MEASURING CONDITIONS OF COLD PROVOCATION TESTS: A REVIEW OF THE LITERATURE

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1. INTRODUCTION

Prolonged exposure to hand-arm vibration is a cause of hand-arm vibration syndrome (HAVS). This disorder is characterized by neurological, vascular and musculoskeletal disturbances in upper extremities. In health screening of HAVS, cold provocation tests (CPTs) have been widely conducted to evaluate the severity of the damage in the peripheral vascular function. However, there is a wide difference in test conditions among countries and researchers.

The International Organization for Standardization (ISO) released ISO 14835-1 in 2005, which proposed a water temperature of 12 °C and an immersion duration of 5 minutes in cold provocation tests (CPTs) for assessing peripheral vascular function. Many results have been reported since the ISO recommendation, but findings are not always consistent. It is necessary to re-evaluate them. The purpose of this study is to review measuring conditions of CPTs recently reported and to establish a new database.

2. METHODS

Relevant articles were identified using the PubMed database from 2002 (the year the latest article ISO 14835-1 referred to was published) to October 2010. The electronic search included both free-text and MeSH terms. Used terms were: "vibration white finger," "hand-arm vibration syndrome," "vibration-induced white finger," "cold temperature [MeSH Terms]," "cold climate [MeSH Terms]," "cold water," and "cold provocation test." Articles included in this review were written in English, published as an original article, with human subjects and had no obvious overlap of subjects with other studies. Case reports, letter articles and reviews were excluded.

Literature searches identified a total of 52 articles. Of these, four review articles, one case report, two articles with nonhuman subjects, four articles which conducted no CPT, three letter articles, and three articles written in non-English languages were excluded, leaving 35 articles.

These 35 articles were reviewed to identify the purpose of tests (diagnosis, compensation, etc.), measuring conditions of CPTs, including acclimatization period, water temperature, hand immersion duration, measuring methods of outcomes (e.g. finger skin temperature, finger systolic blood pressure), and diagnostic criteria. If available, the sensitivity and specificity of CPTs were also noted.

3. RESULTS

A total of 35 studies were selected for this review. Published articles were chiefly from temperate and subarctic zones. They were conducted chiefly for diagnosis while some of them also mentioned compensation. In longitudinal studies, the follow-up period ranged from 1 to 15 years.

Water temperature ranged from 5 to 15 °C, (5 °C in 1 study, 8 °C in 1 study, 10 °C in 23 studies, 12 °C in 4 studies, and 15 °C in 11 studies). In some studies, more than one temperature level was set in a single CPT (e.g., 15 °C for 5 minutes followed by 10 °C for 5 minutes.). Hand immersion period for a single temperature varied from 2 to 10 minutes, mainly 5 or 10 minutes.

Outcomes chiefly measured were the change of finger skin temperature (22 studies) and finger systolic blood pressure (13 studies). In some studies, peripheral vascular function was evaluated with laser-Doppler imaging (2 studies) or infrared thermography (2 studies).

Six studies mentioned the sensitivity and specificity of tests (Table 1). In the 10 °C, 10-min method, both sensitivity and specificity were high while the 15 °C, 5-min method, the sensitivity was lower and the specificity was fairly high. The 10 °C, 5-min method showed lower sensitivity and comparably high specificity. These findings do not support the accuracy of the diagnostic value of the 15 °C, 5-min method.

4. DISCUSSION AND CONCLUSIONS

After the release of ISO 14835-1, there was limited data on the usefulness of the 12°C, 5-min method. More

evidence will be required to establish the diagnostic ability of the 12 °C, 5-min method.

The sensitivity of the 15 °C, 5-min method is relatively low, and insufficient to provoke peripheral vascular dysfunction. This finding is consistent with a previous review (Harada, 2002). However, it seems premature to conclude which method is the best to evaluate peripheral vascular function. To evaluate HAVS, findings from CPTs should be interpreted carefully, and combined with findings from other tests.

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Table 1. Sensitivity and specificity of cold provocation tests.

References	Subjects	Patients vs. controls	Adaptation	Room temp. (°C)	Exposure to cold	Outcome measures (cut-off point)	Se(%)	Sp(%)
Nasu (Japan, 2008)	154 NVEC, 21 VEC, 21 inactive VWF (SV=0), 83 active VWF (SV>0)	(Inactive VWF + active VWF) vs. NVEC	30+ min.	(a) 21±1 (b) 23±1	10 °C, 5 min.	FSBP% (75%)	(a) 73.9 (b) 65.2	(a) 82.5 (b) 87.5
Negro (Italy, 2008)	113 forestry workers, 33 stone workers (Number of VWF cases confirmed with a color chart: (a: baseline)17; (b: 1-year follow-up)18)	VWF vs. non-VWF	20-30 min.	20-22	30 °C, then 10 °C	Medical history (self-reported history of finger whiteness)	(a) 88.2 (b) 94.4	(a) 93.8 (b) 97.7
Terada (Japan, 2007)	31 NVEC, 20 HAVS (SV>0)	HAVS vs. NVEC	Sufficiently long time	24.2±0.4	10 °C, 10 min.	LDPI (Any abnormal LDPI finding)	80.0	84.6
Poole (UK, 2006)	21 NVEC, 33 HAVS (SV=2 or 3)	HAVS vs. NVEC	15 min.	23.1 (SD, 1.4)	15 °C, 5 min.	(a) T4°C (N/A) (b) Tip-middle minute 6 (N/A)	(a) 69.7 (b) 57.6	(a) 66.7 (b) 85.7
Poole (UK, 2004)	22 NVEC, 24 HAVS (SV=2 or 3)	HAVS vs. NVEC	N/A	22±2	15 °C, 5 min.	FSBP% * (56.7-79.5%)	43.5-60.9	90.5-95.2
						T4°C (276 sec.)	70.8	77.3
Mason (UK, 2003)	727 miners (SV=0, 10%; SV>0, 90%)	SV>0 vs. SV=0	N/A	N/A	15 °C, 5 min.	T4°C (173 sec.)	65.8	58.5

UK: United Kingdom. NVEC: non vibration-exposed controls. VEC: vibration-exposed controls. VWF: vibration-induced white finger patients. SV: Stockholm vascular staging. HAVS: hand-arm vibration syndrome patients. Temp: temperature. SD: standard deviation. FSBP: finger systolic blood pressure. LDPI: laser Doppler perfusion imaging. T4°C: time taken to increase the finger skin temperature by 4 °C after exposure to cold. Tip-middle minute 6: difference between finger tip and middle temperature for the sixth minute of recovery. Se: sensitivity. Sp: specificity. N/A: not available.

* FSBP% was calculated with eight formulae, and the ranges of the FSBP% cut-off point, the sensitivity and the specificity are shown.