to record the stature of all subjects at the same time after rising. This field study was intended to reflect a real-life-working situation. Subjects were instructed to awake 90 minutes prior to the first reading. Most previous studies recorded stature 60 minutes after rising. Consequently, the results of this study were expected to show less differences than previous laboratory experiments.

Procedure

Subjects reported to work 90 minutes after waking. They had a light breakfast at home. They were instructed not to sit except for driving to work. During the drive, they were instructed to recline by 20 to 30 degrees from the upright position to reduce spinal loading. They were also instructed to enter the workplace through the same entrance since one of the two entrances was preceded by a few climbing steps. At 8:00 a.m., their stature was recorded. On the day before testing, each subject was familiarized with the stadiometer. The stadiometer was adjusted for each individual's morphology to reduce measurement time on the test day.

After the first reading, the subjects were instructed to carry out their routine job duties. The subjects with 30-minute stand-up periods were instructed to stand four times during the day at 9:00 a.m., 11:00 a.m., 2:00 p.m., and 4:00 p.m. The subjects with 15-minute stand-up periods were instructed to stand once every hour on the quarter hour, i.e. eight times for 15 minutes. However, two subjects in each group chose schedules offset by 15 minutes to match with their work schedule.

Overall, subjects in both groups stood for a total of two hours. All subjects worked in 2.44 m x 2.44 m offices enclosed by 60 cm high panels. For sitting, they were provided highly adjustable chairs with rolling casters. By rolling the chair, they were free to move around in their offices for retrieving documents and accessing phone and other office tools without standing up.

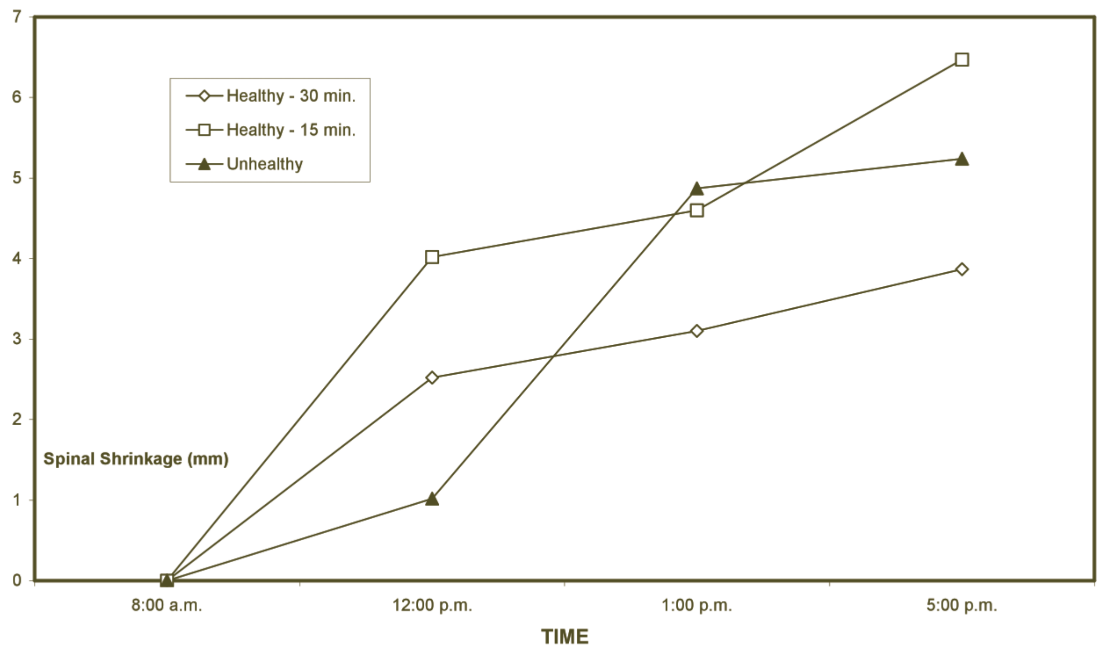
The second set of readings was recorded at 12:00 p.m. From 12:00 p.m. to 1:00 p.m., i.e. the lunch hour, subjects were instructed to sit for 40 minutes and walk for the remaining 20 minutes. The third and fourth sets of readings were recorded immediately after the lunch hour at 1:00 p.m. and at the end of workday at 5:00 p.m. The subjects were allowed one rest break in the morning and another one in the afternoon. During the break, they walked about 30 m to a nearby restroom.

RESULTS

The results are shown in Figure 1. During the morning hours, the spinal shrinkage in healthy VDT operators who stood twice for 30 minutes was 2.52 (1.23) mm compared to 4.02 (1.66) mm in those who stood four times for 15 minutes. By the end of the workday, the cumulative shrinkage was 3.87 (2.27) mm for those who stood for 30 minutes and 6.47 (2.64) mm for those who stood for 15 minutes. Analysis of variance showed that these differences were significant, $p < 0.05$. These results generally agreed with those reported by Michel and Helander (1994). Paul and Helander (1995) reported 6.7 mm shrinkage over a similar nine-hour workday in sedentary VDT operators. Comparatively, the shrinkage with 30-minute sit-stand schedule was significantly less.

The unhealthy operators with spinal disorders experienced much less and statistically insignificant shrinkage during the morning and afternoon hours, 1.02 mm and 0.37 mm respectively. However, during

Figure 1. Spinal shrinkage during the course of a workday



the lunch hour, these subjects recorded significant shrinkage of 3.85 mm. This patter is probably due to the instability of spinal equilibrium in these subjects. Paul and Helander (1995) suggested that in these subjects, the spinal equilibrium could be easily disturbed. Another possible reason is that most of the shrinkage might have occurred during the 90 minutes after waking and before the first reading.

CONCLUSION

The results suggest that:

All VDT operators with sit-stand workstations experienced gradual spinal shrinkage throughout the workday.

Office workers who stood four times in 30 minute sessions experienced significantly less shrinkage than those who stood up eight times in 15 minute sessions. This study and the Helander and Quance (1990) study suggest that longer, infrequent breaks reduce spinal shrinkage as compared to frequent, shorter breaks.

From the study by Michel and Helander (1994), we would have expected that subjects with unhealthy backs would shrink more than those with healthy backs. However, shrinkage is reduced with age, and since subjects with unhealthy discs were on an average 16 years older than those with healthy discs, the data cannot be compared. A greater number of subjects and a stratified selection of subjects are necessary to investigate this variable. Unfortunately, such control is difficult to attain in a naturalistic office setting.

With this study, we have demonstrated that even in a naturalistic setting, without the rigorous control exercised in laboratory research, there are significant differences in the spinal shrinkage due to organization of sitting and standing schedules.

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