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Original Article

Differences in two-point discrimination and sensory threshold in the blind between braille and text reading: a pilot study

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Abstract. [Purpose] This study investigated two-point discrimination (TPD) and the electrical sensory threshold of the blind to define the effect of using Braille on the tactile and electrical senses. [Subjects and Methods] Twenty-eight blind participants were divided equally into a text-reading and a Braille-reading group. We measured tactile sensory and electrical thresholds using the TPD method and a transcutaneous electrical nerve stimulator. [Results] The left palm TPD values were significantly different between the groups. The values of the electrical sensory threshold in the left hand, the electrical pain threshold in the left hand, and the electrical pain threshold in the right hand were significantly lower in the Braille group than in the text group. [Conclusion] These findings make it difficult to explain the difference in tactility between groups, excluding both palms. However, our data show that using Braille can enhance development of the sensory median nerve in the blind, particularly in terms of the electrical sensory and pain thresholds.
Key words: Electrical sensory threshold, Pain threshold, The blind

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INTRODUCTION

Blind individuals develop tactile and auditory senses to replace the sense of sight[1, 2)]. Such "compensatory plasticity" takes place within the visual cortex in response to cross-modal auditory and tactile stimulation[1, 3)]. When reading Braille, the blind use the left index finger (Fig. 1A), and they exhibit an enlarged cortical representation of this reading finger in the somatosensory area[1, 4, 5)]. As such, neural connections are modified after extensive use, practice, and training[4–7)]. The World Health Organization (WHO) defines "blind" according to a maximum vision of 0.05 and a "low vision" by maximum vision of 0.1[2)]. Some people with low vision can read general text with tools, such as a magnifier (Fig 1B). Two-point discrimination (TPD) is one method for measuring tactile effects on the skin[8–10)]. TPD has been found to be particularly helpful in the evaluation of injuries to nerves[9, 11, 12)]. This method has been used to assess hand function following skin grafting, peripheral nerve suture, and digit replantation[11, 12)]. Thus, TPD can measure the sensitivity of innervation to the peripheral nerve. In addition, sensory acuity is most generally determined by a threshold test[13)]. The word "threshold" refers to the levels of stimulus strength at which the participant first notices the stimulation at all and as painful, respectively[13–16)]. The electrical sensory threshold can be measured accurately using a transcutaneous

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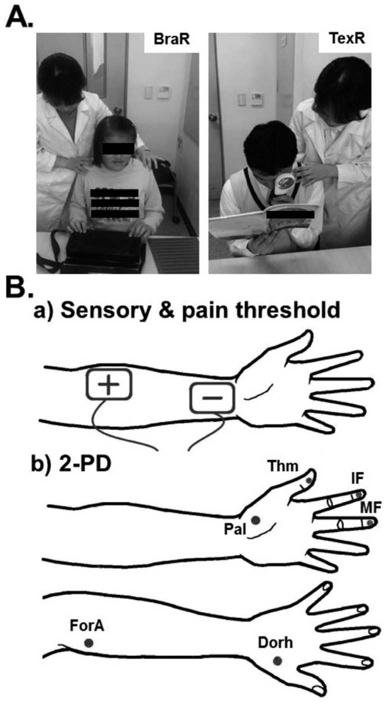

Fig. 1. Schematic and photographic representation of the experimental methods used for measuring threshold
Sensory threshold was determined as described in the Subjects and Methods section.
BraR: Braille reading group; TexR: text reading group; +: anode; −: cathode; 2-PD: two-point discrimination; Thm: thumb; IF: index finger; MF: middle finger; Pal: palm; for a: forearm; Dorh: Dorsal hand

Table 1. General characteristics of the blind.

Variable	The Blind	
	Text reading group	Braille reading group
Age (yrs)	16.0 ± 0.8	13.6 ± 0.8
Gender		
Male (%)	9 (64.3)	5 (35.7)
Female (%)	5 (35.7)	9 (64.3)
Height (cm)		
Male	160.6 ± 4.9	163.9 ± 2.2
Female	153.1 ± 3.6	148.4 ± 3.6
Gender total	158.0 ± 3.4	154.0 ± 3.1
Weight (kg)		
Male	65.2 ± 5.4	54.8 ± 2.5
Female	52.4 ± 5.2	42.8 ± 2.4
Gender total	60.6 ± 4.2	47.1 ± 2.3
BMI (kg/m^2)		
Male	25.0 ± 1.3	20.4 ± 0.5
Female	22.3 ± 2.0	19.4 ± 0.7
Gender total	24.1 ± 1.1	19.7 ± 0.5
Type of blind		
Total blindness		
Male (%)	-	2 (14.3)
Female (%)	-	9 (64.3)
Gender total (%)	-	11 (78.6)
Low vision		
Male (%)	9 (64.3)	3 (21.4)
Female (%)	5 (35.7)	-
Gender total (%)	14 (100.0)	3 (21.4)
Disability rating		
1st level (%)	5 (35.7)	14 (100.0)
2nd level (%)	2 (14.3)	-
3rd level (%)	5 (35.7)	-
4–6th level (%)	2 (14.3)	-

All data were presented as the mean±SE. BMI: body mass index

electrical nerve stimulator (TENS)[13, 14]. A TENS is based on the gate control theory and is commonly used in physical therapy for pain reduction[14]. Much research is currently being conducted on the senses of the blind. However, research on the effect of using Braille on the peripheral senses, by monitoring the tactile and electrical thresholds, is limited. This study used TPD and determined electrical sensory threshold of the blind to define the effect of using Braille on the tactile and electrical senses, respectively.

SUBJECTS AND METHODS

This study consisted of 28 blind individuals, divided equally into a text reading and a Braille reading group. All participants attend class with a regular school curriculum in the H school for the blind located in Incheon city. None of the volunteers had cognitive or cognitive function and tactile sensory challenges. Participants provided written informed consent. Characteristics of the participants are listed in Table 1. Before measuring TPD, each participant was asked about medical history of the skin and peripheral nerves in the hands. They did not have neurological deficits or dermatological conditions, such as scars, burns, or tattoos, which might have influenced cutaneous sensibility. In addition, we checked for disorders that affect sensory ability, such as diabetes mellitus or central nerve system injury[17–19]. We used a TPD esthesiometer (Saehan, Korea) to determine the TPD of the thumb, index, middle finger, palm, dorsal hand, and forearm on both sides (Fig. 1). These regions are innervated by the median nerve, except for the dorsal hand and forearm[9]. Participants were comfortably seated on a chair with their upper extremities positioned on a table. TPD was measured from the distal part to the proximal parts. The two pins of the esthesiometer stimulated measurement points five times at 1.5 seconds of constant pressure. Pin distances were extended to 0.5 mm from 1.0 mm until the subjects were able to discriminate between the two points. In each patient, the forearm was stimulated using the TENS (Duo 500, Gymnaunipgy Co., Belgium), as well as two surface electrodes of the same size (4.5 × 6 cm) for bipolar stimulation. The forearm was placed in the supine position with one electrode placed slightly below and on the ventral side of the elbow joint and the other placed at the ventral side of the carpal, behind the median nerve (Fig. 1). High frequency electrical stimulation was used in the mode of “pain relief for acute pain”. It was ensured that the pad was sufficiently hydrated during every treatment procedure. The current intensity was gradually increased, and the electrical sensory threshold (EST) was measured when the patients perceived the electrical stimulation without pain. The stimulus was then continuously increased in intensity until the patient felt a slight pain-like sensation, and this intensity was considered the electrical pain threshold (EPT). We verified the threshold through the oral expressions of the volunteers. Statistical analyses were conducted using PAWS 18.0 software to calculate averages and standard deviations. The data were expressed as the mean ± standard error (SE) of the measurements. The significance of differences in variables between the two groups was determined using the Mann-Whitney U test, with significance set at α = 0.05. The protocol for the study was approved by the Committee of Ethics in Research of the University of Yongin in accordance with the terms of Resolution 5-1-20, December 2006. Furthermore, all volunteers provided informed consent for participation in the study.

RESULTS

Table 1 summarizes the general characteristics of the participants in the present study. The Braille group had lower TPD values than the text group, but the difference was not significant. However, among the TPD values, only the left palm TPD values were significantly different between the two groups (text group: 6.1 ± 0.7, Braille group: 4.0 ± 0.5, Table 2). In addition, the Braille group had lower electrical sensory threshold and electrical pain threshold values than the text group (Table 3). The Braille group had lower EST values than the text group, but the difference was not significant. However, the values of the EST in the left hand and the EPT in both hands were significantly lower in the Braille group than in the text group (text group: 28.5 ± 6.4, Braille group: 10.6 ± 1.5 of the EST the in left hand, text group: 65.5 ± 6.9, Braille group: 48.9 ± 8.1 of the EPT in the right hand, text group: 78.7 ± 8.7, Braille group: 47.0 ± 8.4 of the EPT in the left hand, $p<0.05$; Table 3).

Table 2. Differences in two-point discrimination between the both groups

Variable		The Blind	
		Text reading group (cm)	Braille reading group (cm)
Thumb	-Right	2.9 ± 0.3	2.5 ± 0.2
	-Left	2.6 ± 0.3	2.4 ± 0.2
Index finger	-Right	2.4 ± 0.2	2.3 ± 0.2
	-Left	2.3 ± 0.2	2.1 ± 0.1
Middle finger	-Right	2.4 ± 0.2	2.4 ± 0.2
	-Left	2.4 ± 0.2	2.1 ± 0.1
Dorsal hand	-Right	9.8 ± 1.5	7.9 ± 1.0
	-Left	9.0 ± 1.2	6.3 ± 0.8
Palm	-Right	6.2 ± 0.8	4.9 ± 0.6
	-Left	6.1 ± 0.7	4.0 ± 0.5*
Forearm	-Right	12.2 ± 2.9	11.6 ± 1.1
	-Left	9.7 ± 0.8	8.7 ± 0.9

All data were presented as the mean±SE. *: $p < 0.05$

Table 3. Differences of sensory threshold between the text and Braille reading groups

Variable		The Blind	
		Text reading group (mA)	Braille reading group (mA)
EST	-Right hand	18.0 ± 2.9	13.3 ± 1.7
	-Left hand	28.5 ± 6.4	10.6 ± 1.5*
EPT	-Right hand	65.5 ± 6.9	48.9 ± 8.1*
	-Left hand	78.7 ± 8.7	47.0 ± 8.4*

All data were presented as the mean±SE. EST: electronic sensory threshold; EPT: electronic pain threshold. * $p < 0.05$

DISCUSSION

We compared the tactile and electrical sensory thresholds of the upper limb in blind individuals reading Braille or text. Generally, the Braille group had more sensitive hands than the text group. This was the case not only for the TPD but also for the EST and EPT values. The results were also shown clearly in the TPD value of the left palm, the EST value of the left arm, and the EPT values of both arms. The blind, use the left index finger when reading Braille. However, our data showed no difference in TPD values among all fingers. All participants of our study were students learning one or more musical instruments. Many of them are learning string instruments, the handling of which causes development of calluses on the fingertips of the left hand because players must press strongly with the fingertips to obtain a clear sound, and skin hardness influences tactile sense[20]. A previous study showed that thick skin is more insensitive than thin skin[20]; yet, our data showed no difference between the fingers. However, the TPD in the left palm of the Braille group was significantly more sensitive than that in the non-Braille group. The thumb, index finger, middle finger, and palm are areas innervated by the median nerve[9]. The TPD value of the left palm was higher in the Braille than in the non-Braille group, suggesting that using Braille develops the sense of the median nerve. Although this may appear to be a controversial statement, our results of the EST of the left arm could support this suggestion. We placed electrodes along the path of the median nerve when measuring EST, which is more sensitive on the left side than on the right. It is well known that reading Braille enhances tactile sensory ability according to the principle that using Braille enhances the plasticity of the somatosensory area of the brain[1–7]. However, we suggest that using Braille can also develop the sensitivity of the median nerve, and this influences the sensitivity of areas innervated by the median nerve. Further systematic studies in the field of physical therapy, such as electrotherapy, neurotherapy, hydrotherapy, and others, are needed[21–24]. In summary, our data could not explain the difference in tactility between the two groups. However, our study proved that using Braille may develop the sensitivity of the median nerve in the blind, especially in terms of electrical sensitivity.

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