



Original Article

Two-point discrimination of the upper extremities of healthy Koreans in their 20's

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Abstract. [Purpose] The present study attempted to measure two-point discrimination in the upper extremities of healthy Koreans in their 20's. [Subjects and Methods] Using a three-point esthesiometer, we conducted an experiment with a group of 256 college students (128 male and 128 female), attending N University in Chonan, Republic of Korea. [Results] Females showed two-point discrimination at a shorter distance than males at the following points: (i) 5 cm above the elbow joint, the middle part, and 5 cm below the shoulder joint of the anterior upper arm; (ii) 5 cm above the elbow joint and 5 cm below the shoulder joint of the posterior upper arm; (iii) 5 cm above the front of the wrist joint of the forearm; 5 cm below the elbow joint, the palmar part of the distal interphalangeal joint of the thumb, the dorsal part of the distal interphalangeal joint of the middle and little fingers. It was also found that females showed greater two-point discrimination than males in distal regions rather than proximal regions. [Conclusion] The findings of this study will help establish normal values for two-point discrimination of upper extremities of young Koreans in their 20's.

Key words: Two-point discrimination, Tactile sensation, Upper extremities

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INTRODUCTION

Tactile sensation protects our body from harmful stimuli by transmitting external stimuli from the skin to the central nerve¹⁾. It also converts external stimuli to electric signals and sends them to the sensorimotor cortex via sensory nerves and the spinal cord. Thus, the assessment of tactile sensation helps to evaluate the function of the peripheral nerve system and the central nervous system²⁾.

If any lesions occur in the somatic sense, they might result in decline or loss of discriminative sensation³⁾. The two-point discrimination test (TPDT) measures the minimal distance at which an individual perceives two points of stimuli presented simultaneously with the same pressure⁴⁻⁶⁾. It is a sensory discrimination modality providing precise information on space and is often used as a reliable method to examine somesthetic sensibility^{7, 8)}. The distance used in the TPDT varies according to which part of the body is measured: 1 mm on the tongue, 2–6 mm on the tips of fingers, 8–12 mm on the palm, and 400–600 mm on the back⁹⁻¹³⁾. Louis et al. reported that regions governed by the ulnar nerve showed lower amplitudes than those governed by the median nerve and that females showed two-point discrimination at a shorter distance than males¹⁴⁾.

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Cope and Antony stated that in their experiment with a group of 112 children aged 2–13, older children showed improved TPD at the tip of the hand, but no significant difference was found in their feet¹¹.

Menier et al. reported in their study of a group of 47 children aged 3 to 6 that their TPD thresholds at the tips of the index finger, thumb and malleolus were similar to those of adults, that hands were more sensitive than ankles, and that lower threshold values were found in dynamic tests as opposed to static tests¹⁵. Other previous studies on TPD examined perception of pressure for static and dynamic two-point discrimination, perception processes of two-point discrimination of normal people, TPDT as an index of aging senses, and evaluation models of TPD depending on ages^{8, 16–21}.

Many studies on TPD have been performed in Western countries, but not much has been reported in Korea. In particular, very few TPD tests for various parts of the bodies of young adults have been conducted. The present study attempted to measure the TPD values of the upper extremities of Korean young people in their 20's with the hope that they might provide baseline data for objective evaluation of sensory functions.

SUBJECTS AND METHODS

The TPDT was administered to a group of 256 college students attending Y University in Gyeonggi Province, Republic of Korea. Applications for participation in the experiment were collected for a year between September 2013 and September 2015. A total of 315 students submitted applications, with a total of 256 students accepted as subjects: 128 male and 128 female. Those who had cutaneous disorders, scars, burns, dermal hypersensitivity, or neurological deficits were excluded. The average age of the subjects was 22.5 years (23.3 years for men and 21.4 years for women). Their average height was 169.5 cm (174.8 and 161.6 for men and women, respectively). Their average weight was 63.6 kg (69.5 and 55 for men women, respectively). All the research subjects received clear instructions about the content, purpose, and method of the study, and they all submitted a consent form to participate in the research. The experiment received permission from the Research Ethics Committee of Y University. The IRB approval number is Research-1041479-201405-HR-016.

The tool used for the TPDT was a three-point esthesiometer (Lafayette Instrument Company, Lafayette, IN, USA) with one fixed and two adjustable needles. This esthesiometer has a Vernier-type construction structure and is easily readable. It consists of three pins and can accurately judge measuring points up to 0.1 mm without any shaking.

Following the basic principles of TPDT, the subjects received an explanation of the test, which was given in a quiet office in which they would not be nervous and could sit comfortably without being disturbed. Physical therapists with at least five years of clinical treatment experience participated in the experiment after a week-long training program that taught them to apply identical stimuli. If a subject failed to respond in three seconds, they performed measurement again.

The measuring areas for TPDT were as follows: (i) 5 cm above the elbow joint, the middle part, and 5 cm below the shoulder joint of an anterior/posterior upper arm; (ii) 5 cm above the front wrist joint of the forearm, the middle part, and 5 cm below the elbow joint; (iii) the dorsum (middle part) and palmar (middle) part of the hand; and (iv) the distal interphalangeal joint and dorsal part of the distal interphalangeal joint of the thumb and middle and little fingers.

The subjects sat on a comfortable chair and had a relaxed posture. They were asked to put an arm on a table and let their palm touch the table surface. We had them close their eyes and let them know that the experiment was to begin. With the fixed pin, we allowed two of esthesiometer's adjustable point to touch the measuring points simultaneously. The two adjustable points of the esthesiometer made vertical contact with the skin for one second with a minimal amount of pressure such that that the skin just began to blanch. The subjects were asked to say either "one point" or "two points." The two-point discrimination value for each subject was the shortest distance for which he or she perceived two distinct stimuli and said "two points." The measuring points were randomly selected and tested on the subject's dominant side.

The PASW Statistics 18.0 software was employed to process collected data. The mean and standard deviation values were extracted for all the variables. An independent samples t-test was conducted to compare two-point discrimination between males and females. The level of statistical significance was set at $p < 0.05$.

RESULTS

In the TPDT on the anterior upper arm, a statistically significant difference was found between men and women in the following areas: 5 cm above the elbow joint, the middle part, and 5 cm below the shoulder joint. In all three areas, women showed two-point discrimination at a shorter distance than men ($p < 0.05$). As for the posterior region of the upper arm, women were found to have two-point discrimination at a shorter distance in two areas: 5 cm above the elbow joint and 5 cm below the shoulder joint. However, men showed the ability to discern two distinct objects at a shorter distance than women in the middle part of the posterior upper arm, although the difference did not reach the level of statistical significance (Table 1).

The test on the anterior forearm showed a statistically significant difference ($p < 0.05$) 5 cm above the wrist joint: women had greater two-point discrimination at a shorter distance than men. On the other hand, no significant difference was found between the genders in the middle part as well as 5 cm below the elbow joint, although men were able discern stimuli at a little shorter distance than women in the middle part of anterior forearm. In the test on the posterior region of the forearm, women showed two-point discrimination at a shorter distance than men in all of the following areas: 5 cm above the wrist joint, the middle part, and 5 cm below the elbow joint. The difference between men and women was statistically significant ($p < 0.05$) (Table 2).

Table 1. Difference of TPD in the upper arm between men and women

	Region	Gender	Mean ± SD
Anterior part	5 cm above elbow*	Male	20.4 ± 10.3
		Female	15.3 ± 6.2
	Middle part	Male	19.4 ± 10.6
		Female	15.6 ± 10.4
	5 cm below shoulder	Male	22.0 ± 8.4
		Female	18.0 ± 12.2
Posterior part	5 cm above elbow	Male	16.2 ± 7.3
		Female	14.4 ± 7.4
	Middle part	Male	16.7 ± 8.4
		Female	19.1 ± 12.8
	5 cm below shoulder	Male	19.8 ± 8.4
		Female	16.5 ± 8.7

Values are shown as the mean SE. *p < 0.05. TPD: two-point discrimination

Table 2. Difference of TPD in the lower arm between men and women

	Region	Gender	Mean ± SD
Anterior part	5 cm above wrist*	Male	18.4 ± 5.7
		Female	13.9 ± 7.1
	Middle part	Male	17.1 ± 8.6
		Female	15.8 ± 8.9
	5 cm below elbow	Male	17.4 ± 9.7
		Female	17.5 ± 11.2
Posterior part	5 cm above wrist*	Male	16.7 ± 10.2
		Female	14.1 ± 6.5
	Middle part*	Male	18.6 ± 8.8
		Female	16.0 ± 8.8
	5 cm below elbow*	Male	15.5 ± 7.3
		Female	13.6 ± 6.6

Values are shown as the mean SE. *p < 0.05. TPD: two-point discrimination

No significant difference between men and women was found in the two-point discrimination tests on both the hand's dorsal surface and palm surface, though women had the ability to discern two distinct objects at a slightly shorter distance. In the test on the palmar part of the distal interphalangeal joint, we found a significant difference ($p < 0.05$): women, again, showed the ability to discern two distinct objects at a shorter distance (Table 3).

Women showed two-point discrimination at a slightly shorter distance than men in the palmar part of the distal interphalangeal joint of the middle finger and palmar part of the distal interphalangeal joint of the little finger. However, the difference was not statistically significant. A significant difference was found in the dorsal part of the distal interphalangeal joint of the middle and little fingers: again, women showed two-point discrimination at a shorter distance than men (Table 4).

DISCUSSION

The present study was performed to identify the two-point discrimination in the upper extremities of healthy Koreans in their 20's. TPD distance may vary depending on the stimulated regions, the amount of pressure applied, and the surrounding environment⁸⁾. Thus, to prevent measuring points from affecting results, we set up a fixed point of 1 cm from the measuring points and then started measuring at a proximal 2.5 cm points until the subjects said "two-points."

Women showed superior TPD ability as compared with men in the following areas: 5 cm above the elbow joint of both the anterior and posterior upper arm, middle part of the anterior upper arm, and 5 cm below the shoulder joint of both anterior and posterior upper arm ($p < 0.05$). In a previous study on the same topic, Nolan reported that women were more sensitive than men at the posterolateral and anterior parts of the upper arm, which agrees with the results of this study²²⁾. In the middle part of the posterior part of the upper arm, men were found to have greater two-point discrimination. We failed to identify a biological reason for why men seem to be more sensitive there. Additional studies are needed.

Table 3. Difference of TPD in the hand and thumb between men and women

	Region	Gender	Mean ± SD
Hand	Dorsal surface	Male	12.2 ± 5.7
		Female	11.1 ± 5.2
	Palm surface	Male	9.0 ± 5.7
		Female	7.8 ± 3.9
Thumb	Palmar part of IP*	Male	5.3 ± 4.0
		Female	4.1 ± 2.4
	Dorsal part of IP	Male	5.4 ± 2.8
		Female	4.8 ± 2.9

Values are shown as the mean SE. *p < 0.05. TPD: two-pointdiscrimination, IP: interphalangeal region

Table 4. Difference of TPD in the finger between men and women

	Region	Gender	Mean ± SD
Middle finger	Palmar part of DIP	Male	4.4 ± 2.5
		Female	3.9 ± 2.4
	Dorsal part of DIP*	Male	5.4 ± 2.4
		Female	4.3 ± 2.9
Little finger	Palmar part of DIP	Male	4.8 ± 4.5
		Female	4.4 ± 3.6
	Dorsal part of DIP*	Male	5.8 ± 4.4
		Female	4.6 ± 3.7

Values are shown as the mean SE. *p < 0.05. TPD: two-pointdiscrimination, DIP: distal interphalangeal region

In the test of TPD on the forearm, women showed better TPD ability in the following areas: 5 cm above the wrist joint of the anterior forearm 5 cm above the wrist joint, the middle part of the forearm, and 5 cm below the elbow joint of the posterior forearm. Nolan also stated that women were more sensitive than men in the mid-lateral forearm, which supports the findings of the present study²²).

Sato et al. performed a study on dental school students whose ages ranged from 20 to 40 and reported no significant difference in their TPD for the dorsum of the hand, though women showed slightly better ability²³). Nolan stated that women were more sensitive to pressure applied to the dorsal interosseous muscle, which is consistent with the present study²²). The difference between our results and those of Nolan in term of the statistical values for the regions of the upper arm, forearm, and dorsum might result from differences in measuring points²²). It is worthwhile to address this question further.

Regarding the TPD in the thumb, women were superior to men in the palmar part of the distal interphalangeal joint and distal interphalangeal joint (p<0.01), but a significant difference was found in the latter only. The TPDT on the fingers showed that women have a better ability than men in the dorsal part of the distal interphalangeal joint of the middle finger and the dorsal part of the distal interphalangeal joint of the little finger (p<0.05). Nolan also reported a similar result: women were significantly more sensitive than men in the palmar part of the distal interphalangeal joint of the middle and index fingers²²). The finding of Louis et al. also support the finding that women are more sensitive, which may enhance the reliability of the present study¹⁴).

To summarize, we conclude that women possess more TPD ability than men. This might be attributable to the fact that the area of the sensory homunculus corresponds to the relative size of the cortex receptive field and that they have greater cortex receptive fields controlling the senses of the hands and mouths and smaller cortex receptive fields in charge of the sensory function of the trunk and back²⁴).

The subjects were most sensitive in the fingers followed by the dorsum and palm, and the upper arm and forearm. This order perhaps results from the fact that the receptive areas for tactile sensation in distal regions get smaller and the density of receptor gets higher and the fact that the receptors in the regions used in everyday life are naturally more developed than those in other regions³). A limitation of the current research is that a manual measurement tool was used for the TPDT. Future studies should use more objective tests including a nerve conduction test and somatosensory evoked potentials to measure the level of sensation delay. Also, future studies of senses should expand to other age groups to allow for generalization.

In a test of healthy Koreans in their 20's, females were superior to males in two-point discrimination, and subjects were more sensitive in distal regions than proximal regions. The findings of the current study are expected to establish normal values for two-point discrimination in the upper extremities of young Koreans in their 20's.

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