The Effect of Sex on Two-Point Discrimination

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***Abstract*— In this paper the impact of sex on two-point discrimination testing is explored. Two-point discrimination is a somatosensory functioning test used to evaluate an individual's ability to discern two distinct points applied at varying intervals to the epidermis. The aim of this study was to substantiate historical evidence supporting the existence of a statistically significant difference in two-point discrimination ability among males and females. The results obtained revealed that female participants had a markedly lower two-point discrimination threshold when compared to their male counterparts, indicating a greater sensitivity to mechanical stimuli applied to the epidermis of the dominant thumb. It was also revealed that the spread of data was much more concentrated in the female sample group, suggesting a greater two-point discrimination accuracy for female participants.**

Index Terms*— *drawing compass, epidermis, mechanoreceptors, sex, somatosensory, thumb

I. INTRODUCTION

TWO-POINT discrimination (TPD) is a diagnostic neurological examination used to assess the functioning of Merkel mechanoreceptor cells in the epidermis. Merkel cells are the sensory receptors found in the top layers of the epidermis, as well as in hair follicles [1]. These receptors are used to transmit mechanical sensory information to the nervous system in order to process and distinguish stimuli, such as the pressure and position with which a stimulus is applied to the epidermis or hair follicle [1].

A TPD test consists of repeated applications of one or two distinct points of an instrument, such as a deformed paperclip or drawing compass, of varying distances directly to the epidermis of a patient. The patient then tells the examiner whether they felt one or two points touch their skin [2]. TPD tests are typically performed on especially sensitive areas of the epidermis, such as the palm, forearm, tongue, lips, or fingertips, with the fingertips often times presenting the greatest sensitivity for TPD [3]. Once a TPD test is performed, an individual's TPD ability level is understood to be the smallest distance between two distinct points that an individual can confidently detect that two points touched their skin. As a result, it is understood that the lower an individual's TPD threshold is, the more sensitive their mechanoreceptors are considered to be [4].

Historically, TPD studies have concluded that an individual's TPD ability is impacted by a variety of factors including sex, test site, the amount of body or facial hair on the test site, and the sharpness of the instrument's points [1] [2] [4] [5]. Won et al. [4] used a standard drawing compass to administer TPD tests to various epidermal test sites on twenty male and twenty female participants in order to examine the effect of test sites and sex on TPD ability. Through their work they found that female participants on average had lower TPD values than their male counterparts, suggesting a higher level of mechanoreceptor sensitivity [4].

In 2009, Peters, Hackeman, and Goldreich offered the hypothesis that the marked difference in female somatosensory sensitivity and TPD ability is due to the fact that on average women have smaller fingers and as a result, the Merkel mechanoreceptors in their fingertips are more densely packed [6]. Subsequently, researchers were led to the belief that the dense packing of mechanoreceptors resulted in the increased sensitivity of female fingertips [1].

In this study, a standard drawing compass instrument like the ones used in Won et al.'s research was used to perform TPD tests on a sample population of female and male participants in an attempt to substantiate the results of historical TPD studies. In particular, this paper will focus on the differences in TPD ability of the pad of the thumb on the dominant hand of males and females.

II. METHODS

A. Description of Subjects

This study was carried out using a sample of ten male and ten female participants between the ages of 18 and 25. A total sample size of twenty participants was selected based on typical sample sizes of historical TPD studies with a focus on the impact of sex. The limited age range enforced when recruiting participants was chosen in order to ensure that extraneous age-related factors were prevented from impacting the collected data as prior TPD studies have demonstrated a variance in TPD ability among different age groups [7]. Additionally, individuals with known neurological diseases,

cutaneous conditions, scars, burns, and/or dermal hypersensitivity that impacted the participant's dominant hand were excluded from this research in order to avoid any condition-related outliers from biasing the data analysis.

B. Dataset

The TPD tests in this study were conducted in a quiet, temperate room, free from obvious visual and auditory distractions. For the duration of the test, participants were asked to sit comfortably on a stable chair, close their eyes, and place their dominant arm on a flat surface with their palm facing upwards.

In this study, each participant's TPD test consisted of two trials. In each trial, a participant was subject to two TPD tests to ensure accuracy in the participants' responses. If researchers determined that the participant's responses between the two tests were inconsistent, a second trial was conducted to obtain more accurate results by ensuring that the subject did not make an error in sensing the number of points.

During each TPD test, a simple technical drawing compass with two identical points, as shown in Fig.1, was used to perform the test. The two points of the instrument were simultaneously applied perpendicular to the pad of the participant's dominant thumb with equal pressure, such that the skin just began to blanch. If the subject was able to detect two points, a mark of "1" was recorded against the specific distance used. However, if the participant was only able to detect one point, a mark of "0" was recorded. This process was repeated on the same testing site for a total of 10 distances in increments of 0.5mm, with the lowest distance being 0.5mm and the highest being 5mm.

Figure 1. Simple technical drawing compass used to perform TPD tests.

Testing of the distances was conducted in a random fashion rather than chronologically to prevent biasing of the subjects' responses. A single point of the instrument was also applied at random intervals to avoid biasing. During each test the points of the compass were in contact with participant's thumbs for approximately 1.5 seconds with an interval of 5 seconds between each trial for consistency.

C. Analysis

Following the collection of TPD data, the recorded data was analyzed by researchers in order to extract the mean and standard deviation values for the female and male sample groups. The research team then evaluated the obtained statistical values and conducted an independent t-test using an alpha-level of 0.1 to compare how the TPD results varied between the sexes. This value was chosen based on a previous study that also evaluated and analyzed TPD on the same test site [8]. The t-test was performed with the null hypothesis such that there is no difference between the mean threshold values of the female and male samples. Conversely, the alternative hypothesis stated that a statistically significant difference is present between the two TPD thresholds.

III. RESULTS

The final TPD test results from all twenty participants are shown in Fig. 2 below. This plot shows the proportion of participants in each group who correctly identified the application of two distinct points based on the distance between the two points for each test. As expected, as the distance between the two points of the drawing compass increased, the proportion of correct responses from participants of both sexes increased. Also the proportion of female participants that were accurately able to distinguish two points at a smaller distance was larger than that of the male participants.

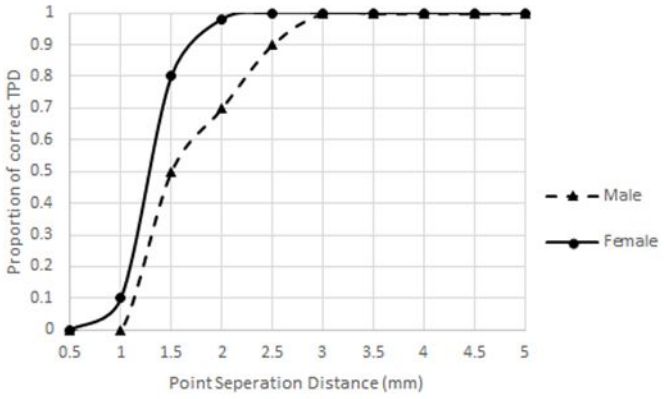

Figure 2. Proportion of correct TPD test responses for each testing distance on the thumb of dominant hand of males and females.

Additionally, the mean and standard deviation of the TPD ability for the female and male participant groups can be seen in Table 1 below. The distribution of the smallest discernible distances between the two points for each participant can also be seen in Fig. 3.

TABLE I
MEAN AND VARIANCE TPD VALUES FOR MALE AND FEMALE GROUPS

	Female	Male
Mean (mm)	1.55	1.95
Variance (mm^2)	0.080	0.302

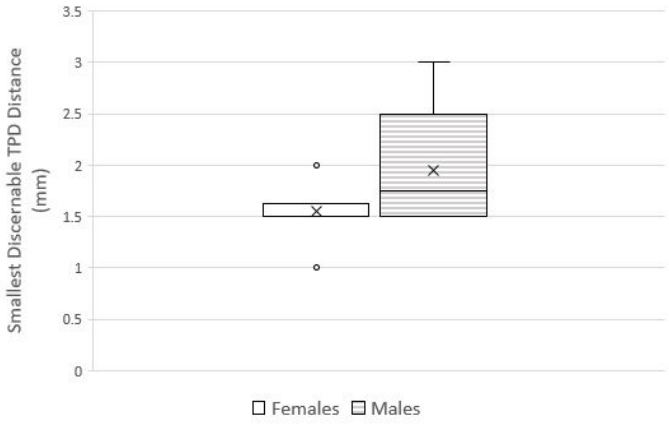

Figure 3. Distribution of smallest discernible TPD distances in mm for males and females.

From the collected data, an independent two-tailed t-test and an alpha value of 0.1 were used, the obtained p-value was 0.055.

IV. DISCUSSION

The results of this study were analyzed to understand male and female intrasubject variability in TPD perception. Plotting the proportion of correct TPD discretion between two groups in Fig. 2 revealed a similar pattern to the results found in the preliminary study of the orofacial region in which females have a higher TPD sensitivity than males [4]. As shown in Table 1, this study found that the mean threshold in which females can feel the two points of the compass being applied to the skin is 1.55mm, whereas males felt the two points at a mean threshold of 1.95mm.

In order to determine whether the difference between the TPD threshold means of the two sample groups was statistically significant, a two-tailed t-test was conducted and the obtained p-value of 0.055 was found to be less than the predetermined alpha value of 0.1. As a result, the null hypothesis was rejected and the alternative hypothesis that the difference between the TPD ability of male and female's dominant thumbs is statistically significant was accepted.

In a study by Peters, Hackerman and Goldreich, it was hypothesized that the marked difference in somatosensory perception between males and females is the result of obvious physical differences that exist between the two sexes [6]. The study discussed the fact that there is a higher density of Merkel cells along the base of sweat pores in smaller fingers [6] which suggests that the Merkel receptors are more densely packed in women due to their smaller finger sizes in comparison to men. The study also noted that the outermost layer of the skin is slightly thicker in male than in female fingers [6], indicating that the physical difference of skin thickness could potentially have an impact on the males reduced thumb sensitivity in comparison to females.

The boxplot in Fig. 3 shows that the minimal TPD threshold values for all participants ranged from 1 to 3 mm, although based on previous studies, the expected average ranged from 2 to 9 mm [4]. Restricting the age range of participants used in this study to be within 18 to 25 years of age could potentially explain such an anomaly of lower threshold values. Since previous studies show that an age-related decline is seen in the ability to distinguish two separate points as age increases [7] individuals in this younger age group are expected to have a higher TPD sensitivity. Additionally, this study used a smaller sample size than most other historical studies, potentially impacting the spread of collected data.

From the plot in Fig. 1, an increasing TPD trend amongst the sexes indicates that the two points of the compass become more distinguishable as the distance between the points are increased. Despite the significant difference in TPD perception between the sexes in this study, the physical factors of finger size, thickness and, as a result, Merkel cell density differing between the two sexes may be the ultimate factors in determining the difference in TPD ability.

Despite the relatively low statistical variances calculated from the collected data, the TPD technique has functional limitations. The most significant limitation of TPD testing occurs when a hand-held mechanical instrument, such as the drawing compass used in this study and other previous studies, is used to perform the TPD testing. The use of manual instruments introduces a vulnerability to human error to the collected data. Such sources of error include applying uneven pressure on the skin with the two points of the instrument or neglecting to place the two points on the skin at the exact same time.

From this study, continued research into the understanding of the differences in innervation and touch sensitivity between the male and female body could lead to more strategic neurological healthcare treatments for stroke victims by improving treatments to be tailored specific to the patient's sex. Previous studies have shown that females are more likely to become disabled after a stroke [9], signifying the importance of substantiating differences in TPD perception, a sense that is severely impaired following a stroke.

V. CONCLUSION

Based on the data collected in this study, researchers were able to substantiate previous findings by observing that on average, female participants had lower TPD thresholds when compared to male participants. The difference between these two groups was concluded to be statistically significant based on statistical testing. Researchers also determined that the variance of data collected from female participants was much smaller than the male participant's group, indicating a smaller spread of data for the group and a greater level of accuracy in the responses.

In the long term, the substantiated findings of this study could be applied to continued research into the assessment and rehabilitation of common somatosensory and neurological disorders with symptoms differing between the sexes. The results of this research could also impact the healthcare sector by providing further insight to clinicians who regularly use TPD testing in order to better understand the relationship between mechanoreceptor sensitivity and a patient's biological sex, thus leading to a more accurate assessment of impaired hand functions, such as fingertip numbness following a stroke.

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