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. The condition, however, has not been clearly demonstrated in the tropical environment. A recent systematic review of HAVS in tropical environment – which found only six papers on cross-sectional studies among vibratory tools workers in Singapore, Indonesia, Papua New Guinea, Southern Vietnam and Malaysia – revealed that none the studies reported vibration white finger in the tropical environment and the symptoms have been predominantly neurological. The quality of the studies included in the review was generally poor and the results could not be aggregated and compared with the published results from the United States National Institute of Occupational Safety and Health (US NIOSH) because the exposure and outcome information collection methods were not standardized. There was no previous study comparing the clinical outcomes of hand-transmitted vibration between the tropical and temperate environments. In Malaysia, periodic medical examinations for vibratory tools workers are not performed routinely because there is no provision under the national legislative framework due to unavailability of clinical evidence on the occurrence of HAVS in tropical environment. 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 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 national preventive measures against HAVS in tropical environments.
METHODS

Study design
This was a cross-sectional study, comparing the clinical characteristics of HAVS between Malaysian (tropical environment) and Japanese (temperate environment) workers.

Malaysian subjects
A total of 172 male Malaysian workers, comprised of 31 tree fellers, 31 construction workers and 110 automobile manufacturing plant workers were recruited. The construction workers used mainly concrete breakers, grinders, impact drills and powered cutters in their daily work. The forestry workers used only chain saws for tree-felling. The automobile manufacturing workers used mainly impact wrenches in their daily work.

Japanese subjects
The Japanese workers consisted of 385 male forestry workers who had undergone annual field medical examination by Wakayama Medical University. They were tree fellers who used mainly chain saws and brush cutters in their daily work.

Tests methodology
The test procedures for Malaysian subjects followed the test procedures utilized by Wakayama Medical University for annual medical examination for the cohort of 385 Japanese forestry workers, except for cold water immersion test. It consisted of questionnaire interview (employment history, type of vibratory tools used, daily, yearly and total years of vibration exposure and HAVS symptoms – tingling, numbness and dullness; white finger; finger coldness; musculoskeletal pain of the upper limbs), clinical physical examination (measurement of height, weight, blood pressure, pulse rate and an evaluation of the muscle power, range of movement and reflexes of the upper limbs) and specific hand examination (measurement of finger skin temperature, finger nail capillary return time, finger vibrotactile perception threshold (VPT), hand grip strength and pinch strength and a cold water immersion test). The cold water immersion test for Malaysian subjects utilized 5°C and a one minute immersion method. A group of 21 Japanese tree fellers confirmed to have HAVS were selected and underwent the same 5°C, one minute immersion cold water immersion test in order to facilitate comparison. We also measured the vibration exposure level for all Malaysian subjects and the selected 21 Japanese tree fellers.

Comparisons methods
1. Comparison between Malaysian and Japanese vibratory tools workers
We randomly matched 172 out of 385 Japanese cohort workers to the Malaysian workers individually according to the total years (+/- 2.5 years) of vibration exposure. We compared the total operating time, prevalence of white finger, finger coldness, finger tingling, numbness and dullness, pain of the upper limb, finger temperatures and finger VPTs between the two groups.

2. Comparison between Malaysian forestry workers and Japanese tree fellers with HAVS
We compared the outcomes of the 31 Malaysian tree fellers against the 21 selected Japanese tree fellers 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 as control subjects. The outcomes compared were the prevalence of white finger, finger coldness, finger tingling, numbness and dullness, pain of the upper limb, finger temperatures, finger VPTs and cold water immersion test finding.

**Dose response relationship**
The lifetime vibration dose, total operating time and cumulative exposure index for all Malaysian subjects were calculated and regressed against the symptoms of HAVS. The correlation between each vibration exposure dose and the hand function evaluation results was analyzed.

**Statistical analysis**
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. The dose response relationship was analyzed by calculating the adjusted prevalence ratio using general linear model Poisson distribution function from STATA Intercooled version 11. The Spearman r correlation was used to analyze the association between two quantitative variables.

**RESULTS**

1. **Comparison between Malaysian and Japanese vibratory tools workers**
None of the Malaysian workers reported white finger, whereas two of the Japanese workers reported the occurrence of white finger during winter. The prevalence of finger tingling, numbness and dullness among the Malaysian and Japanese workers were 25.0% and 21.5% respectively (p = 0.444). There was no difference in the finger coldness and musculoskeletal pain of the upper limbs between the two groups. Malaysian workers had lower finger skin temperatures and higher VPTs compared to Japanese subjects. There were no differences in the finger nail capillary return time, hand grip strength and pinch grip strength between the two groups.

2. **Comparison between Malaysian forestry workers and Japanese tree fellers with HAVS**
The Japanese tree fellers were confirmed cases of HAVS and hence had the highest prevalence of HAVS symptoms (finger tingling, numbness and dullness; white finger; finger coldness; pain of the fingers and hands). They were older and had longer total years of vibration exposure, but with lower frequency of yearly exposure days than the Malaysian tree fellers. Although none of the Malaysian forestry workers reported white finger, the prevalence of finger coldness was as high as Japanese tree fellers. Malaysian tree fellers had a higher prevalence of finger tingling, numbness and dullness, finger coldness, and pain of the upper limbs as compared to Malaysian controls. The finger skin temperatures of the Malaysian tree fellers were consistently lower than those of the Japanese tree fellers and significantly lower than those of the control subjects for some of the fingers. The VPTs for both Malaysian and Japanese tree fellers were significantly higher than those of the control subjects for most fingers. Malaysian tree fellers had weaker hand grip and pinch strength than the controls but stronger than the Japanese tree fellers. The cold water immersion test showed a similar temperature change curve for all three groups of workers. Both
Malaysian and Japanese tree fellers recorded significantly higher VPTs after cold water immersion than the control subjects.

3. Dose response relationship

The adjusted prevalence ratio for finger tingling, numbness and dullness was 3.34 (95%CI = 1.27 to 8.98) for subjects with log lifetime vibration dose (lnLVD) of ≥ 20 lnm²s⁻⁴ against those < 16 lnm²s⁻⁴. Similar dose response pattern was found for log cumulative exposure index (lnCEI) but not for log total operating time (lnTOT). The adjusted prevalence ratio for finger coldness showed non-statistically significant increase with both lnLVD and lnCEI. Vibrotactile perception thresholds correlated moderately with lnLVD and lnCEI. The relationship between 8-hour time weighted average vibration exposure (A(8)) and years of vibration exposure for neurological symptoms follows the similar pattern as finger blanching reported in ISO 5349-1 documentation.

CONCLUSIONS

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 sensory function disorders among the vibratory tool workers in the tropical environment is as bad as the temperate environment. Vascular disturbances do occur in the tropical environment but do not present clinically. Finger coldness is an important surrogate symptom for vascular disorder in tropical environment. The dose response relationship of HAVS in a tropical environment is valid for finger tingling and numbness. The relationship between A(8) and years of vibration exposure for neurological symptoms follows the similar pattern as finger blanching reported in ISO 5349-1 documentation. The LVD and CEI are more useful than TOT when evaluating the dose-response pattern of a heterogeneous group of vibratory tools workers. Hand-arm vibration syndrome should be treated with equal importance in tropical countries as temperate countries. It is proposed to include the dose response relationship information for neurological symptoms in ISO5349-1 to facilitate its application in tropical environment. The results of this study serve as an evidence to formulate a national legislative framework to protect the health of the workers exposed to hand-transmitted vibration in tropical countries.
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<td>My excellence Japanese supervisor in Wakayama Medical University, Prof Kazuhisa Miyashita</td>
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<td>Group photo during field work in Tanabe, Wakayama, after investigating a group of Japanese foresters</td>
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