

Two-point discrimination assessment of the upper extremities of healthy young Turkish individuals

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ABSTRACT

Objectives: This study aims to measure the two-point discrimination (TPD) values of the upper extremities of healthy young Turkish individuals.

Patients and methods: Between March 2016 and June 2016, a total of 60 healthy students (31 males, 29 females; mean age: 22.0±1.7 years; range, 19 to 27 years) were included. Eleven grand upper limb parts which take innervation from the brachial plexus were measured with an esthesiometer.

Results: The values at the dominant sides were statistically significantly greater than the non-dominant sides at those areas: upper lateral arm (p=0.001), lower lateral arm (p=0.001), mid-posterior arm (p=0.001), mid-lateral forearm (p=0.001), mid-posterior forearm (p=0.012), skin over the first dorsal interossei muscle (p=0.031), and palmar surface of distal phalanx of the thumb (p=0.045). Both dominant and non-dominant lower lateral arm TPD measurement results increased in males compared to females, indicating a statistically significant difference (p=0.005 and p=0.011, respectively). Also, dominant and non-dominant mid-posterior arm measurement scores were found to statistically significantly increase in males compared to females (p=0.019 and p=0.040, respectively).

Conclusion: Our study results show that laterality, with lower values on the non-dominant side, but not the sex, has an effect on TPD. The findings of this study may be useful in establishing the normative data for TPD in the upper extremity parts of healthy young Turkish individuals.

Keywords: Esthesiometer, normative data, two-point discrimination, upper extremity.

The two-point discrimination (TPD) is defined as the minimum distance at which a subject feels two points of stimuli applied at the same time with the equal pressure.^[1-3] The TPD test refers to be a functional test used to evaluate the tactile spatial acuity.^[4,5] It has been reported that the TPD test is based on the hypothesis that two different points can be differentiated from each other, when these two points are appropriately separated to trigger spatially distinguishable neural activity.^[6]

The TPD test is frequently used in researches and in daily practice to evaluate tactile acuity and central somatosensory function in several disorders. This test is widely used, as it is an inexpensive, easy, sensitive, and reliable tool in daily practice.^[7] The TPD test is used to evaluate sensory disorders such as carpal tunnel syndrome,^[8,9] systemic sclerosis,^[10] nerve repair after surgery,^[11] diabetic peripheral neuropathy,^[12] and stroke.^[7] Nevertheless, normative values have been reported only in few studies.^[13,14]

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Normative data are extremely useful in interpreting test results from sensory disorders and may guide to the rehabilitation procedures. To the best of our knowledge, there is no report in the literature providing normative data of the TPD in the healthy young Turkish population. In the present study, we aimed to measure the TPD of the upper extremity parts of healthy young Turkish individuals, which may give baseline values for an objective studying of sensory functions.

PATIENTS AND METHODS

This single-center, prospective study was conducted at Istanbul Arel University, Department of Physiotherapy and Rehabilitation between March 2016 and June 2016. A total of 60 healthy students of our department (31 males, 29 females; mean age: 22.0 ± 1.7 years; range, 19 to 27 years) were included. Exclusion criteria were medical conditions which may affect the findings of the test such as cutaneous illness, scars, burns, tattoos or neurological impairments. A written informed consent was obtained from each participant. The study protocol was approved by the Istanbul Arel University Ethics Committee (No: 69396709-300.00.00-768). The study was conducted in accordance with the principles of the Declaration of Helsinki.

A three-point esthesiometer (Lafayette Instrument Company, Lafayette, IN, USA) which has one fixed and two adjustable needles used in the evaluation of the TPD in the upper extremity (Figure 1). This esthesiometer is a Vernier-type tool and is easily useable. It is a small hand-held tool made to measure the smallest distance that two points of touch on the skin can be distinguished. The modality of touch in TPD of this esthesiometer is static TPD with a sharp tip.

After the participants received an explanation of the method, they were instructed to lie down in supine position in a quiet room at a temperature of 22 to 25°C and close their eyes during the procedure. The two adjustable points of the instrument touched the skin for 1 sec applying a minimal amount of

pressure. We did not apply more than 1 mm pressure over the skin to avoid false sensory perception. The individuals were told to respond either '1 point' if they felt the sensation as 1 point or '2 points' if they felt it as 2 points. The uniformity in evaluation was performed by applying light-touch with esthesiometer pointer tips parallel to the branches of nerves of brachial plexus in upper extremity. On the tips of the thumb, middle and little fingers, light touch was made perpendicular to the axis of the finger. The tip of pointer was made close such that the measurement starts from 0 mm and the testing of each skin area was proceeded in the increment of 2 mm, until the individuals could distinguish whether they were touched by 1 point or 2 points simultaneously. The examiner avoided to touch the same area on the skin to reduce accommodation to the two-point touch stimulus.

All the measurements were performed by a single physiotherapist. The dominant and non-dominant sides were randomly selected and tested to reduce the learning effect. Eleven grand areas innervated by the branches of the brachial plexus were determined for testing. These areas were upper lateral arm, lower lateral arm, mid-medial arm, mid-posterior arm, mid-lateral forearm, mid-medial forearm, mid-posterior forearm, skin over the first dorsal interosseous muscle, palmar surface of distal phalanx of the thumb, palmar surface of distal phalanx of the middle finger, and palmar surface of distal phalanx of the little finger.

The minimal two-point distance which could be distinguished by the individual was measured by the aforementioned method. All measurements were done three times for each test with 1-min intervals between each series, and average values were calculated for analysis. The shortest distance the individual marked as a sensation of two points was recorded in cm and evaluated for analysis.

Statistical analysis

Statistical analysis was performed using the NCSS 2007 software (NCSS LLC, Kaysville, UT, USA). Descriptive data were expressed in mean \pm standard deviation (SD), median (min-max) or number and frequency, where applicable. The Shapiro-Wilk test and boxplot graphics were used to evaluate the suitability of the data to normal distribution. The paired sample t-test was used for the comparison of the TPD parameters showing normal distribution between the dominant and non-dominant sides. The Student t-test was used to compare the measurements



Figure 1. Esthesiometer (Lafayette®) used in the study.

according to both sexes. A p value of <0.05 was considered statistically significant.

RESULTS

Of a total of 60 participants, 54 (90%) were right-hand dominant and the right side was defined as the dominant side by these individuals. Six (10%) participants were left-hand dominant and the left side was defined as the dominant side by these individuals. The TPD values of the dominant and non-dominant areas are presented in Table 1. Male and female results were compared including both dominant and non-dominant sides (Table 2).

The reference value of the TPD were between 3.76 and 0.12 cm in the dominant side. Male participants had the lowest discriminating ability of 0.12 cm and female participants had 0.13 cm on the dominant side ($p<0.05$).

The values at the dominant sides were statistically significantly higher than the non-dominant sides at those areas: upper lateral arm ($p=0.001$), lower lateral arm ($p=0.001$), mid-posterior arm ($p=0.001$), mid-lateral forearm ($p=0.001$), mid-posterior forearm ($p=0.012$), skin over the first dorsal interosseous muscle ($p=0.031$) and palmar surface of distal phalanx of the thumb ($p=0.045$). The values at the dominant and the non-dominant sides were not found

statistically significant different at the mid-medial arm, mid-medial forearm, palmar side of distal phalanx of the middle finger and palmar side of the distal phalanx of the little finger ($p>0.05$). The TPD test scores at the dominant side of the mid-medial arm and mid-medial forearm were higher, but not statistically different than the non-dominant side ($p=0.079$ and $p=0.070$, respectively).

Both dominant and non-dominant lower lateral arm TPD measurement results were higher in males than in females, indicating a statistically significant difference ($p=0.005$ and $p=0.011$, respectively). Also, dominant and non-dominant mid-posterior arm measurement scores were found to be statistically significantly higher in males than in females ($p=0.019$ and $p=0.040$, respectively). However, test results on the dominant and non-dominant sides were not statistically significantly different between men and women at the following areas: upper lateral arm, mid-medial arm, mid-lateral forearm, mid-medial forearm, mid-posterior forearm, skin over the first dorsal interosseous muscle, palmar surface of distal phalanx of the thumb, palmar side of distal phalanx of the middle finger, and palmar side of distal phalanx of the little finger ($p>0.05$). Dominant side test values of the skin over the first dorsal interosseous muscle were higher in women than men, although not statistically significant ($p=0.057$).

TABLE 1
Two-point discrimination values of the upper extremity skin areas

	Dominant (in cm)			Nondominant (in cm)			p
	Mean±SD	Median	Min-Max	Mean±SD	Median	Min-Max	
Upper lateral arm	3.7±0.6	3.70	2.00-4.80	3.5±0.5	3.50	2.00-4.90	0.001
Lower lateral arm	3.5±0.6	3.50	2.20-4.50	3.2±0.6	3.20	2.00-4.20	0.001
Mid medial arm	3.8±0.6	4.00	2.20-5.20	3.7±0.7	3.80	2.20-5.50	0.079
Mid posterior arm	3.1±0.6	3.10	1.70-5.00	3.0±0.6	3.00	1.30-5.50	0.001
Mid lateral forearm	2.9±0.6	3.00	1.70-4.00	2.7±0.6	2.70	1.50-4.00	0.001
Mid medial forearm	2.9±0.5	3	1.60-4.3	2.8±0.6	2.90	1.50-4	0.070
Mid posterior forearm	2.7±0.7	2.70	1.20-4.10	2.6±0.6	2.60	1.30-3.50	0.012
Over first dorsal interosseous muscle	1.3±0.5	1.10	0.50-3.60	1.2±0.4	1.00	0.50-2.20	0.031
Palmar surface distal phalanx thumb	0.1±0.1	0.10	0.10-0.50	0.1±0.1	0.10	0.10-0.30	0.045
Palmar surface distal phalanx middle finger	0.1±0.1	0.10	0.10-0.40	0.1±0.1	0.10	0.10-0.40	0.289
Palmar surface distal phalanx little finger	0.1±0.1	0.10	0.10-0.30	0.1±0.1	0.10	0.10-0.40	0.811

SD: Standard deviation; Paired samples t-test.

TABLE 2
Two-point discrimination values of the upper extremity skin areas by sex

	Sex		<i>p</i>
	Female (n=29)	Male (n=31)	
	Mean±SD	Mean±SD	
Upper lateral arm			
Dominant	3.6±0.5	3.8±0.6	0.383
Nondominant	3.5±0.5	3.5±0.6	0.782
Lower lateral arm			
Dominant	3.3±0.5	3.7±0.6	0.005
Nondominant	3.0±0.6	3.4±0.5	0.011
Middle medial arm			
Dominant	3.7±0.6	3.9±0.7	0.259
Nondominant	3.7±0.7	3.7±0.7	0.863
Middle posterior arm			
Dominant	2.9±0.6	3.3±0.7	0.019
Nondominant	2.8±0.5	3.1±0.7	0.040
Middle lateral forearm			
Dominant	2.9±0.6	2.8±0.6	0.518
Nondominant	2.8±0.7	2.6±0.5	0.293
Middle medial forearm			
Dominant	2.9±0.5	3.0±0.6	0.397
Nondominant	2.7±0.5	2.9±0.6	0.234
Middle posterior forearm			
Dominant	2.6±0.5	2.8±0.7	0.097
Nondominant	2.4±0.5	2.7±0.6	0.094
Over first dorsal interosseous muscle			
Dominant	1.4±0.4	1.2±0.6	0.057
Nondominant	1.3±0.4	1.1±0.4	0.108
Palmar surface distal phalanx thumb			
Dominant	0.1±0.1	0.1±0.1	0.844
Nondominant	0.1±0.1	0.1±0.1	0.728
Palmar surface distal phalanx middle finger			
Dominant	0.1±0.1	0.13±0.05	0.906
Nondominant	0.1±0.1	0.12±0.06	0.595
Palmar surface distal phalanx little finger			
Dominant	0.1±0.1	0.1±0.0	0.528
Nondominant	0.1±0.0	0.1±0.1	0.256

SD: Standard deviation; Student t-test.

DISCUSSION

In the current study, we attempted to investigate the TPD values of the upper extremity parts of healthy young Turkish individuals. Normative data of the tests are helpful in clinical settings. In neurological examination, TPD test is used, particularly to evaluate hand injuries.^[15] Therefore, several studies have been conducted in the literature.^[13-15]

It has been shown that age influences the TPD test and discrimination values tend to become elevated with age.^[16] However, in the present study, the participants had an age range of 19 to 27 years.

As the role of height and weight was not proven on the TPD test,^[14] their evaluation was not made in the present study.

In the current study, differences in the TPD test were found between the anatomical regions. The participants were more sensitive in the distal areas than the proximal areas. The measured TPD values ranged from 3.76 to 0.12 cm in the dominant upper extremity parts. The mean TPD threshold measured in the present study was comparable with that found by the study of Shibin and Samuel^[14] with the reference value was between 4.1 and 0.2 cm in the dominant

upper extremity. Finger tips were the most sensitive areas which could discriminate the two-point in a smaller distance compared to the other body parts. The density of receptors in distal areas is higher and that the receptors in the parts used in daily life may be more developed than those in other parts.^[17] Smaller distance correlates with higher receptor density and a denser receptor population leads to finer TPD sense.^[18]

In the present study, 90% of the participants were right-hand dominant. In almost all of the measured regions of the upper extremity, apart from the palmar side of distal phalanx of the middle finger and palmar side of distal phalanx of the little finger, the values at the dominant side were found greater than the non-dominant side. Our results are consistent with the study values of Boles and Givens.^[19] In their study, for TPD, the overall difference was significantly lower at the left side of the body, or right hemisphere, producing lower two-point thresholds. It has been reported that the right hemisphere plays a spatial role in the coordinate tasks that require assessing the degree of distinguishing of two points.^[20,21]

An equal number of male and female participants were included in the present study, which helps to make a better comparison between the groups. In this study, only dominant and non-dominant lower lateral arm and mid-posterior arm TPD measurement results were greater in men than in women. No statistically significant difference was seen between sexes in any of the other measurement areas. In Boles and Givens' study,^[19] there was no significant difference concerning the sex in the TPD test. They reported that females were more sensitive than men in tactile detection thresholds and not in the more spatially demanding TPD task. Shubin and Samuel^[14] also reported that men and women had similar TPD values, and sex differences did not exist between them. Nolan^[15] reported that the mean discrimination results for males and the females in test sample were not significantly different for any of the parts tested, except for the medial surface of the forearm, where females had a greater degree of sensitivity than males. Corroborating Nolan's study^[15] for TPD, there was no sex difference in most of the areas tested in the present study. Conversely to Nolan's study^[15] and to the present study, females showed TPD at a shorter distance than males at the most areas of the upper extremity in Koo et al.'s study.^[13] Consistent with the aforementioned study, females had better TPD ability compared to the males in other studies.^[15,22,23]

In the present study, we could not find a biological cause for why women were more sensitive at the areas described above. Many aspects of the homunculus are still not certainly clarified (e.g., individual variability in somatotopic map).^[24] Findings of a morphometric study shows that there are sex differences in the structure of the human cerebral cortex, characterized by more numerous, smaller neuronal units in males and fewer, larger ones in females.^[25] There may be differences between the male and female primary somatosensory cortex in the respective regions, which may lead to different TPD values between males and females. Further studies are needed.

This study has some limitations. Small study group is the major limitation. The sample group was limited to physical therapy students with an age range of 19 to 27 years and, therefore, the results cannot be generalized to the overall population. Further large-scale studies including different age groups and populations are required to confirm these findings.

In conclusion, our study results show that laterality, with lower values on the non-dominant side, but not the sex, has an effect on TPD. This may be due to probable hemispheric spatial processing differences. The findings of this study may be useful in establishing the normative data for TPD in the upper extremity parts of healthy young Turkish individuals which may guide to rehabilitations procedures.

Declaration of conflicting interests

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