HAND ARM VIBRATION

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

Elke Ochsmann, Alexandra Corominas Cishek, Benjamin Ernst, Uwe Kaulbars, Hans Lindell

1) Institut für Arbeitsmedizin, Prävention und betriebliches Gesundheitsmanagement, Universität zu Lübeck, UKSH Campus Lübeck,

2) Bereich Vibration, Institut für Arbeitsschutz der DGUV (IFA) der DGUV, Sankt Augustin,

3) Ingenieurbüro, Bonn

4) Rise Swerea, Mölndal, Schweden

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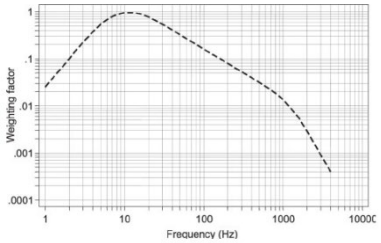
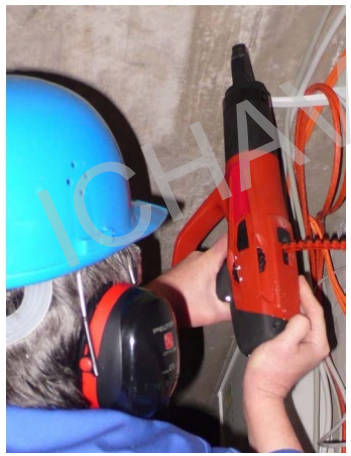
authors declare no conflict of interest
positive vote of ethics committee



Frequency weighting curve W h for hand-transmitted vibration in International Standard ISO 5349-1:2001 4)

Hand axe



bolt setter

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, www.dguv.de

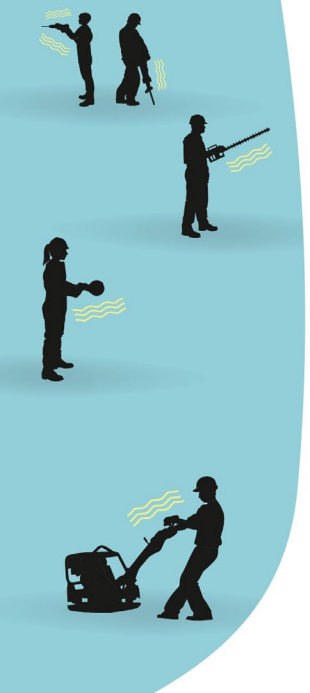
Aim

- 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 oucomes (vibration perception and skin temperature)



Randomized controlled shaker experiment

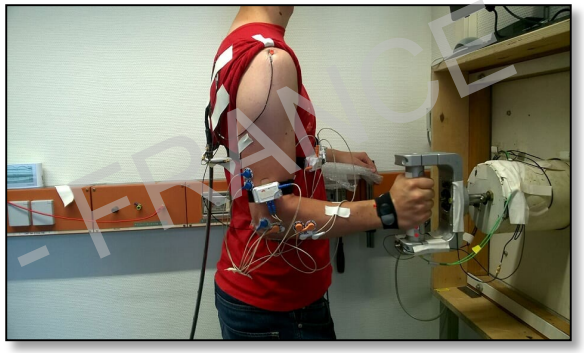


Fig: Shaker (shocks)

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_{hw} = 10 m/s² 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

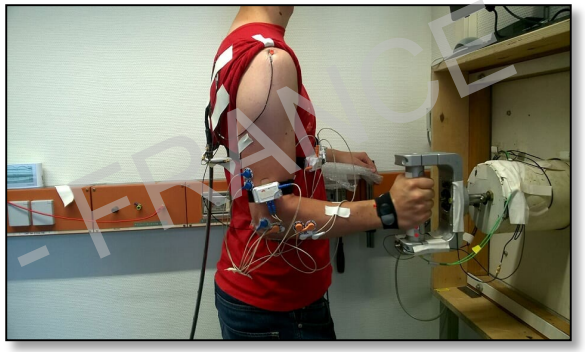


Fig: Shaker (shocks)

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)

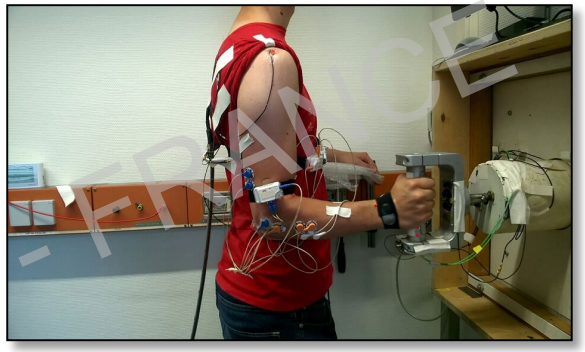


Fig: Shaker (shocks)

Recruited participants:

54 volutary 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 partcipants excluded because of medication

Included participants:

52 (13 per group)

After randomization:

No statistically significant differences between groups regarding age and anthromopetric 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

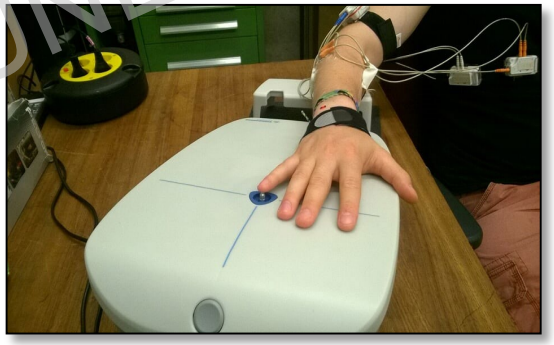


Fig.: VibroSense (VSII); vibration perception threshold

Skin temperature

- ΔT dorsal finger surface
- D2 of the right hand
- three measurement points, mean value

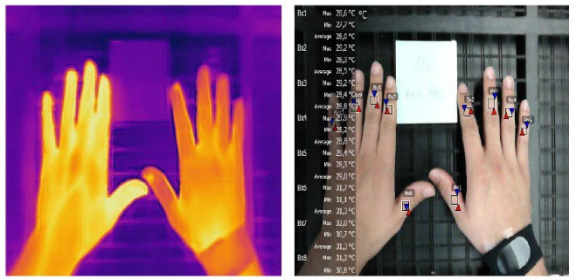
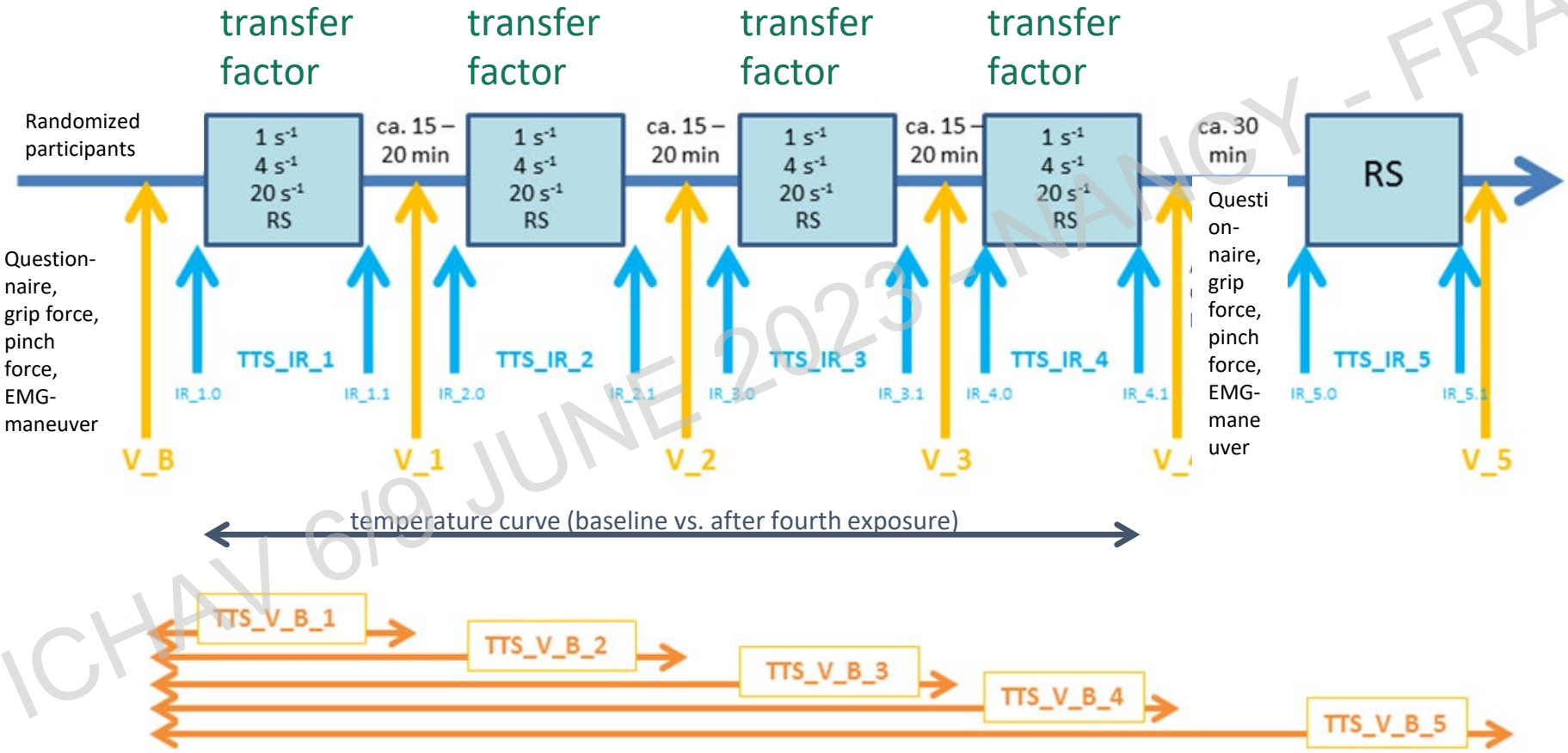


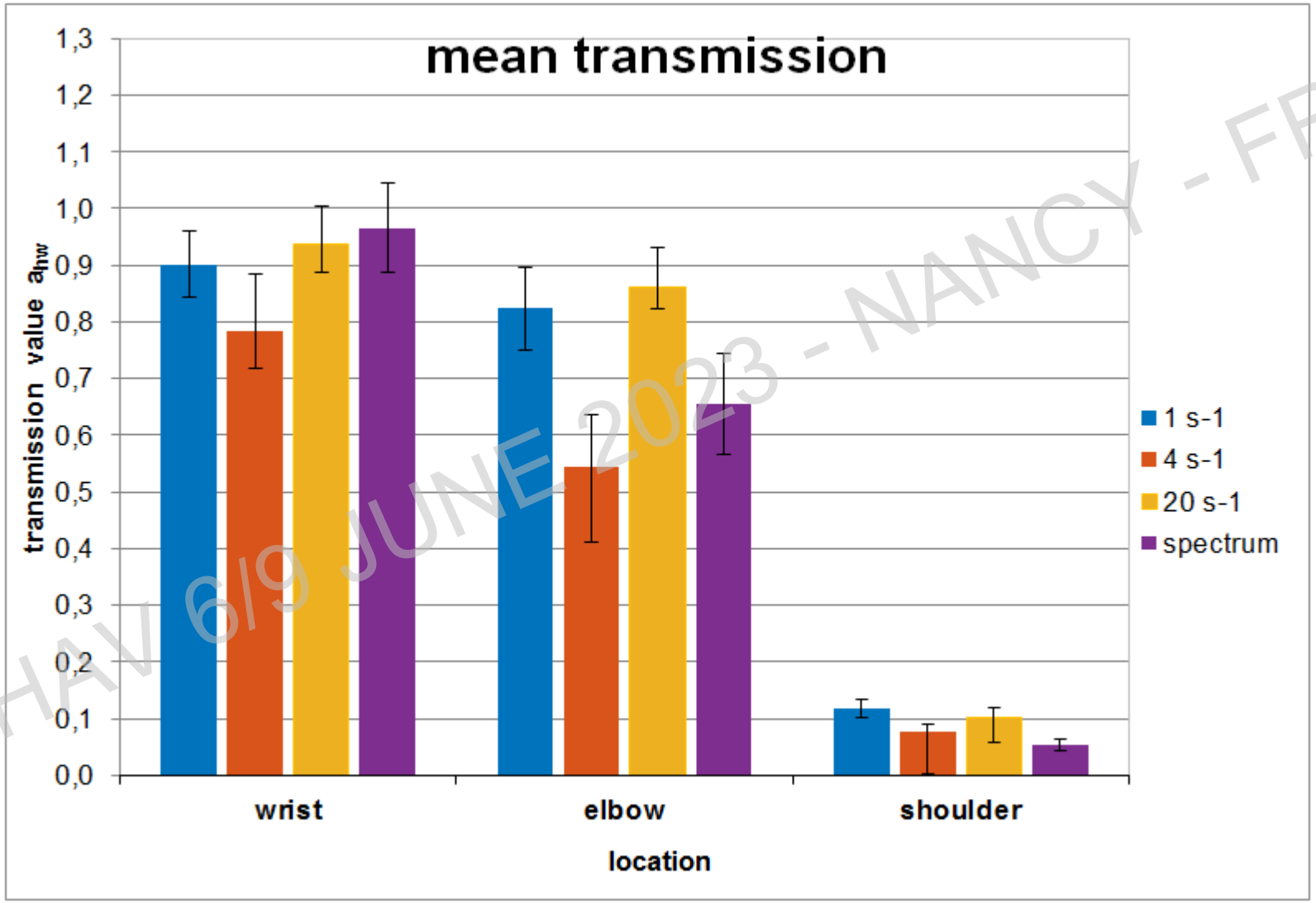
Fig.: IR-measurement, Flir (i-phone) Temperature difference before - after

Experimental setup



Changes in vibration perception threshold compared to baseline measurement

Transfer factors



Vibration perception

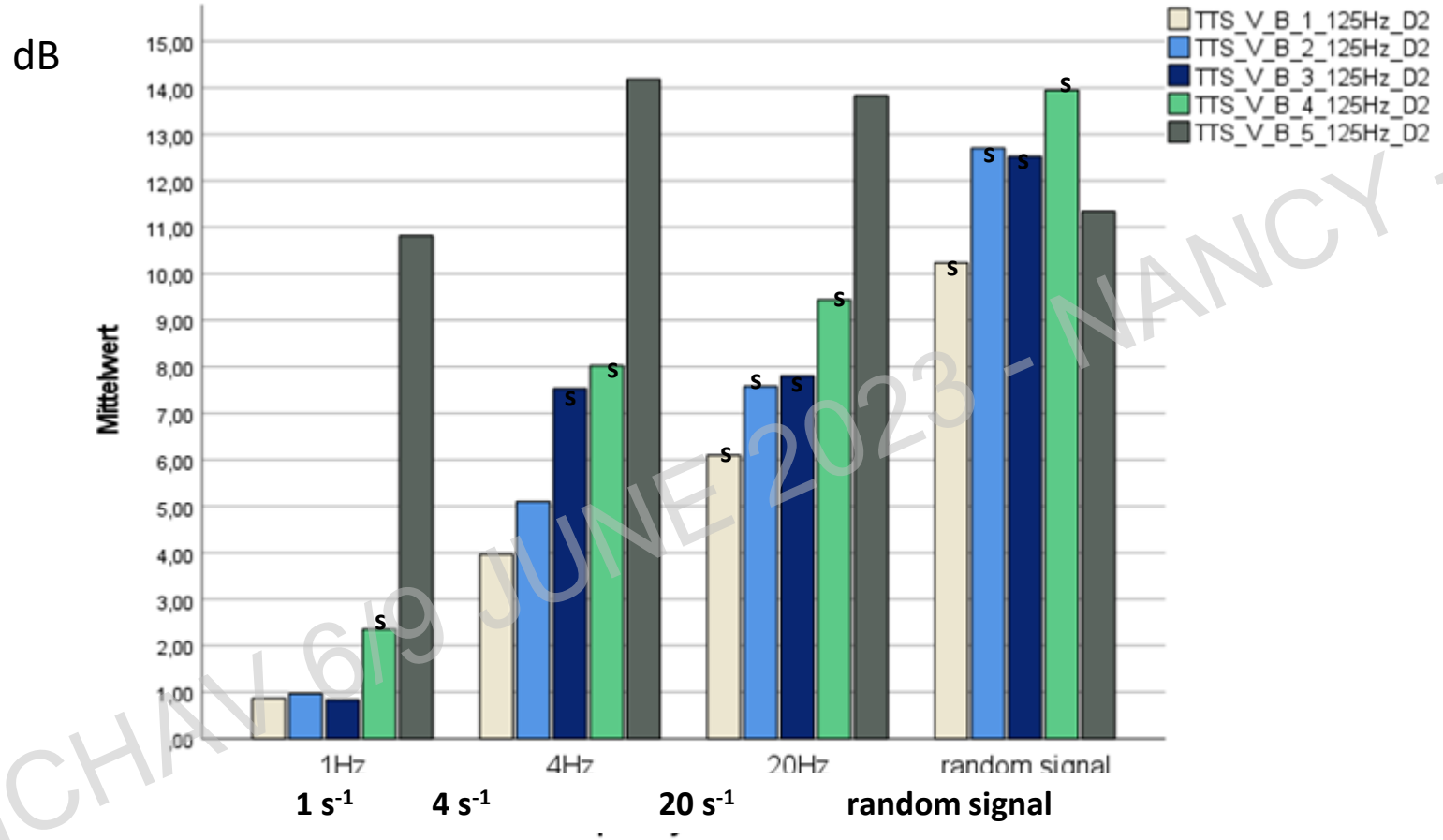


Figure: Vibration perception threshold (after exposure sequence – baseline) in dB; D2 right hand (test frequency 125 Hz); exposure and control groups

Changes in skin temperature

°C

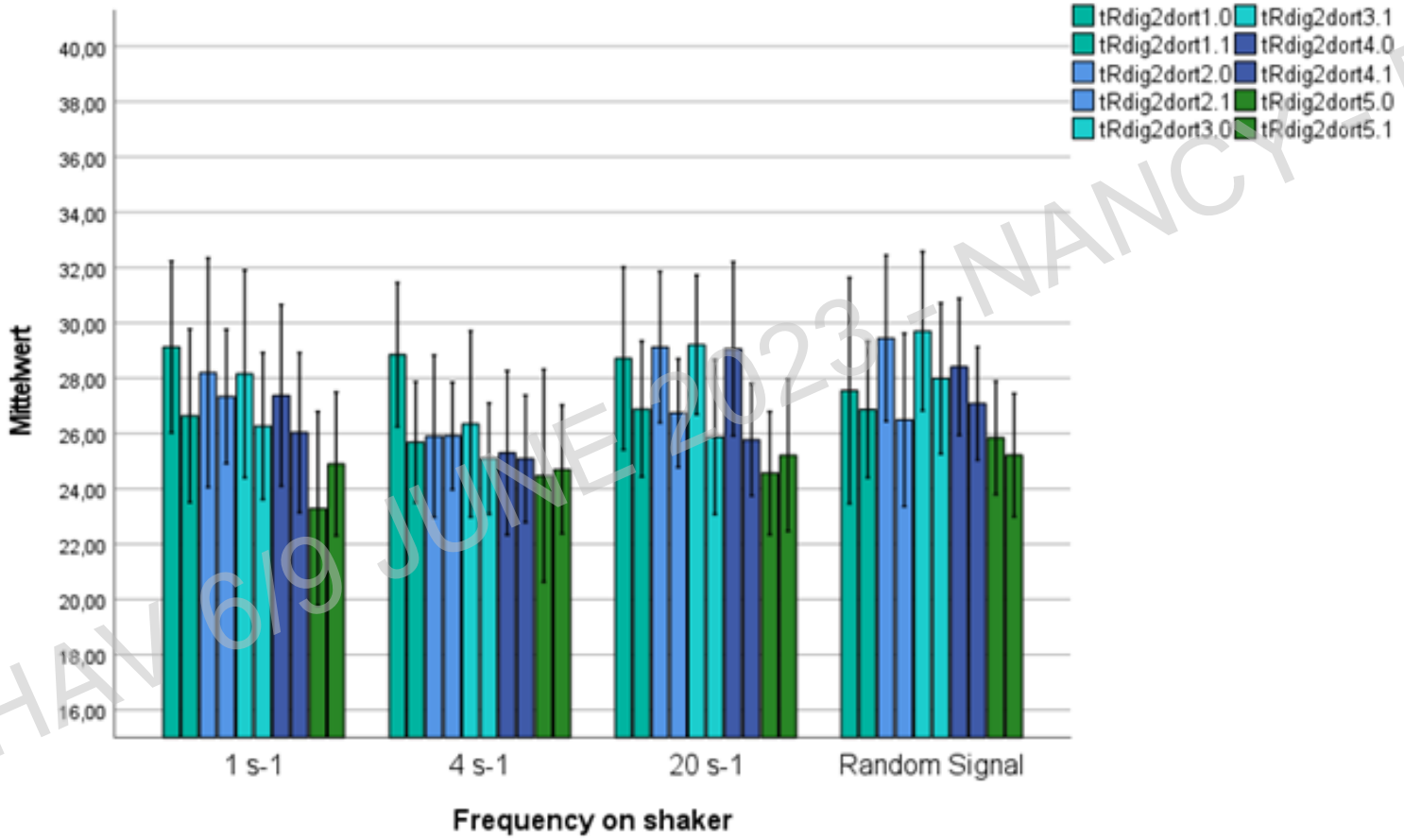


Figure: IR skin temperature (mean values) in °C; dorsal D2 right hand; before and after each exposure sequence, exposure and control groups

Changes in skin temperature

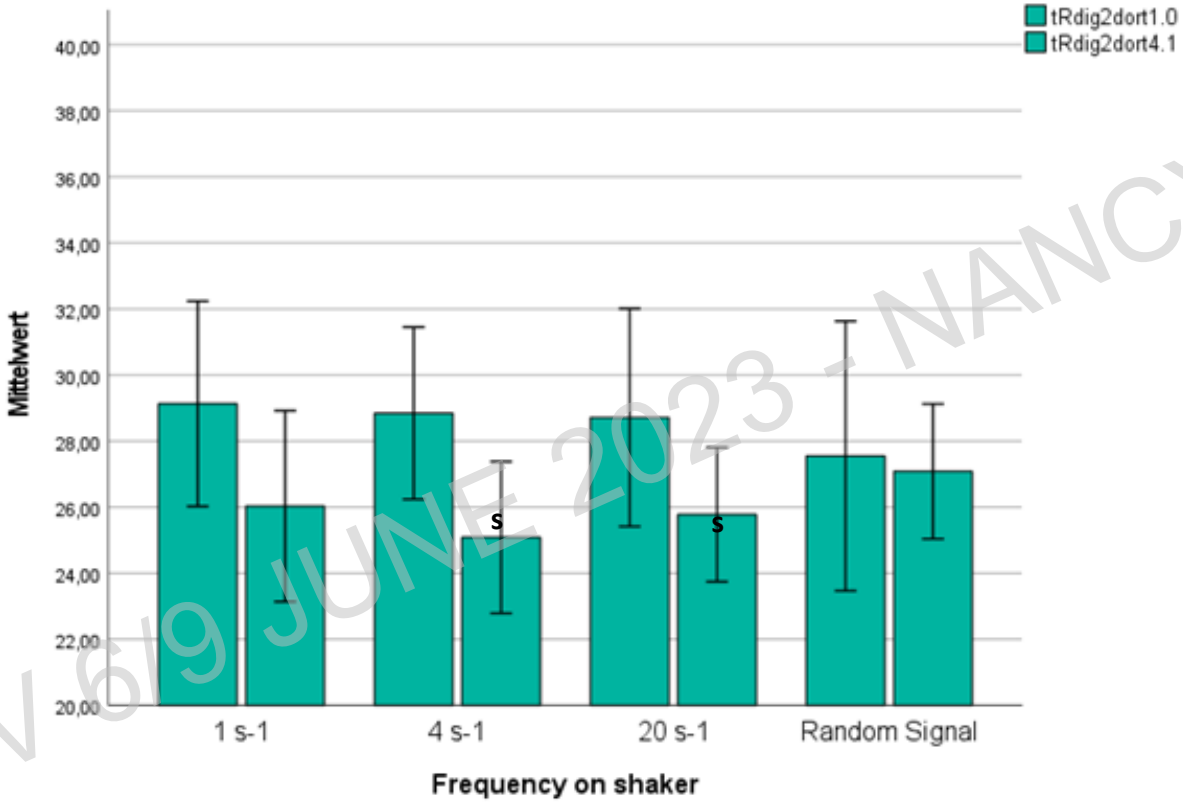


Figure: IR skin temperature (mean values) in °C; dorsal D2 right hand; before and after each forth exposure sequence, exposure and control groups

Correlations: exposure parameters - outcomes

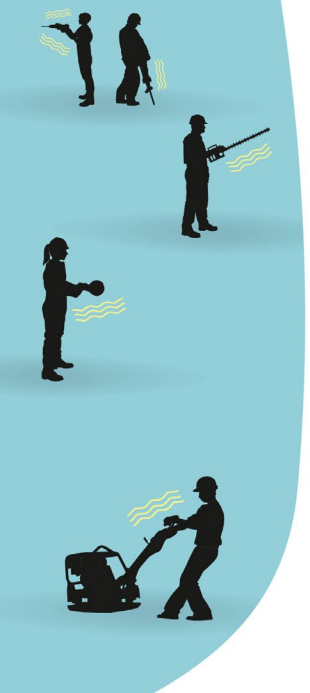
	IR-Temp 1 s^{-1}	IR-Temp 4 s^{-1}	IR-Temp 20 s^{-1}	IR-Temp RS	VPT_1 s^{-1}	VPT_4 s^{-1}	VPT_20 s^{-1}	VPT_RS
impact_1s_flath_rms							x +	
impact_1s_flath_rmq								
impact_1s_wh_rms		x +						
impact_1s_wh_rmq								
impact_3s_flath_rms			x				x +	
impact_3s_flath_rmq			x					
impact_3s_wh_rms		x +						
impact_3s_wh_rmq								
j_hf_rms		x +	x					
sc_h	x					x		
cf_h	x					x		
vsi_1s							x	
vsi_3s							x	
full_wh_rms		x +						x +
full_flath_rms			x					x +
full_wh_rmq								x +
full_flath_rmq			x					x +
cf_h_shaker	x					x +		
sc_h_shaker	x					x +		x +/-
j_fh_rms_shaker		x +	x					
vsi_shaker	x					x +		
ahfv6_full_w_s								
aRWMS_full_w_s								
peak_w_s								

Summary/discussion/further thoughts

- **Transmission rate:**
  - Accelerometer vs. impedance
  - Conspicous 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 – epidemological evidence for vibration exposure – medium term effects



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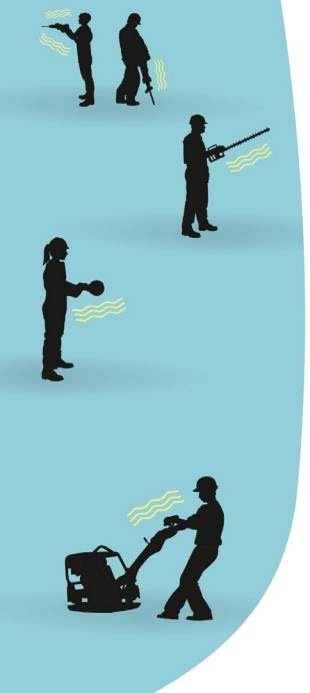

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- practice partners

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