HAND ARM VIBRATION

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# «Comparison between the biomechanical responses of the hand and foot when exposed to vertical vibration»

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# BACKGROUND

## Occupational exposure to Foot-Transmitted Vibration (FTV)

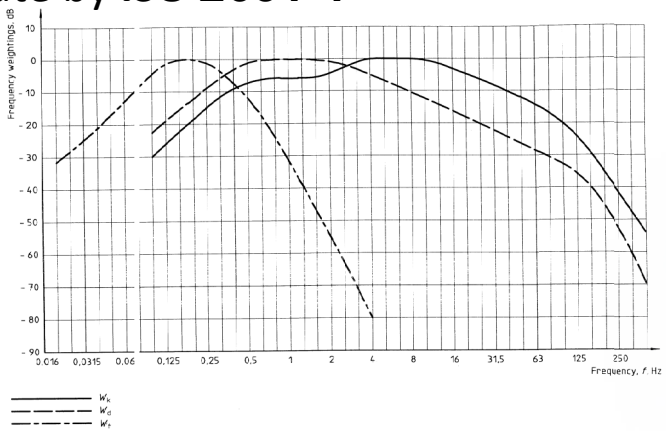
Workers on means of transport, in manufacturing industries and in mines

Prolonged standing on a vibrating floor →

- Musculoskeletal disorders
- Motion sickness
- Neurological diseases
- Vascular diseases

The occurrence of the occupational diseases related to Whole-Body Vibration (WBV) exposure is mitigate by **ISO 2631-1**

- The same standard for standing, seating and recumbent posture
- Effects of vibration on health
  → Musculoskeletal disorders



# BACKGROUND

Case reports have documented that FTV can cause **Vibration-Induced White-Foot (VIWF)**

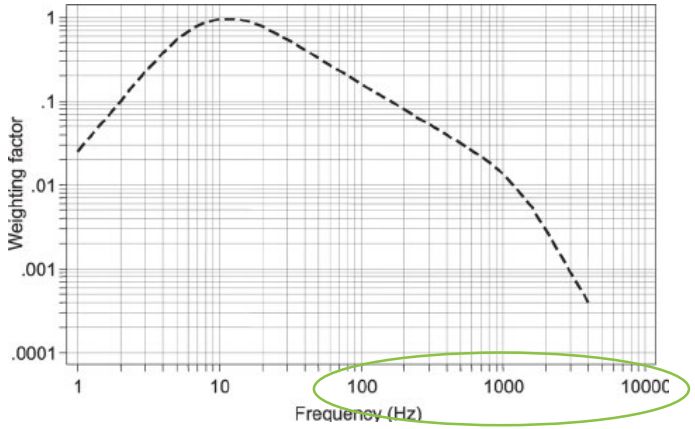
Neurological and vascular disease:

## Raynoud's syndrome

decreased blood flow, blanching, and numbness in the toes

Hand–Arm Vibration Syndrome (HAVS)

Hand-Transmitted Vibration (HTV) exposure regulates by **ISO 5349**



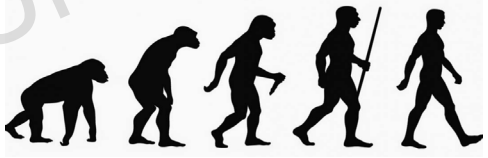
# OBJECTIVE

Considering epidemiological data, the ISO 2631 is not appropriate to regulates the feet vascular risks exposure

**Hand VS Foot**

Similarity of:

- Occupational vascular diseases
- Anatomy and biomechanics



Are ISO 5349 and its weighting curve more appropriate to evaluate feet risks at high frequencies?

Comparison of Frequency Response Functions (FRFs) measured on the hand and on the foot

# METHODOLOGY

## Hand

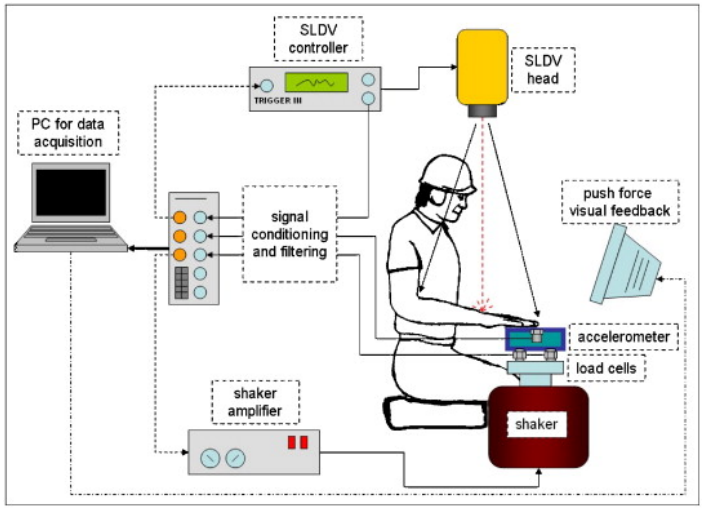
*Concettoni, E. et al.*, « The Apparent Mass and Mechanical Impedance of the Hand and the Transmission of Vibration to the Fingers, Hand, and Arm», 2009

## Foot

*Goggins, K.A. et al.*, «Biomechanical Response of the Human Foot When Standing in a Natural Position While Exposed to Vertical Vibration from 10–200 Hz», 2019

*Goggins, K.A. et al.*, «Standing Centre of Pressure Alters the Vibration Transmissibility Response of the Foot», 2019

- 14 participants
- Random vertical vibration with an RMS of 17 $m/s^2$ in a frequency range between 5 and 500 Hz
- The **transmissibility** functions between acceleration at the driving point (flat plate) and the acceleration measured by a laser Doppler vibrometer at **41 anatomical locations of the hand–arm system in 7 different contact conditions**



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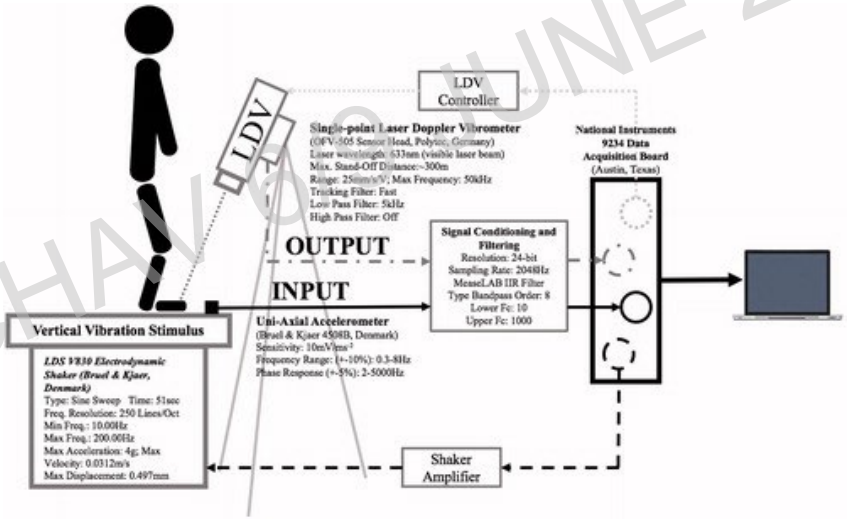



- 21 participants
- A sine sweep of 10 to 200 Hz with a constant peak velocity of 30 mm/s
- The **transmissibility** functions between acceleration at the driving point (vertically vibrating platform) and the acceleration measured by a laser Doppler vibrometer at **24 anatomical locations of the foot in 3 different standing Center Of Pressure (COP) conditions**

# METHODOLOGY

Similar **conditions** and anatomical locations between hand and foot have been compared

**Condition 1**

**Whole hand** on the plate compared to the **natural standing COP** position

**Condition 2**

**Only the fingers** entirely on the plate compared to the **forward COP** position (body weight shifted towards the toes)

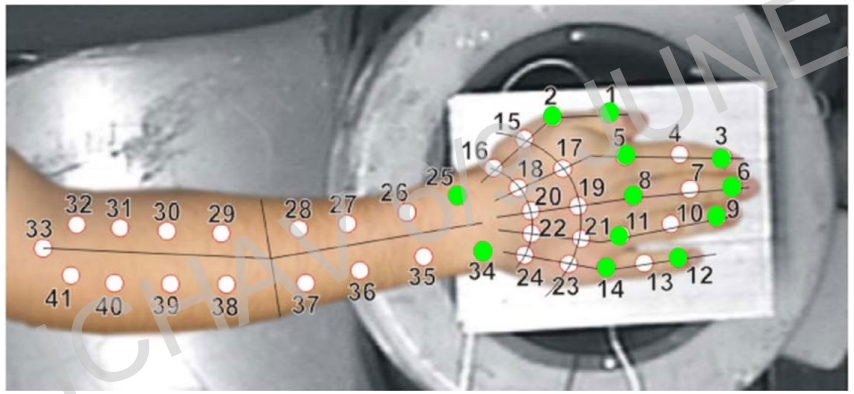
**Condition 3**

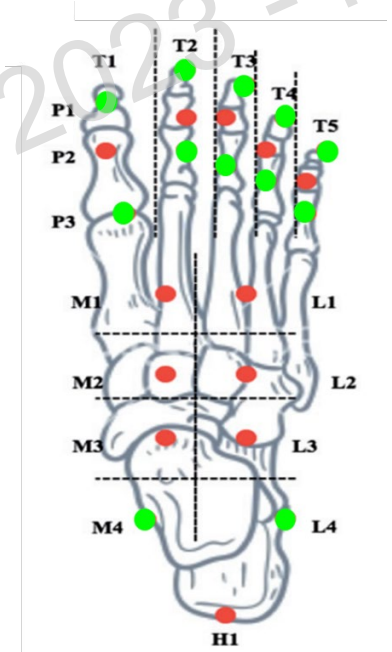
**Only the palm** on the plate compared to the **backward COP** position (body weight shifted towards the heel)

# METHODOLOGY

Similar conditions and **anatomical locations** between hand and foot have been compared

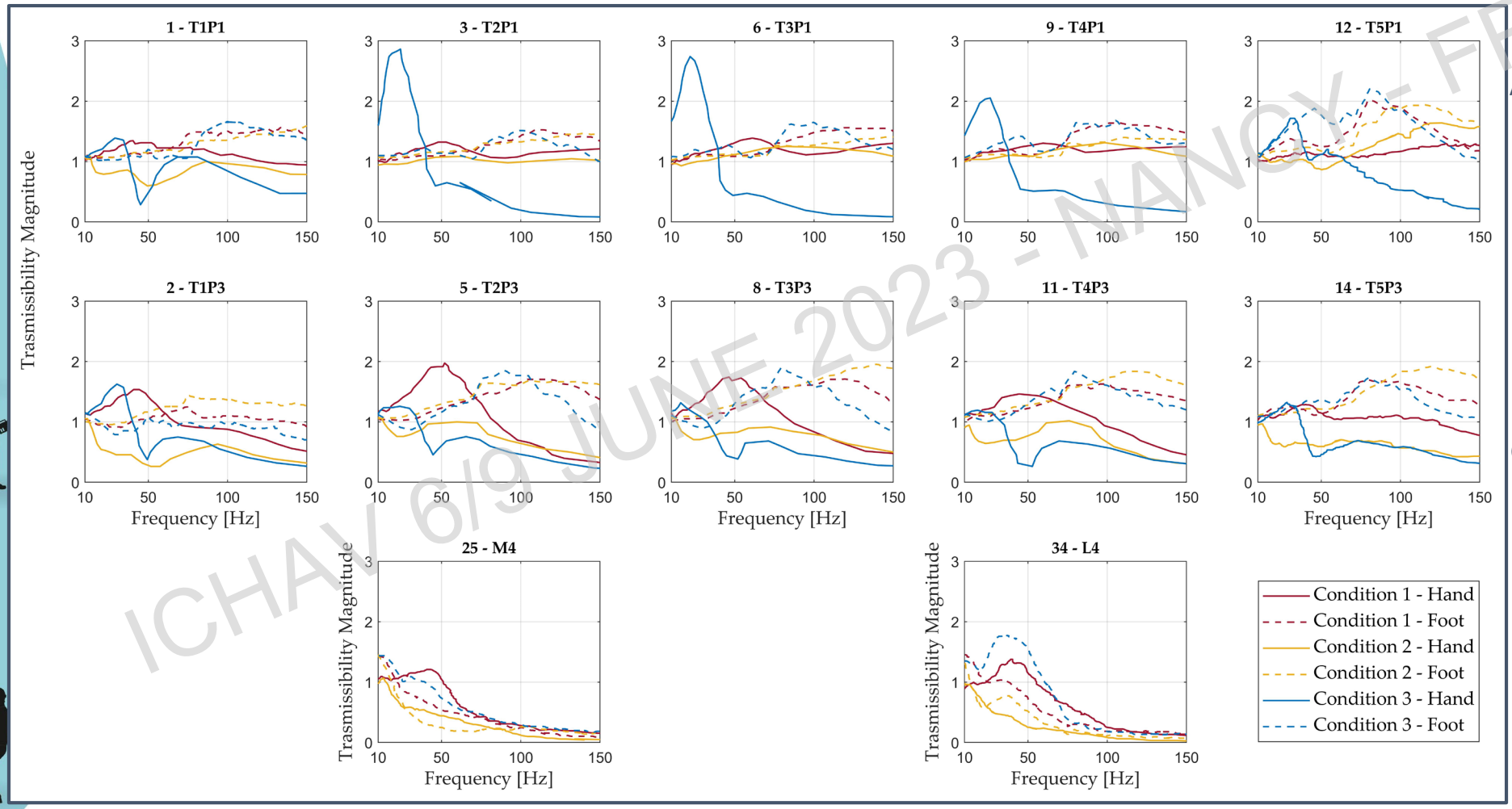
Transmissibility of **12 paired anatomical points** from **10 to 150 Hz**



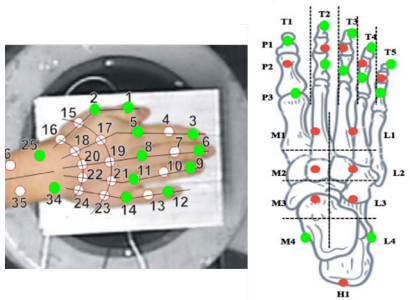

- Tips of the fingers - the tips of the toes (**1-T1P1**, **3-T2P1**, **6-T3P1**, **9-T4P1,** and **12-T5P1**)
- Knuckles - metatarsal heads (**2-T1P3**, **5-T2P3**, **8-T3P3**, **11-T4P3**, and **14-T5P3**)
- Wrist - ankle (**25-M4** and **34-L4**)

# RESULTS






Anatomical locations:

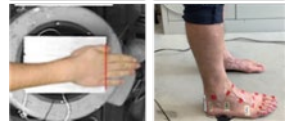


Conditions:

1)

2)

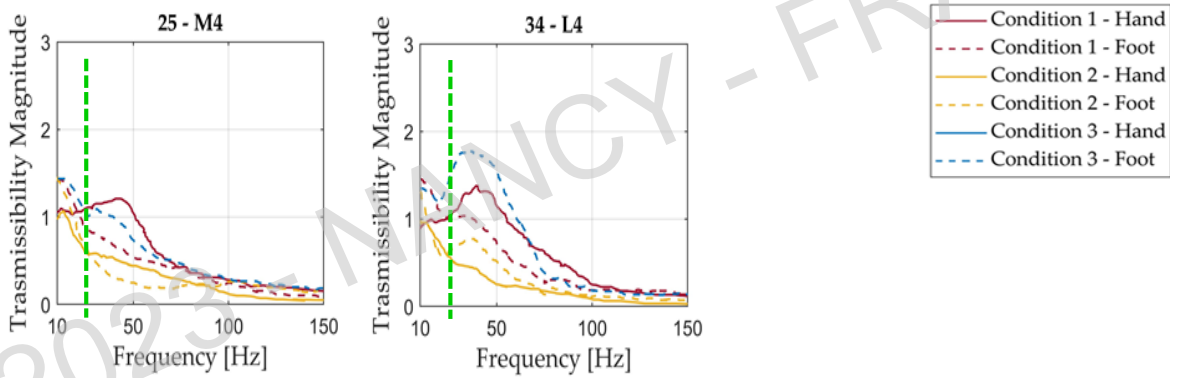
3)



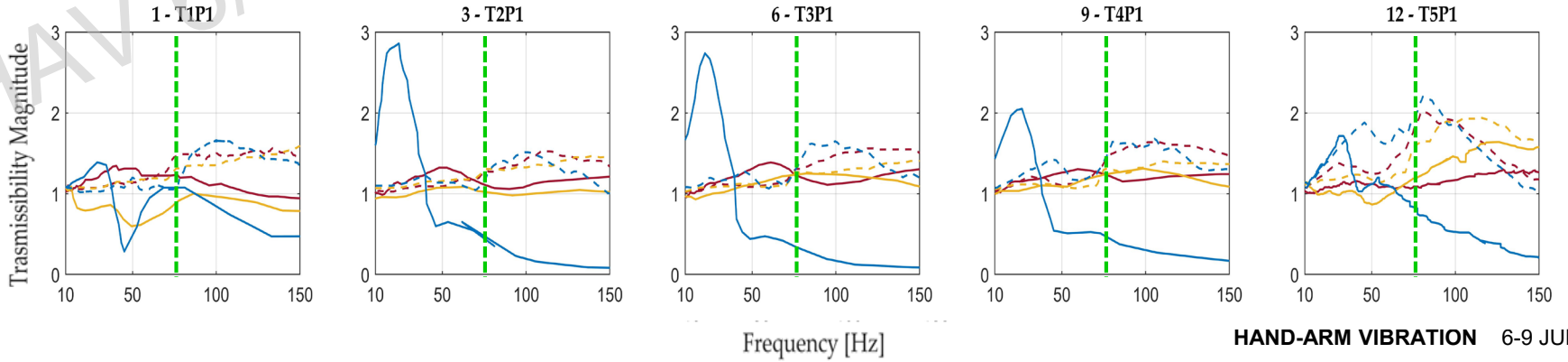
# REsults

- **Wrist - ankle**

Similar FRFs in all three conditions, with a peak below 50 Hz and a decreasing magnitude up to 150 Hz




- **Fingers - toes** and **knuckles - metatarsal heads**
  - In Condition 1 and 2 the transmissibility response is similar until ~75 Hz.
  - Above 75 Hz transmissibility of the foot increases, while the hand transmissibility decreases
  - Toes' resonance frequency (above ~80 Hz) is larger than the fingers' resonance frequency (10-60 Hz)

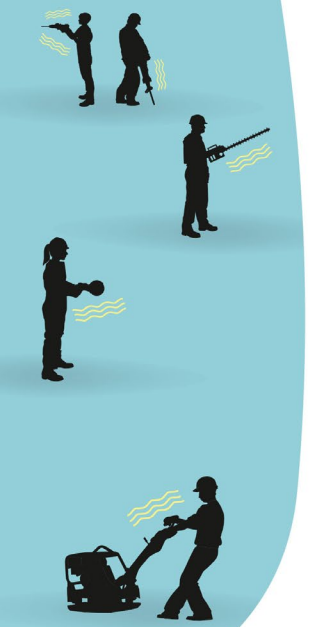


# CONCLUSION

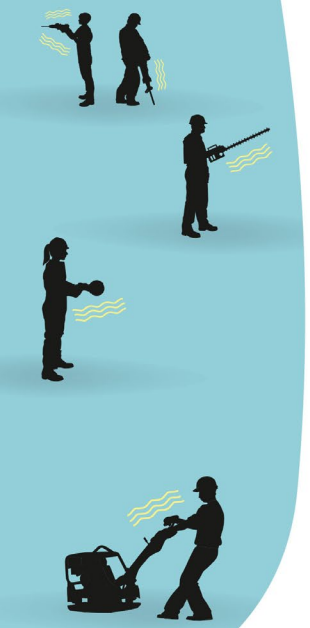
**The comparison between the biomechanical responses of the hand** (*Concettoni, E. et al.*, 2009) **and the foot** (*Goggins, K.A. et al.*, 2019) **when exposed to vertical vibration showed similar FRFs.**

The **similarity between the vibration transmissibility of HTV and FTV** suggests the need for new approaches for FTV evaluation as an alternative to ISO 2631, based on the **HAV standards as reference**.

A specific standard is needed to assess FTV exposure and reduce the occurrence of neurovascular disease



# Thank for your attention



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