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AGE AND NEUROPATHIES IN VIBRATION EXPOSED MANUAL WORKERS

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I. INTRODUCTION

Tingling, pricking or numbness in the hands (paresthesias) are associated with intensive hand use, age, and use of vibratory tools. The Hand-Arm Vibration International Consortium study provides longitudinal data on symptoms, and on some electrophysiological and psychophysical measurements, in four vibration exposed cohorts: shipyard workers, automotive assembly workers, forest workers, and dental hygienists. A raised prevalence of entrapment neuropathy, particularly carpal tunnel syndrome, was associated with age. However, intensive hand use and vibratory exposure predicted hand paresthesias in younger age groups. In industrial settings, where ergonomics and anti-vibration measures were optimized, the prevalence of hand paresthesias and of carpal tunnel syndrome were low. Hand paresthesias are common in certain occupational groups with vibration exposures. There are complex interactions between physiologic age, duration of exposure, and intensity of exposure.

The HAVIC (Hand-Arm Vibration International Consortium) is a multi-national research group, organized to better define exposure-response relationships from segmental vibration through application of longitudinal study design (Cherniack et al., 2006). Study populations include shipyard workers from the United States, dental hygienists using ultrasonics, an inception cohort of Swedish truck cab workers, and Finnish forest workers. The Finnish forest workers and Swedish truck cab workers had been previously studied and the current work incorporates earlier results. The American shipyard workers had been studied previously but with a different set of study metrics. The longitudinal design provided a basis for evaluating disease natural history, providing baseline rates were sufficiently high. The variety of assessment tools – questionnaire and hand diagrams, diagnosis by study physician, past treatment history, and electrophysiological studies – allows for comparative and contingent case definitions.

II. METHODS

Baseline and follow-up questionnaires and structured physical examinations were administered to all study participants. Vibrometry was performed so that mechanoreceptor function could be assessed independently of nerve conduction. Fractionated nerve conduction was also performed providing comparisons of SNCV in the digits with cross-wrist and longer track measurements. Other measurements included vibrotactile thresholds (VTT), cold challenge plethymography (CCP) and a detailed survey. Hand paresthesias generally, and carpal tunnel syndrome (CTS) specifically were of particular interest. CTS was assessed in three independent ways: 1) by self-reported symptoms and hand diagram; 2) by the study physician using fixed criteria, and by prevalent diagnosis external to the study.

Exposure assessment was performed as part of the HAVIC study. The main feature involved datalogging of force and vibration using a force sensor and accelerometer mounted in tandem on the palm with alignment of the primary axis of activation. Data were sampled and stored over a 15-s at an interval at a frequency of 3 kHz per channel. This was
followed by a 45-s interval required for calculation of the vibration exposure and the average, consistent with with international standards (ISO 5349:1, 2001; ISO 5349:2, 2001).

III. RESULTS

Table 1 summarizes baseline evaluation for the four incident HAVIC cohorts and presents the rate of CTS diagnoses by the study physician for each cohort. For comparison, control groups of relatively exposure naïve dental hygiene students and non-manufacturing workers are included as control groups. Although hand paresthesias are common in shipyard workers, dental hygienists and forestry workers, diagnosed CTS is relatively common (>5%) in dental hygienists and shipyard workers. Dental hygiene students, who are both young and unexposed to ultrasonic vibration, had low rates of hand parethesias. Truck cab workers and controls were symptomatically similar. In Table 2, the study groups are examined in terms of total hours of tool or instrument exposure and selected nerve conduction results. Only limited sensory nerve conduction velocities are presented, for wrist-palm and proximal digit-distal digit segments of median nerve of the dominant hand. Abnormalities in the wrist-palm segment, most often associated with CTS were most common in the three oldest and most ergonomically challenged cohorts – dental hygienists, shipyard workers, and forest workers. However, the digital nerve segment, was significantly slowed only for shipyard workers. In Table 3, data logging results are presented for the three industrial cohorts. There were no comparable measurements for dental hygienists who use ultrasonics only, and for whom instrumentation remains a different and more complicated process. Furthermore, the vibration levels measured for truck cab workers and forestry workers are consistently lower than for shipyard workers

IV. DISCUSSION

Neurological symptoms were relatively common in the three cohorts that had longest tenure of work and the most ergonomic demands. CTS was less common in the two industrial cohorts (forestry workers and truck cab workers) with lower daily vibration exposures. The SNCV-PPDD nerve segment has been described as the part of the peripheral nerve most susceptible to the effects of exposure to hand arm vibration (Sakakibara et al., 1998; Cherniack et al. 2004), so its elevation in the cohort with the apparent highest vibration exposures is notable. At low vibration exposure levels (truck cab workers, forestry workers). CTS was near a background rate, even though hand paresthesias were present. Age and biomechanical risk were relatively high in dental hygienists and forestry workers, although vibratory exposure was reduced. The combined pathology of prevalent symptoms, and high levels of physician diagnosed CTS along with abnormal SNCV velocity in the wrist-palm segment was most apparent in the shipyardworkers.While vibration control does not address individual or biomechanical risks, it does appear to effectively eliminate HAV as an independent risk factor for clinical CTS.

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Table I. Characteristics of HAVIC cohorts at Baseline

Cohort	Baseline Test Year	Subjects Tested	Age	+ Hand Paresthesias	CTS Cases Physician Dxed Dominant Hand
Shipyard Workers	2001	217	48.3(6.6)	146 (69%)	74 (35%)
Dental Hygienists (DH)	2002	94	45.5 (8.8)	42 (45%)	14 (15%)
Dental Hygiene Students	2002	66	26.1 (6.4)	6(9%)	3 (5%)
Forestry Workers	2003	61	48.7 (5.3)	17(29%)	3 (6%)
Truck Cab Workers	2002	54	30.1 (3.2)	7 (12%)	2 (4%)
Controls	2002	36	35.1 (5.8)	4 (11%)	0 (0%)

Table 2. Sensory nerve conduction (SNCV) in HAVIC cohorts – median nerve, dominant hand

	Shipyard	DH	Student DH	Forestry	Truck Cab	Control
Exposure Yr.	18.3 (8.8)	17.1 (8.7)	1.0 (1.9)	25.6 (7.3)	9.3 (3.6)	0
SNCV-WP	**41.6 (8.1)**	**43.6 (7.5)**	50.3(4.7)	**41.9 (7.7)**	47.3 (5.8)	49.4 (5.9)
SNCV-PPDD	***43.1 (9.4)***	46.4 (8.7)	46.9(7.6)	49.9 (7.2)	45.4 (5.8)	46.7 (5.5)

SNCV-WP is the segmental sensory nerve conduction velocity in the dominant hand across the carpal tunnel
SNCV-PDDD is the segmental nerve conduction velocity in the dominant index or long finger

Table 3. Summary of Data Logging Results Operating Time = minutes RMS= m/s^2, RMQ = m/s^4, RMO = m/s^8

	SHIPYARD (n = 52)		TRUCK CAB (n = 38)		FORESTRY (n = 8)	
	mean (sd)	min - max	mean (sd)	min - max	mean (sd)	min - max
Data Logger Operating Time	243.20 (99.40)	17 - 414	222.9 (64.20)	85 - 312	206.37 (7.54)	193 - 215
Weighted Accel^n – RMS	4.96 (7.27)	0.66 - 35.95	2.92 (2.05)	1.06 - 10.2	2.42 (0.88)	1.64 - 4.29
Weighted Accel^n – RMQ	14.66 (12.29)	2.88 - 63.32	11.85 (5.52)	6.06 - 29.41	7.8 (2.34)	5.97 - 12.72
Weighted Accel^n – RMO	33.06 (16.79)	9.31 - 89.81	29.4 (7.41)	21.35 - 53.85	24.81 (5.66)	21.59 - 38.64