Webinar Magistrali 2025

Società Italiana di Medicina del Lavoro

LAVORO E PREVENZIONE: EVOLUZIONE DEI PARADIGMI PER L'EVIDENZA DI EFFETTI NOCIVI SUI LAVORATORI

The role of occupational and personal risk factors in the occurrence of the hand-arm vibration syndrome

Massimo Bovenzi

Clinical Unit of Occupational Medicine
Department of Medical Sciences
University of Trieste

Percentage of workers whose job involves exposure to mechanical vibration

Time period	Total (%)	Member State														
		A	B	DK	FIN	F	D	EL	NL	IRL	I	L	P	E	S	UK
1 All or almost all the time	10.3	10	9	4	8	11	10	14	5	9	11	11	14	18	5	7
2 Around ¾ or ½ the time	6.5	8	5	4	9	6	7	9	3	7	8	4	7	8	4	6
3 Around ¼ of the time	6.8	6	6	7	12	6	9	7	6	9	7	5	7	5	8	5
Total 1 + 2 + 3	23.6	24	20	15	29	23	26	30	14	25	26	20	28	31	17	18

Source- 3rd European Survey on Working Conditions, European Foundation, 2000 Dublin

DIRECTIVE 2002/44/EC OF THE EUROPEAN PARLIAMENT AND OF THE COUNCIL

of 25 June 2002

on the minimum health and safety requirements regarding the exposure of workers to the risks arising from physical agents (vibration) (sixteenth individual Directive within the meaning of Article 16(1) of Directive 89/391/EEC)

Decreto Legislativo n. 187 del 19/8/2005

Attuazione della direttiva 2002/44/CE sulle prescrizioni minime di sicurezza e di salute relative all'esposizione dei lavoratori ai rischi derivanti da vibrazioni meccaniche.

(G.U. del 21/9/2005 n. 220)

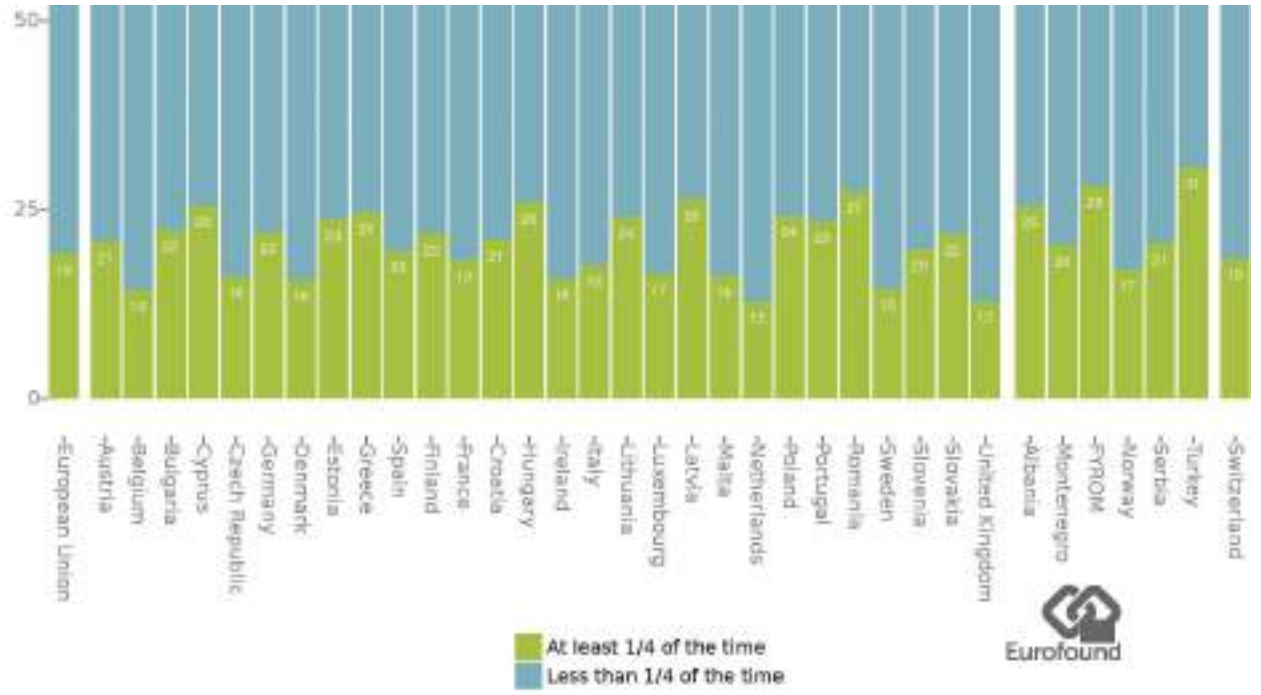
D.Lgs. 9 aprile 2008, n. 81

TESTO UNICO SULLA SALUTE E SICUREZZA SUL LAVORO

CAPO III - PROTEZIONE DEI LAVORATORI DAI RISCHI DI ESPOSIZIONE A VIBRAZIONI

6th EU Working Conditions Survey

Occupational risk factor	2005	2010	2015
	Proportion of workers in *EU28* (%)		
Vibration from hand tools, machinery (1/4 of the time or more)	24	23	19



Measurement and risk assessments

International Standard ISO 5349.

Part 1 General requirements

Part 2 Practical guidelines for measurement at the workplace

ISO 5349 is based on the measurement of vibration magnitude (m/s^2) and exposure times (hours)

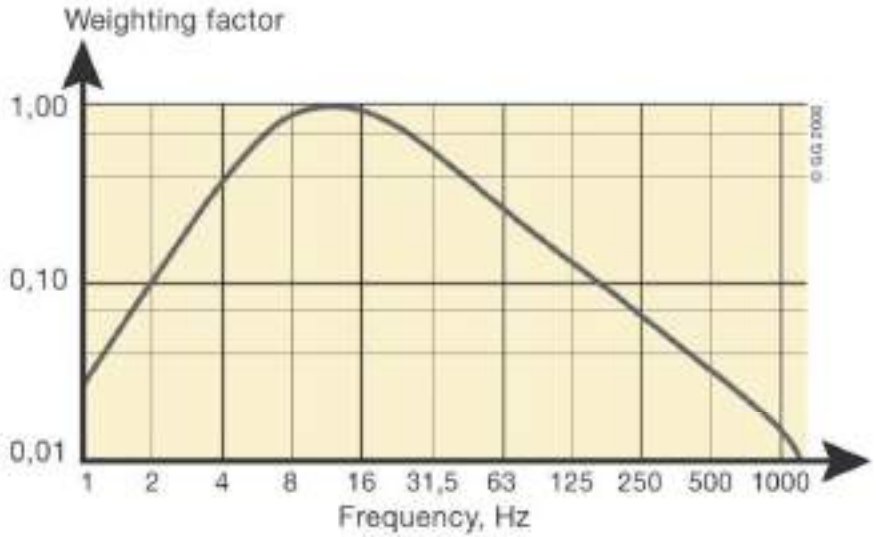
Measurement and evaluation strategy

- Identifying the vibrating operations
- Evaluation of the daily exposure time
- Selection of operations to be measured
- Measuring the frequency weighted acceleration
- Calculating the 8-hour energy-equivalent acceleration
- Risk assessment

Measurement equipment

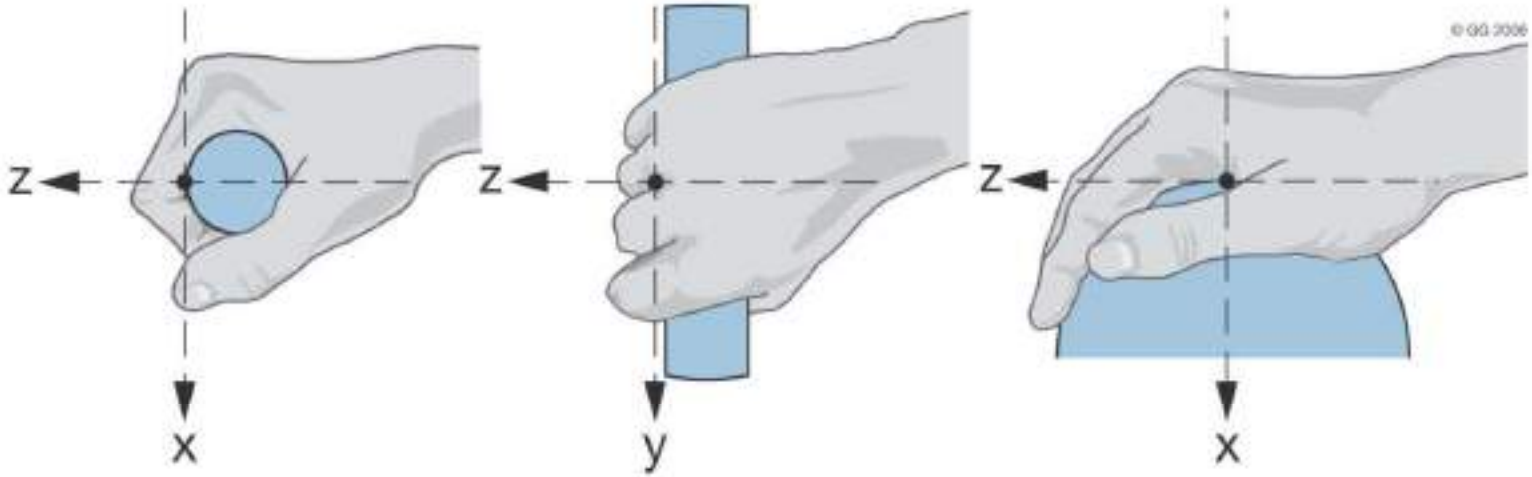
Frequency range and weighting

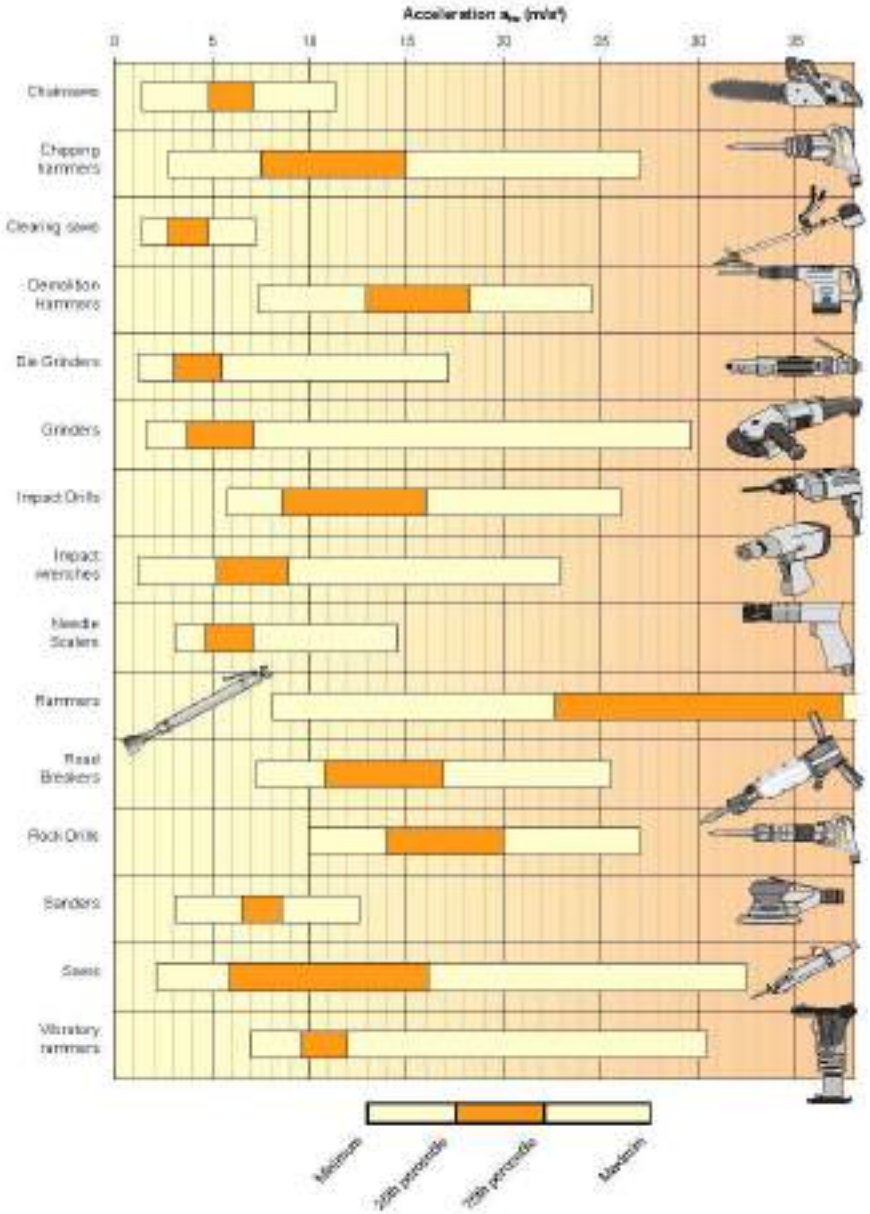
Frequency range: 5 Hz to 1500 Hz.



Frequency weighting according to ISO 5349-1

Measurement directions





Vibration Total Value (vector sum)

$$a_{hvi} = \sqrt{a_{hwxi}^2 + a_{hwyi}^2 + a_{hwzi}^2} \qquad (ms^{-2}\ r.m.s.)$$

MACCHINARI IN BANCA DATI **2.558** - MISURE IN BANCA DATI **7.989**

PAF
PORTALE AGENTI FISICI
PREVENZIONE E SICUREZZA

- **Home**
- **Rumore**
- **Vibrazioni Mano-Braccio**
- **Vibrazioni Corpo Intero**
- **Campi Elettromagnetici**
- **Radiazioni Ottiche Artificiali**
- **Radiazioni Ottiche Naturali**
- **Normativa e Linee Guida**
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- **Documentazione per la Fornitura dati**
- **Materiale Didattico**

Benvenuto nel Portale Agenti Fisici

*Le Banche Dati **"Vibrazioni Mano Braccio"** e **"Vibrazioni Corpo Intero"** sono valevoli ai fini della valutazione dei rischi ai sensi del D.Lgs. 30 aprile 2008 n. 81 (art. 202, comma 2/ Allegato XXXV).*

*Le banche dati su **Campi Elettromagnetici** e **Radiazioni ottiche** sono utilizzabili per la Valutazione del rischio, mentre per quanto concerne il rischio **rumore** le informazioni presenti sul Portale saranno utilizzabili ai fini della valutazione del rischio a seguito della validazione della Commissione consultiva ex art.6, DLgs.81/2008*

Il Portale Agenti Fisici è realizzato dal Laboratorio Agenti Fisici del Dipartimento di Prevenzione dell'Azienda Sanitaria USL 7 Siena nell'ambito del "Piano Mirato sui rischi derivanti dagli Agenti Fisici" approvato con decreto di Giunta Regione Toscana n° 5888 dell' 1 dicembre 2008. Il Portale è stato sviluppato con la collaborazione dell'INAIL e dell'Azienda USL di Modena nell'ambito del Progetto del Ministero della Salute – CCM "Rischio di esposizione da agenti fisici negli ambienti di lavoro: sviluppo e adeguamento di banche dati per supportare la valutazione del rischio e gli interventi di prevenzione in tutti i comparti lavorativi", al fine di mettere a disposizione uno strumento informativo che orienti gli attori aziendali della sicurezza e gli operatori della prevenzione ad una risposta corretta ai fini della prevenzione e protezione da AGENTI FISICI. L'utente dovrà consultare i documenti di"Guida all'utilizzo della Banca Dati" per ogni singolo Agente Fisico al fine di poter utilizzare in maniera appropriata i dati in essa contenuti. Si declina qualsiasi responsabilità derivante da un utilizzo improprio dei dati e delle informazioni contenute nelle Banche Dati e nel Portale.


RUMORE


VIBRAZIONI MANOBRACCIO


VIBRAZIONI CORPOINTERO


CAMPI ELETTROMAGNETICI


RADIAZIONI OTTICHE ARTIFICIALI


RADIAZIONI OTTICHE NATURALI

INAIL

Regione Toscana
Diritti Valori Innovazione

Azienda USL 7 Siena
Servizio Sanitario della Toscana

SERVIZIO SANITARIO REGIONALE EMILIA-ROMAGNA
Azienda Unità Sanitaria Locale di Modena

eventi

Rischi Fisici: Convegno AIRA 2015

Modena

27 Maggio 2015

news

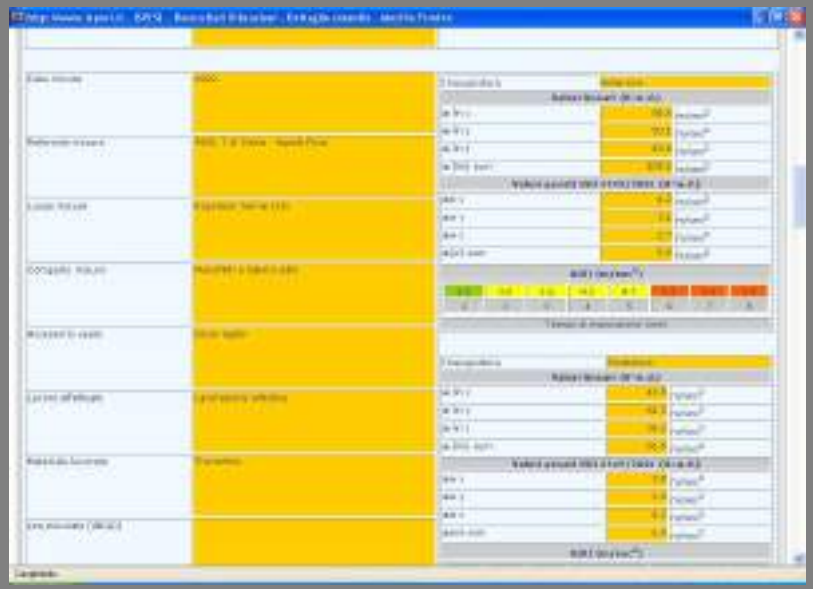
Pubblicato sul Portale Agenti Fisici il RAPPORTO PAF 1/15 - 02 APRILE 2015

Aggiornata Banca Dati Campi Elettromagnetici

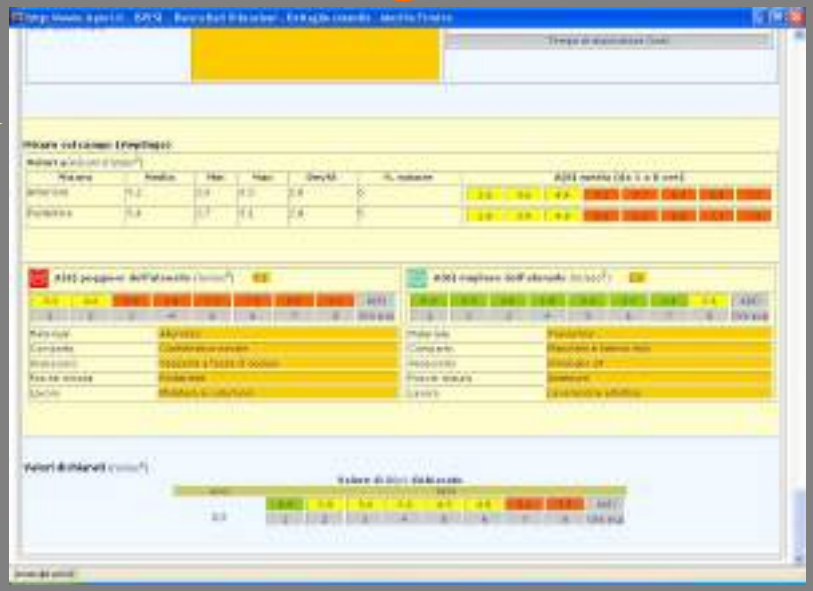
Procedura software per la valutazione del rischio ROA da limitate ad alogenuri metallici

E' in vigore norma UNI ISO 2631-1 2014

Aggiornamento norma UNI ISO 2631-1:2008



scheda
utensile



Daily exposure time

Evaluation of the daily exposure time

Stopwatch

Time Study

Calculating the 8-hour energy-equivalent vibration

The equivalent 8-hour acceleration

$$a_{eq(8)} = \sqrt{\frac{T}{8}} \cdot a_T$$

$\mathbf{a_{eq(8)}}$ is the 8- hour equivalent acceleration, **T** the actual exposure time in hours and $\mathbf{a_T}$ acceleration during the period T hours

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TITOLO VIII - AGENTI FISICI D.lgs. 09 aprile 2008 n. 81

CAPO III - PROTEZIONE DEI LAVORATORI DAI RISCHI DI ESPOSIZIONE A VIBRAZIONI

Hand-Arm Vibration

Action value: $A(8)$ = **2.5** ms^{-2} r.m.s.

Exposure limit value: $A(8)$ = **5** ms^{-2} r.m.s.

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Hand-Arm Vibration

The mechanical vibration that, when transmitted to the human hand-arm system, entails risks to the health and safety of workers, in particular vascular, bone or joint, neurological or muscular disorders

Hand-Arm Vibration Syndrome

- Vascular component
- Sensorineural component
- Musculoskeletal component

HAND-ARM VIBRATION SYNDROME

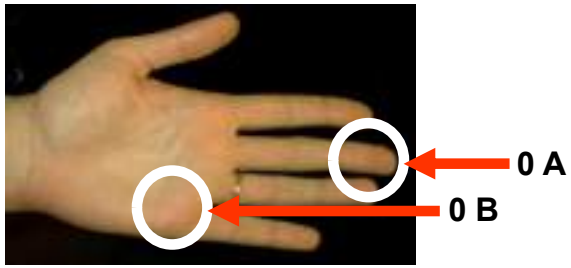
- Vibration-induced white finger (secondary form of Raynaud's phenomenon)
- Diffuse-multifocal neuropathy with predominant sensory impairment
- Nerve trunk entrapment syndromes in the upper limbs
- Changes in the bones and joints of the upper limbs
- Upper limb muscle and tendon disorders

HAND-ARM VIBRATION SYNDROME

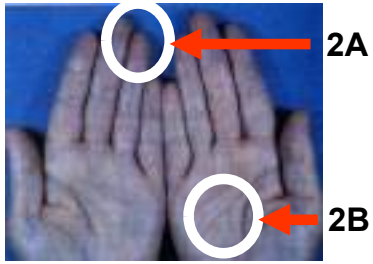
- Vibration-induced white finger (secondary form of Raynaud's phenomenon)

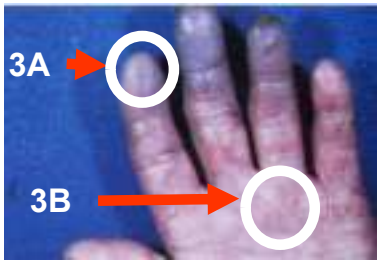
MINIMAL REQUISITES FOR THE ANAMNESTIC DIAGNOSIS OF ACTIVE VWF
(Stockholm Workshop '94)

- Cold provoked episodes of well demarcated distal whiteness in one or more fingers.
- First appearance of white finger after start of professional exposure to HTV and no other probable causes of Raynaud's phenomenon.
- VWF is currently active if episodes have been noticed during the last two years.

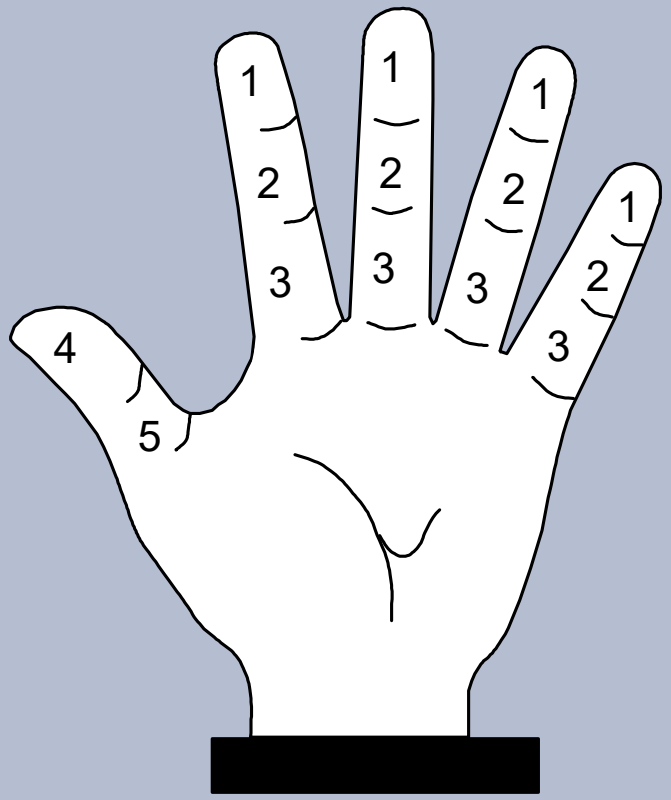

0 A
0 B


1A
1B

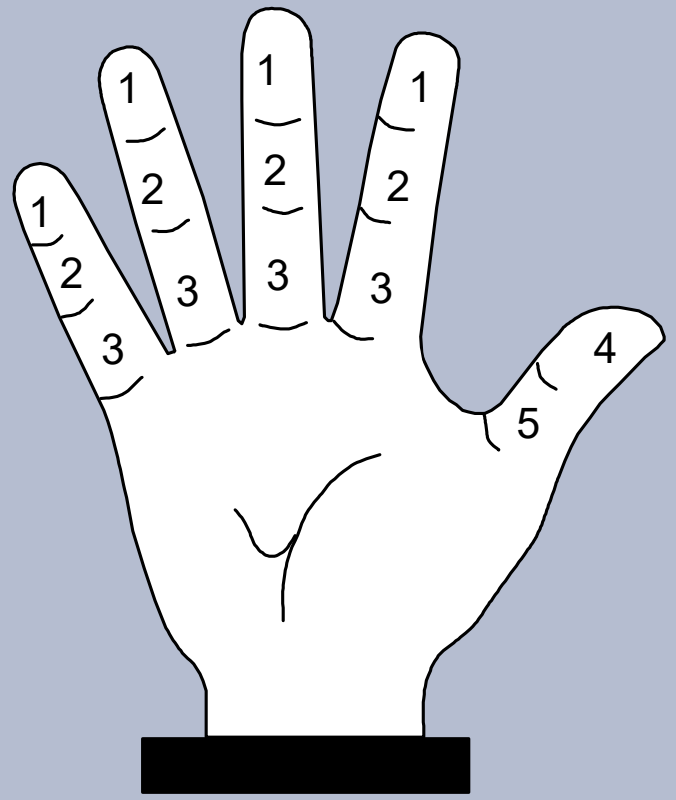

2A
2B


3A
3B


4 B
4 A



Mano sinistra



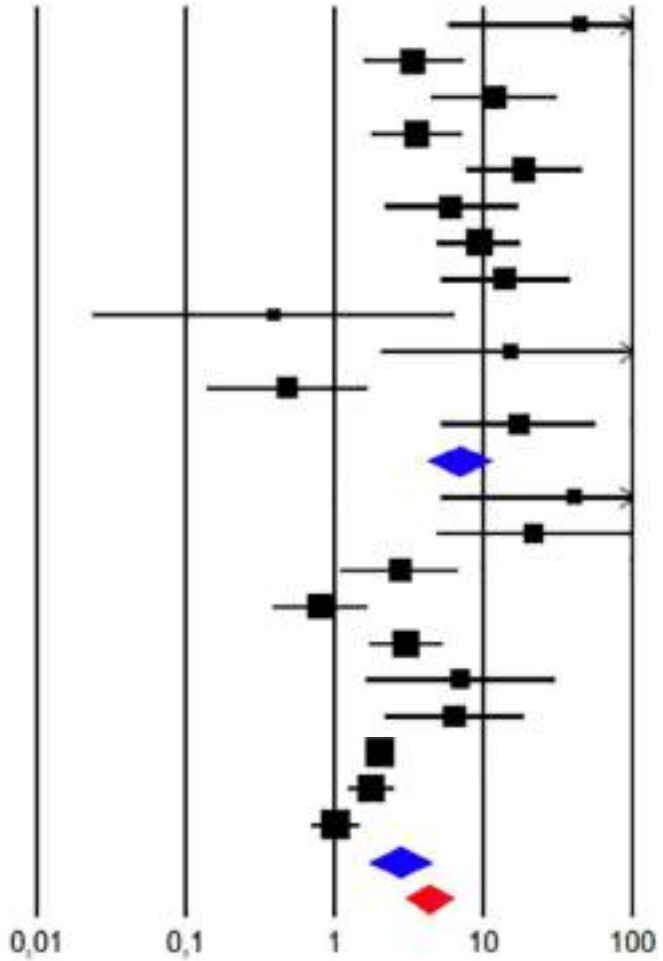
Mano destra

HAVS Vascular Component

ICC Stage	Description
0V	No attacks of blanching
1V	Digit blanching score 1 - 4
2V	Digit blanching score 5 - 12
3V	Digit blanching score >12

Meta-analysis for vascular disorders (VWF) *vs* HTV (Nilsson *et al.* 2017)

Group by Bias	Studie namn	Odds ratio	Lower limit	Upper limit
Low	38 Bovenzi, 2008*#	45,04	5,90	343,67
Low	40 Bovenzi, 2010*	3,39	1,55	7,44
Low	41 Bovenzi, 1995	11,80	4,47	31,12
Low	42 Bovenzi, 2010*	3,54	1,74	7,21
Low	43 Bovenzi, 1998*	18,63	7,58	45,83
Low	47 Bovenzi, 1988*	6,06	2,17	16,96
Low	49 Bovenzi, 1994	9,33	4,90	17,76
Low	50 Nilsson, 1989	13,90	5,09	37,94
Low	52 Futatsuka, 2005*#	0,39	0,02	6,43
Low	54 Jang, 2002*#	15,25	2,07	112,08
Low	56 Bovenzi, 2005*	0,48	0,14	1,65
Low	57 Letz, 1992*	17,29	5,23	57,11
Low		6,85	4,17	11,25
Unclear	58 Chatterjee, 1978*#	41,00	5,15	326,18
Unclear	59 Brubaker, 1985*	21,94	4,88	98,63
Unclear	60 Burdorf, 1991*	2,75	1,11	6,82
Unclear	61 Cherniack, 2004*	0,81	0,39	1,68
Unclear	62 Anttonen, 1994*	3,00	1,71	5,28
Unclear	63 Virokannas, 1995*	6,99	1,62	30,08
Unclear	64 Bovenzi, 1980*	6,40	2,20	18,56
Unclear	66 Burstrom, 2010	2,02	1,66	2,46
Unclear	67 Mirbod, 1994*	1,76	1,21	2,55
Unclear	68 Tominaga, 1994*	1,01	0,70	1,46
Unclear		2,76	1,69	4,50
Overall		4,32	3,05	6,12



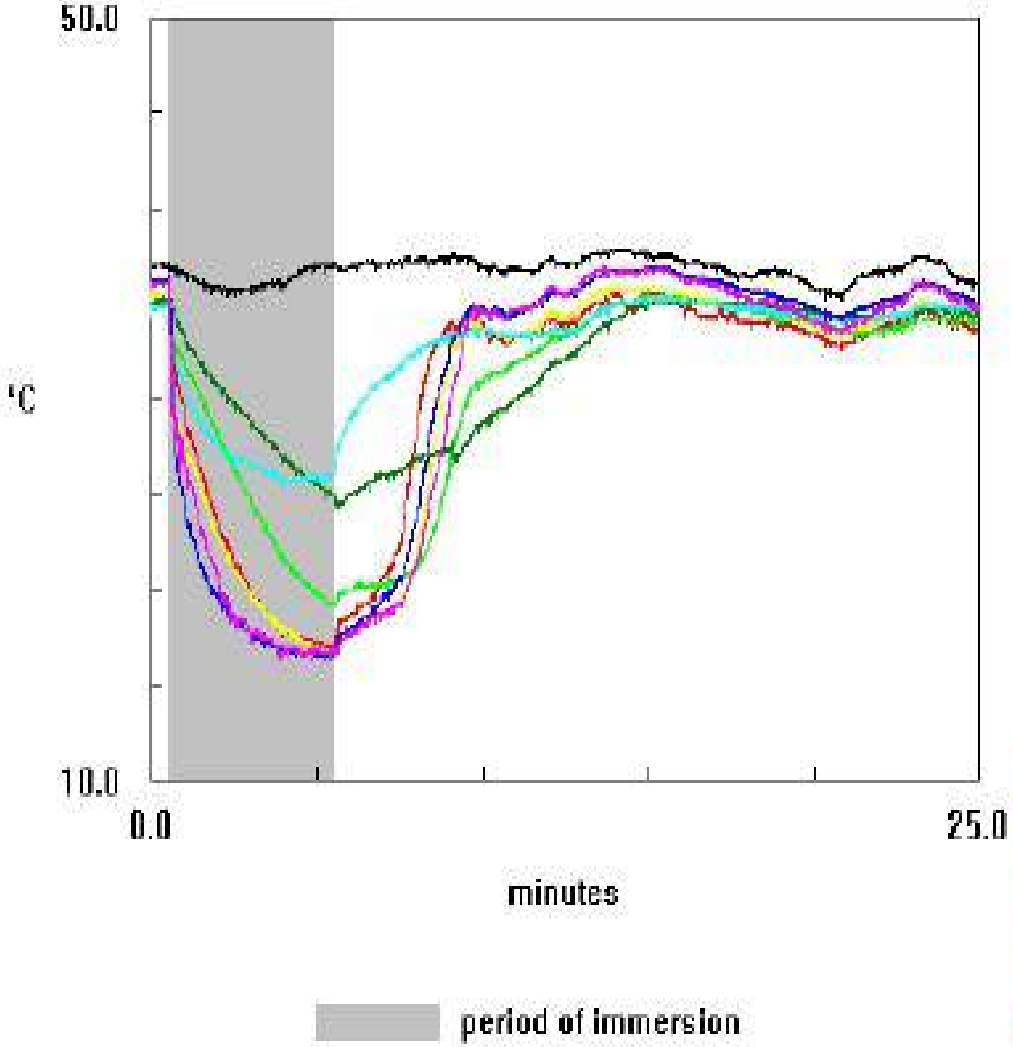
SPECIAL DIAGNOSTIC INVESTIGATIONS

Vascular investigations

- Cold provocation test with visual inspection of changes in finger colour
- Measurement and evaluation of finger skin temperature after cooling (ISO 14835-1, 2005)
- Measurement and evaluation of finger systolic blood pressure after cooling (ISO 14835-2, 2005)

REWARMING TEST

SUBJECT = A N OTHER



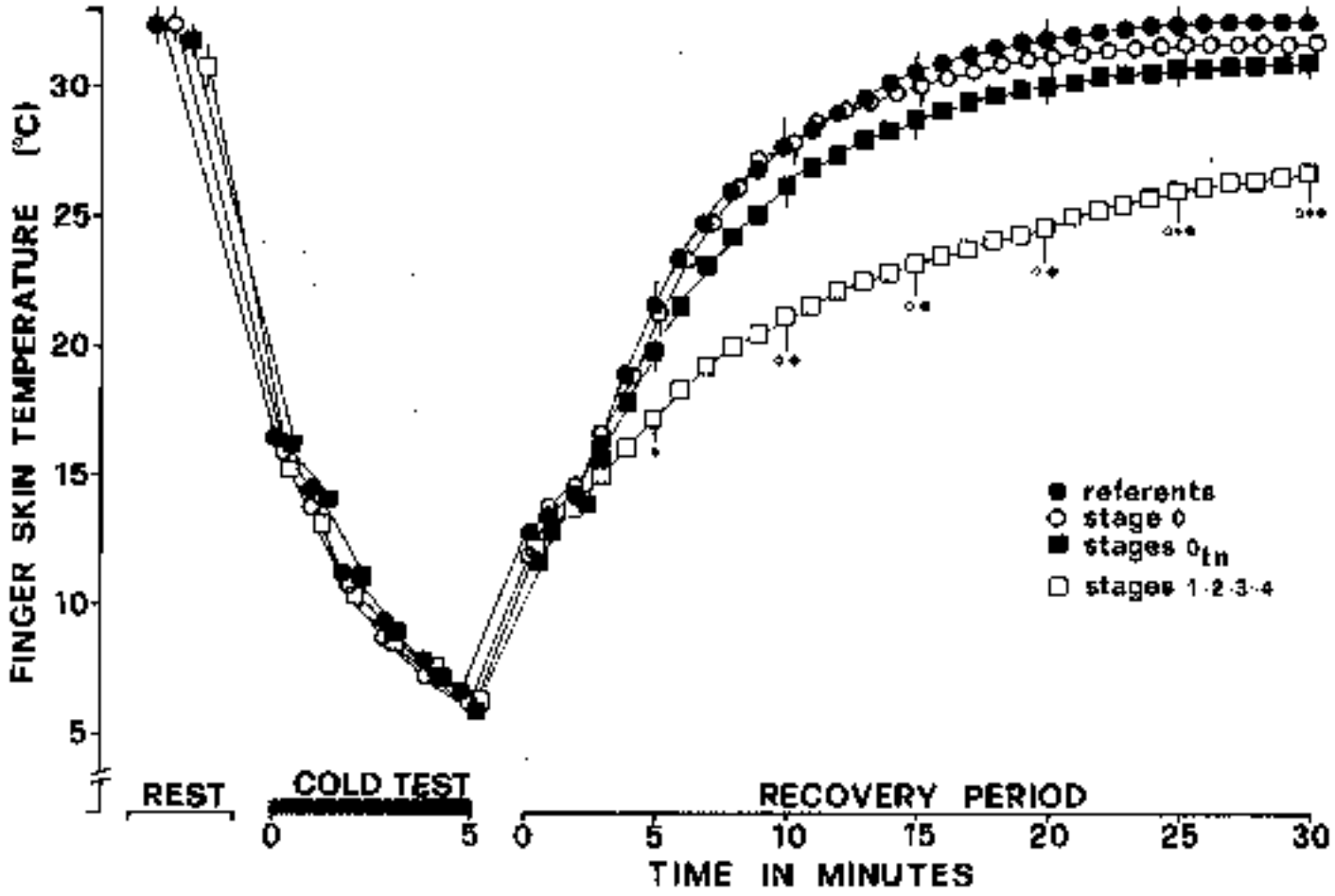
RESULTS:

t/c	T(+3°)	T(+4°)	T(+6°)	°minimum	°rewarm
1	77s	102s	125s	17.1°C	16.2°C
2	124s	137s	157s	16.7°C	17.2°C
3	173s	184s	200s	19.2°C	14.5°C
4	222s	242s	332s	24.2°C	10.1°C
5	32s	56s	130s	26.0°C	8.5°C
6	99s	124s	141s	16.6°C	18.2°C
7	126s	137s	162s	16.5°C	17.9°C
8	274s	274s	274s	35.3°C	1.0°C

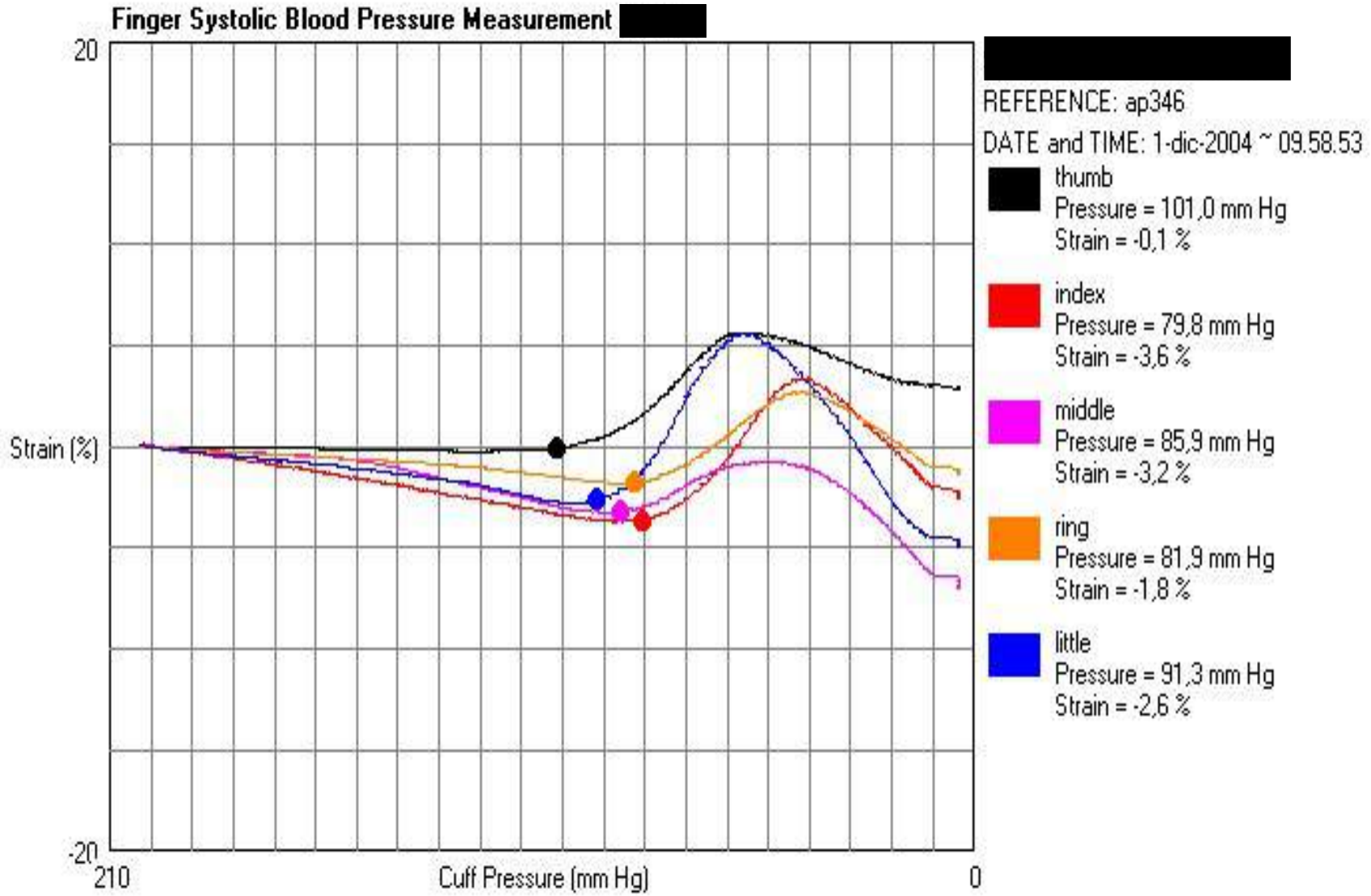
TEST PARAMETERS:

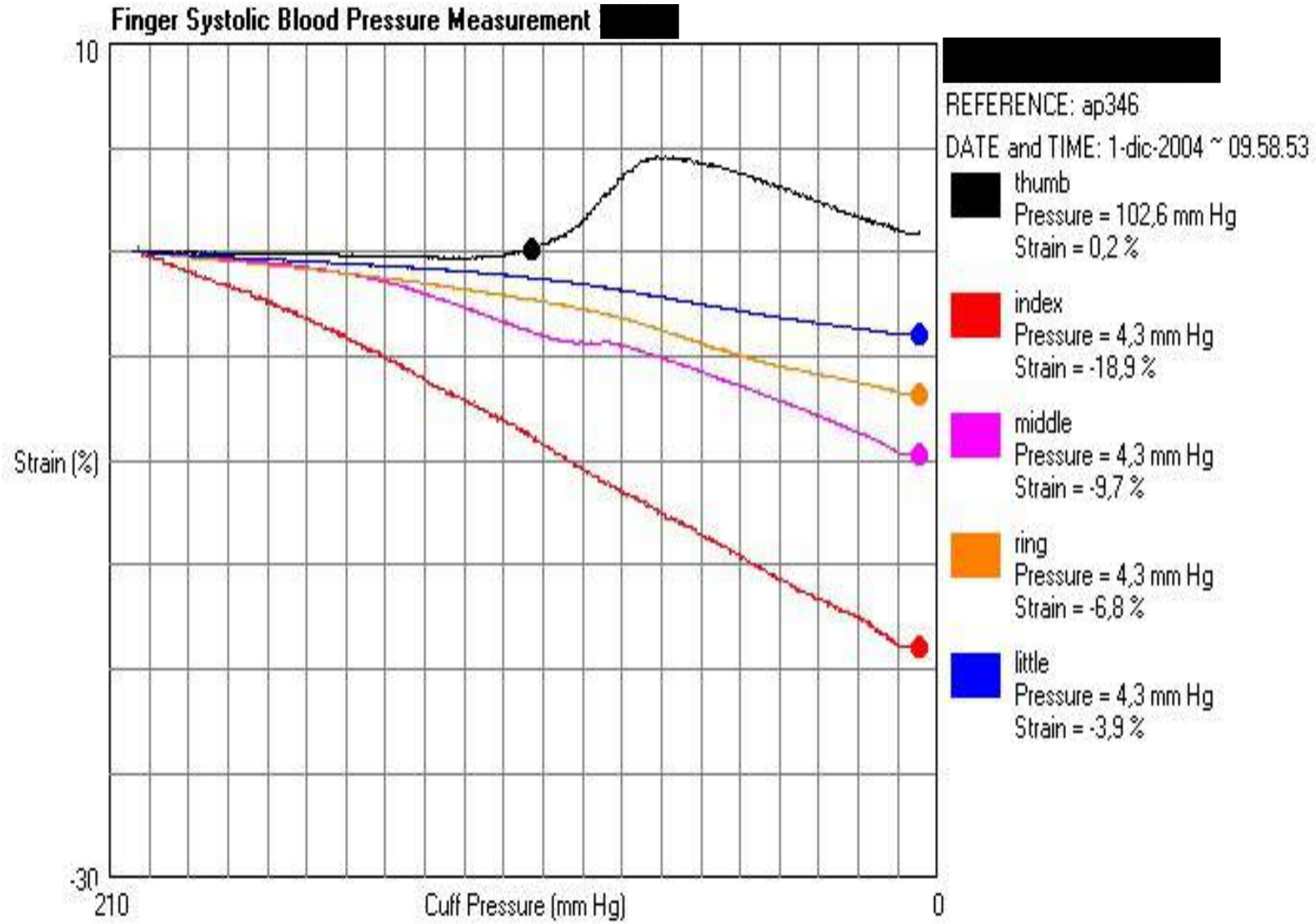
settling time = 0.5 minutes
immersion time = 5.0 minutes
recovery time = 20.0 minutes
water bath temperature = 0.0 °C

test site 1 =
test site 2 =
test site 3 =
test site 4 =
test site 5 =
test site 6 =
test site 7 =
test site 8 =


FINGER SKIN TEMPERATURE (°C)
30
25
20
15
10
5
REST
COLD TEST
RECOVERY PERIOD
0
5
0
5
10
15
20
25
30
TIME IN MINUTES
referents
stage 0
stages 0tn
stages 1·2·3·4


On
Off
Water
Air
Water
Transducers


Finger Systolic Blood Pressure Measurement [redacted]
20
Strain (%)
-20
210
Cuff Pressure (mm Hg)
0
[redacted]
REFERENCE: ap346
DATE and TIME: 1-dic-2004 ~ 09.58.53
thumb
Pressure = 101,0 mm Hg
Strain = -0,1 %
index
Pressure = 79,8 mm Hg
Strain = -3,6 %
middle
Pressure = 85,9 mm Hg
Strain = -3,2 %
ring
Pressure = 81,9 mm Hg
Strain = -1,8 %
little
Pressure = 91,3 mm Hg
Strain = -2,6 %


Finger Systolic Blood Pressure Measurement [redacted]
10
Strain (%)
-30
210
Cuff Pressure (mm Hg)
0
[redacted]
REFERENCE: ap346
DATE and TIME: 1-dic-2004 ~ 09.58.53
thumb
Pressure = 102,6 mm Hg
Strain = 0,2 %
index
Pressure = 4,3 mm Hg
Strain = -18,9 %
middle
Pressure = 4,3 mm Hg
Strain = -9,7 %
ring
Pressure = 4,3 mm Hg
Strain = -6,8 %
little
Pressure = 4,3 mm Hg
Strain = -3,9 %

MINISTERO DI AGRICOLTURA, INDUSTRIA E COMMERCIO

UFFICIO DEL LAVORO

Bollettino dell'Ispettorato del Lavoro

V.e II - N. 1 - Gennaio 1911.

ROMA
OFFICINA POLIGRAFICA ITALIANA
—
1911

VI.

INCHIESTE E RAPPORTI

Il lavoro con i martelli pneumatici.

(Seconda Relazione del prof. Giovanni Lorenzoni *a S. E. il Ministro di Agric. e Comm.).*

In seguito ai risultati del mio studio sul modo con cui si compie la lavorazione delle pietre e dei marmi con i martelli pneumatici nei cantieri di Roma e sulle condizioni sanitarie degli operai che vi sono addetti (1) piacque alla E. V. di affidarmi l'incarico di estendere le mie indagini a tutte le altre forme di applicazione dei suddetti martelli al lavoro manuale.

Sono grato alla E. V. dell'incarico onorevolissimo, il quale mi ha dato occasione di fare osservazioni non prive di importanza sopra un argomento nuovo di Patologia ed Igiene del lavoro, di cui esiste soltanto qualche vago cenno nella letteratura medica italiana e straniera, mentre era indispensabile ed urgente di acquistarne una conoscenza più profonda e più precisa, e ciò non solo perchè l'applicazione dell'aria compressa per trasformare in piccole macchine a motore gli umili utensili si estende ogni giorno di più in un grande numero di industrie, ma anche perchè era doveroso ricercare le ragioni delle lagnanze o delle acquiescenze dei singoli gruppi di operai verso le nuove forme di lavoro e trarne ammaestramenti per la tutela della salute dei lavoratori.

Nel rendere conto dei risultati del nuovo studio mi sembra logico prendere separatamente in esame il lavoro delle pietre e dei marmi e quello dei metalli, corrispondentemente ai due gruppi di materiali adoperati, per arrivare ad intendere meglio i caratteri specifici e l'influenza sull'organismo di ciascuna forma di lavoro, quali risultano dalle loro eventuali analogie o differenze.

Lavorazione delle pietre e dei marmi. — Allo scopo di completare e controllare le osservazioni già fatte nei cantieri romani ho visitato otto fra i principali cantieri per la lavorazione dei marmi in Carrara, due laboratori di marmi e di pietre dure per uso artistico in Milano ed il cantiere istituito in Mazzano (Brescia) dalla Ditta Cafferi e Massardi per la lavorazione del *bollicino*, che è la stessa pietra impiegata per la costruzione del monumento a V. Emanuele in Roma.

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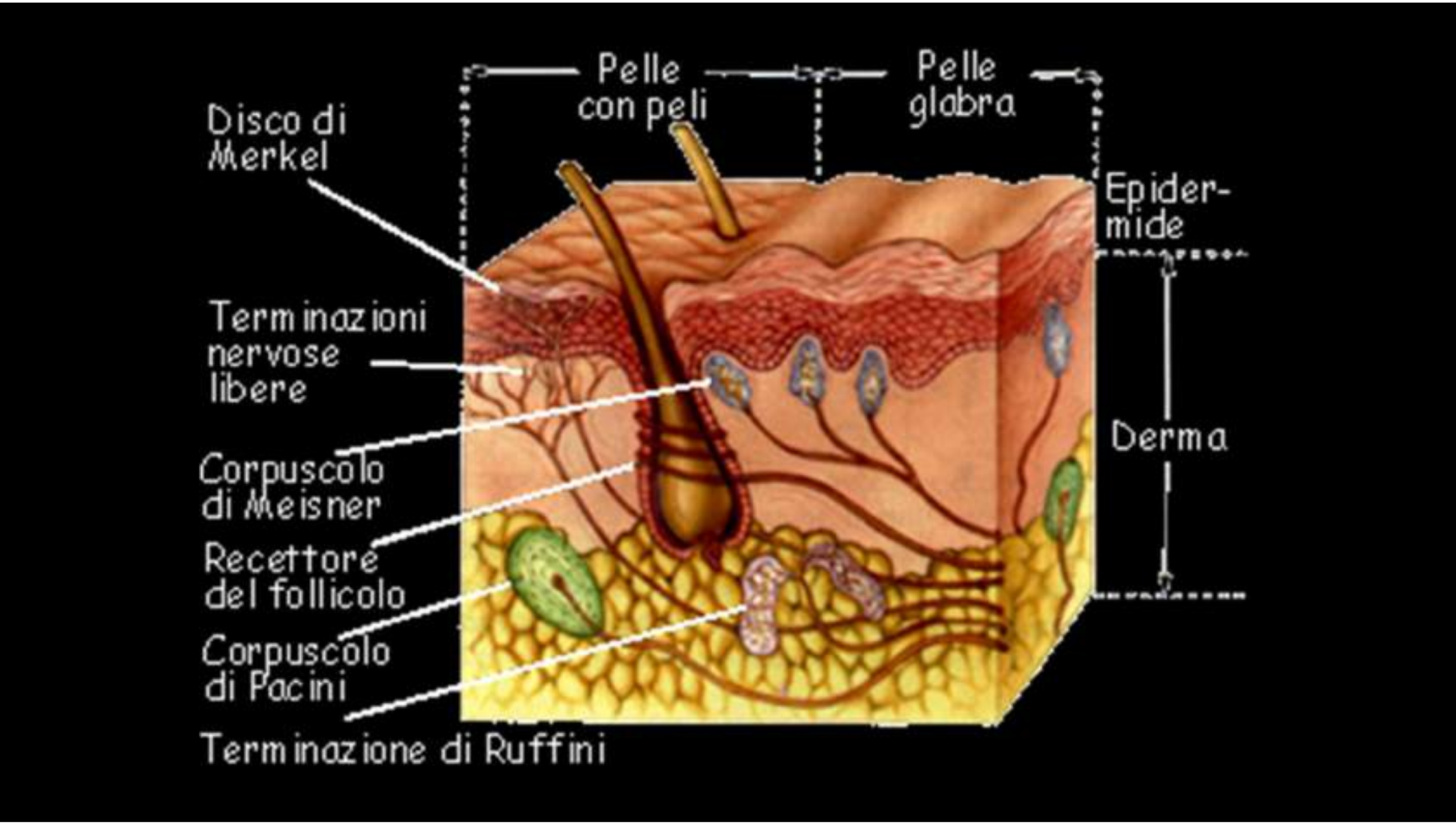
(1) Tale studio viene ripubblicato in allegato alla presente relazione.

HAND-ARM VIBRATION SYNDROME

- Vibration-induced white finger (secondary form of Raynaud's phenomenon)
- Diffuse-multifocal neuropathy with predominant sensory impairment
- Nerve trunk entrapment syndromes in the upper limbs

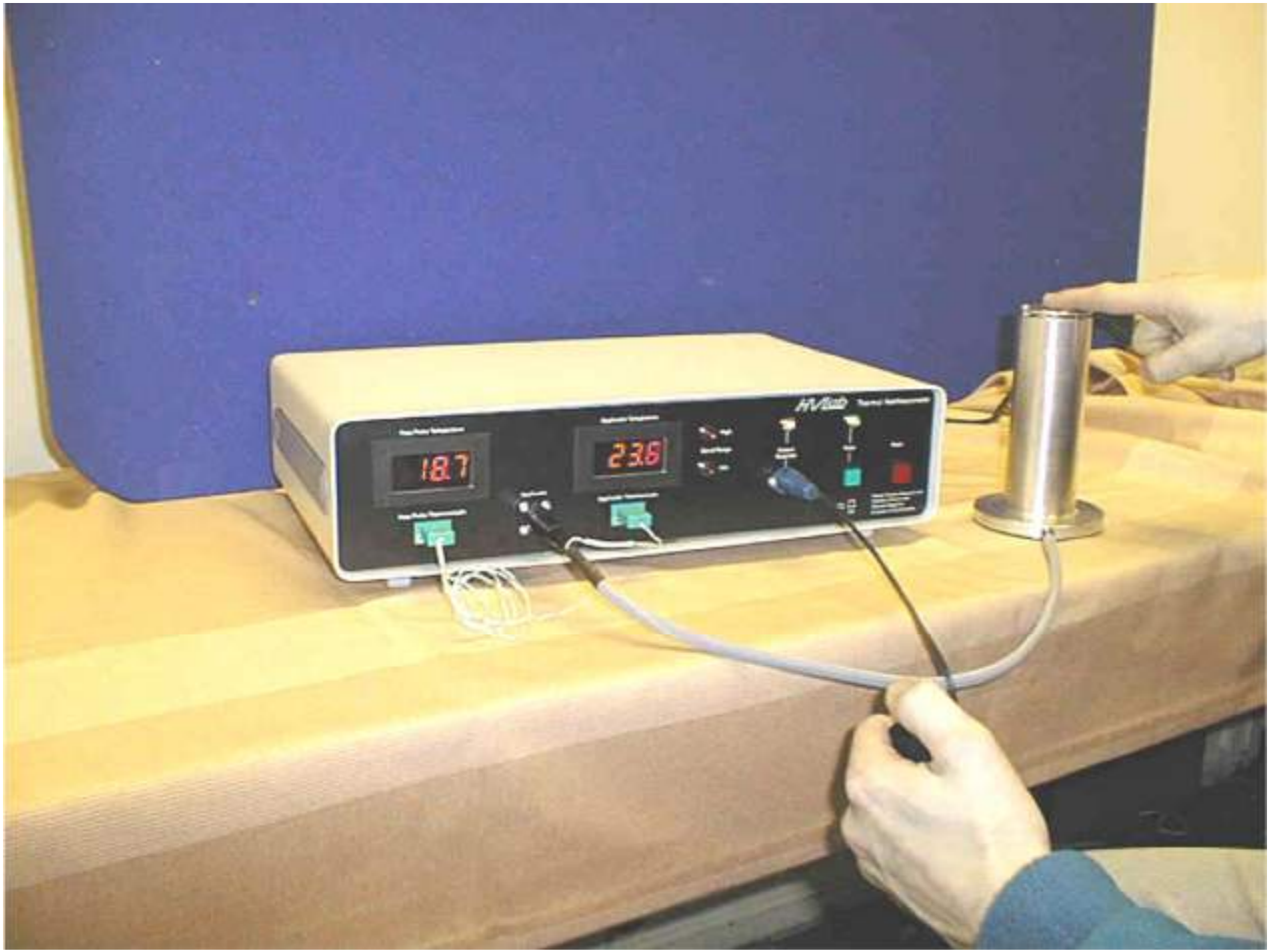

Pelle con peli
Pelle glabra
Disco di Merkel
Epider-mide
Terminazioni nervose libere
Derma
Corpuscolo di Meisner
Recettore del follicolo
Corpuscolo di Pacini
Terminazione di Ruffini

Fiber	Diameter (μ)	Conduction velocity (m/s)	Function
Aα	13-22	70-120	Motor, proprioceptive
Aβ	8-13	40-70	Touch, kinesthesia
Aγ	4-8	15-40	Touch, pressure, neuromuscular spindles
Aδ	1-4	5-15	Pain, cool/cold
B	1-3	3-14	ANS pregangliar fibers
C	0.2-1.0	0.2-2	Pain, warm/hot

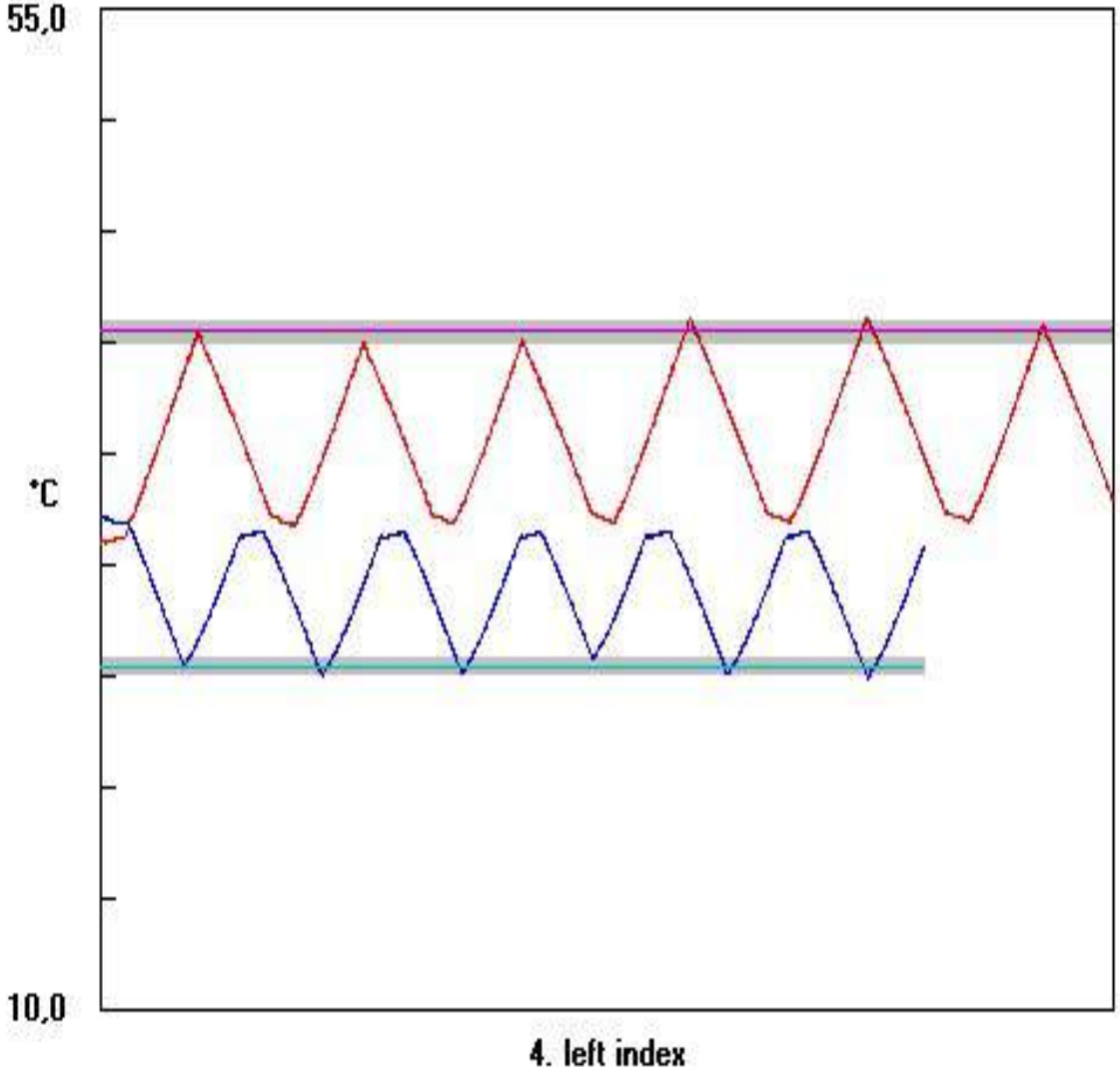
SPECIAL DIAGNOSTIC INVESTIGATIONS

Neurological investigations

- Vibrotactile perception thresholds (ISO 13091, 2001)
- Thermal perception thresholds
- Touch pressure (Semmes-Weinstein monofilaments)
- Manipulative dexterity tests (e.g. Purdue pegboard)
- Sensory and motor nerve conduction velocities in the upper and lower limbs


18.7
23.6

Thermotactile Thresholds



REFERENCE: gb374

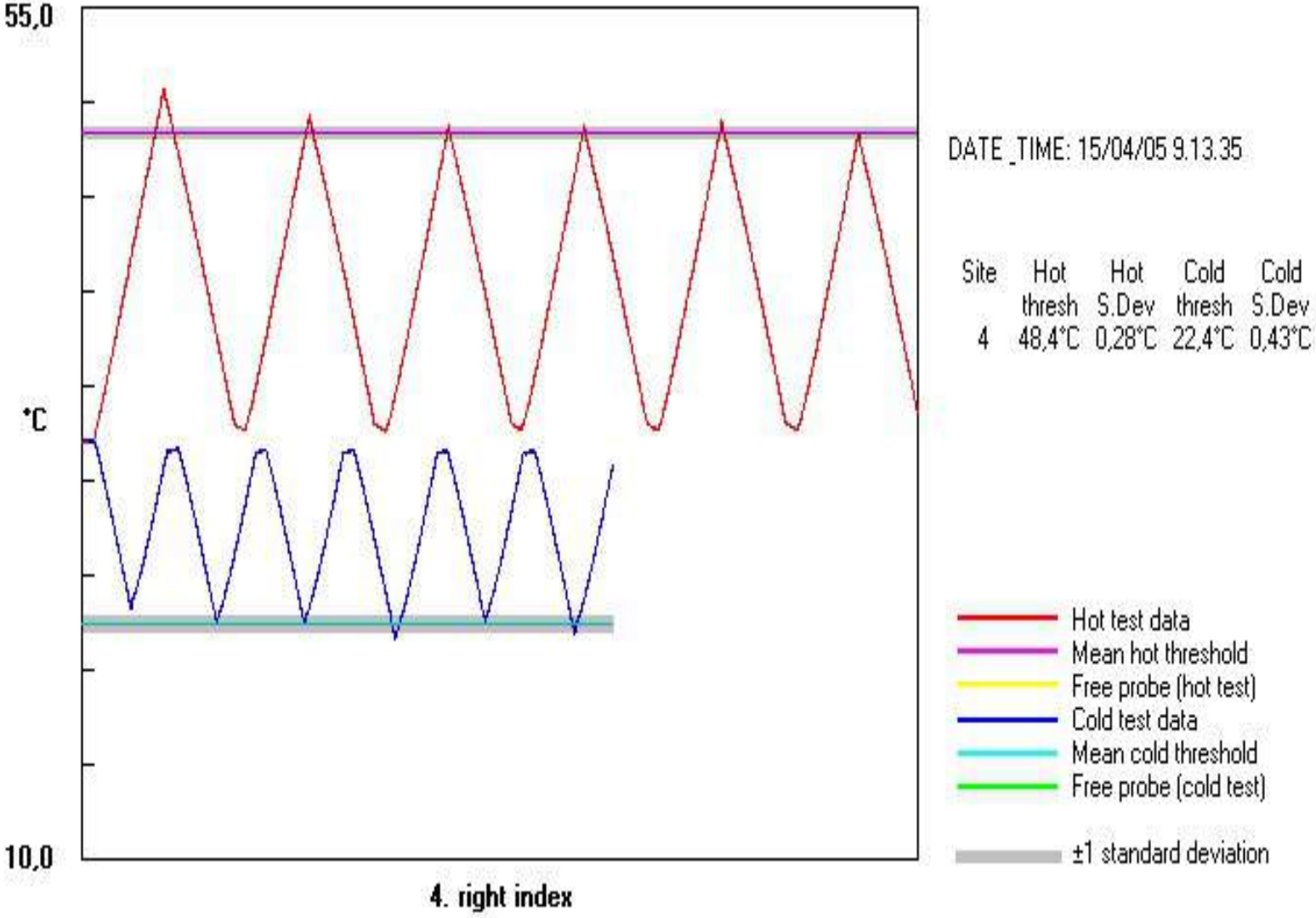
DATE _TIME: 15/04/05 9.13.35

Site	Hot thresh	Hot S.Dev	Cold thresh	Cold S.Dev
4	40,5°C	0,49°C	25,5°C	0,36°C

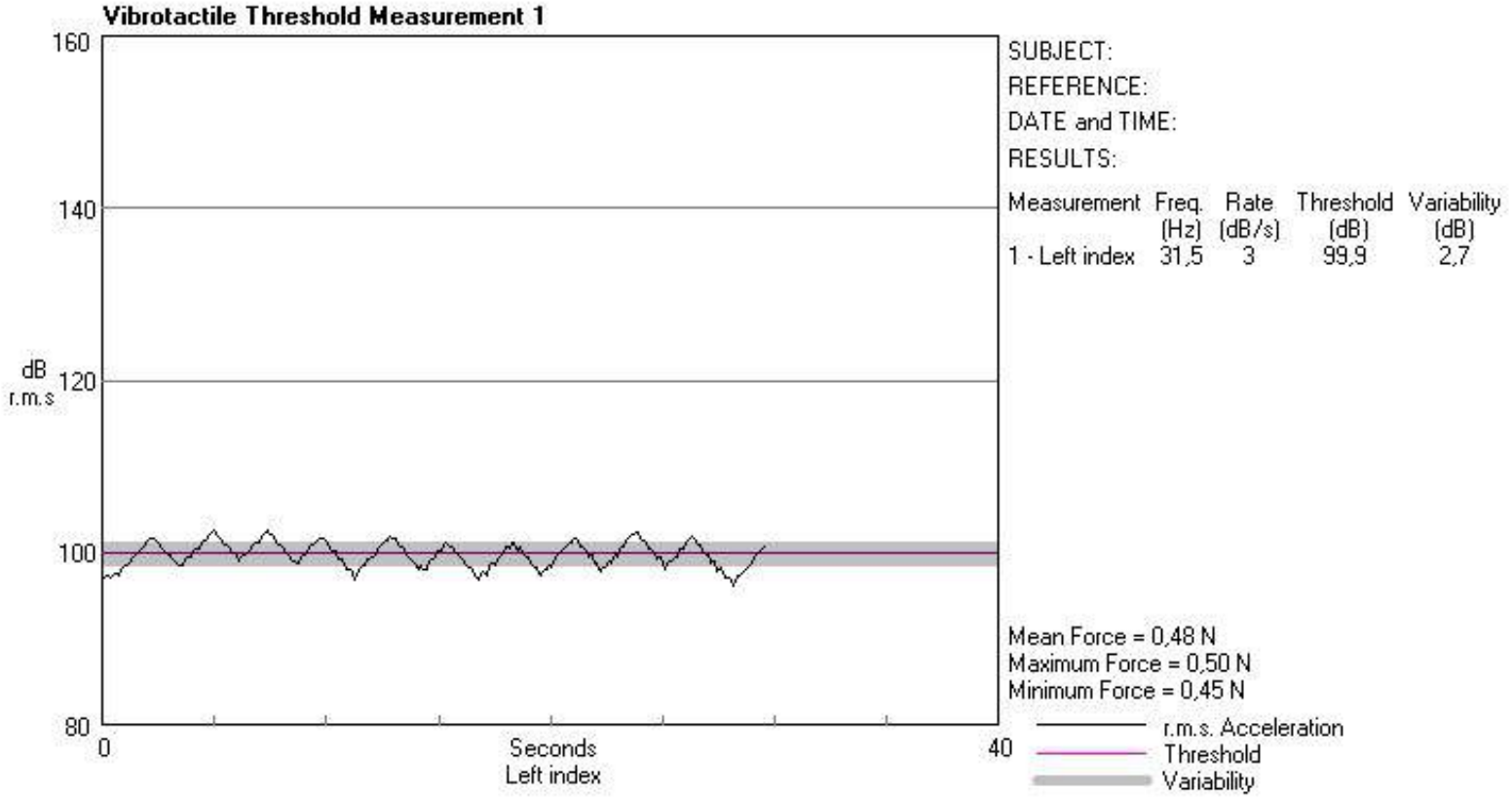
Hot test data
Mean hot threshold
Free probe (hot test)
Cold test data
Mean cold threshold
Free probe (cold test)

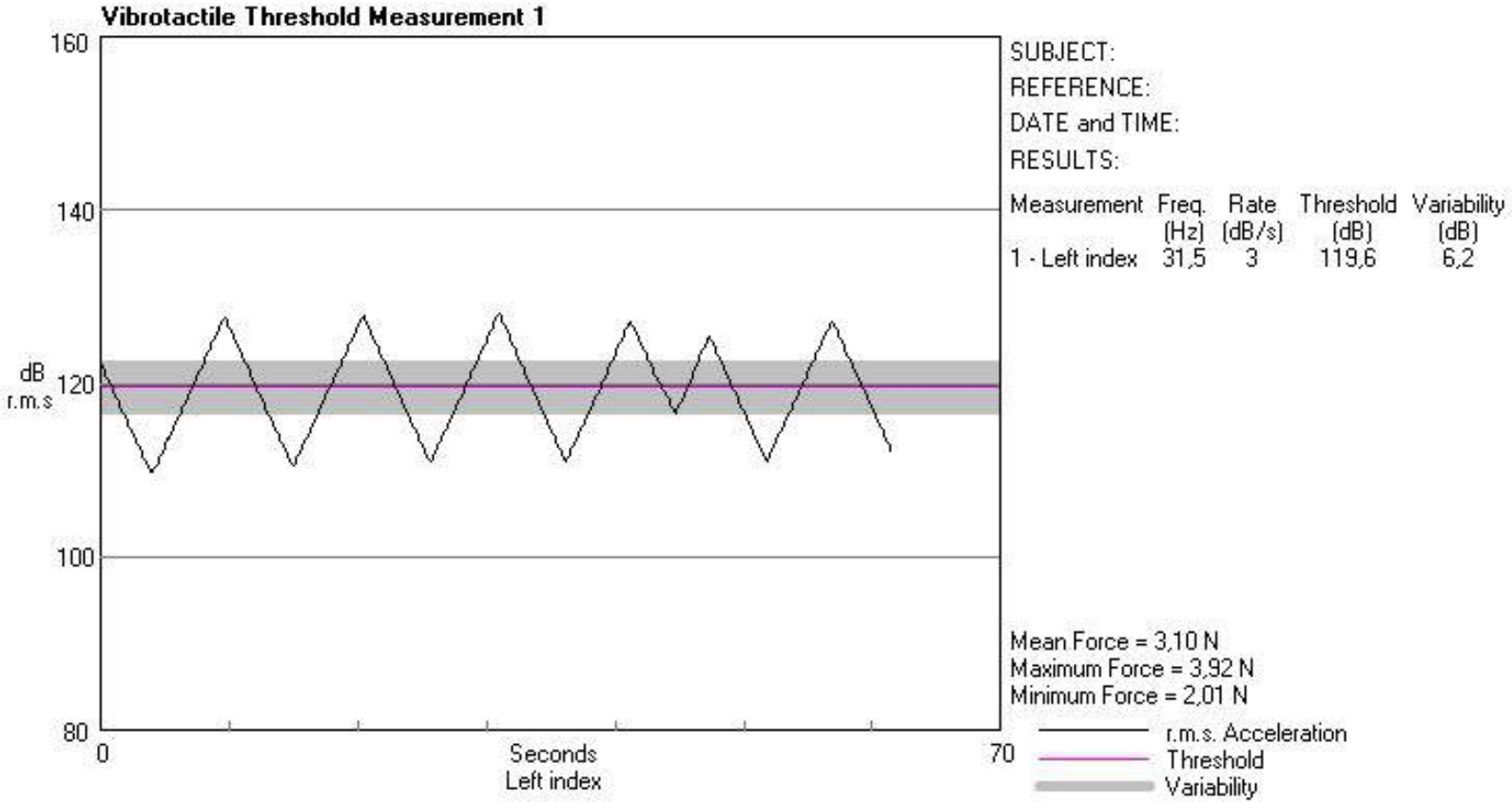
±1 standard deviation

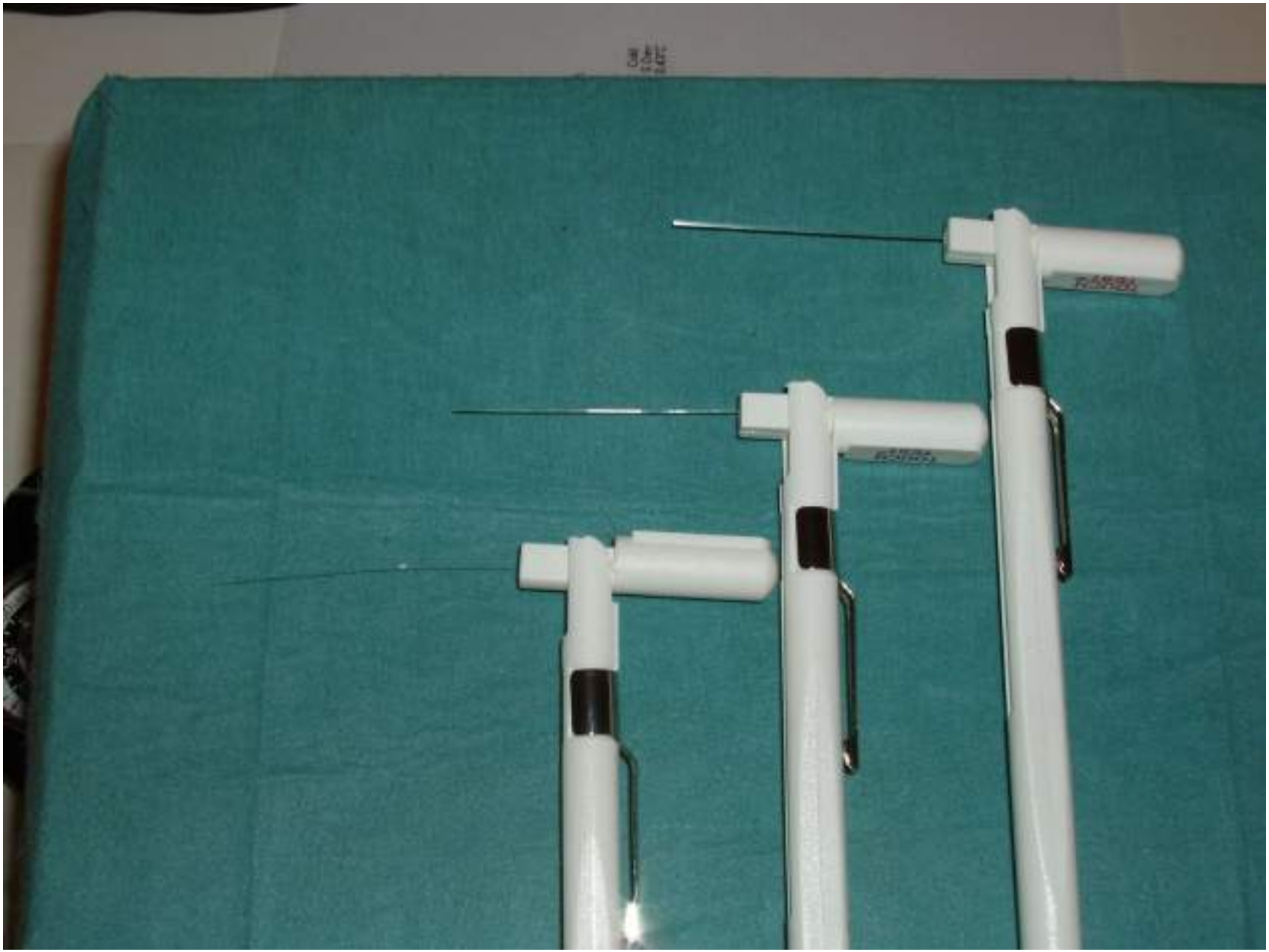
Thermotactile Thresholds

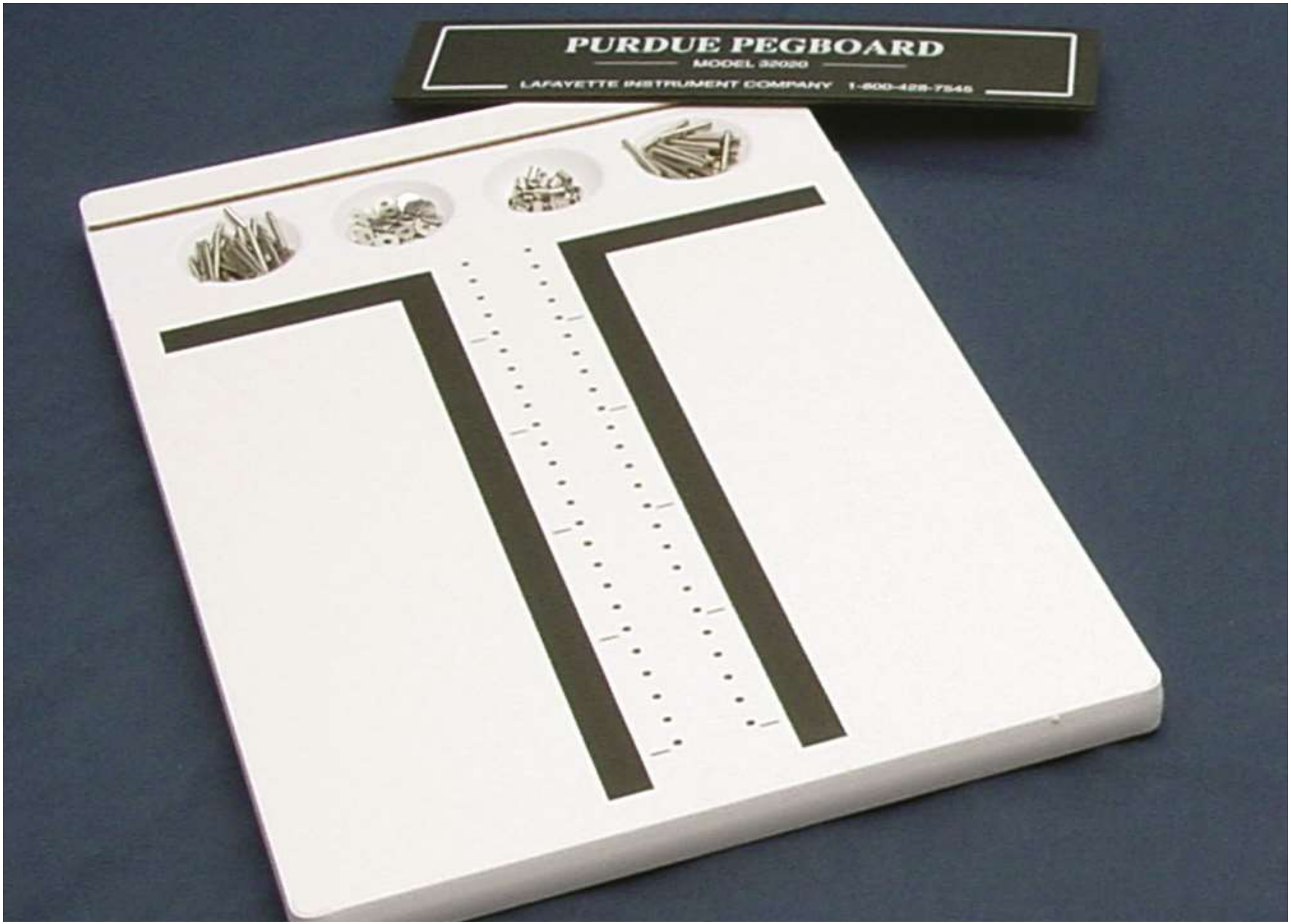



221
HVLab


Vibrotactile Threshold Measurement 1
160
140
120
100
80
dB
r.m.s
0
40
Seconds
Left index
SUBJECT:
REFERENCE:
DATE and TIME:
RESULTS:
Measurement Freq. (Hz) Rate (dB/s) Threshold (dB) Variability (dB)
1 - Left index 31,5 3 99,9 2,7
Mean Force = 0,48 N
Maximum Force = 0,50 N
Minimum Force = 0,45 N
r.m.s. Acceleration
Threshold
Variability


Vibrotactile Threshold Measurement 1
160
140
120
100
80
dB
r.m.s
0
70
Seconds
Left index
SUBJECT:
REFERENCE:
DATE and TIME:
RESULTS:
Measurement Freq. (Hz) Rate (dB/s) Threshold (dB) Variability (dB)
1 - Left index 31,5 3 119,6 6,2
Mean Force = 3,10 N
Maximum Force = 3,92 N
Minimum Force = 2,01 N
r.m.s. Acceleration
Threshold
Variability



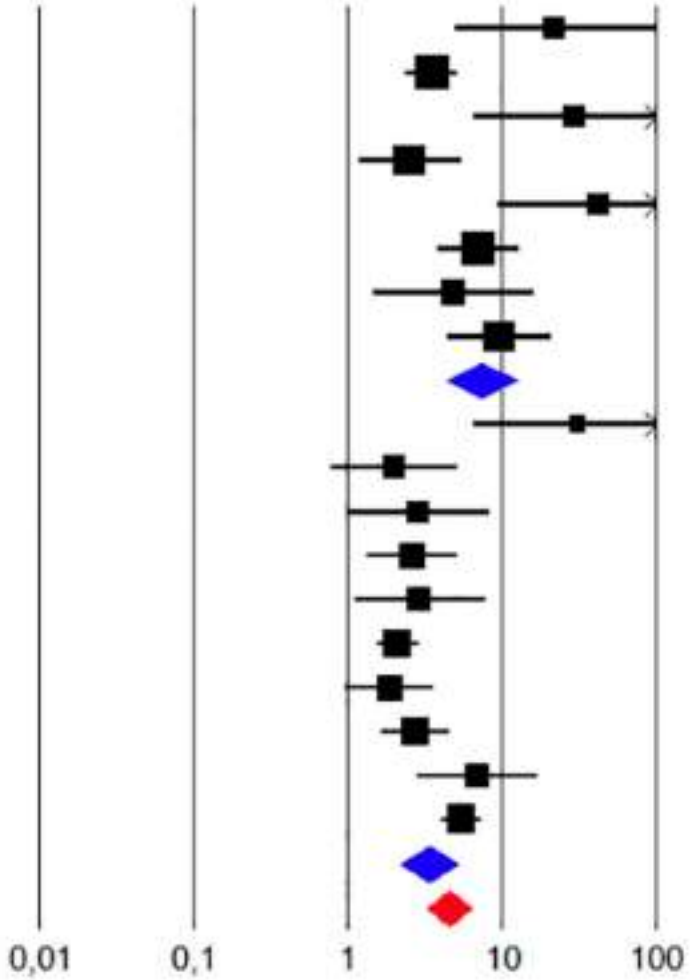

PURDUE PEGBOARD
MODEL 32020
LAFAYETTE INSTRUMENT COMPANY 1-800-428-7545

HAVS Neurological Component

ICC Stage	Description
0N	No numbness or tingling of digits
1N	Intermittent numbness and/or tingling of digits
2N	As in stage 1 but with sensory perception loss in at least one digit as evidenced by two or more validated methods such as monofilaments, thermal aesthesiometry and vibrotactile thresholds
3N	As in stage 2 but with symptoms of impaired dexterity and objetive evidence of impaired dexterity by the Purdue pegboard test

Meta-analysis for neurosensory disorders *vs* HTV (Nilsson *et al.* 2017)

Group by Risk of bias	Study name	Odds ratio	Lower limit	Upper limit
Low	69 Bovenzi, 2011*	21,94	4,88	98,63
Low	49 Bovenzi, 1994	3,49	2,36	5,16
Low	52 Futatsuka, 2005*	29,35	6,43	134,03
Low	47 Bovenzi, 1988*	2,49	1,16	5,36
Low	48 Bovenzi, 1985*	42,09	9,35	189,40
Low	54 Jang, 2002*	6,97	3,74	13,01
Low	71 Matsumoto, 1995*	4,80	1,45	15,94
Low	57 Letz, 1992*	9,51	4,41	20,54
Low		7,37	4,39	12,37
Unclear	58 Chatterjee, 1978*	30,47	6,45	144,04
Unclear	72 Malchaire, 2001*	1,98	0,77	5,12
Unclear	60 Burdorf, 1991*	2,87	1,01	8,18
Unclear	61 Cherniack, 2004*	2,62	1,34	5,15
Unclear	59 Brubaker, 1985*	2,90	1,10	7,68
Unclear	62 Anttonen, 1994*	2,09	1,52	2,86
Unclear	63 Virokannas, 1995*	1,86	0,96	3,60
Unclear	56 Bovenzi, 2005	2,70	1,63	4,48
Unclear	64 Bovenzi, 1980*	6,84	2,79	16,78
Unclear	67 Mirbod, 1994*	5,43	4,03	7,31
Unclear		3,31	2,17	5,06
Overall		4,56	3,29	6,33

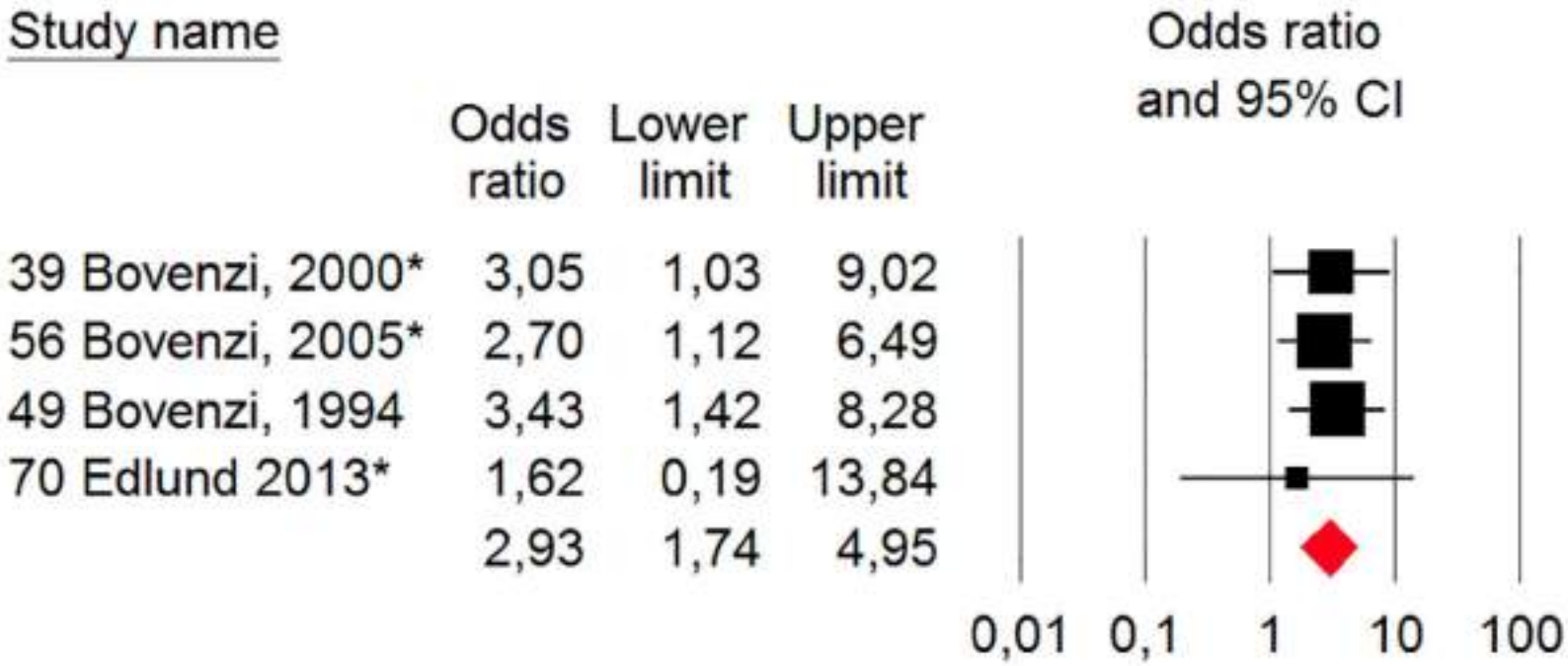


Consensus criteria for the classification of CTS symptoms/signs in epidemiologic studies

(*Am J Public Health* 1998; 88:1447-1451)

- Classic/probable symptoms (numbness, tingling, burning or pain in at least two of digits 1, 2, or 3)
- Nocturnal symptoms
- Positive physical examination (Tinel's test or Phalen's test)

Meta-analysis for carpal tunnel syndrome (CTS) *vs* HTV (Nilsson *et al.* 2017)



HAND-ARM VIBRATION SYNDROME

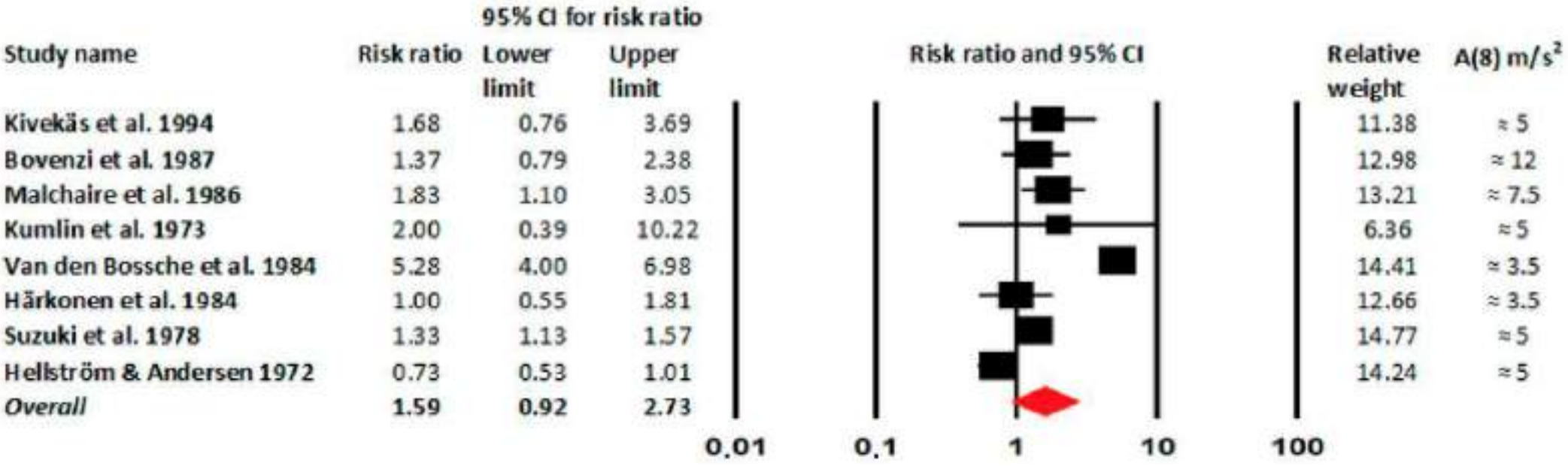
- Vibration-induced white finger (secondary form of Raynaud's phenomenon)
- Diffuse or multifocal neuropathy with predominant sensory impairment
- Nerve trunk entrapment syndromes in the upper limbs
- Changes in the bones and joints of the upper limbs

Bone and joint disorders of the upper limbs

- Cysts or vacuoles of the carpal-metacarpal bones (?)
- Elbow and wrist osteoarthrosis
- Elbow enthesopathies (olecranon spurs)

- Exposure to high magnitudes of low frequency vibration (< 50 Hz) from percussive tools
- Ergonomic risks factors
- Individual susceptibility (?)

Meta-analysis of X-ray-diagnosed hand osteoarthritis *vs* HTV (Nilsson *et al.* 2023)



HAND-ARM VIBRATION SYNDROME

- Vibration-induced white finger (secondary form of Raynaud's phenomenon)
- Diffuse-multifocal neuropathy with predominant sensory impairment
- Nerve trunk entrapment syndromes in the upper limbs
- Changes in the bones and joints of the upper limbs
- Upper limb muscle and tendon disorders

Work-related musculoskeletal and tendon disorders associated with work with vibratory tools

- Cervicobrachial disorders
- Degenerative and inflammatory tendon disorders of the upper limbs (tendinitis, tenosynovitis, peritendinitis)
- Other disorders: Dupuytren's contracture, De Quervain's disease, trigger finger, tendon cysts, bursitis

SPECIAL DIAGNOSTIC INVESTIGATIONS

Muscular strength investigations

- Grip strength
- Tip, key, and palmar pinch strength

Imaging procedures

- Ultrasound & X-ray films of shoulders, elbows, wrists and hands

Laboratory tests

- Blood tests
- Autoimmune serology


Pitch Gauge

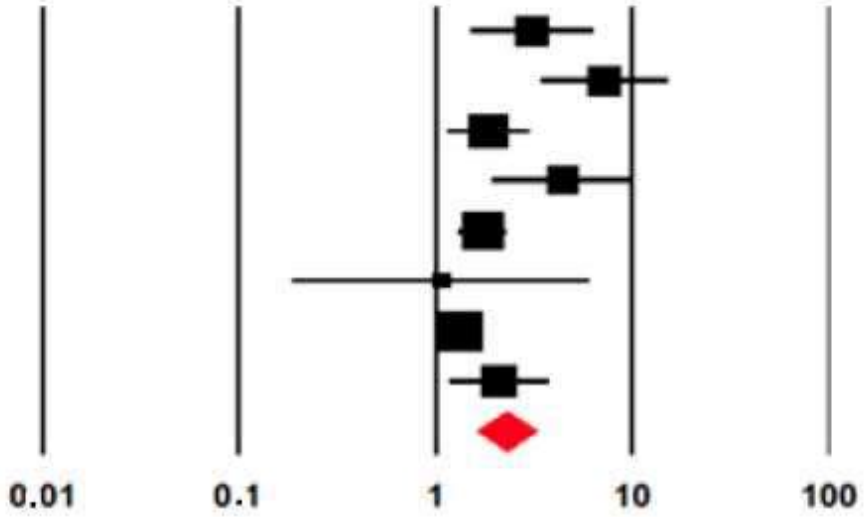
Dupuytren's contracture

(*Am J Ind Med* 1996; 29:521-532)

Nodules and cords in the palmar aponeurosis eventually resulting in irreversible flexion contracture of one or more fingers of the hand.

Meta-analysis for Dupuytren's contracture *vs* HTV (Nilsson *et al.* 2023)

Study name	Odds ratio	95% CI for odds ratio Lower limit	Upper limit	Relative weight
Bovenzi (1994)	3.07	1.50	6.31	11.14
Murinova et al (2021)	7.16	3.40	15.09	10.78
Palmer et al (2014)	1.86	1.15	3.00	14.88
Descatha et al (2012)	4.46	1.93	10.31	9.60
Lucas et al (2008)	1.73	1.29	2.31	17.82
Dasgupta & Harrison (1996)	1.07	0.19	6.12	3.47
Descatha et al (2014)	1.35	1.13	1.62	19.23
Thomas & Clarke (1992)	2.09	1.16	3.76	13.08
Overall	***2.29***	***1.60***	***3.27***	



Consorzio per l'accreditamento
e aggiornamento in Medicina del Lavoro

Società Italiana di Medicina del Lavoro
ed Igiene Industriale

Fondazione Salvatore Maugeri
Clinica del Lavoro e della Riabilitazione
I.R.C.C.S.

Centro Studi

LINEE GUIDA

per la prevenzione dei disturbi e delle patologie da esposizione a vibrazioni meccaniche negli ambienti di lavoro

M. Bovenzi *(coordinatore)*
G. Angotzi, P. Apostoli, C. Negro, W. Versini

Vol. 5
PRIMA REVISIONE

Lista I – Gruppo 2 – Malattie da agenti fisici

(DM 15.11.2023, GU n.10 dd. 13.01.2024)

Vibrazioni mano-braccio

- Sindrome di Raynaud secondaria (angioneurosi dita mani)
- Osteoartropatie (polso, gomito, spalla)
- Neuropatie periferiche dei nervi mediano e ulnare

Revisione delle tabelle delle malattie professionali nell'industria e nell'agricoltura

(D.M. 10.10.2023, GU n. 270 dd. 18.11.2023)

MALATTIE CAUSATE DA VIBRAZIONI MANO-BRACCIO

a) SINDROME DI RAYNAUD SECONDARIA dita mani

b) OSTEOARTROPATIE (polso, gomito, spalla)

c) NEUROPATIE PERIFERICHE dei nervi mediano e ulnare

Periodo max indennizzabilità: a) 1 anno; b) 4 anni; c) 2 anni

Lavorazioni, svolte in modo abituale e sistematico, che comportano l'impiego di utensili, attrezzature, macchine ed apparecchi che trasmettono vibrazioni al sistema mano-braccio.

Bando ricerche BRiC 2022

Progetto: *No Risks – nuovi modelli per ridurre il rischio derivante dall'esposizione dei lavoratori a vibrazioni*

WP1

Il ruolo dei fattori di rischio personali, non-occupazionali, nell'occorrenza della sindrome da vibrazioni mano-braccio: analisi aggregata di studi epidemiologici italiani con disegno trasversale e longitudinale

Pooled cross-sectional study

- The study populations included **1272 HTV exposed male workers** and **579 unexposed control men** who were investigated in a series of cross-sectional studies conducted in geographic areas of the Central and North-Eastern Italy during the autumn/winter seasons in the calendar period 1990-2010.
- The **HTV exposed workers** were employed in various industrial sectors: forestry (n=524), construction (n=221), shipbuiding (n=192), engineering (n=206), iron and steel (n=129).
- The **control men** were manual workers (n=429) or inspectors/supervisors (n=150) not exposed to HTV and recruited in the same enterprises or companies of the HTV exposed workers.

Pooled cohort study

- Two prospective cohort studies included **377 HTV exposed workers** (343 forestry operators and 34 stone workers) and **138 control men** employed at the same companies (129 maintenance operators, 5 inspectors, 4 supervisors).

- They were investigated at the cross-sectional survey and over either 1 or 5 yr-interval follow-up investigations carried out in the autumn-winter seasons of the calendar period 1990-2007.

Symptoms and signs of HTV induced vascular disorders

- Medical interview according to the criteria of the Stockholm Workshop ’94.

- Administration of colour charts.
- Abnormal findings at a cold test with measurement of finger systolic blood pressure at 10° C

Symptoms and signs of HTV induced neurosensory disorders

- Medical interview according to the criteria of the Stockholm Workshop ’94.
- *Persistent* finger numbness.
- Impaired perception thresholds for touch, heat, cold and vibration sensations.
- Impaired manipulative dexterity.

Disorders of soft tissues of the hand-wrist

Carpal tunnel syndrome (CTS)

Consensus criteria for the classification of CTS symptoms/ signs in epidemiologic studies.

(*Am J Public Health* 1998; 88:1447-1451).

Dupuytren's contracture

Nodules and cords in the palmar aponeurosis eventually resulting in irreversible flexion contracture of one or more fingers of the hand.

(*Am J Ind Med* 1996; 29:521-532)

Personal risk factors

EU VIBRISKs Questionnaire
(*http://www.vibrisks.soton.ac.uk*)

- Age (y)
- BMI (kg/m^2)
- Smoking habit (pack-yrs)
- Drinking habit (alcohol units/d)
- Regular intake of medicines
- Traumas/surgery of the neck-upper limbs
- Disorders of the cervical spine
- Metabolic disorders
- Cardiovascular diseases

Vibration measurement and exposure

- Vibration measurements were made in three orthogonal directions (*x*-, *y*-, *z*-axes) according to the procedure in ISO 5349-1.
- Acceleration magnitudes were weighted according to ISO frequency weighting (w_{hi}) and daily HTV exposure was expressed in terms of ***A*(8)** according to ISO 5349-1 and the EU Directive on vibration.

$$a_{hvi} = \sqrt{a_{hwxi}^2 + a_{hwyi}^2 + a_{hwzi}^2} \qquad (ms^{-2}\ r.m.s.)$$

$$A(8) = \sqrt{\sum_{i=1}^{n} a_{hvi}^2 \frac{T_i}{T_0}} \qquad (ms^{-2}\ r.m.s.)$$

Ergonomic risk factors for CTS

- EU VIBRISKS questionnaire: five questions concerning twisting, forceful or repetitive movements, uncomfortable hand positions/grips, and heavy demands on precision scored on a 4-point response scale (*http://www.vibrisks.soton.ac.uk*).
- The score of hand/forearm physical load was categorised into quartiles corresponding to four grades of increasing physical load from mild to hard load grade (*SJWEH* 2015; 41:247-258).

Data analysis

Pooled cross-sectional study

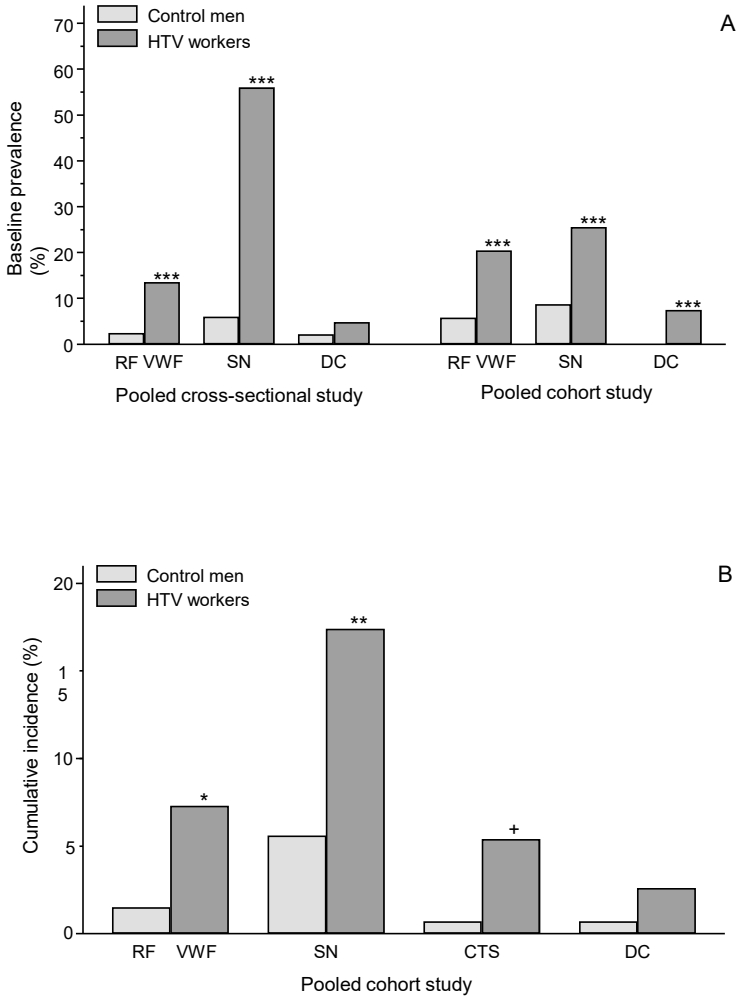
- Prevalence data
- Multivariable linear and logistic regression analyses
- Likelihood ratio test
- Goodness-of-fit statistic (H-L method)

Pooled cohort study

- Prevalence and incidence data
- GEE method
- Identity and logit link functions
- Autoregressive correlation structure
- Time-dependent covariates

Individual characteristics in the pooled cross-sectional and cohort studies

Factors median (q) n (%)	Cross-sectional study		Cohort study	
	Controls (n=579)	HTV workers (n=1272)	Controls (n=138)	HTV workers (n=377)
Age (y)	**42 (34-50)**	**46 (39-52)[c]**	**38.8 (34.1-45.9)**	**43.1 (35.2 – 49.8)[b]**
BMI (kg/m^2)	**25.3 (23.1-27.7)**	**26.1(23.8-28.4)[c]**	**24.5 (23.0-27.2)**	**25.9(23.8 – 27.7)[c]**
Smoking	266 (45.9)	710 (55.8)	**49 (35.5)**	**256 (67.9)[c]**
Drinking	444 (76.7)	943 (74.1)	104 (75.4)	282 (74.8)
Regular intake of medicines	85 (14.6)	228 (17.9)	24 (17.4)	50 (13.3)
Trauma/surgery neck-upper limb	**239 (41.3)**	**631 (49.6)[c]**	58 (42.0)	157 (41.6)
Disorders of the cervical spine	28 (4.9)	83 (6.5)	**6 (4.4)**	**38 (10.1)[a]**
Metabolic disorders	**12 (2.1)**	**55 (4.3)[c]**	**4 (2.9)**	**36 (9.6)[a]**
Cardiovascular disorders	64 (11.1)	197 (15.5)[a]	14 (10.1)	55 (14.6)
***A*(8) (ms^{-2} r.m.s.)**	-	2.98 (1.90 – 4.41)	-	3.72 (2.80 – 4.98)


A
Control men
HTV workers
Baseline prevalence (%)
70
60
50
40
30
20
10
0
***
***
***
***
***
RF VWF
SN
DC
RF VWF
SN
DC
Pooled cross-sectional study
Pooled cohort study
B
Control men
HTV workers
Cumulative incidence (%)
20
1
5
10
5
0
*
**
+
RF
VWF
SN
CTS
DC
Pooled cohort study

Relations of vascular disorders to HTV exposure and personal risk factors

Factors	Cross-sectional study		Cohort study	
	Total sample (n=1851)	**HTV workers (n=1272)**	**Total sample (obs=1665)**	**HTV workers (obs=1172)**
Age (×10 y)	**1.72 (1.27-2.30)**	**2.20 (1.48-3.27)**	**1.83 (1.45-2.31)**	**2.16 (1.66-2.81)**
BMI (kg/m^2)	**0.89 (0.83-0.97)**	**0.88 (0.84-0.93)**	0.95 (0.89-1.01)	0.97 (0.90-1.04)
Smoking (current-exsmoker)	1.53 (0.92-2.55)	1.74 (0.95-3.20)	1.21 (0.72-2.05)	1.09 (0.62-1.92)
Drinking (≥ 3 alcohol units/d)	1.65 (0.76-3.57)	1.26 (0.83-1.92)	1.41 (0.90-2.19)	1.25 (0.83-1.88)
Regular intake of medicines	0.83 (0.35-1.97)	0.53 (0.18-1.53)	1.06 (0.68-1.64)	1.09 (0.65-1.82)
Trauma/surgery neck-upper limb	0.61 (0.37-1.10)	0.54 (0.30-1.35)	0.93 (0.62-1.39)	0.82 (0.58-1.17)
Disorders of the cervical spine	1.51 (0.66-3.44)	1.59 (0.65-3.91)	1.14 (0.64-2.04)	1.25 (0.64-2.42)
Metabolic disorders	**3.16 (1.10-9.10)**	**3.35 (1.09-10.3)**	**2.14 (1.12-4.11)**	**2.46 (1.15-5.25)**
Cardiovascular disorders	1.90 (0.82-4.38)	1.41 (0.53-3.76)	1.10 (0.67-1.81)	0.90 (0.52-1.56)
Exposure to HTV (yes vs no) ***A*(8) (ms^{-2} r.m.s.)**	**2.87 (1.56-5.30)** –	– **1.19 (1.10-1.29)**	**4.20 (1.93-9.11)** –	– **1.22 (1.13-1.32)**

Relations of cold-induced vascular dysfunction to HTV exp. and personal risk factors

Factors	Cross-sectional study		Cohort study	
	%FSBP$_{10°}$		%FSBP$_{10°}$	
	Total sample (n=1504)	**HTV workers (n=1070)**	**Total sample (obs=1665)**	**HTV workers (obs=1172)**
Age (×10 y)	0.05 (-1.97; 2.07)	-0.53 (-2.90; 1.83)	-0.88 (-2.14; 0.39)	**-2.29 (-3.86; -0.72)**
BMI (kg/m^2)	**0.54 (0.005; 1.07)**	0.47 (-0.15; 1.09)	**0.67 (0.31; 1.03)**	**0.74 (0.29; 1.18)**
Smoking (current-exsmoker)	1.27 (-2.75; 5.28)	1.86 (-3.03; 6.76)	0.54 (-1.70; 2.78)	1.08 (-1.74; 3.91)
Drinking	-0.84 (-4.87; 3.18)	0.51 (-4.52; 5.55)	-1.42 (-3.91; 1.07)	1.33 (-1.83; 4.49)
Raynaud's phenomenon	**-18.1 (-26.4;-9.85)**	**-15.6 (-24.5; -6.75)**	**-19.3 (-22.3; -16.3)**	**-15.8 (-19.3; -12.2)**
Regular intake of medicines	2.46 (-4.07; 8.99)	4.11 (-4.78; 13.0)	0.84 (-2.21; 3.88)	3.29 (-0.52; 7.11)
Trauma/surgery neck-upper limb	-0.05 (-3.76; 3.67)	0.97 (-3.82; 5.76)	-0.14 (-2.27; 1.99)	0.25 (-2.46; 2.95)
Disorders of the cervical spine	-1.20 (-9.76; 7.36)	2.44 (-6.46; 11.3)	1.78 (-2.41; 5.98)	4.32 (-0.58; 9.23)
Metabolic disorders	-7.43 (-20.3; 5.46)	-2.13 (-17.0; 12.7)	-0.13 (-4.74; 4.47)	1.29 (-4.00; 6.58)
Cardiovascular disorders	-1.77 (-9.16; 5.61)	-0.54 (-9.96; 8.88)	-2.65 (-6.34; 1.04)	-3.41 (-7.86; 1.05)
Exposure to HTV (yes vs no)	**-6.03 (-9.62; -2.44)**	–	**-6.30 (-8.76; -3.85)**	–
***A*(8) (ms^{-2} r.m.s.)**	–	**-1.61 (-2.54; -0.68)**	–	**-2.14 (-2.59; -1.69)**

Relations of neurosensory disorders to HTV exposure and personal risk factors

Factors	Cross-sectional study		Cohort study	
	Total sample (n=1851)	**HTV workers (n=1272)**	**Total sample (obs=1665)**	**HTV workers (obs=1172)**
Age (×10 y)	**1.53 (1.20-1.96)**	**1.67 (1.28-2.18)**	**1.93 (1.50-2.47)**	**2.06 (1.66-2.56)**
BMI (kg/m^2)	1.02 (0.97-1.07)	1.02 (0.96-1.07)	1.00 (0.95-1.05)	1.00 (0.95-1.06)
Smoking (current-exsmoker)	1.28 (0.85-1.92)	1.10 (0.70-1.74)	1.31 (0.87-1.99)	1.19 (0.76-1.86)
Drinking (≥ 3 alcohol units/d)	1.84 (0.99-3.43)	1.87 (0.94-3.73)	1.08 (0.83-1.42)	1.11 (0.83-1.48)
Regular intake of medicines	1.12 (0.56-2.23)	1.13 (0.55-2.35)	0.91 (0.63-1.30)	0.87 (0.63-1.20)
Trauma/surgery neck-upper limb	**2.32 (1.56-3.45)**	**1.90 (1.21-2.97)**	**1.35 (1.03-1.76)**	1.35 (0.95-1.92)
Disorders of the cervical spine	**3.56 (2.17-6.10)**	**4.22 (1.93-9.23)**	0.99 (0.68-1.45)	1.26 (0.69-2.30)
Metabolic disorders	1.61 (0.61-4.22)	2.13 (0.72-6.32)	0.94 (0.54-1.63)	1.12 (0.56-2.22)
Cardiovascular disorders	1.57 (0.77-3.20)	1.44 (0.67-3.06)	1.23 (0.64-2.35)	1.01 (0.64-1.59)
Exposure to HTV (yes vs no)	**3.64 (2.17-6.10)**	–	**2.70 (1.50-4.87)**	–
***A*(8) (ms^{-2} r.m.s.)**	–	**1.09 (1.01-1.17)**	–	**1.13 (1.05-1.21)**

Relations of suspected CTS to HTV exposure and personal risk factors

Factors	Cohort study	
	Total sample (n=515; obs=1665)	**HTV workers (n=377; obs=1172)**
Age (×10 y)	**1.63 (1.17 – 2.77)**	**1.61 (1.15 – 2.27)**
BMI (kg/m^2)	1.06 (0.99 – 1.15)	1.08 (0.99 – 1.17)
Smoking (current-exsmoker)	1.11 (0.64 – 1.95)	0.98 (0.54 – 1.74)
Drinking (≥ 3 alcohol units/d)	**2.97 (1.26 – 6.99)**	**3.41 (1.37 – 8.44)**
Regular intake of medicines	1.67 (0.87 – 3.22)	1.87 (0.94 – 3.72)
Trauma/surgery neck-upper limb	**1.89 (1.09 – 3.26)**	**1.90 (1.08 – 3.35)**
Disorders of the cervical spine	1.70 (0.70 – 4.15)	2.04 (0.81 – 5.13)
Metabolic disorders	1.39 (0.38 – 5.08)	1.49 (0.38 – 5.81)
Cardiovascular disorders	0.66 (0.28 – 1.54)	0.45 (0.18 – 1.16)
Exposure to HTV (yes vs no) **$A(8)$ (ms^{-2} r.m.s.)**	**14.9 (4.12 – 54.3)** –	– **1.12 (1.05 – 1.19)**

Relations of Dupuytren's contracture to HTV exposure and personal risk factors

Factors	Cross-sectional study		Cohort study	
	Total sample (n=803)	**HTV workers (n=515)**	**Total sample (obs=1665)**	**HTV workers (obs=1172)**
Age (×10 y)	**1.95 (1.17-3.25)**	**1.84 (1.05-3.24)**	**1.95 (1.28-2.99)**	**1.47 (0.97-2.22)**
BMI (kg/m^2)	0.99 (0.87-1.15)	0.93 (0.81-1.08)	0.97 (0.86-1.08)	1.00 (0.89-1.11)
Smoking (current-exsmoker)	0.69 (0.29-1.65)	0.52 (0.21-1.29)	0.70 (0.31-1.57)	0.66 (0.30-1.46)
Drinking (≥ 3 alcohol units/d)	**3.49 (1.04-11.7)**	2.24 (0.59-8.56)	**2.65 (1.02-6.04)**	**2.72 (1.18-6.28)**
Regular intake of medicines	0.59 (0.16-2.19)	0.71 (0.16-3.06)	0.28 (0.07-1.16)	0.27 (0.09-1.20)
Trauma/surgery neck-upper limb	1.19 (0.52-2.71)	1.03 (0.41-2.58)	0.84 (0.25-2.71)	0.87 (0.42-1.81)
Disorders of the cervical spine	2.20 (0.70-6.92)	1.92 (0.43-8.45)	0.87 (0.32-2.38)	0.73 (0.21-2.61)
Metabolic disorders	3.77 (0.76-18.7)	**6.31 (1.34-29.7)**	**4.99 (1.88-13.3)**	**5.05 (1.89-13.5)**
Cardiovascular disorders	1.53 (0.49-4.80)	1.98 (0.50-7.93)	1.67 (0.63-4.40)	1.85 (0.74-4.62)
Exposure to HTV (yes vs no)	2.00 (0.70-5.68)	–	**23.9 (3.05-188)**	–
***A*(8) (ms^{-2} r.m.s.)**	–	0.97 (0.81-1.17)	–	0.96 (0.82-1.13)

Summary of the associations between the components of the HAVS and occupational and personal risk factors

Factors	Pooled cross-sectional study			Pooled cohort study			
	Vascular	Neurosensory	DC	Vascular	Neurosensory	CTS	DC
Age	+++	+++	++/+	+++	+++	++	++
BMI	+++/++	-	-	++	-	-	-
Smoking	-	-	-	-	-	-	-
Drinking	-	-	+	-	-	++/+	+
Regular intake of medicines	-	-	-	-	-	-	-
Trauma/surgery of neck-upper limbs	-	+++/++	-	-	+	+	
Disorders of the cervical spine	-	+++	-	-	-	-	-
Metabolic disorders	+	-	+/-	++/+	-	-	+++
Cardiovascular disorders	-	-	-	-	-	-	-
HTV exposure	+++	+++/+	-	+++	+++/++	+++/++	++/-

+++ P<0.001; ++ 0.001<P<0.01; + 0.01<P<0.05; - NS

General considerations (1)

- Data modelling did not show significant interactions between HTV exposure and individual characteristics suggesting that occupational and personal risks factors may play independent roles in the occurrence of upper limb disorders.
- The lack of statistical significance for interactions between variables does not exclude possible underlying biological synergy between risk factors which can cooperate to the occurrence of upper limb disorders in the exposed workers.

General considerations (2)

- The presence of non-occupational risk factors should not be considered a sufficient justification for rebutting the presumption of work relatedness for the disorders in the upper limbs of HTV exposed workers providing that the symptoms and signs of the disorders arise after the first exposure to HTV.

General considerations (3)

- These findings may be helpful for occupational physicians who have the responsibility to manage and to update protocols for the health surveillance of vibration exposed workers.

- Targeted preventative measures at the workplace and programs for health promotion should be implemented to protect vulnerable workers, with particular considerations for the elderly workers and those affected with comorbidities which can make them more susceptible to the adverse effects of HTV.

Treatment
Vascular disorders (1)

- No controlled trial to assess the effectiveness of pharmacological agents commonly used for the treatment of Raynaud's phenomenon, such as calcium channel antagonists, α_1-adrenoreceptor antagonists, antifibrinolytics, prostanoids or nitroglycerin paste applied to digits
- In case series reports, the calcium channel blocker nifedipine was the most frequently used drug, but its long-term effectiveness on the relief of VWF is not known

Treatment
Vascular disorders (2)

- Digital sympathectomy or pharmacologically-induced regional nerve blockage are associated with temporary benefit even in patients with trophic cutaneous changes in severe Raynaud's phenomenon. These invasive practices are rarely justified in persons affected with VWF

Treatment
Vascular disorders (3)

- Workers suffering from white fingers should be instructed to wear adequate clothing and suitable gloves to keep their hands, feet and body dry and warm, mainly when travelling or working with vibrating tools
- Anti-vibration gloves, as defined in ISO 10819, can be beneficial to reduce vibration exposure
- Other measures (use of chemical heat packs, breaks in a warm environment, abstaining from smoking) may be useful to reduce the frequency of finger blanching attacks

Treatment
Neurological disorders (1)

- At present, there is no specific treatment regimen for the neurological component of the HAVS
- Carpal tunnel-release surgery may be effective in HTV workers affected with CTS, even though the prognosis may be less favourable than in patients not exposed to HTV, mainly if CTS symptoms coexist with other vibration-induced neurological disorders such as digital neuropathy.

Treatment
Neurological disorders (2)

- Conservative treatment for CTS (splinting, nonsteroidal antiinflammatory medication, local corticosteroid injection) have been proven to be effective in mild form of nerve impairment when associated with reduction of activities at home and work which can exacerbate symptoms

Treatment
Musculoskeletal disorders (1)

- The medical management of musculoskeletal symptoms caused by working with vibrating tools is similar to that adopted for work-related neck and upper limb disorders associated with exposure to adverse ergonomic stressors at the workplace
- A primary goal of treatment strategy is to avoid the development of a chronic pain syndrome which can make the worker unable or unwilling to return to work

Treatment
Musculoskeletal disorders (2)

- The occupational health physician shall take into account the several individual, medical, physical, and psychosocial variables that may play a role in the etiopathogenesis of the musculoskeletal symptoms complained by the worker
- Randomised trials have suggested that intensive muscular training, chiropractic treatments, learning and behavioral therapies, and/or biofeedback techniques can result in some improvement of pain and function in the upper limbs of workers with specific and non-specific musculoskeletal syndromes

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