Introduction
Sudden movements of the spinal column have been shown to appear during health-care work (Andersen, et al., 2001), and in general it is believed that sudden loading (SL) in work situations may be a risk factor for low back disorders in situations without sufficient spine stability. The spine stability is obtained from both passive and active structures around the back. Among the active structure intra-abdominal pressure (IAP) is suggested to have a stabilising effect on the spine (Cresswell et al., 1994; Radebold et al., 2000). Models are supporting this possibility of IAP (Cholewicki et al., 1999a). However, we do not know whether IAP can be developed fast enough to stabilise the system in a sudden loading situation. The timing of IAP related to the SL is not fully understood. During sudden perturbations it has previously been shown that the M. transversus abdominus is activated prior to other abdominal muscles, and the M. erector spinae (Cresswell et al. 1994). M. transversus abdominus is the prime muscle in the generation of IAP (Cresswell et al., 1992). The aim of this study was to investigate rise in IAP and the timing between IAP and the low back muscles during isolated sudden horizontal loading of the trunk.

Methods
The set-up for creating the SL is constructed as a load (60N) that momentarily can be attached to a wire. The wire is running over a wheel hereby transmitting the gravitational force on the load to a horizontal force applied to the trunk, to avoid a direct effect of the external load on the IAP. The movement of the body is measured by a potentiometer mounted on the wheel. The subject is fixed at the hip to get isolated trunk movements, and to avoid any changes related to maintenance of postural stability (figure 1). After the start of the data sampling nothing happens the first 15 sec, but during the next 15 sec the SL is triggered at a random time. Neither the subject nor the observer knows when the SL is trigged. Eleven subjects attended 10 SL trials each with at least 1 min break between each trial.

Figure 1. Illustration of the sudden loading. Upon release the weight is released from the grey stative, and attached to the black core hanging in the yellow wire, this instantly increases the pull in the wire from 6 N to 60 N.

The surface EMG signals were recorded using pre-gelled Ag/AgCl surface electrodes (720-01-k Medicotest A/S Denmark) on the Erector spinae muscle (ES) at both sides at L3, approximately 3 cm lateral to the spinal column in the middle of the muscle bulb, the External Oblique muscle between the anterior superior iliac spine (ASIS) and the caudal border of the ribcage, and the Internal Oblique muscle at the midpoint between the ASIS and the symphysis pubis. The inter-electrode distance was 3 cm. The raw EMG signals were pre-amplified, low-pass filtered at 450 Hz and sampled with a frequency of 1000 Hz. The recorded data were high-pass filtered with a cut-off of 10 Hz rectified and finally the mean of 10 trials were calculated. IAP was measured with a transducer, inserted into the stomach through the nose.
Onset of muscle activity was determined as the time point where the EMG signals rose to 3 standard deviations above the mean EMG the last second before the loading (Hodges and Bui, 1996; Stokes et al., 2000). All the onsets were checked visually, and if noise had affected the onset estimation, a correction was made.

Results
Example of response from a sudden loading trial is shown in figure 2. EMG signals from external and internal oblique muscles were less than 10% of EMG during a Valsalva Manoeuvre and an estimation of onset in relation to the SL was not possible. The onset of right and left ES was $91 \pm 7.3$ ms and $91 \pm 8.5$ ms after the SL. The onset of IAP was $222 \pm 33.1$ ms after the SL and increased to $13 \pm 4.7$ mmHg. The forward trunk movement were stopped after $391 \pm 91.2$ ms, and the wire moved $4.8 \pm 1.4$ cm.

![Graph of sudden loading trial](image)

Figure 2. Example of sudden loading trial from 200 ms before the sudden loading to 700 ms after. Movement of the wire attached to the upper body, rectified EMG signals of right M. erector spinae, intra-abdominal pressure and the trigger signal are shown. The load was released at 200 ms.

Discussion
Rise in IAP did occur as a consequence of the SL. Both IAP and ES activity were present before the trunk movement ended. The IAP raise could not directly be related to the EMG of the external and internal oblique muscle, probably because M. transversus abdominus is the primary muscle for IAP development. With an electromechanical delay of $125 \pm 28.1$ ms for ES (van Dieen et al., 1991), IAP and back muscle force seems to develop at the same time. In relation to timing it is therefore possible for IAP to stabilise the spine as the back muscles decelerate the trunk movement. The increase in M. erector spinae activity increases the stiffness of the muscle and therefore also the stiffness of the spine (Bergmark, 1989). This is
probably the most important stabilising factor in this system. The final proof of IAP as a spinal stabiliser is still lacking. When people develop the IAP many trunk muscles are involved, and increased activity in the erector spinae muscle is also seen. A stabilising effect of the IAP has been indicated by Cholewicki (Cholewicki et al., 1999b), but in his study the erector spinae muscle activity rose along with the IAP, making it difficult to separate the influence on spine stability from IAP and increased ES muscle stiffness from each other. Faster onset of the IAP has been found (Cresswell et al., 1994), however since SL were applied vertical, and the subject were standing freely with blinded vision, the IAP rise may be related directly to the SL or to the maintenance of postural stability.

**Conclusion**
There seem to be timing between IAP and ES activity during SL enabling IAP to have risen at the time-point, where ES decelerate the trunk. The present study has shown, that IAP is developed fast enough to be present as a spine stabiliser in situations with sudden loading of the spine.

**Reference List**


