



Research paper

Vibrotactile and thermal perception and its relation to finger skin thickness

Ronnie Lundström^{a,*}, Håkan Dahlqvist^b, Mats Hagberg^c, Tohr Nilsson^d^a Department of Radiation Sciences, Biomedical Engineering and Radiation Physics, Umeå University, Umeå, Sweden^b ElMeKon HB, Karlstad, Sweden^c Department of Occupational Medicine, Sahlgrenska University Hospital, Göteborg University, Sweden^d Department of Public Health and Clinical Medicine, Occupational Medicine, Umeå University, Umeå, Sweden

ARTICLE INFO

Article history:

Received 16 December 2016

Received in revised form 8 January 2018

Accepted 13 January 2018

Keywords:

Vibrotactile
Thermotactile
Skin thickness
Perception
Threshold
Vibration

ABSTRACT

Objective: Quantitative measurements of vibrotactile and thermotactile perception thresholds (VPT and TPT, respectively) rely on responses from sensory receptors in the skin when mechanical or thermal stimuli are applied to the skin. The objective was to examine if there is a relation between skin thickness (epidermis and dermis) and VPT or TPT.

Methods: Perception thresholds were measured on the volar side of the fingertip on 148 male subjects, out of which 116 were manual workers exposed to hand-transmitted vibration and 32 were white-collar (office) workers. Skin thickness was measured using a high-frequency ultrasonic derma scanner system.

Results: The difference in age, perception thresholds and skin thickness between manual and office workers was small and non-significant except for the perception of cold, which was decreased by vibration exposure. Skin thickness for both subgroups was mean 0.57 mm (range 0.25–0.93 mm). Increased age was associated with decreased perception of warmth and vibration. Lifetime cumulative exposure to vibration, but not age, was associated with decreased perception of cold.

Conclusion: No association ($p > .05$) was found between finger skin thickness in the range of about 0.1–1 mm and vibration perception threshold for test frequencies from 8 to 500 Hz and thermotactile perception thresholds for warmth and cold. Increasing age was associated with reduced perception of vibration and warmth. Vibration exposure was associated with decreased perception of cold.

Significance: Skin thickness is a factor that may affect the response from sensory receptors, e.g., due to mechanical attenuation and thermal insulation. Thus, to evaluate perception threshold measurements, it is necessary to know if elevated thresholds can be attributed to skin thickness. No previous studies have measured skin thickness as related to vibrotactile and thermotactile perception thresholds. This study showed no association between skin thickness and vibrotactile perception or thermotactile perception.

© 2018 International Federation of Clinical Neurophysiology. Published by Elsevier B.V. This is an open access article under the CC BY-NC-ND license (<http://creativecommons.org/licenses/by-nc-nd/4.0/>).

1. Introduction

The outcome of vibrotactile and thermotactile perception measurements (VPT and TPT, respectively) is often used for quantitative sensory testing. This involves an integrated response in the brain from cutaneous sensory receptors in the skin in response to mechanical or thermal stimuli to the skin (Lundström, 2002, Nilsson, 2002). Most sensory receptors are located in the dermis (such as thermal receptors, tactile receptors, nociceptors), i.e., between the exterior (epidermis) and the interior (hypodermis) layers, while free nerve endings are also found within the

epidermis. The mechanical or thermal stimulus must be transmitted from the contact point on the skin surface and through the epidermis layer before it can be perceived through evoked activity in suitable receptors. Skin thickness is related to several different factors such as body site, gender, skin type, age, pigmentation and smoking habits (Lee and Hwang, 2002, Sanby-Möller et al., 2003, Waller and Maibach, 2005, Gambichler et al., 2006). The thickness of the epidermis varies in different types of skin, i.e., thinnest on the eyelids (0.05 mm) and thickest on the palms and soles (1.5 mm). The corresponding figures for the dermis are 0.3 mm on the eyelid and 3.0 mm on the back. In addition, if the skin is exposed to heavy, long-term mechanical load, then the thickness of the epidermis will usually increase, most likely as a protective measure. Examples of this are seen among bricklayers

* Corresponding author.

E-mail address: ronnie.lundstrom@umu.se (R. Lundström).

and guitar players. Neurophysiological clinicians and occupational health professionals ask whether the thickness of the skin may affect the person's VPT and TPT. This question does not seem to have been addressed in the scientific literature previously.

2. Objective

The primary objective was to study the relationship between skin thickness and the vibrotactile and thermotactile perception thresholds on the volar side of the right index finger tip. If skin thickness affects the thresholds, then the secondary aim was to discuss how this knowledge should affect clinical practice.

3. Methods

3.1. Subjects

The study was based on a cohort of 229 males, employed either as blue-collar construction workers or as white-collar office workers, at an engineering company that produces heavy equipment for paper and pulp mills. Data for this particular study was collected in May 1997 as a part of a 10-year follow-up. The blue-collar workers performed heavy manual work and were exposed to hand-transmitted vibration (EV). The white-collar office workers sat at desks and were not exposed to heavy manual work or hand-transmitted vibration (NEV). Basic information about age, work assignment, years at work, general state of health, previous and present exposure to vibration was sought in a questionnaire. All participants underwent a medical examination conducted by an occupational physician (TN), and the examination included sensory and motor nerve conduction measurements. Some employees had symptoms of diseases known to cause sensory neuropathies, e.g., diabetes or metabolic disturbances, and were therefore excluded from the study. Electrodiagnostic results indicating sensory block at the wrist and/or clinical symptoms of carpal tunnel syndrome resulted in exclusion. Missing data for vibrotactile perception threshold (VPT), thermotactile perception threshold (TPT) and skin thickness (SkinT) were also cause for exclusion. After applying these exclusion criteria the final study group consisted of 148 individuals, 115 of whom were exposed to, or had been previously exposed to, hand-arm vibration in their work. The lifetime accumulated vibration dose (LTVD) was determined for all of the subjects based on vibration measurements conducted at their work site together with estimation of total duration (questionnaires, diaries and interviews) (Nilsson and Lundström, 2001).

This study was approved by the Regional Ethics Review Board in Umeå, Sweden (Registration number 97-76) and conducted accordingly. All subjects signed an informed consent before entering the study.

3.2. Vibrotactile perception threshold measurement (VPT)

The VPT was measured in accordance with ISO standard 13091-1 (ISO 13091-1, 2001), using a modified version of a von Békésy audiometer (Brüel & Kjaer 1800/WH 1763). The equipment provided a sinusoidal vibration at seven discrete frequencies from 8 to 500 Hz with a magnitude remotely regulated through a button on a hand switch. When the button was pressed, the stimulus amplitude gradually declined, and when the button was released the amplitude gradually increased. The rate of the amplitude change was 3 dB/s. The vibration was delivered perpendicularly from above to the volar aspect of the right hand's index fingertip through a cylindrical Perspex probe with a flat contact surface (diameter 6 mm). The vibration exciter was mounted in accordance

with a beam balance to provide a constant static pressure of 3.5 N/cm² to the skin.

The subjects were asked to sit on a chair with the forearm and the dorsum of the hand resting extended and relaxed on a supportive cushion formed around the person's hand and wrist. The ISO standard 13091-1 (ISO 13091-1, 2001) specifies that VPT measurements should be conducted when the skin temperature at the test location is within the range of 27–35 °C. Therefore, if the subject's skin temperature at the test location was lower than 28 °C, then the hand was warmed with the help of an infrared lamp. The position of the stimulator probe was carefully adjusted so it covered the pulp of the right index finger. The subject was instructed to press the button on the hand switch with the left hand as soon as the vibration to the right index finger was perceived and to keep it depressed as long as the vibration was felt. In this way, the subject's VPT was continuously tracked between the levels for perception and non-perception. The increasing and decreasing level of vibration was recorded as a zigzag pattern, a vibrogram. This psychophysical "up-and-down" threshold tracking method of limits is sometimes called the von Békésy threshold tracking method (For a review, see (Lundström, 2002)). The threshold at each frequency was defined as the average midpoint between the upper and lower limits, expressed in dB relative to 10⁻⁶ m/s_{rms}², (ISO 13091-1). The test equipment software did not automatically compensate thresholds for age or skin thickness.

The vibration perception threshold at different frequencies was conducted in the following ascending order: 8, 16, 32, 63, 125, 250, and 500 Hz. At each frequency, the threshold was tracked for about 30 s with no pauses between frequencies. The whole test took an average of 20 min to perform, including a period of installation, familiarization, and training to obtain stabilized and reproducible threshold levels.

3.3. Thermotactile perception threshold measurement (TPT)

Thermal perception thresholds were determined without automatic software compensation for age or skin thickness using a Somic modification of the Marstock method (Fruhstorfer et al., 1976) with computer-assisted automatic exposure and response recording (Thermotest; Somic, Sales AB, Sweden). A thermostimulator, i.e., a Peltier contact thermode, was applied to the skin. When measuring perception of cold and warmth the probe (25 × 50 mm) was gently applied to the volar surface of the distal and intermediate phalanges of the index finger (lengthways along the finger). Perception thresholds for cold and warmth were assessed using the "Method of limits". The rate of the temperature change was linear and about 1 °C/s. Before the quantitative evaluation of thermal sensibility, the subject's skin temperature at the test site was measured by contact thermometry. This "indifferent" temperature was then used as a neutral starting temperature for the TPT measurements. The lowest acceptable starting temperature was set to 28 °C by applying a similar reasoning as for VPT measurements.

The subject was instructed to press a switch with the left hand when a change of temperature (cold or warmth) was detected after which the temperature of the thermode returned to the pre-set neutral baseline temperature. The measurement of warm and cold thresholds was repeated 10 times. The mean value of these was then calculated. The inter-stimulus interval for all threshold measurements was randomly distributed within 2 s. The operating temperature range was set at 10–52 °C.

3.4. Measurement of finger skin thickness (SkinT)

Skin thickness (SkinT) was measured using a high-frequency ultrasonic scanner system (DermaSCAN C from Cortex Technology,

Download English Version:

<https://daneshyari.com/en/article/8683293>

Download Persian Version:

<https://daneshyari.com/article/8683293>

[Daneshyari.com](https://daneshyari.com)