COMPARISON OF COLD IMMERSION TESTS WITH WATER AT 12°C AND 10°C FOR 5 MINUTES IN DIAGNOSING VIBRATION-INDUCED WHITE FINGER

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1. INTRODUCTION

To diagnose vibration-induced white finger (VWF) objectively, application of a cold provocation with immersion of the hand/s in water is a commonly employed test modality. But questions have been raised regarding the diagnostic ability of such a test (Harada and Mahbub 2008). For the cold water immersion test, ISO 14835-1 (2005) recommends a 12°C water temperature, with immersion of the hand/s for a duration of 5 min. In Japan, immersion of the hand/s in water at 10°C temperature for 10 min is commonly applied for this purpose (Harada et al. 1999). A cold water immersion test is desirable that is less painful to the subject, but sufficient to demonstrate the augmented vasoconstriction among VWF patients (Lindsell and Griffin 2000). There is a lack of studies investigating and comparing the diagnostic performance of cold water immersion tests including the ISO recommended test for the above-mentioned purpose. The objective of this study was to compare the diagnostic performances of two different cold provocation tests with water immersion at 12°C and 10°C for 5 min in distinguishing VWF.

2. METHODS

The cold water immersion tests were conducted on 26 male patients diagnosed with VWF, and 27 healthy male controls who did not regularly use hand-held vibrating power tools, using the protocol of ISO 14835-1:2005. The subjects were acclimatized to the room temperature (21±1°C) for a period of approximately 30 min in a temperature-controlled room, seated comfortably on a chair. Thermistors (SZL-64, Technol Seven, Japan) were fixed with adhesive tape but without tape tension to the middle of the palmar side of the distal phalanges of all fingers. The baseline values of finger skin temperature (FST) were recorded after ensuring stable FST in both hands positioned approximately at heart level, palm up on a wooden table. Then the subjects immersed both hands up to the wrist into stirred water at 12°C or 10°C (on different days) for 5 min, with waterproof coverings on both hands (AS ONE Corp., Japan). The gloves were removed immediately after the immersion period. The FST values were continued to be recorded at each minute during immersion and during a 15 min recovery period.

Twenty individually matched (by age) case-control pairs were selected. For the analysis, the minimum value of FST among 4 fingers (excluding thumb) was used. Data were analyzed at five time points: just before immersion (Baseline), last minute during immersion (Immersion5), at 5 (Recovery5), 10 (Recovery10) and 15 min (Recovery15) during the re-warming period. The Wilcoxon signed-ranks test was used to examine the differences between the patient and control groups (significant difference if Wilcoxon signed-ranks test $P < 0.05$, shown as * in Table 1). To evaluate the diagnostic performances of two different immersion tests, receiver operating characteristic (ROC) curve analysis was performed and sensitivities were calculated at 70% and 95% specificities. Using a nonparametric approach, the areas under the ROC curves (AUCs) with the related 95% confidence interval was determined; the differences between the paired areas for the AUCs under 12°C and 10°C immersion conditions were compared. Statistical analysis was done using Medcalc v. 10.0.2 and SPSS v. 16.0.

3. RESULTS

Average ages and average values of body mass index did not differ between patient and control groups. Among the 20 patients with current symptoms of VWF, 2, 12 and 6 subjects had vascular stages 1, 2 and 3 of the Stockholm Workshop Scale, respectively. The baseline and during immersion values of FST did not differ significantly between the patient and control groups under any immersion

Table 1. Median (inter-quartile range) values of FST (°C) from right and left hands at different time points

	12 °C		10 °C	
Time point	Patient	Control	Patient	Control
Right hand				
Baseline	29.7 (7.8)	31.7 (4.5)	29.8 (7.8)	31.5 (6.5)
Immersion5	13.2 (0.7)	13.5 (1.0)	11.2 (1.0)	11.8 (1.3)
Recovery5	16.0 (2.5)*	17.3 (2.6)	15.0 (3.7)	17.6 (2.9)
Recovery10	17.3 (2.7)	19.1 (4.1)	16.6 (5.8)*	19.2 (7.7)
Recovery15	18.3 (3.7)*	20.1 (12.9)	17.7 (7.9)*	20.0 (13.7)
Left hand				
Baseline	29.4 (9.8)	30.0 (5.7)	26.2 (8.5)	29.1 (8.6)
Immersion5	13.0 (1.2)	13.1 (1.0)	10.9 (1.6)	11.5 (1.7)
Recovery5	15.9 (2.5)*	17.0 (1.9)	14.9 (3.2)	17.6 (4.0)
Recovery10	17.1 (3.6)	18.6 (5.0)	16.4 (4.1)*	20.1 (8.4)
Recovery15	17.9 (8.8)*	19.7 (11.6)	17.5 (4.6)*	22.1 (12.5)

n = 20 at each time point;
Significant difference if Wilcoxon signed-ranks test *P < 0.05;.

Table 2. Sensitivity (Sn%) and specificity (Sp%) with cut-off value for 12°C and 10°C immersion conditions.

	12°C				10°C			
	Sp 95%		Sp 70%		Sp 95%		Sp 70%	
Time point	Sn%	Cut-off value (°C)	Sn%	Cut-off value (°C)	Sn%	Cut-off value (°C)	Sn%	Cut-off value (°C)
Right hand								
Baseline	25	23.8	45	28.2	10	22.2	45	27.6
Immersion5	5	12.4	50	13.1	0	10.3	55	11.2
Recovery5	20	15.4	60	16.3	20	14.4	65	15.7
Recovery10	20	16.5	60	17.8	15	15.8	65	17.7
Recovery15	35	17.7	60	18.9	25	16.9	65	18.6
Left hand								
Baseline	30	23.6	45	27.7	15	22.0	30	24.2
Immersion5	10	12.4	35	12.8	0	10.3	50	10.8
Recovery5	15	14.8	65	16.3	30	14.3	65	15.3
Recovery10	35	16.8	65	18.0	35	15.9	60	16.8
Recovery15	45	17.8	65	19.0	35	16.9	60	17.7

condition. In contrast, during recovery, the FST values of the patients were significantly ($P < 0.05$) lower at 5th and 15th min under 12 °C immersion condition, and at 10th and 15th min under 10°C immersion condition, for both hands (Table 1).

Table 2 shows the sensitivity and specificity at different time points with the corresponding cut-off values for both immersion conditions. During recovery at 95% specificity, the sensitivity ranged from 15% to 45% and 15% to 35% for the 12°C and 10°C immersion conditions, respectively. On the other hand, the values of sensitivity at 70% specificity ranged from 60% to 65% under both immersion conditions. Overall, the larger value of AUC was found at the 15th min of recovery (results not shown). However, the paired AUCs for the two different immersion conditions did not differ significantly at any time before, during, or after immersion.

4. DISCUSSION

In diagnosis of a prescribed disease like VWF, a diagnostic test needs to be highly specific so that as few subjects as possible without it are diagnosed as having it (Cm 6098). During recovery at 95% specificity, the sensitivity was low under both immersion conditions. On the other hand, at 70% specificity during recovery, the sensitivity was found to be around 60-65% for both tests. Furthermore AUCs, which are commonly used measures to compare the overall diagnostic performances of different tests, showed similar values for 12°C and 10°C immersion conditions in this study, indicating that the two tests yield the same overall diagnostic performance.

A good diagnostic performance of cold water immersion tests was not demonstrated convincingly in previous studies (Harada and Mahbub 2008). Also, in this study at 95% and 70% specificities, the corresponding sensitivities were not satisfactorily high for both conditions: however, the positive group differences observed only during the recovery period emphasize the importance of conducting such a test for the discrimination of patients with VWF.

5. CONCLUSIONS

Cold provocation tests with hands immersed in water at 12°C or 10°C for 5 min could reveal group differences between VWF patients and matched healthy controls, and the diagnostic performance of these tests in distinguishing patients with VWF were similar.

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