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A Comparison of Hand-arm Vibration Syndrome between Malaysian and Japanese Workers

Anselm Ting SU[1,2,6], Jin FUKUMOTO[3], Azlan DARUS[1], Victor CW HOE[1], Nobuyuki MIYAI[3], Marzuki ISAHAK[1], Shigeki TAKEMURA[2], Awang BULGIBA[4], Kouichi YOSHIMASU[2], Setsuo MAEDA[5] and Kazuhisa MIYASHITA[2]

[1]Centre for Occupational and Environmental Health, Department of Social and Preventive Medicine, University of Malaya, Malaysia, [2]Department of Hygiene, School of Medicine, Wakayama Medical University, Japan, [3]School of Health and Nursing Science, Wakayama Medical University, Japan, [4]Julius Centre University of Malaya, Department of Social and Preventive Medicine, Faculty of Medicine, University of Malaya, Malaysia, [5]Faculty of Applied Sociology, Kinki University, Japan and [6]Department of Community Medicine and Public Health, Faculty of Medicine and Health Sciences, Universiti Malaysia Sarawak, Malaysia

Abstract: A Comparison of Hand-arm Vibration Syndrome between Malaysian and Japanese Workers: Anselm Ting SU, *et al*. Centre for Occupational and Environmental Health, Department of Social and Preventive Medicine, University of Malaya, Malaysia—The evidence on hand-arm vibration syndrome (HAVS) in tropical environments is limited. The legislation for the control of occupational vibration exposure has yet to be established in Malaysia. **Objectives:** The aim of this study was to investigate the clinical characteristics of HAVS in a tropical environment in comparison with a temperate environment. **Methods:** We conducted a series medical examinations among the forestry, construction and automobile industry workers in Malaysia adopting the compulsory medical examination procedure used by Wakayama Medical University for Japanese vibratory tools workers. We matched the duration of vibration exposure and compared our results against the Japanese workers. We also compared the results of the Malaysian tree fellers against a group of symptomatic Japanese tree fellers diagnosed with HAVS. **Results:** Malaysian subjects reported a similar prevalence of finger tingling, numbness and dullness (Malaysian=25.0%, Japanese=21.5%, p=0.444) but had a lower finger skin temperature (FST) and higher vibrotactile perception threshold (VPT) values as compared with the Japanese workers. No white finger was reported in Malaysian subjects. The FST and VPT of the Malaysian tree fellers were at least as bad as the Japanese tree fellers despite a shorter duration (mean difference=20.12 years, 95%CI=14.50, 25.40) of vibration exposure. **Conclusions:** Although the vascular disorder does not manifest clinically in the tropical environment, the severity of HAVS can be as bad as in the temperate environment with predominantly neurological disorder. Hence, it is essential to formulate national legislation for the control of the occupational vibration exposure.
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Key words: Comparison, Hand-arm vibration syndrome, Hand-transmitted vibration, Tropical

Hand-arm vibration syndrome (HAVS) is a well-recognized health disorder in temperate climate countries because of the appearance of its peripheral circulatory disturbances, especially the "white fingers", along with its neurological disorders such as tingling, numbness and dullness of the fingers during cold seasons[1–6]. The condition, however, has not been clearly demonstrated in the tropical environment. Up to now, only six papers have reported cross-sectional studies among vibratory tools workers in Singapore, Indonesia, Papua New Guinea, Southern Vietnam and Malaysia[7–12]. A recent systematic review of HAVS in the tropical environment revealed that vibration white finger has not been reported in tropical countries and that the symptoms have been predominantly neurological[13]. There is no previous study comparing the clinical outcomes of hand-transmitted vibration between the tropical and temperate environments.

In Malaysia, periodic medical examinations for

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Correspondence to: A. T. Su, Department of Community Medicine and Health Sciences, Faculty of Medicine and Health Sciences, Universiti Malaysia Sarawak, Lot 77 , Section 22, KLTD, Tun Ahmad Zaidi Adruce Road, 93150 Kuching, Sarawak, Malaysia (e-mail: stanselm@fmhs.unimas.my; anselmsuting@yahoo.com)

vibratory tools workers are not performed routinely because there is no provision under the national legislative framework. Workers exposed to hand-arm vibration are mainly construction and forestry workers. There was no enforcement of the use of anti-vibration gloves or control of vibratory tool levels in the workplace. Workers were not aware of the risk of vibration hazard, and there was no safety training in relation to hand-arm vibration. Workers in these two industries tend to work overtime because of low wages and lack of effective enforcement. Hence, the potential health risk due to hand transmitted vibration in the local context is high. However, the diagnosis of HAVS did not exist in the government hospitals' patient medical record database. The national social security organization received only 65 reported cases of claims under the "diseases caused by vibration" in 2011[14]. As there was no medical surveillance among workers exposed to hand-arm vibration, the extent of the occurrence of HAVS in this country is unknown.

The Centre of Occupational and Environmental Health, University of Malaya, conducted the first medical examination among three groups of vibratory tools workers in Malaysia to investigate the clinical characteristic of HAVS in the tropical environment. As the project was performed in collaboration with Wakayama Medical University in Japan, we used a somewhat similar medical examination procedure compared with that utilized by the Wakayama Medical University for Japanese vibratory tools workers in Wakayama Prefecture of Japan. In the current report, we compare the results of our medical examination against a sample of Japanese vibratory tools workers. The aim of this paper was to compare the clinical features of HAVS in the tropical environment against cases from temperate climate environment who have more established and distinct characteristics. It is important to understand the differences in the clinical features of HAVS between the tropical and temperate environments, as this will affect both the clinical management and the formulation of effective preventive measures for cases related to HAVS especially in warm climate countries.

Subjects and Methods

This was a cross-sectional study. Three groups of vibratory tools workers in Malaysia (namely, construction workers, forestry workers and automobile manufacturing plant workers) were selected to include workers with a broad range of vibration exposure so as to be able to investigate the spectrum of clinical effects due to hand-transmitted vibration. The participants included in this study were all male vibratory tools workers allocated by the respective employer. The medical examination was carried out in phases from August 2011 until August 2012.

The characteristic features of the Malaysian climate are uniform temperature, high humidity and copious rainfall. The average temperature is above 25°C throughout the year, varying from 24°C at night to 33°C during the day. The average relative humidity is 85% throughout the year. The construction workers were located at a shopping mall construction site in an urban area. The workers used mainly concrete breakers, grinders, impact drills and powered cutters in their daily work. The environmental temperature was generally high, ranging from 30 to 33°C throughout the day. The forestry workers recruited into this study were tree fellers, located in a logging camp about 30 km from the sea coast on hilly land, who used only chain saws for tree-felling. The environmental temperature in this location ranges from 22°C at night to 33°C during day time. The automobile manufacturing workers worked in an indoor factory environment with a cooling system and average temperature of about 26°C. The workers used mainly impact wrenches in their daily work.

Wakayama Medical University has conducted an annual compulsory medical examination among a cohort of Japanese vibratory tools workers for over 30 years in Wakayama Prefecture, Japan, and has maintained a database. These Japanese vibratory tools workers underwent annual compulsory medical examinations as required under Japanese law. The medical examinations were carried out annually in the months of November and December at several field locations in Wakayama Prefecture. The local annual temperature is about 15°C, falling to as low as 4°C during winter. The Japanese vibratory tools workers consisted mainly of tree fellers who used mainly chain saws and brush cutters in their daily work, with a small fraction of them in involved in timber processing and park maintenance work. We used the data of 385 Japanese vibratory tools workers who underwent medical examinations in November and December 2011 for the purpose of comparison.

The procedures for the history taking and medical examination for the Malaysian participants were based on the procedures for the Japanese vibratory tools workers. The annual medical examination procedures conducted in Japan consisted of history taking, a general physical examination and special hand examination. The history taking consisted of employment history, type of vibratory tools used, daily, yearly and total years of vibration exposure, symptoms related to possible HAVS such as tingling, numbness and dullness, Raynaud's phenomenon, musculoskeletal pain of the upper limbs, finger coldness and a detailed account of frequency, occurrence and severity of each symptom. The history taking was carried out using a standard questionnaire used in Japan for the surveillance of workers exposed to hand-transmitted vibration. The history taking was followed by a physical examination consisting of measurement of height, weight, blood pressure, pulse rate and an evaluation of the muscle power, range of movement and reflexes of the upper limbs. The special hand examination included measurement of finger skin temperature, finger nail capillary return time, finger vibrotactile perception threshold, hand grip strength and pinch strength and a cold water immersion test. The finger skin temperature was measured over the pulp of the index, middle, ring and little fingers using an infrared thermometer, model IT-550S, manufactured by Horiba Ltd, Japan. The finger nail capillary return was measured for the index, middle, ring and little fingers using a stopwatch after pressing the nail bed gently for 10 seconds. The hand grip strength was obtained using a digital dynamometer in a standing position with both arms in a neutral position, the elbows extended and the forearms pronated at 90°. The patient was asked to grip the dynamometer as strong as possible using one hand followed by the other hand, and the procedure was repeated for 5 times. The pinch strength between the thumb and index, middle and ring fingers was measured respectively using a pinch meter manufactured by Takei Kiki Kogyo Co., Ltd., Japan, by asking the patient to pinch the gauge using the thumb pad and distal phalanx of each finger as strong as possible while preventing other fingers from assisting in the pinching effort. The vibrotactile perception threshold was measured for the index, middle, ring and little fingers using a vibration sensation meter, model AU-02, manufactured by Rion Co., Ltd., Japan, with a vibration frequency setting of 125 Hz. During the test, the patient was asked to touch the vibrator probe (without a surround platform) with the pulp of the finger, while the other fingers, hand, wrist and arm were positioned to prevent contact with the surface of the vibration sensation meter and examination table. The vibration level was then increased gradually at an interval of 2.5 dB from the starting intensity of −10 dB. The patient was instructed to lift up the other hand immediately when he felt the vibration sensation. The procedure was repeated three times, and the vibration intensity level with at least two out of three similar responses was considered as the correct vibration perception threshold. The interview and all test procedures were carried out in the same session. The room temperature for the examination was maintained at 21−23°C, there was an adaptation period of 30 minutes, and a hand warming procedure was performed prior to the physical examination.

The medical examination for Malaysian participants followed the same procedure as described above with two modifications to suit the local scenario. First, the questionnaire used for history taking was translated into Malay from the English version of the Japanese questionnaire[15]. The questionnaire underwent forward and backward translation from English to the Malay language and vice versa. There was no problem in the language translation, as all the terminology used in the English questionnaire was available in the Malay language. All workers understood and were able to speak the Malay language well without any problem. Second, the cold water immersion test was adopted in the examination using a water temperature of 5°C and a one minute immersion duration. The cold water provocation test was carried out to evaluate the change in the response to skin temperature measurement and vibration perception threshold following immersion of the dominant/symptomatic/worst affected hand in the water at 5°C for one minute. A K-type thermistor wire temperature probe was attached to the middle finger of the test hand and masked with a paper tape. White petroleum gel was then applied to cover the entire tape to prevent water from wetting and seeping into the paper tape. The wire was secured at the wrist level using a paper tape. The test was carried out after an adaptation period of 30 minutes, with the subject in a sitting and relaxed posture and both hands at heart height during the settling and recovery period with the wrist in a neutral position. The test hand was immersed in the cold water up to the wrist level. The immersed hand was gently wiped dry immediately after the cold provocation to prevent heat loss from evaporation. The skin temperature was monitored at zero, one, two and three minutes before immersion, 15, 30, 45 and 60 seconds during immersion and at every minute after immersion until 10 minutes post immersion. The vibration perception threshold was measured at the index finger immediately post immersion and at 5 minutes and 10 minutes post immersion. Throughout the test, the water temperature was maintained at 5°C +/− 0.5°C and the room temperature was maintained between 21−23°C. Hand movement during the measurement of VPT was kept to a minimum by keeping the wrist in a neutral position throughout the test. During the test, an assistant helped to immerse and withdraw the subject's hand from the cold water by supporting the arm and elbow while keeping the wrist in a neutral position. Similarly, during VPT measurement, the assistant assisted in transferring the hand from resting in a neutral position to the probe by rotating the shoulder and supporting the elbow while keeping the wrist in neutral position. Before VPT measurement, the assistant asked the subject to stay in that position, and the measurement was carried out after the assistant was not in contact with the subject. All subjects were able to stay in the above position because the duration of measurement was short.

There were two reasons for utilizing a short immersion duration with a lower temperature. First, for ethical reasons, we considered Malaysian workers as being acclimatized to a hotter environment and thought that the original test conditions might lead to intense pain during the test and an inability to withstand the cold water temperature for 10 minutes. Second, a one-minute duration was simple and quick to administer, and the duration was acceptable to both the employers and workers' representatives of the companies as compared with the 10-minute immersion method. This method was found to be comparable to another method in the evaluation of vascular function of HAVS as reported by Miyashita[16].

We recruited a total of 172 male Malaysian workers, comprised of 31 tree fellers, 31 construction workers and 110 automobile manufacturing plant workers. The Japanese workers consisted of 385 male workers who had undergone an annual medical examination in November and December 2011. The Japanese workers formed a sample containing information on varying degrees of duration and frequency of vibration exposure. In order to facilitate comparison, we randomly matched 172 Japanese workers from this sample to the Malaysian workers individually according to the total years (+/− 2.5 years) of vibration exposure. We also calculated total operating time (TOT) of the vibratory tools based on the formula popularized by Miyashita *et al.*[17] and compared the values between the two groups. The TOT was calculated as the product of total operating hours per day x total operating days per year x total years of operation. We compared the prevalence of HAVS symptoms and the special hand examination, except findings from the cold water immersion test, between the Malaysian and Japanese participants.

In order to compare the outcomes of the cold water immersion test between the Malaysian and Japanese workers, a group of 21 Japanese tree fellers confirmed to have HAVS were selected and underwent the same cold water immersion test procedure used to test the Malaysian participants. We then compared the findings of the 31 Malaysian tree fellers against these 21 Japanese workers with HAVS symptoms. For the purpose of the baseline comparison, we also included all 15 Malaysian forestry workers in the same logging camp who had not used vibratory tools. These 15 forestry workers consisted of administrative staff, field researchers and field supervisors. They underwent a similar medical examination procedure as the tree fellers as described above.

This study was approved by the Medical Ethics Committee of the University of Malaya Medical Centre and the management of the respective company participating in this study. All participants were informed about the procedure, confidentiality and non-liability of the employer prior to the interview. Written consent was obtained from each participant before the commencement of data collection.

Data entry, data cleaning and data analysis were performed using Statistical Package for the Social Sciences (IBM SPSS) software version 19. We utilized nonparametric tests for the comparisons of quantitative data. The distribution of the symptoms of HAVS and other categorical data were analyzed using the chi-square test. We set the significance level at 0.05 for all statistical tests unless otherwise specified.

Results

Comparison between Malaysian and Japanese vibratory tools workers

Table 1 shows the characteristics of Malaysian and Japanese workers after matching by years of vibration exposure. Malaysian workers were significantly younger than Japanese workers. Although there was no statistically significant difference in the TOT between the two groups, Malaysian workers had more days per year (mean difference=121.82 days, 95%CI=95.59, 148.05) but shorter hours per day (0.77 hours, 95%CI=−0.34, 1.87) of exposure compared with Japanese workers. The prevalence of alcoholic drinkers was higher among Japanese workers compared with Malaysian workers. This finding was expected because most of the Malaysian workers were Muslims. There was no difference in other parameters such as height, weight, blood pressure, pulse rate and smoking status between the two groups (data not shown).

The prevalences of HAVS symptoms among the Malaysian and Japanese workers are shown in Table 2. None of the Malaysian workers reported white finger, whereas two of the Japanese workers reported the occurrence of white finger during winter. Although the prevalence of finger tingling, numbness and dullness was higher among the Malaysian workers, the difference was not statistically significant. There was no difference in the musculoskeletal pain of the upper limbs between the two groups, but Malaysian workers reported a significantly higher prevalence of musculoskeletal pain over the back compared with Japanese workers. The higher prevalence of musculoskeletal pain over the back among the Malaysian subjects was probably contributed by the construction workers (data not shown).

The comparison of special hand examination results revealed that Malaysian workers had a lower finger skin temperature and higher vibrotactile perception threshold compared with Japanese subjects. The

Table 1. Profile of matched Malaysian and Japanese workers

Characteristics	Malaysian workers (n=172)	Japanese workers (n=172)	*p*-value[a]
Age (years)	30.67 ± 6.33	38.34 ± 8.61	<0.001
Vibration exposure:			
Total years (Y) (years)	7.81 ± 5.47	7.60 ± 5.01	0.702
Yearly frequency (D) (days/year)	220.94 ± 70.24	162.80 ± 66.18	<0.001
Daily duration (H) (hours/day)	2.69 ± 1.98	4.29 ± 2.07	<0.001
TOT (Y × D × H) (hours)	5,311.37 ± 7,639.47	5,036.53 ± 5,059.09	0.694
Presence of previous disease/injury[b]			0.572
No	158 (91.9)	155 (90.1)	
Yes	14 (8.1)	17 (9.9)	
Regular alcohol consumption			<0.001
No	158 (91.9)	68 (39.5)	
Yes	14 (8.1)	104 (60.5)	

[a] *p*-value obtained from Mann-Whitney U test for quantitative variables and chi-square test for categorical data. [b] Previous disease / injury include diabetes, hypertension, back pain, minor injuries to the lower limbs and back (such as muscle sprain, prolapsed intervertebral discs and osteoarthritis).
TOT, total operating time. Values are mean ± standard deviation values or numbers (%).

Table 2. The prevalence of HAVS symptoms between matched Malaysian and Japanese workers

HAVS symptoms	Malaysian workers (n=172)	Japanese workers (n=172)	*p*-value[a]
Tingling, numbness and dullness			0.444
No	129 (75.0)	135 (78.5)	
Yes	43 (25.0)	37 (21.5)	
White finger			0.499
No	172 (100)	170 (98.8)	
Yes	0	2 (1.2)	
Pain of the fingers and hands			0.455
No	165 (95.9)	162 (94.2)	
Yes	7 (4.1)	10 (5.8)	
Pain of the upper limbs (above wrist)			0.115
No	154 (89.5)	162 (94.2)	
Yes	18 (10.5)	10 (5.8)	
Pain of the back			0.007
No	141 (82.0)	158 (91.9)	
Yes	31 (18.0)	14 (8.1)	

[a] *p*-value obtained from chi-square test. HAVS, hand-arm vibration syndrome. Values are numbers (%).

results are shown in Fig. 1 (1a) and Fig. 1 (1b). There were no differences in the finger nail capillary return time, hand grip strength and pinch grip strength between the two groups (results not shown).

Comparison between Malaysian forestry workers and Japanese tree fellers with HAVS

The Japanese tree fellers were confirmed cases of HAVS. They were significantly older and had longer durations of employment than the Malaysian tree fellers (Table 3). Although their total years of vibration exposure and total operating time were also longer than those of the Malaysian tree fellers, Malaysian tree fellers were exposed to vibration for a greater number of days per year compared with Japanese tree fellers.

As shown in Table 4, none of the Malaysian forestry workers reported white finger. The prevalences of HAVS symptoms (finger tingling, numbness and dullness; white finger; pain of the fingers and hands)

Table 3. The characteristics of Malaysian tree fellers and Japanese tree fellers with HAVS

Characteristics	Malaysian tree fellers (n=31)	Japanese tree fellers (n=21)	*p*-value[a]	Malaysian controls (n=15)	*p*-value[b]
Age (years)	35.90 ± 9.00	64.19 ± 8.13	<0.001	35.67 ± 11.50	0.940
Employment (years)	13.10 ± 8.25	34.90 ± 15.55	<0.001	11.96 ± 8.05	0.659
Vibration exposure:				NA	NA
Total years (Y) (years)	12.69 ± 8.17	32.81 ± 10.77	<0.001		
Yearly frequency (D) (days/year)	275.32 ± 45.92	153.50 ± 44.87	<0.001		
Daily duration (H) (hours/day)	3.83 ± 2.10	4.60 ± 1.56	0.141		
TOT (Y × D × H) (× 10^3 hours)	13.69 ± 13.39	22.19 ± 11.41	0.003		
Height (cm)	160.46 ± 4.88	161.53 ± 6.71	0.867	166.00 ± 7.55	0.004
Weight (cm)	57.66 ± 7.01	64.97 ± 10.66	0.010	68.56 ± 12.00	<0.001
SBP (mmHg)	127.63 ± 11.74	146.90 ± 20.36	0.001	134.63 ± 20.77	0.150
DBP (mmHg)	75.10 ± 11.51	79.83 ± 10.99	0.195	79.70 ± 12.52	0.223
Presence of previous disease/injury			<0.001		0.524
No	27 (87.1)	1 (4.8)		14 (93.3)	
Yes	4 (12.9)	20 (95.2)		1 (6.7)	
Regular alcohol consumption			0.005		0.467
No	18 (58.1)	4 (19.0)		7 (46.7)	
Yes	13 (41.9)	17 (81.0)		8 (53.3)	

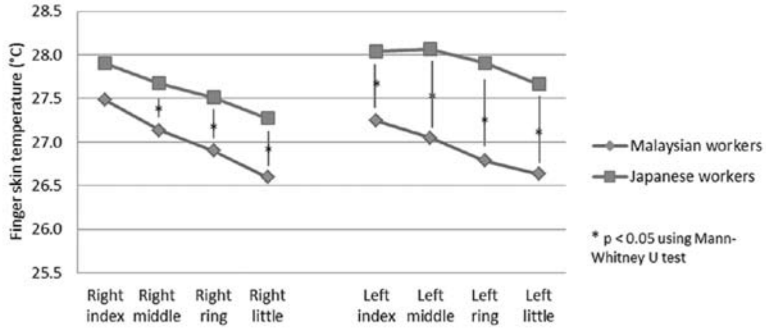
[a] *p*-value obtained from Mann-Whitney U test for quantitative variables and chi-square test for categorical data, comparing Malaysian tree fellers against Japanese tree fellers. [b] *p*-value obtained from Mann-Whitney U test for quantitative variables and chi-square test for categorical data, comparing Malaysian tree fellers against Malaysian controls. TOT, total operating time; SBP, systolic blood pressure; DBP, diastolic blood pressure; NA, not applicable. Values are mean ± standard deviation values or numbers (%).

Table 4. The prevalence of HAVS symptoms in Malaysian tree fellers in comparison with Japanese tree fellers with HAVS

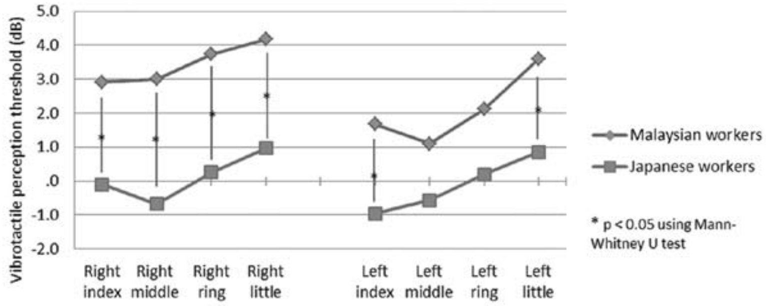
HAVS symptoms	Malaysian tree fellers (n=31)	Japanese tree fellers (n=21)	*p*-value[a]	Malaysian controls (n=15)	*p*-value[b]
Tingling, numbness, dullness			<0.001		0.037
No	20 (64.5)	3 (14.3)		14 (93.3)	
Yes	11 (35.5)	18 (85.7)		1 (6.7)	
White finger			<0.001		NA
No	31 (100)	13 (61.9)		15 (100)	
Yes	0	8 (38.1)		0	
Pain of the fingers and hands			<0.001		0.482
No	30 (96.8)	8 (38.1)		15 (100)	
Yes	1 (3.2)	13 (61.9)		0	
Pain of the upper limbs (above wrist)			0.147		0.013
No	21 (67.7)	10 (47.6)		15 (100)	
Yes	10 (32.3)	11 (52.4)		0	
Pain of the back			0.089		0.242
No	22 (71.0)	10 (47.6)		13 (86.7)	
Yes	9 (29.0)	11 (52.4)		2 (13.3)	

[a] *p*-value obtained from chi-square test, comparing Malaysian tree fellers against Japanese tree fellers. [b] *p*-value obtained from Chi-square test, comparing Malaysian tree fellers against Malaysian controls.
HAVS, hand-arm vibration syndrome; NA, not applicable. Values are numbers (%).

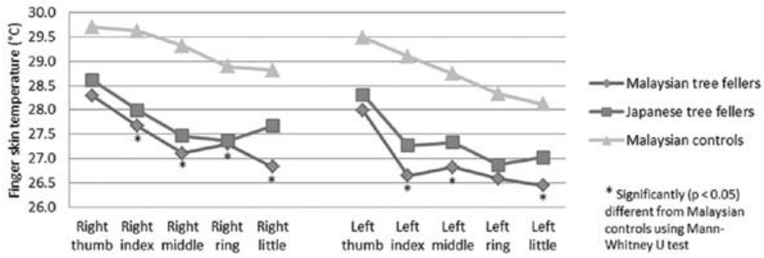
(1a) Finger skin temperature comparison between matched Malaysian and Japanese vibratory tools workers



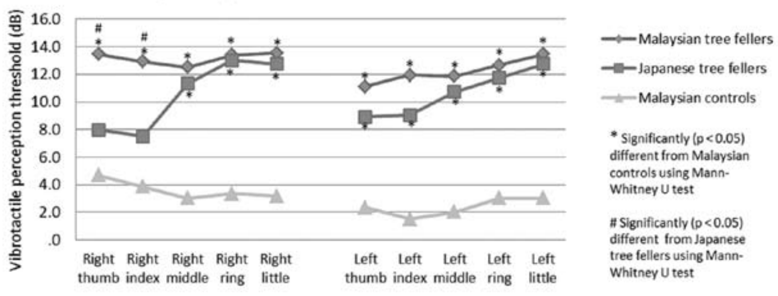
(1b) Vibrotactile perception thresholds comparison between matched Malaysian and Japanese vibratory tools workers



(2a) Comparison of finger skin temperature of Malaysian forestry workers against Japanese tree fellers with HAVS



(2b) Comparison of vibrotactile perception threshold of Malaysian forestry workers against Japanese tree fellers with HAVS



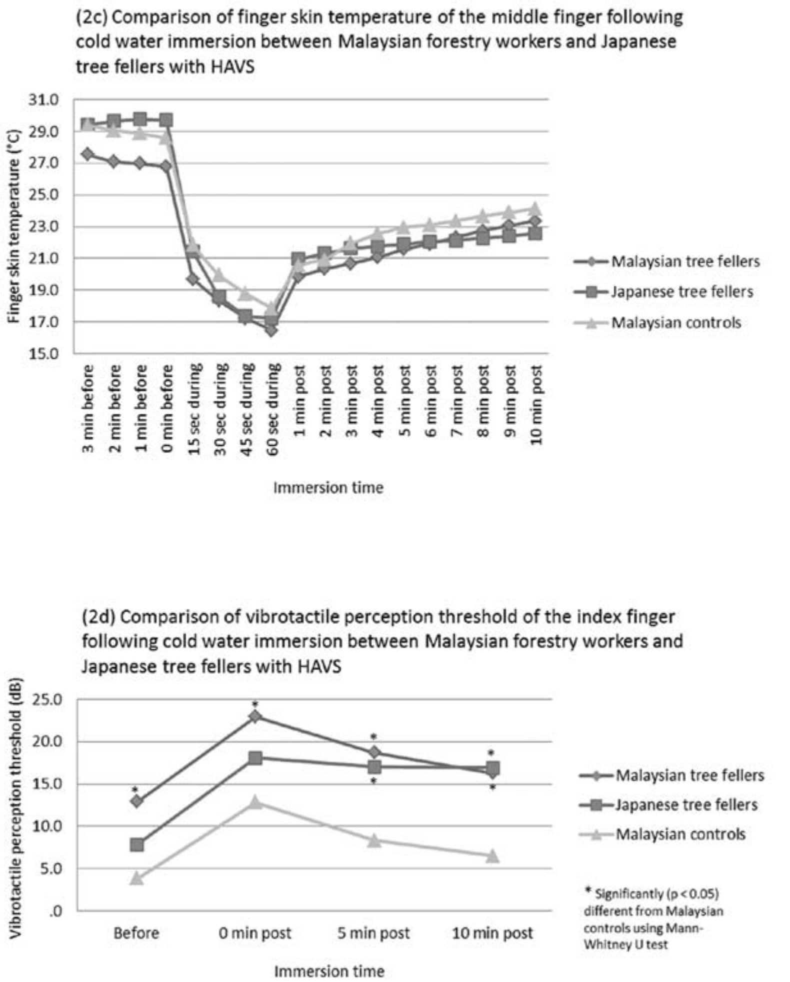


Fig. 1. Comparison of (1a) finger skin temperature and (1b) vibrotactile perception threshold between matched Malaysian and Japanese vibratory tools workers and of (2a) finger skin temperature, (2b) vibrotactile perception threshold, (2c) middle finger skin temperature and (2d) index finger vibrotactile perception threshold of the dominant or symptomatic hand following the cold water immersion test between Malaysian tree fellers and the Japanese tree fellers with hand-arm vibration syndrome. The p values of panel (2a)–(2d) were adjusted using simple Bonferroni adjustment for 3 paired comparisons.

were higher in the Japanese tree fellers than in the Malaysian tree fellers. This finding was expected because the Japanese the tree fellers were confirmed cases of HAVS and were exposed to longer durations of hand-transmitted vibration. In comparison with Malaysian controls, Malaysian tree fellers had a higher prevalences of finger tingling, numbness and dullness and pain of the upper limbs.

The finger skin temperatures of the Malaysian tree fellers were consistently lower than those of the Japanese tree fellers across all fingers, although the differences were not statistically significant as the values were very close to each other (Fig. 1 (2a)). The finger skin temperatures of the Malaysian tree fellers were significantly lower than those of the control subjects for some of the fingers. The vibrotactile perception thresholds for both Malaysian and Japanese tree fellers were significantly higher than those of the control subjects for most of the fingers (Fig. 1 (2b)). Although there was no difference in the vibrotactile perception threshold between the Malaysian and Japanese tree fellers (except for right thumb and index finger), Malaysian tree fellers were found to have a higher threshold for all fingers.

The results for other hand examinations—finger nail capillary return time, hand grip strength and pinch strength—are shown in Table 5. In general, Japanese tree fellers were slightly weaker than both Malaysian fellers and controls in terms of hand grip and pinch strength. The differences in the finger nail capillary return time were insignificant.

The cold water immersion test showed a similar temperature change curve for all three groups of workers following cold water immersion (Fig. 1 (2c)).

Table 5. Finger nail capillary return duration, hand grip strength and pinch strength comparisons between Japanese and Malaysian forestry workers

Test	Japanese tree fellers (n=21)	Malaysian tree fellers (n=31)	*p*-value[a]	Malaysian controls (n=15)	*p*-value[b]
Finger nail capillary return (s):					
Right thumb	1.41 ± 0.40	1.59 ± 0.34	0.046	1.39 ± 0.33	0.949
Right index	1.43 ± 0.46	1.70 ± 0.34	0.051	1.34 ± 0.24	0.649
Right middle	1.43 ± 0.54	1.59 ± 0.29	0.049	1.23 ± 0.17	0.649
Right ring	1.41 ± 0.55	1.57 ± 0.37	0.061	1.21 ± 0.24	0.462
Right little	1.37 ± 0.43	1.63 ± 0.40	0.015	1.28 ± 0.34	0.542
Left thumb	1.44 ± 0.39	1.59 ± 0.30	0.076	1.33 ± 0.30	0.377
Left index	1.46 ± 0.43	1.57 ± 0.30	0.121	1.33 ± 0.30	0.463
Left middle	1.55 ± 0.75	1.50 ± 0.31	0.630	1.27 ± 0.23	0.297
Left ring	1.39 ± 0.38	1.57 ± 0.35	0.110	1.25 ± 0.28	0.259
Left little	1.42 ± 0.54	1.57 ± 0.33	0.065	1.25 ± 0.22	0.608
Average hand grip strength (kg):					
Right hand	31.40 ± 9.23	41.41 ± 7.95	<0.001	46.4 ± 7.28	<0.001
Left hand	30.55 ± 8.01	39.22 ± 8.63	0.001	44.01 ± 6.49	<0.001
Pinch strength (kg):					
Right thumb-index	3.86 ± 1.23	5.91 ± 1.75	<0.001	6.35 ± 2.18	<0.001
Right thumb-middle	2.82 ± 1.17	4.77 ± 1.72	<0.001	5.19 ± 2.24	0.001
Right thumb-little	1.56 ± 0.96	2.84 ± 1.11	<0.001	3.24 ± 1.72	0.002
Left thumb-index	3.98 ± 1.43	5.18 ± 1.75	0.013	5.78 ± 1.78	0.011
Left thumb-middle	3.04 ± 1.27	4.38 ± 1.77	0.006	5.10 ± 1.85	0.001
Left thumb-little	1.33 ± 0.76	2.75 ± 1.36	<0.001	3.02 ± 1.47	<0.001

[a] *p*-value obtained from Mann-Whitney U test, comparing Japanese tree fellers against Malaysian tree fellers.
[b] *p*-value obtained from Mann-Whitney U test, comparing Japanese tree fellers against Malaysian controls.

For vibrotactile perception threshold, both Malaysian and Japanese tree fellers recorded significantly higher thresholds after cold water immersion than the control subjects (Fig. 1 (2d)).

Discussions

There were some limitations in this study in regards to the comparability of the participants between the two countries. First, Malaysian participants were comprised of a heterogenous group of forestry, construction and automobile manufacturing workers, whereas a majority of the Japanese vibratory tools workers were homogeneously forestry workers. The nature of work, type of equipment used and environmental temperature might affect the original outcome of the vibration exposure. We have tried to overcome this limitation by matching the years of vibration exposure of the Japanese workers with those of the Malaysian workers. We were unable to match the level of vibration due to the unavailability of information from the Japanese sample. Hence the results of the current comparisons should be interpreted with caution. Second, the language used for interviewing was different between the two groups, which might cause subtle differences in terms of understanding the same questions among the subjects from the two countries. We tried to minimize this difference by utilizing trained occupational physicians to interview the subjects in order to obtain accurate answer for each question in the questionnaire. Third, the procedure for the cold water immersion test was different between the two countries. Hence, we were unable to compare the results of the cold water immersion test directly, and so we conducted a special examination session using a similar test procedure for a group of confirmed HAVS Japanese tree fellers in order to enable comparison between the two groups. However, due to a logistic problem, the number of subjects was small. Fourth, the laboratory room temperature for the examination of the Malaysian subjects was relatively low as compared with the Japanese environment. As there is no normative data for the Malaysian population using such a room temperature, this might increase the incidence of false-positive cases. We tried to overcome this limitation by obtaining a group of control workers among the foresters for comparison purposes. Unfortunately, control workers for the other two industries were not obtainable due to logistic issues with the respective company. Finally, convenient sampling was used because the subjects were allocated for medical examination based on selection and approval by the respective employer. We were unable to overcome this limitation due to the logistic issues.

In the current study, the matched Malaysian-Japanese data analysis revealed that Malaysian vibratory tools workers, although younger, had a similar prevalence of HAVS symptoms compared with the Japanese workers. The findings for their hand functions were at least similar to those of the Japanese workers. We expected poorer outcomes in the Japanese workers because of their older ages and colder climatic environment, as the body temperature of older people is lower than that of younger people and their tolerance of thermal extremes is more limited[18]. Instead, the finger skin temperatures were lower and the vibrotactile perception thresholds were higher among the Malaysian workers. This might indicate poorer circulatory and sensory functions, which could be attributed to the greater number of days of vibration exposure per year and also possibly to a higher vibration level due to the presence of construction workers in the Malaysian workers group compared with the Japanese workers. Another possible explanation for this observation is that the low finger temperature of Malaysian workers could be due to the relatively low laboratory room temperature during the examination, which might give rise to some false-positive cases in the results. Besides, the low finger temperature among the Malaysian subjects could also be caused by the presence of construction workers in the group who had lower finger temperatures than the other two groups (data not shown). These differences were not apparent when comparing the similar occupational group between the Malaysian and Japanese tree fellers (Fig. 1 (2a) and Fig. 1 (2b)). As the skin temperature of most of the fingers among the Malaysian subjects was less than 27°C, the validity of the VPT measurement among this group of subjects might not be sufficient. On the other hand, in reference to Fig. 1 (2a) and Fig. 1 (2b), the finger skin temperatures of all fingers were significantly higher among the controls than the tree fellers. This indicated that the tree fellers have a more sensitive vascular response to the low temperature as compared with the non-vibration-exposed subjects. Hence, despite the possible insufficient validity of the results of VPT measurement due to the presence of low finger temperature (<27°C), the finding was important because it showed evidence of vascular damage that had affected the neurological outcomes of the tree fellers despite working in a warm environment.

When we compared the symptoms and hand examination results of the Malaysian tree fellers with the confirmed cases of HAVS of the Japanese tree fellers, we found that the prevalences of neurological symptoms (finger tingling, numbness and dullness) were about half of those of the Japanese tree fellers and significantly higher than those of the control subjects. The circulatory and sensory functions—in terms of finger skin temperature and vibrotactile perception threshold—of the fingers were at least as bad as those of the Japanese tree fellers. The cold water immersion test, however, did not distinguish the derangement of digital circulatory function between the tree fellers and the control subjects. Instead, the sensory function derangement was worse in both Japanese and Malaysian tree fellers as compared with the control subjects following cold water immersion. The strength of the small muscles of the hand in the Malaysian tree fellers was preserved compared with the Japanese tree fellers. This finding suggested that early derangement of sensory function among the Malaysian tree fellers had raised to a level as bad as that of the Japanese HAVS subjects despite a much shorter duration of exposure to hand-transmitted vibration in the tropical climate. The cold water immersion test does not seem to provide additional benefit in detecting vascular derangement in HAVS in Malaysia.

The findings of this study suggests that sensory function deterioration among vibratory tools workers in a tropical climate environment can occur earlier and become worse than in workers in a temperate climate environment despite a shorter duration of vibration exposure. This could be attributed to a different working environment, such as more frequent exposure to vibration, higher vibration level and lack of control measures in hand-transmitted vibration exposure, especially in developing countries such as Malaysia. Despite deterioration in the sensory function of the hands, the workers tend to have fewer complaints about the symptoms, probably attributable to the absence of a Raynaud's phenomenon attack and provocative factors such as a winter season.

In summary, hand-arm vibration syndrome presents with predominantly neurological symptoms in the tropical environment. Deterioration in the sensory function of the hands is likely to precede the symptoms. The severity of the sensory function disorder in the tropical environment can be as bad as or even worse than in the subject in the temperate environment. Vascular disturbances do occur in the tropical environment but do not present clinically. Hence, HAVS should be treated with equal importance in tropical countries as temperate countries, and there should be a national legislative framework to protect the health of the workers exposed to hand-transmitted vibration.

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