

Temporary neurosensory effects after short term exposure to hand-arm vibration

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Previous studies

- Evaluation of the neurosensory effects as a function of vibration frequencies and amplitudes.
- Evaluation of the frequency weighting proposed in ISO 5349.

Objectives

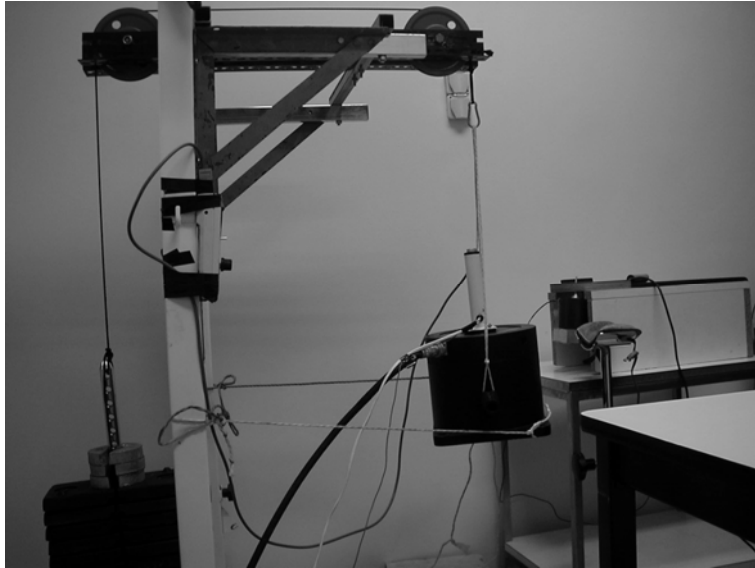
Test the equal energy principle:

In comparing the temporary neurological effects

- **Study 1:**
 - ♦ Same 8-h equivalent acceleration level of 1 ms^{-2}
(same vibration energy at 125 Hz)
 - ♦ Different exposure durations (10, 20, 40 min)
- **Study 2:**
 - ♦ Same instantaneous amplitude (40 ms^{-2})
 - ♦ Different exposure durations (10, 20, 40 min)

Methodology

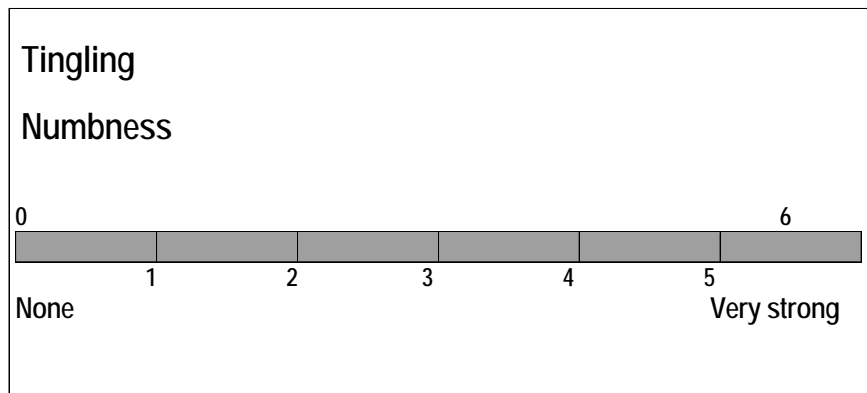
Shaker and handle



Sensorineural and functional tests

- Vibration Perception Threshold (VPT)
- Pressure Perception Threshold (PPT)
- Temperature Perception Threshold (TPT)
- Manual dexterity: Purdue Peg Board (PPB)
- Maximal Voluntary Force (MVF)

Sensation questionnaire



Subjects

- 14 Volunteers male, righthanded
 - ◆ Good health, non smoker
 - ◆ Without history of peripheral or central neuropathies, nor musculoskeletal disorders
 - ◆ Never exposed to vibration.
- 36 experiments

Experimental conditions: study 1

Code	Frequency (Hz)	Acceleration unweighted : ms ⁻²	Acceleration weighted: ms ⁻²	Exposure duration (min)	Acceleration equivalent on 8 h
1	125	28	3.5	40	1,0ms ⁻²
2	125	40	5	20	1,0ms ⁻²
3	125	56	7	10	1,0ms ⁻²
REF		-		40	0

Statistical analysis

• MANOVA:

- ◆ Subject effect (12 subjects for each study)
- ◆ Condition effect (4 conditions per study)
- ◆ Moment effect (3 moments: before, after exposure, after 20 min recovery)

Experimental conditions: study 2

Code	Frequency (Hz)	Acceleration unweighted: ms ⁻²	Acceleration weighted: ms ⁻²	Exposure duration (min)	Acceleration equivalent on 8 h
5 (1)	125	40	5	10	0,7
2(2)	125	40	5	20	1,0
4(3)	125	40	5	40	1,4
REF				40	0

Statistical protocol: Incomplete block design

Subjects	Experimental conditions					
	REF	1	2	3	4	5
1	X		X			
2	X	X			X	
3	X			X		X
4	X		X			
5	X	X			X	
6	X			X		X
7		X	X		X	
8			X	X		X
9		X	X		X	
10			X	X		X
11		X		X		
12		X		X		
13					X	X
14					X	X
	6	6	6	6	6	6

Sequence of the tests

	VPT 31,5 Hz VPT 125 Hz	Sensations	PPT	TPT	PPB	MVF
Before	1	1	1	1	1	1
	2		2	2	2	2
	3		3	3	3	3
EXPOSURE						
RECOVERY						
Moment 1 00 min	4	2	4	4	4	4
Moment 2 05 min	5	3				
Moment 3 10 min	6	4				
Moment 4 15 min	7	5				
Moment 5 20 min	8	6	5	5	5	5

Results: study 1: equal energy principle

Tests	Effect after exposure	
	Associated with vibration	Associated with gripping the handle
VPT 31.5	X	
VPT 125	X	
PPT		X
Threshold warm		X
Threshold cold		
Neutral zone		X
PPB		X
MVF		X
Tingling	X	
Numbness		X

- Only the variations in VPT (at 31,5 and 125 Hz) and in tingling sensations appear related to the exposure to vibration

Results: study 1: equal energy principle

Parameter		Experimental condition			
		Ref	28 ms ⁻² 40'	40 ms ⁻² 20'	56 ms ⁻² 10'
SPV _{31,5}	Before	106,2	108,9	108,5	109,5
	After	113,7	125,6	123,7	121,9
SPV ₁₂₅	Before	99,4	100,6	101,9	101,4
	After	107,9	116,7	121,7	120,4

- Increase in VPT not statistically different in the 3 conditions
- The 3 conditions give the same order of magnitude of increase of VPT

Results: study 2: duration of exposure

Tests	Variations after exposure	
	Associated with vibration	Associated with gripping of the handle
VPT 31.5	X	
VPT 125	X	
PPT		X
Threshold warm		X
Threshold cold		
Neutral zone		X
PPB		X
MVF		X
Tingling		
Numbness		X

- Only the variations in VPT (at 31,5 and 125 Hz) appear related to the exposure to vibration

Results: study 2: duration of exposure

Parameter		Experimental condition			
		Ref	40 ms ⁻² 10'	40 ms ⁻² 20'	40 ms ⁻² 40'
VPT _{31,5}	Before	107,1	109,2	108,8	109,2
	After	114,8	118,5	122,9	125,4
VPT ₁₂₅	Before	101,1	102,1	102,6	101,1
	After	108,3	117,7	121,5	118,3

- Increase in VPT not statistically different in the 3 conditions

Results: study 2: duration of exposure

- The 3 conditions give the same order of magnitude of increase of VPT
- After 10 min exposure, a steady state is reached. time constant: 3 min (Malchaire et al., 1998).

Conclusions:

- From previous studies: (Malchaire et al., 1998, 2001)
 - ◆ Temporary threshold shift of VPT of 3 dB per 2 * amplitude
 - ◆ VPT varies as a 1st order system with time constant of 3 min
 - ◆ Exposure to 125 Hz leads to greater effects than exposure to 31.5 ou 500 HZ

Conclusions:

- Study 2: duration of exposure
 - ◆ Same variation of VPT after 10, 20, 40 min exposure
 - 10, 20, 40 min = 3, 6, 12 time constant
 - Steady state reached
 - ◆ The 3 conditions differ by factors of 1, 2, and 4 in terms of energy
 - Equal energy principle not valid
 - ◆ VPT variations
 - Dependent upon the vibration amplitude
 - Independent of the exposure duration (between 10 and 40 min)

Conclusions:

- **Study 1: equal energy principal**
 - ◆ The 3 conditions lead to the same effects
 - ◆ However, no confirmation of the equal energy principle (or contradiction with study 2)
 - Chosen amplitudes (28, 40, 56 ms⁻²) not very different
 - Differences in VPT masked by interindividual differences

Thank you...