Trunk muscle activity and acceleration of the spine during partial-body vibration in sitting position
A single case study

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Figure 1. Experimental setup

Figure 2. Acceleration propagation

Figure 3. EMG response to vibration exposure

Background
Whole-body vibration (WBV) is established in rehabilitation, in physiotherapy and in sports. WBV may potentially stimulate sensorimotor processes [1]. Recent reviews revealed positive effects on muscle force [2], posture control [3], pelvic floor [4], bone density [5] and musculoskeletal complaints [6]. On this account WBV might be important in deconditioned persons such as frailty, patients with musculoskeletal complaints or after stroke, Parkinson’s disease or multiple sclerosis for skilling up. The research focuses on the use of WBV, which is carried out in standing position. But only a few studies examined partial-body vibration (PBV) in sitting position. For this reason a PBV device has been developed for sitting.

Purpose
The aim of this single case study was to evaluate trunk muscle activity and acceleration propagation in sitting position during PBV with different vibration parameters.

Material and Methods
A vibrating plate with three rotational degrees of freedom was used which lets the operator to choose a rotation axis, amplitude (°), frequency (Hz) and the underlying sinusoidal or stochastic nature of the oscillation. Sinusoidal (S-PBV) and stochastic (ST-PBV) with amplitudes from 0.1° to 1° and frequencies from 1 Hz to 12 Hz were applied in anterior-posterior and medial-lateral direction.

Muscle activity (EMG) and acceleration propagation (3-axis accelerometers) during PBV in sitting position in a 26 year old healthy male were examined. EMG was measured for M. erector spinae (ES, left), M. obliquis externus abdominis (OE, left), M. trapezius ascendens (TA, left) and M. trapezius descendens (TD, left). Acceleration was captured on the vibrating plate, on the spinal processes of L4 and C7 and on top of the cranium in medial-lateral (ML), anterior-posterior (AP) and in cranial-caudal (CC) direction (Figure 1).

Vibration exposure was analyzed according to the EU directive 2002/44/EG. EMG data was rectified by calculating maximum voluntary contraction (MVC).

Results
In general, ST-PBV resulted in higher mean accelerations but had smaller peak accelerations compared to S-PBV. The ES showed the highest relative mean activations with 2.9% - 7.3% MVC. AP and ML oscillations determined a slightly higher ES-activation during ST-PBV compared to S-PBV (Figure 3).

Discussion and Conclusions
Decreasing accelerations were observed with increasing distance from the vibrating plate due to damping properties of involved body structures. Higher activation of muscles closer to the vibrating plate, what means muscles with higher acceleration exposure, was found. This effect is plausible from a biomechanical point of view. Nevertheless, the maximum observed vibrations at L4 were relatively intensive. Meaning that the daily dose for whole body vibration according to 2002/44/EG would be exceeded after one minute of vibration exposure. Erector spinae muscles seem to invoke higher muscle activation during ST-PBV compared to S-PBV despite similar acceleration exposure at L4. In fact, we account the ES activation difference to the stochastic nature of the vibration itself. The finding of increased muscle activation due to stochastic vibration exposure is similar to that from other authors [7].

Implications
ST-PBV should be preferred in practice because the stochastic nature itself seems to imply higher muscle activation compared to S-PBV.

References

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Ethics
No ethics approval was necessary, since the study was conducted in form of a self-experiment.

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