

Significance of Finger Coldness in Hand-Arm Vibration Syndrome

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Abstract

Objectives: To evaluate the relationship between subjective symptoms of coldness in fingers and peripheral circulation in patients with hand-arm vibration syndrome (HAVS).

Methods: Thirty-five male patients confirmed to have HAVS as an occupational disease took part in this study. Their mean age was 62 years (SD 5) and all were chain-saw operators exposed to vibration for an average of 25 years. Their annual health examination included the history of their daily habits (smoking, drinking, and therapeutic exercise), report of subjective symptoms such as coldness, numbness and tingling in the fingers, and a physical examination; laboratory tests consisted of skin temperature measurement, and pain and vibration perception under conditions of cold provocation. A frequently used method of cold provocation, immersion of the left hand up to the wrist in water of 10°C for 10 min, was used.

Results: Finger coldness was classified into 3 groups according to its severity: mild group (n=8), moderate group (n=17) and severe group (n=10). There was no significant difference in age or occupational background between the groups. A significant association was found between finger coldness and prevalence of Raynaud's phenomenon ($p<0.01$, χ^2 -test). The mean skin temperature was significantly lower with the severity of finger coldness (ANOVA, $p<0.05$). In the cold provocation test, there was no significant difference between skin temperature and coldness at 5 min and 10 min after immersion, though a difference was observed immediately after immersion. No significant difference was observed in the relationship between finger coldness and vibrotactile threshold before, during or after the cold provocation test.

Conclusions: The severity of coldness in the fingers is significantly related to skin temperature. The severity of finger coldness reflects the extent of peripheral circulatory vasoconstriction. Coldness in the fingers may be a good warning of potential problems in peripheral circulatory function.

Key words: hand-arm vibration syndrome, finger coldness, significance

Introduction

In Japan, occupational health problems relating to hand-arm vibration syndrome (HAVS) were investigated in the late 1960s by studying national forestry workers in and subsequently, those in mining and stone quarry industries. Based on previous research, a comprehensive system intended to prevent HAVS in Japan was introduced in the 1970s. The greatest peak of new patients was observed in all sectors of industry in the late 1970s (1). Following the introduction of preventive strategies, such as improvements in vibrating tools and insis-

tence on special annual health examinations, the number of new patients has decreased dramatically (1).

A special annual health examination for hand-arm vibration syndrome (HAVS) was introduced and regulated by the Industrial Safety and Health Law in Japan, starting from 1975 (2). About 40,000 workers underwent this health examination in 2004 and the rate of prevalence of abnormal findings was 6.0%. In Japan, the number of workers who use vibratory tools in their occupations was estimated to be at least 2 million, and the number of workers requiring annual health examination was 200,000. It seems that most workers who use vibratory tools occupationally had no chance to undergo this special annual health examination. In fact the number of new patients has increased again in recent years, particularly in the construction and manufacturing industries. About 600 people per year, mainly ex-workers, were designated as new cases of HAVS. It is therefore very important to detect the early stage of HAVS to stop its progression.

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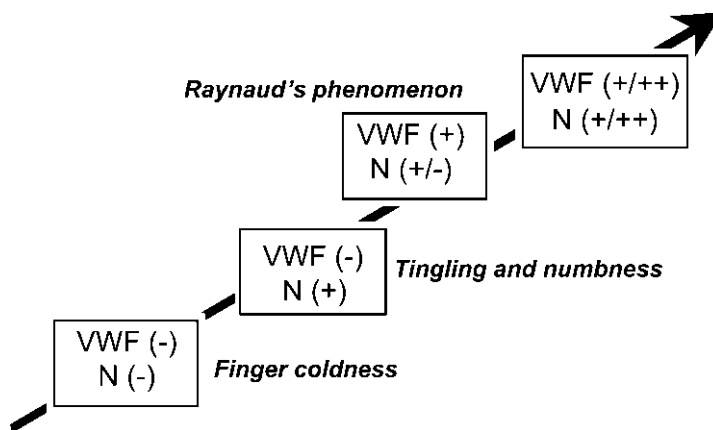


Fig. 1 Natural clinical course of main symptoms in patients with HAVS. VWF and N represent vibration-induced white finger and numbness, respectively. (-) and (+) indicate negative and positive symptoms, respectively.

Finger coldness has so far not been well evaluated, because of various difficulties. The Stockholm criterion, used internationally to evaluate the stages of clinical features in affected workers exposed to hand-transmitted vibration, involves Raynaud's phenomenon for vascular findings but not finger coldness (3). Some researchers have reported that symptoms of finger coldness preceded the initial occurrence of Raynaud's phenomenon in workers who had used vibratory tools for long periods (4–6). Finger coldness could be a reflex condition of spastic vasoconstriction in peripheral circulation. Yamada et al. (5) proposed a typical clinical course for the stages of HAVS (Fig. 1). Although finger coldness is based on subjective complaints and is not evaluated quantitatively, this index could be helpful in evaluating peripheral circulatory disorder in the early stage of HAVS. The present study is aimed at evaluating the relationship between subjective symptoms of coldness in the fingers and peripheral circulation in patients with HAVS. We also consider the relationship between coldness in the fingers and peripheral circulation in healthy women. New patients with HAVS are likely to be female workers, particularly those in manufacturing industries.

Methods

Study 1

Thirty-five male patients confirmed to have HAVS as an occupational disease took part in this study. Their mean age was 62 years (SD 5) and all were chain-saw operators exposed to vibration for an average of 25 years. Their annual health examination included a history of their daily habits (smoking, drinking, and therapeutic exercise), report of subjective symptoms such as coldness, numbness, and tingling in the fingers, and laboratory tests including skin temperature measurement, and pain and vibration perception under conditions of cold provocation. The degree of finger coldness was defined by its severity and area of the finger, using a special health examination questionnaire for hand-arm vibration syndrome. Finger coldness was divided into 3 grades according to its severity: mild, moderate, and severe. A frequently used method of cold provocation, immersion of the left hand up to the wrist in water

at 10°C for 10 min, was used. Finger skin temperature was continuously measured at the back of the middle phalanx of the third finger of the left hand, using a thermometer (HD-111, Takara, Japan) before, during and after cold-water immersion. Finger vibrotactile thresholds, as measures of peripheral neurological functions, were examined at the palmar distal phalanx before immersion, immediately after immersion, and 5 min and 10 min after immersion. The vibrotactile threshold was measured at 125 Hz with a vibration sensimeter (AU-02, RION, Japan). The room temperature during laboratory testing was maintained at 20°C to 22°C by an air-conditioning system.

Study 2

We examined the relationship between sensations of cold and peripheral circulation in healthy young women. Twenty healthy females (nurse students) took part in this preliminary study. Their mean age was 20 years, and there was no history of Raynaud's phenomenon. The questionnaire concerned: 1) the history of daily habits: smoking, drinking, and physical exercise, and 2) subjective symptoms of coldness: finger coldness, intolerance to cold, intolerance to air conditioning. Skin temperature was measured under conditions of cold provocation (10°C-water immersion for 10 min). The room temperature during laboratory testing was maintained at 20°C to 22°C strictly by an artificial climate control system. Prior to the study, the contents of the experiment were carefully explained to all the subjects, and informed written consent was obtained from them. However, this study was not approved by the Ethical Committee for the Clinical Research of Kurume University because this study had done in 2001 before this committee was established. In statistical analysis of the data, a χ^2 -test was used to compare the prevalence of Raynaud's phenomenon and finger coldness. An ANOVA (analysis of variance) method was used for comparison of finger coldness and skin temperature. Differences were taken to be statistically significant when p was less than 0.05. These statistical analyses were conducted using a JMP computer program (SAS Institute, USA; version 5).

Results

1) Relationship between finger coldness and peripheral circulation in patients with HAVS

Finger coldness was classified into 3 groups according to its severity: mild group (n=8), moderate group (n=17), and severe group (n=10). There was no significant difference in age or occupational background between the groups. Figure 2 shows a significant association between finger coldness and the prevalence of Raynaud’s phenomenon (p<001, χ^2 -test). Figure

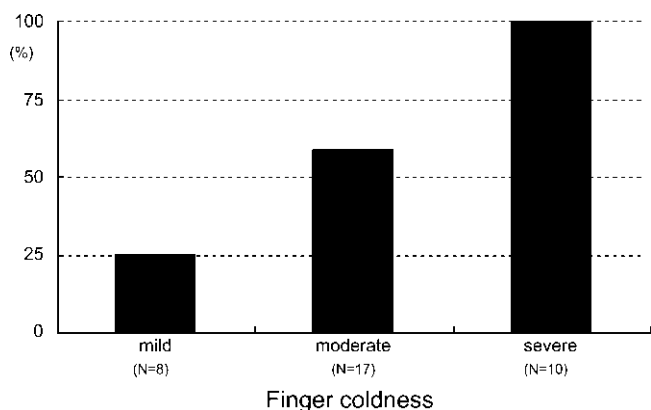


Fig. 2 Prevalence rate of Raynaud’s phenomenon according to severity of finger coldness.

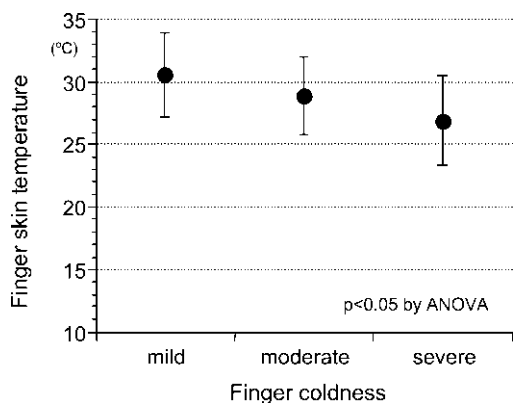


Fig. 3 Finger skin temperature before cold provocation test (10°C-10 min) versus severity of finger coldness.

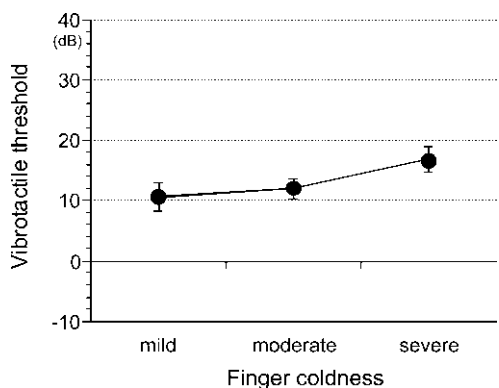


Fig. 4 Finger vibrotactile threshold before cold provocation test versus severity of finger coldness.

3 shows the relationship between finger coldness and skin temperature prior to the cold provocation test. The mean skin temperature was significantly lower with increasing severity of finger coldness (ANOVA, p<0.05). In the cold provocation test, there was no significant difference between skin temperature and coldness at 5 min and 10 min after cold immersion, though a difference was observed immediately after immersion. No significant difference was observed in the relationship between finger coldness and vibrotactile thresholds before, during or after the cold provocation test (Fig. 4).

2) Relationship between finger coldness and peripheral circulation in healthy young women

Figure 5 shows the percentage of abnormal cold sensation. We asked about three kinds of cold sensation: finger coldness, intolerance to cold environment, and intolerance to air conditioning in summer. The first question concerns a local cold sensation, and the other two concern general cold sensations. For finger coldness, the perception of subjects in the severe group was 20%, and 35% of subjects were in each of the mild and moderate groups. Only 10% of subjects experienced no finger coldness. Eighty-five percent of subjects reported intolerance to cold. Figure 6 shows the relationship between severity of finger coldness and skin temperature before the cold provocation test. The mean skin temperature differed significantly

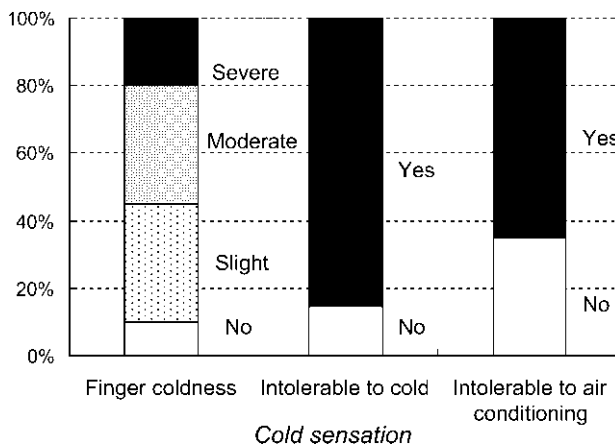


Fig. 5 Percentages of young healthy women experiencing several aspects of cold sensation.

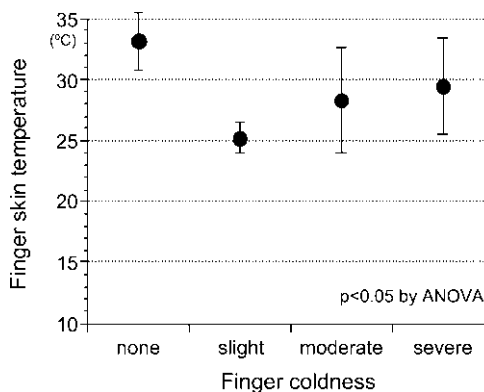


Fig. 6 Finger skin temperature before cold provocation test (10°C-10 min) versus severity of finger coldness.

with severity of finger coldness (ANOVA, $p < 0.05$). The highest skin temperature was observed in the group with no finger coldness. However, there was no relationship between severity of finger coldness and skin temperature.

Discussion

We have investigated the relationship between finger coldness and peripheral skin temperature in patients with HAVS and healthy young women in order to evaluate the usefulness of finger coldness as a signal of potential peripheral circulatory disorder. We found that the severity of coldness in the fingers in patients with HAVS is significantly correlated with the prevalence of Raynaud's phenomenon and skin temperature in the cold provocation test. However, there was no relationship between finger coldness and vibrotactile thresholds before, during or after the cold provocation test. Coldness in the fingers may be a good signal of potential impairment of peripheral circulatory function.

Several researchers have studied whether finger coldness precedes the initial occurrence of Raynaud's phenomenon (4–6). Yamada et al. (5) examined the correlations between examination findings, subjective symptoms and classification of stages in vibration syndrome in their follow-up study. They found a significant increase in the prevalence of VWF (vibration-induced white finger) with longer periods of chain-saw operation. In line with the severity of VWF–N groups, skin temperature was significantly reduced and prevalence of hypersensitivity to cold increased. Based on these results, they proposed that the initial stage was VWF (–) N (–), progressing to the VWF (–) N (+) stage, the VWF (+) N (+/–) stage, and finally the VWF (+/++) N (+/++) stage (Fig. 1). The symbols (–), (+) and (++) used here denote the frequency and existence of the signs and symptoms. Finger coldness is the initial symptom in the stage of VWF (–) N (–).

The Stockholm criterion is used internationally for the stages of clinical features in workers with HAVS. This criterion is graded on the basis of Raynaud's phenomenon only for peripheral circulation (3). However, a problem arises in the disagreement between the symptoms and laboratory findings. Ishitake et al. (6) compared the Stockholm criterion and the criterion used by the Ministry of Labor in Japan for assessing the therapeutic effects in a 3-year follow-up study. The agreement between the two criteria was 30%. The Ministry of Labor's criterion was more severe than the Stockholm criterion. In the Stockholm criterion for the vascular component, 16 patients (40%) in stage 0 were classified into stages 1–3 according to the Ministry of Labor criteria. Eleven of them (70%) complained of coldness in the fingers. This large discrepancy in the stages for the vascular component is attributed to the difference in the stages when evaluated on the basis of Raynaud's phenomenon alone or upon including numbness and coldness in the fingers. The prevalence of Raynaud's phenome-

non differs between the sexes and races. It is 0.5 to 4.0% in Japanese, 2% in Chinese, and 4 to 18% in Western Europeans.

From the large standard deviations for the moderate and severe groups (Fig. 6), two distinct relationships are suspected between finger coldness and peripheral circulation: one is the presence of both finger coldness and poor peripheral circulation, and the other is good peripheral circulation in spite of finger coldness. Following acute exposure to hand-transmitted vibration, the response to cold provocation was augmented among healthy young women with cold sensation (data not shown). Unfortunately, we were not able to distinguish between these two types on the basis of severity of cold sensation in our preliminary study. These two types should be considered when evaluating peripheral circulation in healthy young women, since most young women suffer from finger coldness in daily life.

In our preliminary study of healthy young women, we found a high rate of abnormal cold sensation based on subjective evaluation. Although the pathophysiological mechanisms of finger coldness are: 1) peripheral circulatory disorder related to finger skin and muscle blood flow, 2) metabolic control disorder, 3) neurological control disorder, and 4) behavioral control disorder (7), the mechanism of finger coldness in women was not clear. We could not find any the relationship between severity of finger coldness and finger skin temperature, as shown in the results of study 1. This discrepancy may depend on the presence of organic changes in peripheral blood vessels. Generally, the presence of finger coldness may be related to peripheral circulatory disorder. An increase of women in the workforce under hazardous working conditions can be expected in the near future. If women are generally more vulnerable to hand-transmitted vibration exposure due to poor peripheral circulation, we must consider the possibility of a high risk for peripheral circulatory disorders in women workers. Unfortunately, we have no adequate health data on women who work with vibratory tools. This will be an important issue in Japanese occupational health. Future research should focus on (1) higher vulnerability to hand-transmitted vibration for women, and (2) more sensitive and early indicators of health effects of occupational vibration exposure.

Conclusions

Severity of coldness in the fingers is significantly related to skin temperature in patients with HAVS. The degree of finger coldness might reflect the extent of peripheral circulatory vasoconstriction. Coldness in the fingers may be a good warning signal of potential problems in peripheral circulatory function. In our preliminary study, we found that most young women complained of finger coldness. We should pay attention to subjects who have good peripheral circulatory function in spite of severe finger coldness.

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