Physiological effects of single shocks on the hand-arm system – a randomized experiment

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positive vote of ethics committee
Introduction

• **Exposure:**
  - Shock exposures on the hand-arm system at work and during spare time quite common
  - Definition of single shocks not yet regulated
  - Often combination of vibration and shock

• **Health effect:**
  - Hazardous aspect of single shocks
  - Human/individual factors
  - White finger disease, arthrosis, sensineurological symptoms

• **Cause-effect:**
  - Same hazard for each outcome
  - Workplace safety: filter used in DIN standards

Sources pictures: [www.bauredakteur.de](http://www.bauredakteur.de), [www.dguv.de](http://www.dguv.de)
Aim

• to assess physiological effects (vibration perception and skin temperature) of low-frequency single shocks

• ... in exposure groups with different shock repetition rates

• ... in a control group with a „random signal“, spectrum vibration

• To explore correlation patterns between exposure parameters and outcomes (vibration perception and skin temperature)
Randomized controlled shaker experiment

exposure/control groups:
3 single shock exposure groups (repetition rate: 1 s⁻¹, 4 s⁻¹, 20 s⁻¹),
1 control group (RandomSignal, RS, used for testing quality of anti-vibration gloves),

exposure duration: 20 min, 4 x 5 min sequences, 5th sequence of random vibration

Shaker: Ling Dynamic Systems, V 726, Royston, GB

other factors defining exposure/control
• $a_{h,w} = 10 \text{ m/s}^2$ for all exposures/controls
• $A(8)$ 4 sequences = 1,77 m/s² after 4 x 5 min shock exposure
• $A(8)$ 5 sequences = 2,04 m/s² after additional random signal exposure
Randomized controlled shaker experiment

Body posture:
• Standing
• Right hand grip (all participants right-handed) on vertical aluminum handle
• According to ISO-Norm 10819 for testing of anti-vibration gloves

Transfer of shocks/vibration into the hand-arm system:
• Constant push force (50 N)
• Measurement of grip force

Room temperature/room conditions:
• Mean temperature range 24.4 - 25.6°C
Participants

A priori case number calculation (G-power)

(assumed medium effect size): 48 (12 per group)

Recruited participants:

54 voluntary healthy male participants (working age, non-smoker, no medical condition regarding the vascular, neurological and musculoskeletal system, no relevant medication, no occupational or recreational exposure to single shocks) – 2 participants excluded because of medication

Included participants:

52 (13 per group)

After randomization:

No statistically significant differences between groups regarding age and anthropometric values of the hand-arm-system)
Outcomes

- **Transfer values**
- accelerometer
- Wrist (foveola radialis)
- Elbow (lateral epicondylus)
- Shoulder (acromion)
- Z-direction

- **Vibration perception**
- D2 right/exposed hand
- test frequency of vibrosense: 125 Hz
- Results in dB

- **Skin temperature**
- $\Delta T$ dorsal finger surface
- D2 of the right hand
- three measurement points, mean value

**Fig.:** VibroSense (VSII); vibration perception threshold

**Fig.:** IR-measurement, Flir (i-phone)
Temperature difference before - after
Experimental setup

Randomized participants

- Questionnaire
- Grip force
- Pinch force
- EMG-maneuver

- Transfer factor
  - 1 s⁻¹
  - 4 s⁻¹
  - 20 s⁻¹
  - RS

- Temperature curve (baseline vs. after fourth exposure)

Changes in vibration perception threshold compared to baseline measurement
Transfer factors

Mean transmission

<table>
<thead>
<tr>
<th>Location</th>
<th>1 s⁻¹</th>
<th>4 s⁻¹</th>
<th>20 s⁻¹</th>
<th>Spectrum</th>
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Figure: Vibration perception threshold (after exposure sequence – baseline) in dB; D2 right hand (test frequency 125 Hz); exposure and control groups
Changes in skin temperature

Figure: IR skin temperature (mean values) in °C; dorsal D2 right hand; before and after each exposure sequence, exposure and control groups.
Changes in skin temperature

Figure: IR skin temperature (mean values) in °C; dorsal D2 right hand; before and after each forth exposure sequence, exposure and control groups
Correlations: exposure parameters - outcomes

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Summary/discussion/further thoughts

• **Transmission rate:**
  - Accelerometer vs. impedance
  - Conspicuous in comparison to other shock repetition rates: 4 s⁻¹
  - Random signal: decrease through forearm

• **Vibration perception threshold:**
  - Good practicality, depending on patient cooperation
  - Physiological effects depending on repetition rate, type of exposure
  - Significant effects more likely with increasing dose
  - Increase caused by spectrum vibration the higher, the lower the prior repetition rate – order of different exposures might be of interest

• **IR-Temperature:**
  - Good measurement practicality, digital solutions for mean values beneficial
  - Short term physiological effect depending on repetition rate, type of exposure
  - Significant decrease after 20 min exposure to single shocks, but not after 20 min exposure to vibration exposure – epidemiological evidence for vibration exposure – medium term effects
Some references


Thanks goes to

• participants
• cooperation partners
• sponsors
• practice partners

• and to you for your attention.