A Study on the Effectiveness of Information Obtained from Long-term Observation of Somatosensory Sensitivity

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Abstract: In this study, the somatosensory sensitivity of the toe thumbs of healthy adults was measured for more than 14 weeks using a device that records the distance traveled by the skin-contact probe in micrometers when the subject senses the probe's movement and presses the response button. The results showed that the variation in the somatosensory sensitivity of the subjects was about 10 to 20 micrometers, and the reproducibility of the measurements was confirmed. When the sensitivity of only one or both legs worsened during the observation period, it was found that there was a reason, such as an injury, poor physical condition, or taking analgesics. This study confirms that somatosensory sensitivity can be quantified and introduced into health care.

1. Background

In an aging society, nursing support covers not only patients in the hospital but also routine health management at home and the population living in the community. Routine health management requires some non-invasive indicators, is easy to measure, and is able to detect early and small abnormalities. We focused on **somatosensory sensitivity.** Small changes in somatosensory sensitivity, such as numbness and discomfort in the fingertips, are some of the most common and important information reported by patients and are often cited as a precursor to various diseases, health conditions, and pre-illness states. However, these have been recorded qualitatively as patients' subjective complaints and have not been fully utilized for the early detection of abnormalities.

In this study, we report on what information can be obtained by long-term observation of somatosensory sensitivity using a device that can measure somatic sensation down to the micrometer level. It also discussed how these measurements can help in health management, particularly in pre-symptomatic health management, a condition that maintains homeostasis.

2. Device for Measuring Somatic Sensation

The somatic sensation is measured with a skin sensory sensitivity threshold test device, planter foot sensation-testing instrument, i.e., PFS tester (Fig.1) [1][2]. The probe travel distance and the increment can be set

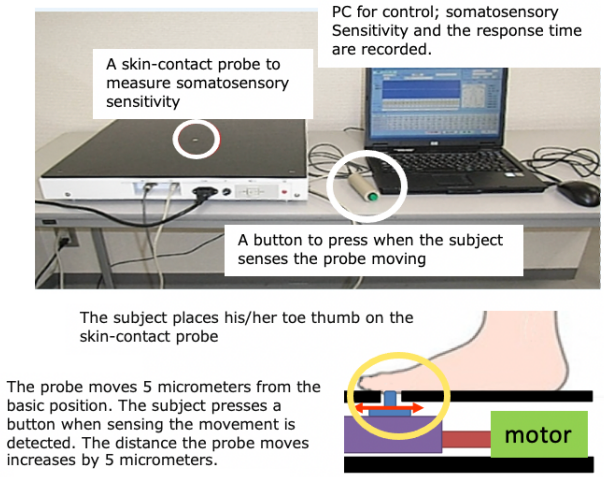

Fig. 1 PFS tester

arbitrarily by 1 micrometer. The time between the probe starting to move and the subject pressing the button is also recorded as a response time in milliseconds. The somatosensory sensitivity is the shortest probe traveled distance when the subject has answered correctly three times in a row.

3. Experimental Methods

Using a PFS tester, the sensitivity of the toe thumb was measured repeatedly in nine healthy women, ages 19 to 27, for more than 14 weeks. Each time during the experiment, subjects were interviewed about changes in their daily habits, physical condition, and the type of shoes they wear, such as high heels or sneakers. The changes in toe-thumb sensory sensitivity and the response time were examined in terms of intra- and inter-individual variability and the observed rapid changes.

4. Results & Discussion

(1) Long-term repeated measurements of toe-thumb sensory sensitivity

Figure 2 shows the change in repeated measures of toe-thumb sensitivity in three subjects over a year and a half. The scale on the vertical axis is 10μm. The most stable subject's inter-individual variability was in the 10μm

range. At 69 weeks, her sensitivity deteriorated by 10μm; however, the sensitivity has improved again.

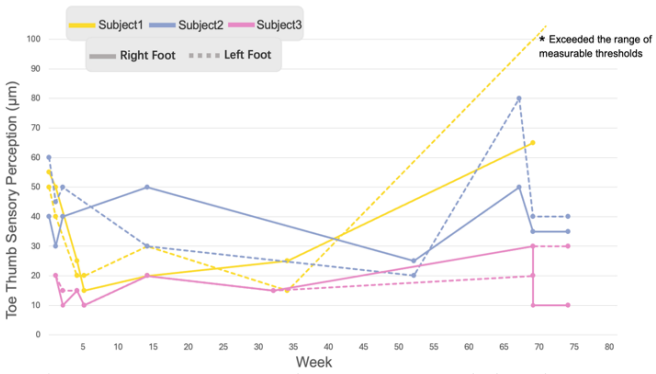

Fig 2 Long-term repeated measurement of the plantar sensory sensitivity in 3 subjects

Of the nine subjects measured over a 14-week period, six had remained mostly stable sensitivity, and there was not much difference in the measurement between the left and right legs. The change of sensitivity was in the range of 10 to 20 micrometers throughout the examined period. The remaining three had periods when the sensitivity of left-right difference suddenly increased, or that of both legs worsened. According to the results of interviews at such periods, a subject had broken one leg, and one had back pain. In such cases, the healthy leg's sensitivity showed worse than usual, which implied that the healthy side of the leg was also under strain, protecting the sick side. In the cases where the sensitivities of both legs worsened, this seemed to be due to the wearing of high heels and lack of exercise. After the subject switched from high heels to athletic shoes for exercise, the plantar sensation improved in approximately one week.

In healthy people, the sensitivity of the left and right legs shows almost the same value and similar fluctuation. If sensitivity is "poor for one's age" or "suddenly deteriorates", it may be associated with illnesses, poor health conditions, or using a kind of analgesics; improvements in these conditions often seemed to recover to better sensitivity. Dulling of the toe sensation is a common symptom in diabetics, and medical specialists said that early detection of blunted sensation could lead to medical attention and prevent diabetes aggravation. It is reported that many cancer patients undergoing chemotherapy complain of discomfort of cutaneous sensation in their fingertips. If the discomfort is detected earlier, the quality of life of the treatment may be improved. These are to be future research. Finally, we would like to mention some cases with excessive good somatosensory sensitivity, such as around 5 micrometers, they responded in the interviews that they were a little depressed or stressed. A person with too much sensitivity also needs to be examined.

(2) The relation between the somatosensory sensitivity and the response time

The time taken from sensing "this might be the probe movement" to pressing the response button is also recorded as response time in the PFS tester. The value and the variability in response time seemed more challenging to investigate than somatosensory sensitivity. In the study, for example, one subject's response time changed from 0.413 msec, 0.285 msec, and 0.399 msec as the probe traveled distance from the shortest to the longest. The other one's response time varied from 0.592 msec, 0.414 msec, and 0.731 msec. We expected the response time would gradually shorten as the probe traveled distance increased and the probe movement became easier to recognize, but in fact, many subjects showed the fastest response at the second length. A short response time would mean that the subject pressed the button without hesitation, i.e., the subject recognized the probe movement clearly. In case of a longer response time, the subject might need more time to identify if the probe has moved. Or it might take a long time for the brain to issue the command for the action of pushing the button, or it might take time for the brain to take action after receiving the command. These would be investigated in the future using neuroscientific methods [3].

(3) For the nursing support and early detection of the abnormalities

The conventional method used to examine cutaneous sensory abnormalities is the test with a Semmes-Weinstein monofilament set, which consists of 20 pen-type testing devices with monofilaments of different thicknesses attached to the tip of the pen. The examiner lowers the device to the test site until the filament deflects, and the subject responds whether he/she felt it or not. This test is said to need more accuracy and reproducibility. Because it was essentially information based on the patient's subjective sensations, somatic sensation has long been treated insufficiently.

Measuring the somatosensory sensitivity with the PFS tester on the micrometer order can detect small and/or rapid abnormalities and lead to pre-symptomatic health management, a condition that maintains homeostasis.

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