# DO EXPOSURE LIMITS FOR HAND-TRANSMITTED VIBRATION PREVENT CARPAL TUNNEL SYNDROME?

**Susanna Gillibranda**

**Georgia Ntanib,c**

**David Coggonb,c**

aIndependent occupational physician, Southampton, UK

bArthritis Research-UK/MRC Centre for Musculoskeletal Health and Work, University of Southampton, Southampton, UK

cMRC Lifecourse Epidemiology Unit, University of Southampton, Southampton, UK

**Correspondence to:**

Professor David Coggon

MRC Lifecourse Epidemiology Unit

Southampton General Hospital

Southampton

SO16 6YD

UK

**Abstract**

***Background;*** An apparently high frequency of carpal tunnel syndrome (CTS) among shipyard workers undergoing health surveillance because of exposure to hand-transmitted vibration (HTV) prompted concerns that current regulatory limits on exposure might not protect adequately against the disorder.

***Aims:***To explore whether within regulatory limits, higher exposures to HTV predispose to CTS.

***Methods:*** As part of a retrospective audit, we compared duration and current intensity of exposure to HTV in cases with new onset CTS and controls matched for age. Conditional logistic regression was used to quantify associations, which were summarised by odds ratios (ORs) and 95% confidence intervals (CIs).

***Results:*** There were 23 cases and 55 controls. After adjustment for body mass index and previous diagnosis of diabetes, no clear associations were observed either with duration of exposure to HTV or with current intensity of exposure. Risk was non-significantly elevated in men with ≥30 years’ exposure to HTV (OR 1.6), but in the highest category of current exposure (8-hour energy-equivalent frequency-weighted acceleration (A8) ≥ 4.0 m/s2) risk was lower than in the reference category (A8 < 2.5 m/s2). Moreover, there was a significantly reduced risk of CTS in men with a previous diagnosis of HAVS (OR 0.2, 95%CI 0.1-0.9).

***Conclusions;*** We found no evidence that below the current limit for A(8) of 5 m/s2, higher exposures to HTV predispose to CTS. However, care should be taken not to overlook the possibility of treatable CTS when workers with diagnosed HAVS present with new or worsening sensory symptoms in the hand.

Key words**:** Carpal tunnel syndrome, hand-arm vibration syndrome, occupation, hand-transmitted vibration, regulatory controls

**Introduction**

To reduce the risk of hand-arm vibration syndrome (HAVS), occupational exposures to hand-transmitted vibration (HTV) in the UK are limited by regulation to a maximum 8-hour energy-equivalent frequency-weighted acceleration (A(8)) of 5 m/s2 [1]. Furthermore, where exposures exceed an action level of 2.5 m/s2, employers are required to reduce them as far as is reasonably practicable, and to provide regular health surveillance of exposed workers so that any cases of HAVS can be detected at an early stage and managed appropriately.

As well as the hazard of HAVS, HTV is a cause of carpal tunnel syndrome (CTS) [2,3]. In the course of routine surveillance for HAVS at a shipyard, the frequency of CTS appeared unusually high, raising the possibility that current exposure limits provide inadequate protection against CTS. To explore this question, we carried out a case-control analysis as part of an audit of control measures.

**Methods**

In accordance with regulatory requirements, all workers at the shipyard who regularly used hand-held vibratory tools were required to undergo mandatory annual health surveillance for HAVS. During 2005-13, 147 employees (all men) were screened at least once within the surveillance scheme. This sub-population of the total workforce (approximately 1100) used a range of vibratory tools while working as welders, platers, painters, laminators, pipeworkers, joiners, outfitters, and in various other jobs. The main tools used in recent years included angle grinders, barrel grinders, drills and sanders, but in the past some men had worked also with needleguns, riveters, saws and caulking guns, which produced higher levels of vibration.

At each attendance, a screening questionnaire was administered by a nurse, covering date of birth; lifetime occupational history (updated each year); vascular, sensorineural and motor symptoms in the hands; and any clinical investigation and treatment of CTS. Workers who reported possible symptoms of HAVS or CTS were then referred for more detailed assessment and formal diagnosis by a doctor (SG). Where CTS was suspected and had not previously been treated, Tinel’s and Phalen’s tests were performed [4].

Information from the surveillance programme was recorded in a database. In addition, past history of diabetes and measurements of height and weight were available from occupational health records. From the data collected, we identified workers with new onset of confirmed or probable CTS after entry to the surveillance programme (i.e. their symptoms began after their first attendance for screening).

In accordance with a prescribed algorithm, each case was individually matched with up to three controls of similar age (to within two years), who had entered the surveillance programme before the onset of the case’s symptoms, and who did not have confirmed or probable CTS according to our criteria (i.e. relevant symptoms in combination with neurophysiological confirmation, surgical decompression or positive findings on both Tinel’s and Phalen’s tests). For each matched set, exposures to HTV and other risk factors for CTS were assessed as at the date when the symptoms of the case began.

To estimate exposures to HTV, we first created a job-exposure matrix relating job titles to the use of specific tools. Detailed information was obtained from the company’s health and safety department and other local experts who had knowledge of past use of tools at the company. The information was recorded for three different time periods (1970-1989; 1990-2005; and 2006 onwards) to allow for changes as methods of working had improved. For each job, time period and type of vibratory tool the estimated approximate daily duration of exposure while the tool was operational was classified in time bands of 0 hours, 0.25-0.5, 1-2, 3 and 3.5-4 hours.

Next, a second matrix was constructed to assign an estimated level of vibration to each type of tool in each of the three time periods. Detailed information on the vibration magnitudes for tools used since 2006 was available from the report of an earlier independent assessment, undertaken by an external company. Vibration characteristics for tools used before 2006 were taken from a Health and Safety Executive (HSE) guidance document on the Control of Vibration at Work Regulations 2005 [5].

Individual exposures to HTV were estimated by applying the two matrices successively to occupational histories. Partial A(8) exposures were calculated separately for each tool likely to have been used, based on the estimated magnitude of vibration and duration of exposure. The total exposure for each job type in A(8) was then calculated from the partial exposures using the HSE’s online vibration calculator [6].

Associations with risk factors were analysed by conditional logistic regression, and summarised by odds ratios (ORs) with 95% confidence intervals (CIs).

**Results**

We identified 23 workers with new onset of confirmed or probable CTS. All had suffered from numbness and/or tingling in the affected hand(s), in addition to which, 20 had experienced pain and 17 weakness in the hand. In 18, the diagnosis of CTS had been confirmed by neurophysiological investigation, another had been offered surgical decompression of the carpal tunnel after specialist assessment, and the remaining four were positive on both Tinel’s and Phalen’s tests.

The 23 cases were compared with a total of 55 controls. After adjustment for body mass index and previous diagnosis of diabetes, no clear associations were observed either with duration of exposure to HTV or with current intensity of exposure (Table 1). Risk was non-significantly elevated in men with ≥30 years’ exposure to HTV (OR 1.6), but in the highest category of current exposure (A8 ≥ 4.0 m/s2) risk was lower than in the reference category (A8 < 2.5 m/s2). Moreover, there was a significantly reduced risk of CTS in men with a previous diagnosis of HAVS (OR 0.2, 95%CI 0.1-0.9).

In a sensitivity analysis restricted to the 19 cases that were confirmed neurophysiologically and/or treated surgically, risk estimates were little changed.

Table 2 shows levels of current exposure to HTV among cases and controls, according to previous diagnosis of HAVS. When adjusted for current exposure to HTV, the risk estimate for previous diagnosis of HAVS increased only slightly (OR 0.3, 95%CI 0.7-1.1).

**Discussion**

Our audit confirmed a high incidence of CTS among the workers in the HAVS surveillance programme. The new occurrence of 19 confirmed cases among 147 men followed for up to nine years corresponds to an annual incidence of more than 1400 per 100,000, which is well in excess of the rates of 40-350 per 100,000 that have been reported for general population groups [7]. However, there was no clear indication of an association with intensity of exposure to HTV.

Because our data came from a retrospective audit rather than a prospective research study, the assessment of CTS was not fully standardised. All of the cases had experienced numbness or tingling in the affected hand(s), and most (18 of 23) had impaired neurophysiological function according to the criteria of the hospital department at which they had been investigated. Although neurophysiological abnormalities cannot be regarded as a diagnostic gold standard [4], among the general population of patients with suspected CTS, they usefully distinguish a group with distinctive risk factors [8] and better response to surgical treatment [9]. The concern remains, however, that neurological symptoms of HAVS might in some cases be misdiagnosed as CTS. The difficulties in distinguishing between the two diseases have been noted previously [10-12], and HAVS may in some cases cause abnormalities of median nerve conduction [12]. The inclusion of some men with HAVS that had been misdiagnosed as CTS would not be expected to obscure a true association between CTS and HTV, but it may have contributed to the apparently high incidence of CTS.

Inevitably, there may have been some misclassification of exposures to HTV, which in reality will not have been identical in all workers performing the same jobs (because of differences between individual tools, and the way in which they were used). Also, all members of our study sample had sufficient exposure to HTV to warrant health surveillance, and we could not compare risks with those in workers who were totally unexposed and therefore did not undergo screening. Nevertheless, if exposures less than 5 m/s2 were an important cause of CTS, we would have expected a gradation of risk across the exposure categories analysed. In particular, it seems unlikely that risk would be elevated by exposures less than 2.5 m/s2, but with no greater risk at higher levels.

Because the surveillance scheme was limited to workers who were exposed during 2005-13, there is a possibility of healthy worker selection such that some members of the workforce who had developed symptoms of CTS or HAVS before 2005 had as a consequence transferred to unexposed jobs (within the company or elsewhere), and therefore did not enter the study. If among these leavers there was over-representation of men who were unusually sensitive to the effects of vibration, the incidence of cases that we recorded may have been spuriously low. However, healthy worker selection would not be expected to inflate incidence rates.

Statistical power was limited by the size of the workforce, and it is possible that an effect of HTV was missed because by chance, the incidence of CTS was unrepresentatively high among workers with low exposures to HTV, or unrepresentatively low in those with the highest exposures. However in that scenario HTV would seem unlikely to explain the high overall rate of CTS in the workforce. Alternatively, it could be that jobs also entailed repetitive, forceful movement of the wrists and hands, which is another established risk factor for the disorder [2,3]. That possibility merits further investigation.

The inverse association with earlier diagnosis of HAVS was unexpected and could not be explained by transfer of affected workers to jobs with lower exposure to HTV (odds ratio adjusted for current exposure = 0.3). It could have occurred if a substantial proportion of men with CTS were misdiagnosed cases of HAVS, since such misdiagnosis would be less likely to occur when HAVS had already been diagnosed. Alternatively, it might reflect a tendency to attribute sensory symptoms to HAVS where the disorder has previously been diagnosed, rather than investigate them for other possible causes.

In conclusion, the incidence of diagnosed CTS was elevated in the workers studied, but this did not appear to be explained by their exposure to HTV, and we found no evidence that below the current limit for A(8) of 5 m/s2, higher exposures to HTV predispose to CTS. There is a possibility that some men with CTS were misdiagnosed cases of HAVS. However, our findings highlight a need for care not to overlook the possibility of treatable CTS when workers with diagnosed HAVS present with new or worsening sensory symptoms in the hand.

**Key points**

* An elevated incidence of diagnosed carpal tunnel syndrome among shipyard workers exposed to hand-transmitted vibration was not explained by their exposure to vibration.
* We found no evidence that below the current hand-transmitted vibration exposure limit for A(8) of 5 m/s2, higher exposures predispose to CTS.
* Care is needed not to overlook the possibility of treatable CTS when workers with diagnosed hand arm vibration syndrome present with new or worsening sensory symptoms in the hand.

**References**

1. Health and Safety Executive. Control of Vibration at Work Regulations 2005. <http://www.hse.gov.uk/VIBRATION/hav/regulations.htm>
2. Palmer KT, Harris EC, Coggon D. Carpal tunnel syndrome and its relation to occupation: a systematic literature review. Occup Med 2007;57:57-66.
3. Van Rijn RM, Huisstede BMA, Koes B, Burdorf A. Associations between work-related factors and the carpal tunnel syndrome – a systematic review. Scand J Work Environ Health 2009;35:19-36.
4. Ntani G, Palmer KT, Linaker C et al. Symptoms, signs and nerve conduction velocities in patients with suspected carpal tunnel syndrome. BMC Musculoskeletal Disorders 2013, 14:242.
5. Health and Safety Executive. Hand-arm vibration – The Control of Vibration at Work Regulations 2005. HSE Books: Sudbury, 2005 (ISBN 0-7176-6125-3).

.

1. Health and Safety Executive. Hand-arm vibration exposure calculator. <http://www.hse.gov.uk/vibration/hav/vibrationcalc.htm>
2. Burke FD. Carpal tunnel syndrome: reconciling “demand management” with clinical need. J Hand Surg 200;25B:121-7.
3. Coggon D, Ntani G, Harris EC, Linaker C, Van der Star R, Cooper C and Palmer KT. Differences in risk factors for neurophysiologically confirmed Carpal Tunnel Syndrome and illness with similar symptoms but normal median nerve function: A case-control study BMC Musculoskeletal Disorders2013;14:240.
4. Coggon D, Ntani G, Harris EC, Linaker C, Van der Star R, Cooper C and Palmer KT. Impact of Carpal Tunnel surgery according to pre-operative abnormality of sensory conduction in median nerve: A longitudinal study. BMC Musculoskeletal Disorders 2013;14:241.
5. Pelmear PL, Taylor W. Carpal tunnel syndrome and hand-arm vibration syndrome: a diagnostic enigma. Arch Neurol 1994;50:416-420.
6. Cherniack M, Brammer AJ, Lundstrom R, Morse TF, Neely G, Nilsson T et al. Syndromes from segmental vibration and nerve entrapment: observations on case definitions for carpal tunnel syndrome. Int Arch Occup Environ Health 2008;81:661-9.
7. Stromberg T, Dahlin LB, Brun A, et al. Structural nerve changes at wrist level in workers exposed to vibration. Occup Environ Med 1997; 54:307-11.

#### Table 1 Associations of carpal tunnel syndrome with exposure to hand-transmitted vibration and past history of hand-arm vibration syndrome

#### 

|  |  |  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- | --- | --- |
| **Risk factora** |  | **Number of cases exposed** | **Number of controls exposed** |  | **OR** | **(95%CI)b** |  | **OR** | **(95%CI)c** |
|  |  |  |  |  |  |  |  |  |  |
| **Total years exposure to HTV** |  |  |  |  |  |  |  |  |  |
| <15 |  | 7 | 15 |  | 1 |  |  | 1 |  |
| 15-29.9 |  | 6 | 22 |  | 0.7 | (0.2-2.5) |  | 0.7 | (0.2-2.7) |
| ≥30 |  | 10 | 18 |  | 1.8 | (0.3-9.1) |  | 1.6 | (0.3-8.3) |
|  |  |  |  |  |  |  |  |  |  |
| **Current exposure to HTV (A8 in m/s2)** |  |  |  |  |  |  |  |  |  |
| <2.5 |  | 3 | 15 |  | 1 |  |  | 1 |  |
| 2.5-3.9 |  | 17 | 24 |  | 3.3 | (0.8-13.5) |  | 2.8 | (0.6-12.8) |
| ≥4.0 |  | 3 | 14 |  | 1.0 | (0.2-5.8) |  | 0.9 | (0.1-6.1) |
|  |  |  |  |  |  |  |  |  |  |
| **Previous diagnosis of HAVS** |  |  |  |  |  |  |  |  |  |
| No |  | 16 | 23 |  | 1 |  |  | 1 |  |
| Yes |  | 7 | 32 |  | 0.3 | (0.1-0.9) |  | 0.2 | (0.1-0.9) |
|  |  |  |  |  |  |  |  |  |  |

aEach risk factor was examined independently

bUnadjusted

cAdjusted for body mass index (<25, 25-29.9, ≥30 kg/m2) and past history of diabetes

#### Table 2 Current exposure to hand-transmitted vibration among workers with a previous diagnosis of hand-arm vibration syndrome

|  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- |
| **Current exposure to HTV (A8 in m/s2)** |  | **CTS cases** | |  | **Controls** | |
|  | **Previous diagnosis of HAVS** | **No previous diagnosis of HAVS** |  | **Previous diagnosis of HAVS** | **No previous diagnosis of HAVS** |
|  |  |  |  |  |  |  |
| <2.5 |  | 2 | 1 |  | 4 | 11 |
| 2.5-3.9 |  | 12 | 5 |  | 11 | 13 |
| ≥4.0 |  | 2 | 1 |  | 7 | 7 |