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THE VALIDITY OF USING QUESTIONNAIRES FOR SCREENING FOR HAND-ARM VIBRATION SYNDROME AND CARPAL TUNNEL SYNDROME AMONG WELDERS

BY

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Abstract

Introduction: During the welding process and surface finishing, vibrating tools are often used. Long-term occupational exposure to vibration may result in hand-arm vibration syndrome (HAVS). It can either mimic or occur concomitantly with carpal tunnel syndrome (CTS), which represents a diagnostic challenge in workers with CTS exposed to hand-arm vibration for several years. **Aim of Work:** To investigate the validity of using questionnaires in screening for hand-arm vibration syndrome (HAVS) and carpal tunnel syndrome (CTS) among welders. **Materials and Methods:** The study included two groups: an exposed and a non-exposed group. The exposed group included 60 welders in several iron forge workshops. The control group included 64 office workers in Cairo University Hospitals. The participants were subjected to a questionnaire including socio demographic characteristics, and to respond to the hand-arm vibration questionnaire (HAVQ) and carpal tunnel syndrome questionnaire (CTSQ). QuickDASH outcome measure was used to calculate the CTS-related disability for all participants. **Results:** Numbness/tingling for >20 minutes, whitening of finger(s), decreased tolerance to cold were statistically significantly higher among welders compared to controls (30% vs. 7.8%, 10% vs. 1.6%, 23.3% vs. 1.6% respectively). CTS severity scale was statistically significantly higher among welders (12.5%) compared to controls (11%). QuickDASH outcome measure revealed .that 56.7% of welders had CTS-related disability compared to 18.8% of controls **Conclusion and Recommendations:** Symptoms of HAVS, CTS and CTS-related disability were significantly higher among welders compared to controls. HAV Questionnaire, CTS Questionnaire, and QuickDASH may be useful in screening for .HAVS, CTS and CTS-related disability among welders

Keywords: Hand-arm vibration syndrome (HAVS); Carpal tunnel syndrome (CTS); QuickDASH; Welding and screnning Questionnaire.

Introduction

Welding involves joining metals by melting the work pieces and adding a filler substance to form a pool of molten material (the weld pool) that cools to make a strong joint. Manual welding is common in industry. During the welding process and surface finishing, percussive tools such as chipping hammers and rotary tools such as grinders are often used (ISO, 2021).

Long-term occupational exposure to vibration may result in hand-arm vibration syndrome (HAVS) (Gerhardsson et al. 2020). Risk factors for HAVS include genetic predisposition and smoking (Falkiner et al., 2003).

Manifestations of HAVS include vibration white fingers (VWF) and neurosensory manifestations in the hands, including tingling, numbness, reduced hand grip strength and reduced manual dexterity (Gerhardsson et al., 2020). Unfortunately, no 'gold standard' diagnostic tests are available for HAVS. It can either mimic or occur concomitantly with carpal tunnel syndrome (CTS) in temperate climates, which represents a diagnostic challenge in workers with CTS symptoms who have history of working with vibrating tools for several years (Falkiner et al., 2003).

CTS is a condition of the hand that occurs as a result of compression of the median nerve at the wrist. There has been increased public health awareness that CTS is a disorder that is related to some occupational tasks, especially in the manufacturing processes (Rosecrance et al., 2002).

Vihlborg et al., 2022 reported an increased risk of CTS among workers using hand-arm vibrating tools. It has been assumed that paresthesia of the hands at night might be the only differentiating symptom between HAVS and CTS (Burke et al., 2005). However, in another study, hand symptoms at night were associated with HAVS, which indicates a true co-existence between HAVS and CTS (Sauni et al., 2009[a]).

It has been postulated that the causal relationship of vibration exposure would be weaker for neurosensory manifestations and not as directly proportional as for vascular symptoms (Bovenzi, 1994). However, some studies from tropical countries reported that the clinical manifestations of HAVS in warm climate areas differed from those of temperate climate areas regarding the occurrence of VWF (Su et al., 2011). Neurological manifestations (finger

tingling, numbness, or paraesthesia) prevailed in most of the included studies in their review and were obviously more prevalent than the vascular symptoms. VWF was not detected in studies conducted in tropical countries. The more prevalent symptoms in these studies were neurological symptoms in the form of finger tingling and numbness (Su et al., 2012). In another study, VWF was only found in workers with high level of exposure to HAV such as rock drillers (Clemm et al., 2020).

According to the guidelines published by the Society of Occupational Medicine HAVS Special Interest Group (SIG) as a resource to assist those involved in the diagnosis and management of workers with HAVS, or at risk of developing HAVS, screening questionnaires should be repeated annually in the periodic medical surveillance for workers at risk but with no symptoms of HAVS. The questionnaire can be a useful tool for early detection of potential cases of HAVS and for providing suitable advice on management (Lawson and Poole, 2019).

In a previous prospective study, the results showed a sensitivity of 85% for the scored questionnaire in the diagnosis of CTS with a positive predictive value of 90% (Kamath and Stothard, 2003).

Moreover, the results of surgical treatment for CTS showed less improvement in workers exposed to HAV, which shows the importance of early detection of CTS among HAV-exposed workers (Stirling et al., 2020).

Aim of Work

To investigate the applicability of using questionnaires in screening for manifestations of hand-arm vibration syndrome and carpal tunnel syndrome due to exposure to vibration among welders.

Materials and Methods

- **Study design:** This is a cross-sectional comparative study.

- **Place and duration of the study:** The study group included 60 welders in iron forge workshops in 15th of May City, Cairo, Egypt and 64 office workers from Cairo University Hospitals. The duration of the study was 6 months from July to December 2023.

- **Study sample:** The study included an exposed and a non-exposed group. The exposed group included 60 welders in iron forge workshops in 15th

of May City, Cairo. Their work involved making iron doors, windows, and fences. Their work consisted mainly of welding iron that requires working with hand-held vibrating tools. The non-exposed (control) group included 64 office workers from Cairo University Hospitals, with no history of exposure to any type of vibration or chemicals. The control group was matched with the exposed group as regards their age, gender (all participants were males), and smoking habits.

Sample size calculation:

Sample size was calculated by power and sample size calculator P.S. version 3.1.2. A previous study reported that carpal tunnel syndrome in a group of low exposure index to HAV was diagnosed in 27% of participants, meanwhile, in a group with high exposure index to HAV, CTS was diagnosed in 64% of participants (Sauni et al., 2009[b]). So based on comparison of the two proportions using uncorrected chi square test, at type I error 0.05 and power of the study 0.8, 56 participants are needed in this study.

Inclusion criteria of the exposed group: Workers had work duration of at least one year in their current job. **Inclusion criteria of the non-exposed group**: The control group was recruited from office workers in Cairo University Hospitals who agreed to participate in the study and who had no history of exposure to any type of vibration or chemicals at work or outside the workplace.

Exclusion criteria of the studied group: Workers with other types of exposures from other jobs, or with previous injuries or surgeries of the hands or arms, who had a history of neurological diseases or diabetes.

Study Methods:

Both groups (exposed and non-exposed) were subjected to a questionnaires including the following:

A - Socio demographic characteristics: age, special habits as smoking

B- Medical and occupational histories were taken from each participant in private by an occupational physician to clarify workplace hazards in full details and duration of exposure to those hazards especially using hand-held vibrating tools.

C- Hand-Arm Vibration Questionnaire (HAVQ) was filled by interviewing each participant in private using the questionnaire provided

by Health and Safety Executive in United Kingdom (HSE publication L140, 2019), under supervision of an occupational physician. The HAVQ included questions about feeling tingling and numbness in the hands, whitening of fingers, decreased tolerance to cold and difficulty in picking up very small objects e.g. screws or buttons.

D-Carpal Tunnel Syndrome questionnaire (CTSQ) was filled by interviewing each participant using the CTSQ questionnaire (Levine et al., 1993). The CTSQ included questions concerning pain in the wrists during night and daytime, tingling and numbness in the hands especially at night, weakness in the hands or wrists and difficulty in grasping small objects e.g. keys or pens.

E-The QuickDASH outcome measure (Beaton et al., 2005) was calculated by the authors for each participant. The participants were asked to answer the questions on a scale from 1 to 5 for each question in order to determine the difficulty in performing some daily activities with hands either at work or at home, and also to grade the severity of their symptoms, if any, such as pain, tingling in the hands, wrists, shoulders or arms, and whether these symptoms interferes with their sleep. The score was calculated according to the following equation:

$$\text{QuickDASH disability/symptom score} = \left[\frac{\text{Sum of responses}}{n} - 1\right] \times 25$$

(Where n = the number of completed responses)

The resulting score determined whether the worker had disability from CTS or not, and the severity of the disability, if present. A participant with a zero score was considered not disabled, while any participant with a score above zero was considered having a certain degree of disability.

Consent

A written consent to participate in the research and to answer the questionnaires was voluntarily obtained from all participants. Also consent was taken from the managers of iron forge workshops in 15th of May City, Cairo, Egypt.

Ethical Approval

Prior to the study, the Research Ethics Committee of the Faculty of Medicine, Cairo University approved the study protocol (N-146-2023).

Data Management

Pre coded data was entered on the

computer using the statistical package for social sciences (SPSS), version 23, to be statistically analyzed. Data was summarized using median and interquartile range (IQR) for quantitative variables, and number and percent for qualitative variable. The Shapiro test of normality was used to check normal distribution of data. Mann-Whitney test was used for comparison of quantitative variables between groups for data which were not normally distributed. Comparison between qualitative variables was done using chi square test for qualitative variables. Fisher's exact test was used instead of chi-square when expected count in cell is less than 5. Other statistical tests were used when appropriate. P value ≤ 0.05 was considered statistically significant.

Results

Table (1) Comparison between exposed and non-exposed groups as regards their age and smoking habits

	Exposed (No=60)	**Control (No =64)**	**Test value**	**p-value**	**Test of significance**
Age Median (IQR)#	57 (55-58.5)	55.5 (53-58)	1704	0.277	Mann Whitney
Smoking status No (%)					
Non-smoker	14 (23.3)	18 (28.1)			
			0.371	0.542	Chi square
Smoker	46 (76.7)	46 (71.9)			
Smoking (Pack-year) median (IQR) #	20 (20-30)	20 (15-30)	1032	0.834	Mann Whitney

#:IQR: Interquartile range

Table 1 showed that no statistically significant differences were found between the exposed and control groups regarding their age and smoking habits (p>0.05).

Table (2): Comparison between the studied groups as regards their responses to the hand-arm vibration questionnaire (HAVQ).

Questions of HAVQ No. (%)		Group		Test value	p-value	Test of significance
		Welders (No=60) No. (%)	Controls (No =64)			
V-Q.0 (Using vibrating tools)	NO	0 (0)	57 (89.1)	124	**<0.001***	Chi square
	Yes	60 (100)	0 (0)			
V-Q.1 (Numbness/tingling>20 min. after exposure)	NO	42 (70)	59 (92.2)	10.091	**0.001***	Chi square
	Yes	18 (30)	5 (7.8)			
V-Q.2 (Numbness/tingling at any time)	NO	46 (76.7)	56 (87.5)	2.49	0.115	Chi square
	Yes	14 (23.3)	8 (12.5)			
V-Q.3 (Pain/tingling/numbness at night)	NO	50 (83.3)	59 (92.2)	2.283	0.131	Chi square
	Yes	10 (16.7)	5 (7.8)			
V-Q.4 (Whitening finger(s) on cold exposure)	NO	54 (90)	63 (98.4)	4.139	**0.042***	Chi square
	Yes	6 (10)	1 (1.6)			
V-Q.5 (Decreased tolerance to cold)	NO	46 (76.7)	63 (98.4)	13.803	**<0.001***	Chi square
	Yes	14(23.3)	1(1.6)			
V-Q.6 (Any other problems in hand, arm)	NO	42 (70)	63 (98.4)	19.302	**<0.001***	Chi square
	Yes	18 (30)	1 (1.6)			
V-Q.7 (Difficulty in picking up small objects)	NO	58 (96.7)	63 (98.4)	0.411	0.518	Fisher Exact
	Yes	2 (3.3)	1 (1.6)			
V-Q.8 (Any other health problems e.g. diabetes, hypertension)	NO	53 (88.3)	64 (100)	7.913	**0.001***	Chi square
	Yes	7 (11.7)	0 (0)			

*Statistically significant ($p \leq 0.05$) V-Q: Vibration question

Table (2) showed that concerning the response of the studied group to the hand-arm vibration questionnaire (HAVQ), all welders (100%) endorsed their use of vibrating tools, with a statistically significant difference compared to the control group, as none of them was exposed to HAV ($p<0.001$).There was also a statistically significant difference between exposed and controls as regards numbness/tingling for >20 minutes after exposure, whitening finger(s) on cold exposure, decreased tolerance to cold and other problems in the hands and/or arms or any other health problems. Meanwhile, feeling numbness and/or tingling at any time and pain, tingling and/or numbness at night were more common among welders compared to controls, yet the difference was not statistically significant ($p=0.115$). Difficulty in picking up small objects did not represent a problem for either group, with no statistically significant difference.

Table (3): Comparison between the studied groups as regards carpal tunnel symptom severity scale.

Carpal tunnel symptom severity scale	Exposed (No=60)	Control (No =64)	Test value	p-value	Test of significance
Median (IQR)#	12.5 (11-22)	11 (11-11)	1115	**<0.001***	Mann Whitney

*: Statistically significant ($p\leq0.05$) #:IQR: Interquartile range

Table 3 showed that carpal tunnel syndrome severity scale among welders had a median of 12.5, with a statistically significant difference compared to the control group, in which the median of the severity scale was 11 ($p<0.001$).

Table (4): Comparison between the studied groups as regards carpal tunnel index (The QuickDASH outcome measure).

QuickDASH	Exposed (No =60)	Non exposed (No =64)	Test value	p-value	Test of significance
No disability	26 (43.3%)	52 (81.3%)	19.079	**0.001***	Chi square
Disability	34 (56.7%)	12 (18.8%)			
QuickDASH disability score median## (IQR) #	18.2 (9.1-27.3)	6.8 (2.3-38.6)	156	0.229	Mann Whitney

*: Statistically significant (p≤0.05) #IQR: Interquartile range

##: QuickDASH disability score median was calculated for patients with disability (34 of exposed and 12 of control)

Table 4 showed that there was a statistically significant difference between exposed and controls as regards carpal tunnel index (The QuickDASH outcome measure) as 56.7% of the exposed group had disability resulting from carpal tunnel syndrome. But, when comparing the QuickDASH score for patients with disability (34 of exposed and 12 of control), no significant difference was found between the exposed and control groups as regards the severity of disability (P= 0.229).

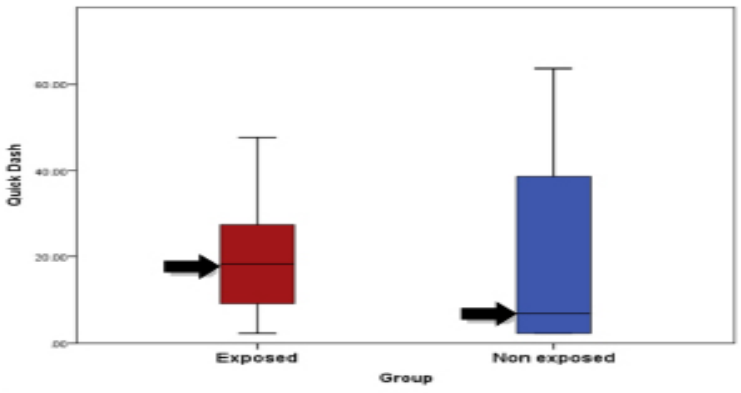

Figure (1): Comparison between the studied groups as regards the QuickDASH outcome measure

Figure 1 showed that the median (black arrow) of the exposed group subjects with CTS-related disability was 34 compared to the median of the control group subjects with CTS-related disability (12), but the IQR was wider in the control group reaching a maximum of 38.6. However, the IQR was narrower in the exposed group reaching a maximum of 27.3 (Table 4).

Discussion:

Exposure to hand-arm vibration may affect the blood vessels together with the nervous system of the upper limbs, leading to the hand-arm vibration syndrome (HAVS). The vascular manifestations include whitening of fingers on exposure to cold. Peripheral neuropathy manifestations include tingling and/or numbness of the fingers, decreased grip force, and impaired manual dexterity. The manifestations of carpal tunnel syndrome (CTS), which are paresthesia of the hand and muscular weakness, may simulate HAVS. Thus, HAVS may be misdiagnosed as CTS, but both conditions may co-exist (Sauni et al., 2010).

The current study included an exposed group of 60 welders and a non-exposed group (64 office workers). Hand-arm vibration questionnaire (HAVQ) (HSE publication L140 2019), and carpal tunnel syndrome questionnaire (CTSQ) (Levine et al. 1993) were used as screening for manifestations of HAVS and CTS due to exposure to vibration among welders. QuickDASH outcome measure (Beaton et al. 2005) was used to evaluate the degree of disability in workers with carpal tunnel syndrome.

Comparison between welders exposed to hand-arm vibration and non-exposed control group as regards their age and smoking habits revealed no statistically significant differences between the two groups (Table 1), which confirms the matching of the exposed and non-exposed group, and that age and smoking habits can no longer be considered as confounding factors.

As regards the responses of the studied population to HAVQ, there were a significantly higher percentage of welders with positive symptoms of HAVS compared to the control group (Table 2). The symptoms included numbness and/or tingling for >20 minutes after exposure (30%), whitening of finger(s) on exposure to cold (10%), decreased tolerance to cold (23.3%), any other hands and/or arms problems (30%), and any other health problems such as diabetes and hypertension (11.7%). These results agreed with those reported by a previous study on the association between vibration exposure and hand-arm vibration symptoms in a Swedish mechanical industry (Vihlborg et al. 2017). They found that workers exposed to hand-arm vibration suffered from HAVS symptoms including intermittent numbness and/or tingling

(57%), occasional attacks of whiteness of one or more fingers (22%), and decreased tolerance to cold (9%).

In another study done by Gerhardsson et al., 2020 on vibration-induced injuries in workers exposed to transient and high frequency vibrations, they found that VWF showed a prevalence of 30% and the prevalence of neurosensory findings was 70% among male workers after a mean exposure of 14 yrs. They explained their findings by the fact that perception of vibration in the skin is mediated by mechanoreceptors, e.g. Meissner's and Pacinian corpuscles, which transmit the information through large, myelinated A-β fibres. Exposure to vibration may also affect small, myelinated A-δ fibres and unmyelinated C-fibres, which transmits information about temperature. Thus, temperature-related symptoms are part of the manifestations in vibration-exposed workers.

CTSQ revealed that the exposed workers had significantly higher severity scale compared to the controls (Table 3). Moreover, calculation of QuickDASH outcome measure for the studied population revealed that 56.7% of the exposed workers had a CTS-related disability, which was a significantly higher percentage compared to prevalence of disability among controls (18.8%) (Table 4). The mechanism that HAV exposure can cause CTS is still unclear, but the combination of both vibration exposure and other ergonomic factors may explain it (Vihlborg, et al., 2022). In a study done by (Sauni et al. 2009[a]) on Finnish metalworkers who were exposed to hand-arm vibration (HAV), they found that stressful postures of the wrist can lead to the occurrence of median nerve compression in the carpal tunnel, and the proportion of CTS cases was 29% of vibration-exposed workers who also had HAVS.

On the other hand, comparison of the median and IQR for the patients with disability (34 of exposed and 12 of control) showed no statistically significant difference (Table 4). This may indicate that higher prevalence of CTS-related disability was found among vibration-exposed workers, however, the degree of disability was not affected by whether the cause of CTS was exposure to vibration or not. These results were in line with a previous study by Vihlborg et al., 2022 on CTS among HAV-exposed workers, they found an overall increased risk of

CTS in association with HAV exposure.

In another study done by Eren et al., 2018 on the relationship between QuickDASH score, clinical and electrophysiological findings in CTS, a statistically significant positive correlation was found between QuickDASH score, disease duration and clinical severity of CTS.

Conclusion

The results of the current study showed that using vibrating tools is common among welders. Symptoms of HAVS were more common among welders compared to the control group. CTS symptoms and related disability were more prevalent among welders compared to controls. Meanwhile, the degree of disability among CTS patients was not related to the causative factor.

The key results of the study showed that the HAVS and CTSQ together with QuickDASH score helped in screening for HAVS and CTS in welders and determining the degree of disability resulting from CTS in the studied population.

Recommendations

From the current results, it is recommended to use the HAVQ and CTSQ together with QuickDASH outcome measure as easy, non-invasive, and inexpensive methods in the screening for HAVS and CTS among workers exposed to vibration.

Conflict of Interest

No conflict of interest was declared by the authors.

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References

1. Beaton DE , Wright JG and Katz JN (2005): Upper Extremity Collaborative Group. Development of the QuickDASH: comparison of three item-reduction approaches. J Bone Joint Surg Am; 87(5):1038-46. DOI: 10.2106/JBJS.D.02060.
2. Bovenzi M (1994): Hand-arm vibration syndrome and dose-response relation for vibration induced white finger among quarry drillers and stonecarvers. Occup Environ Med; 51(9): 603-11. DOI: 10.1136/oem.51.9.603.
3. Burke FD, Lawson IJ, McGeoch KL, Miles JNV and Proud G (2005): Carpal tunnel syndrome in association with hand–arm vibration syndrome: a review of claimants seeking compensation in the mining industry. J Hand Surg [Br]; 30(2): 199-203.DOI:10.1016/j.jhsb.2004.11.007
4. Clemm T, Færden K, Ulvestad B, Lunde LK and Nordby KC (2020): Dose–response relationship between hand–arm vibration

exposure and vibrotactile thresholds among roadworkers. Occup Environ Med; 77:188-93. DOI:10.1136/oemed-2019-105926.

5. Eren Y, Yavasoglu NG and Comoglu SS (2018): The relationship between QuickDASH scale and clinical, electrophysiological findings in carpal tunnel syndrome. Adv Clin Exp Med; 27(1):71-5. DOI: 10.17219/acem/67947. PMID: 29521045.
6. Falkiner S (2003): Diagnosis and treatment of hand-arm vibration syndrome and its relationship to carpal tunnel syndrome. Aust Fam Physician; 32(7): 530-4. PMID: 12901208
7. Gerhardsson L, Ahlstrand C, Ersson P and Gustafsson E (2020): Vibration-induced injuries in workers exposed to transient and high frequency vibrations. J Occup Med Toxicol; 15:18. DOI: 10.1186/s12995-020-00269-w
8. HSE publication (Health and Safety Executive) L140 (2019): Screening Questionnaire for Workers Using Hand-held Vibrating Tools, Hand-guided Vibrating Machines and Hand-fed Vibrating Machines (Appendix 9). In: Hand-Arm Vibration - The Control of Vibration at Work Regulations 2005. Published by TSO (The Stationery Office), part of Williams Lea. ISBN 978 0 7176 6565 5. 2nd ed, United Kingdom, pp 95-6.
9. ISO (International Organization for Standardization) 5349-1:2001 (2021): Mechanical vibration – Measurement and evaluation of human exposure to hand-transmitted vibration – part 1: general guidelines, 2001. Last reviewed and confirmed in 2021.
10. Kamath V and Stothard J (2003): A Clinical Questionnaire for the Diagnosis of Carpal Tunnel Syndrome. J Hand Surg [Br and Eu]; 28(5):455-9. DOI:10.1016/S0266-7681(03)00151-7.
11. Lawson I and Poole J (2020): Hand Arm Vibration Syndrome: Tiered Health Surveillance. In: The Identification and Management of Hand Arm Vibration Syndrome (HAVS). Society of occupational medicine (SOM) (ed.). Drafted by the SOM HAVS Special Interest Group. March, 2019. Revised v20 Dec 2020; 4:13.
12. Levine DW, Simmons BP, Koris MJ Daltroy LH, Hohl GG et al. (1993): A self-administered questionnaire for the assessment of severity of symptoms and functional status in carpal tunnel syndrome. J Bone Joint Surg; 75(11):1585-92. DOI: 10.2106/00004623-199311000-00002.
13. Rosecrance JC, Cook TM, Anton DC and Merlino LA (2002): Carpal Tunnel Syndrome Among Apprentice Construction Workers. Am J Ind Med; 42(2): 107–16.DOI: 10.1002/ajim.10093.
14. Sauni R, Paakkonen R, Virtema P, Jäntti V, Kähönen M et al. (2009a): Vibration-induced white finger syndrome and carpal tunnel syndrome among Finnish metal workers. Int Arch Occup Environ Health; 82(4):445–53. DOI 10.1007/s00420-008-0357-6.
15. Sauni R, Pääkkönen R, Virtema P, Toppila E and Uitti J (2009b): Dose–response relationship between exposure to hand-arm vibration and health effects among metalworkers. Ann Occup Hyg; 53(1):55-62. DOI: 10.1093/annhyg/men075.
16. Sauni R, Virtema P, Pääkönen R, Toppila E, Pyykkö I et al. (2010): Quality of life (EQ-5D) and hand-arm vibration syndrome. Int Arch Occup Environ Health; 83:209–16. DOI 10.1007/s00420-009-0441-6.
17. Stirling PHC, Jenkins PJ, Clement ND, Duckworth AD and McEac JE (2020): The influence of self-reported hand-arm vibration exposure on functional outcomes following carpal tunnel release. J Hand Surg [Am];45(11):1029–36. DOI: 10.1016/j.jhsa.2020.08.018.
18. Su TA, Hoe VCW, Masilamani R and Awang Mahmud AB (2011): Hand-arm vibration syndrome among a group of construction workers in Malaysia. Occup Environ Med; 68(1): 58–63. DOI: 10.1136/oem.2009.052373.
19. Su TA, Darus A, Bulgiba A, Maeda S and Miyashita K (2012): The Clinical Features

of Hand-arm Vibration Syndrome in a Warm Environment—A Review of the Literature. J Occup Health; 54(5): 349–60. DOI: 10.1539/joh.12-0089-ra.

20. Vihlborg P, Bryngelsson IL, Lindgren B, Gunnarsson LG and Graff P (2017): Association between vibration exposure and hand-arm vibration symptoms in a Swedish mechanical industry. Int J Ind Ergon; 62:77-81. DOI: 10.1016/j.ergon.2017.02.010
21. Vihlborg P, Pettersson H, Makdoumi K, Wikström S, Bryngelsson I, et al. (2022): Carpal Tunnel Syndrome and Hand-Arm Vibration: A Swedish National Registry Case–Control Study. JOEM; 64(3):197-201. DOI: 10.1097/JOM.0000000000002451.