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RESEARCH ARTICLE

DO DIFFERENT VISUAL CONDITIONS AFFECT TACTILE ACUITY AT HAND IN HEALTHY YOUNG ADULTS?

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ABSTRACT

Purpose: Subjects should not see the area tested during the two-point discrimination (TPD) test. In literature, various methods are used to hide the test area. However, there is yet to be a consensus on which method is the best. This study investigated the tactile acuity of different methods to obscure the line of vision in TPD testing in healthy young adults.
Material and Methods: We evaluated the TPD thresholds of the dominant hand's three regions in 30 healthy young adults under four different visual conditions (two eyes open and two eyes closed). The statistical analysis involved the use of the Friedman test and the Wilcoxon signed-rank test.
Results: In all areas tested, it was found that the distance between two stimuli was smaller with eyes open. 46.70% of the participants reported being more comfortable and could distinguish two points more quickly when their eyes were open.
Conclusion: Although the threshold values of TPD are within clinically appropriate ranges in all four visual conditions, we suggest performing TPD testing while the patients' eyes are open. Clinicians may obtain more accurate results during TPD tests if subjects are tested with their eyes open rather than closed.

Keywords: somatosensory function, tactile acuity, touch perception, two-point discrimination, young adults

INTRODUCTION

The somatosensory system is a multimodal system that defines, identifies, and distinguishes sensory patterns to guide different types of stimuli, such as joint position (proprioception), thermal, noxious, and tactile stimuli (1,2). The sense of touch, or tactile sensation, is responsible for processing information from our surroundings. Tactile information is crucial for daily activities, differentiating and protecting the body from the environment. It is also essential for physical and social interaction (3).

Tactile acuity is the ability to accurately detect the location and quality of touch (4). Tactile acuity can be impaired in a wide range of clinical conditions such as multiple sclerosis (5,6), cerebral palsy (7), chronic musculoskeletal pain (8,9,10), migraine (11), and carpal tunnel syndrome, etc. (12), so tactile acuity evaluation is essential for clinical examination and follow-up of these conditions. The Two Point Discrimination (TPD) test is a clinical measure of tactile acuity. TPD test has traditionally been used to measure cutaneous innervation density and evaluate the central somatosensorial functions (13). The TPD test is a simple and cost-effective method for measuring the smallest distance at which an individual can consciously identify two pressure points applied simultaneously to nearby areas of the skin (14,15). As the distance required to distinguish between the two stimuli decreases, the precision of tactile sensation improves. So, shorter distances indicate a higher level of tactile acuity (16).

During testing of TPD, subjects should not see the tested area. In the literature, different methods were used to hide the tested area. In some studies, the eyes were closed with a blindfold (17,18), or the participants were either instructed to keep their eyes closed (19-24) or asked to look away from the evaluated area (19,25). In other studies, a folder was preferred for obscuring the line of vision (26-28). According to Bell-Krotoski (2011), using a folder to obstruct the line of vision is recommended instead of a blindfold to cover the eyes (29). Different methods have been used to blind individuals or patients during tests, but it is still unclear which method works best for consistent assessments. For this reason, this study was planned to investigate the tactile acuity of different methods that obscure the line of vision in TPD testing.

MATERIALS AND METHODS

Participants

A total of 30 healthy young adults aged between 18 and 35 years were included in the study. All participants were informed about the study's aim and methods and signed an informed consent form. The study excluded participants who reported any of the following criteria: 1) current acute or chronic pain symptoms (especially in the evaluated areas or widespread) within the last two years due to traumatic injuries, overuse, rheumatoid arthritis, complex regional pain syndrome, or systemic musculoskeletal pain disorders such as fibromyalgia; 2) previous surgeries in the evaluated regions; 3) any skin conditions such as skin allergy or skin burn; 4) amputation; 5) neurological conditions such as peripheral nerve injuries or neuropathies; 6) any neurological signs such as numbness or tingling; 7) diabetes mellitus; 8) inability to follow instructions due to attention or cognitive disorders; 9) pregnancy.

Procedure

Prior to commencing the study, the Clinical Research Ethics Committee of the Kutahya Health Sciences University approved the ethical considerations (Date: 08.08.2018; Decision No: 2018/10-7). The data were collected between March 2019 and July 2019. Prior to conducting the TPD test, we recorded the participant's age, gender, and dominant hand. The same physical therapist carried out all of the evaluations. The testing environment was maintained at 25℃ with a relative humidity of 30%.

The TPD test was performed in four different visual conditions in order. The first two visual conditions were performed on the first day, and the last two were performed on the second day of evaluation to prevent mental fatigue and reduce the possibility of accommodating the test stimuli. At least five minutes of rest periods were given between each visual condition tested. The visual conditions were as follows.

I. Visual condition: Eyes closed with a blindfold
II. Visual condition: Eyes closed, in which the participants were asked to keep their eyes closed.
III. Visual condition: Eyes open, but a folder obscured the vision
IV. Visual condition: Eyes open, but the participants were asked to look away from the evaluated area

Test instruments and areas

The TPD test was conducted using a commercially available mechanical caliper (Aesthesiometer, Baseline® Two-Point Discriminator, 12-1481, New York, USA). The test was performed on three regions in the dominant hand of each participant: the palmar surface of the distal phalanx of the long finger (for the median nerve), the palmar surface of the distal phalanx of the little finger (for the ulnar nerve), and the area over the first dorsal interosseal muscle (for the radial nerve). For the distal phalanges of the long and little fingers, the caliper was positioned perpendicular to the skin so that the stimulus was applied perpendicular to the digit's axis. The caliper was parallel to the skin and the peripheral nerve trunk, which innervates the area over the first interosseal muscle (14,15).

Determination of two-point discrimination threshold

In the TPD test, two non-harmful, light touch stimuli are applied to the skin at equal pressures as a separate stimulus with two tips of the mechanical caliper. During the TPD assessment, the participants were comfortably seated in a relaxed position. They were asked to indicate if they felt one or two points of pressure by either verbally expressing it or holding up one or two fingers. In case of uncertainty, they were instructed to report a single point. The participants were also asked to indicate if they perceived two points due to a temporal delay between each point of the caliper. If the report was not accepted, the stimulus was reapplied. A TPD demonstration was performed before the actual administration while the participants' eyes were open.

The distance between the tips is measured by increasing or decreasing until the participants perceive two points or only one point, respectively. The study involved conducting three sets of ascending and descending assessments. The results of six measurements were averaged and used for statistical analysis. During the descending assessments, the test began at the maximum distance that the subjects could easily perceive as two separate points of the caliper. The distance between the two points of the caliper was then gradually decreased by one mm increments until the subjects could only perceive one point. Conversely, the ascending assessments began testing from the distance where the subjects perceived a single point and gradually increased the distance by one mm increments until the subjects could perceive two points separately.

During the testing process, the evaluator applied single stimuli randomly between one to three times to reduce the possibility of participants guessing the pattern. Attention was given to applying the stimuli simultaneously and with equal pressure. After completing all visual conditions, the participants were asked to state which visual condition they were more comfortable with and distinguish two points of the caliper more easily and clearly (22).

Statistical analysis

All data were analyzed using SPSS® Statistics 15 (Chicago, IL, USA). Due to the non-normal distribution of variables (Shapiro-Wilk test), all data were presented as medians and inter-quartile ranges (IQR). The study used the Friedman test to compare the threshold values of various visual conditions. A p-value of less than 0.05 was considered significant for the Friedman test. The Wilcoxon signed-rank test was employed to discern variations between every visual condition. For multiple pair-wise comparisons, the alpha value was adjusted and set at 0.00625 with the Bonferroni correction method, and the confidence interval was set at 95%.

RESULTS

A total of 30 healthy young adults (22 female, 8 male) with a median age of 22 (IQR=21-27) years were included in the study. The right hand was dominant for most of the participants (90%, n=27). TPD threshold values for each visual condition and test region were reported in Table 1. The comparison of each visual condition with each other was also reported in Table 1. The distance required to perceive two distinct stimuli was smaller for all test regions in III and IV visual conditions when compared to I and II. A statistically significant difference was found between TPD threshold values of I-III visual conditions and I-IV visual conditions in the distal phalanx of the long and the little fingers, respectively. Moreover, a significant difference was found between the threshold values of the first dorsal interosseal muscle in I-III, I-IV, II-III, and II-IV visual conditions (Table 1).

46.70% of the participants reported being more comfortable and distinguished two points easily when their eyes were open (III and IV visual condition). 23.30 % reported difficulty in distinguishing two points when their eyes were closed (I and II visual conditions). 16.70% of the participants could not decide which condition was more comfortable.

DISCUSSION

The TPD test is a widely used neurosensory test to assess mechanoperception in a clinical setting (30). However, it has been criticized for the unexplained variability within and between subjects and studies (31,32). This criticism stems from the need for a standard procedure for measuring TPD (33), making it difficult to compare findings across studies or clinics and create normative data (34). A standardized TPD protocol should be developed to reduce variability and minimize clinician judgment. As in all other sensory tests, some method of occluding the patients' vision should be used during the evaluation of TPD. Preventing visual input during testing reduces compensation of a sensory deficit and improves test accuracy (35). However, there is no standardization

Table 1. Comparison of the TPD threshold values of four visual conditions used in clinical sensory testings.

<table>
<tr><th>Test region</th><th>Different visual conditions</th><th>Mean ± SD</th><th>Median (IQR)</th><th>Friedman test p-value</th><th>Wilcoxon signed rank test</th><th>I.-II. visual condition</th><th>I.-III. visual condition</th><th>I.-IV. visual condition</th><th>II.-III. visual condition</th><th>II.-IV. visual condition</th><th>III.-IV. visual condition</th></tr>
<tr><td rowspan="4">The palmar surface of distal phalanx of long finger</td><td>I.visual condition</td><td>2.50 ± 0.45</td><td>2.50 (2.16-2.83)</td><td rowspan="4">0.041*</td><td rowspan="2">Z</td><td rowspan="2">-2.049[b]</td><td rowspan="2">-2.915[b]</td><td rowspan="2">-2.560[b]</td><td rowspan="2">-1.094[b]</td><td rowspan="2">-1.225[b]</td><td rowspan="2">-0.041[b]</td></tr>
<tr><td>II.visual condition</td><td>2.30 ± 0.46</td><td>2.41 (1.83-2.66)</td></tr>
<tr><td>III.visual condition</td><td>2.23 ± 0.40</td><td>2.24 (2.00-2.50)</td><td rowspan="2">p-value</td><td rowspan="2">0.040</td><td rowspan="2">0.004**</td><td rowspan="2">0.010</td><td rowspan="2">0.274</td><td rowspan="2">0.221</td><td rowspan="2">0.967</td></tr>
<tr><td>IV.visual condition</td><td>2.23 ± 0.44</td><td>2.00 (1.83-2.70)</td></tr>
<tr><td rowspan="4">The palmar surface of distal phalanx of little finger</td><td>I.visual condition</td><td>2.61 ± 0.52</td><td>2.66 (2.16-3.04)</td><td rowspan="4">0.096</td><td rowspan="2">Z</td><td rowspan="2">-1.853[b]</td><td rowspan="2">-2.375[b]</td><td rowspan="2">-2.778[b]</td><td rowspan="2">-0.582[b]</td><td rowspan="2">-0.757[b]</td><td rowspan="2">-0.350[b]</td></tr>
<tr><td>II.visual condition</td><td>2.44 ± 0.48</td><td>2.50 (2.12-2.83)</td></tr>
<tr><td>III.visual condition</td><td>2.37 ± 0.50</td><td>2.33 (1.83-2.70)</td><td rowspan="2">p-value</td><td rowspan="2">0.064</td><td rowspan="2">0.018</td><td rowspan="2">0.005**</td><td rowspan="2">0.560</td><td rowspan="2">0.449</td><td rowspan="2">0.726</td></tr>
<tr><td>IV.visual condition</td><td>2.39 ± 0.55</td><td>2.33 (1.83-2.83)</td></tr>
<tr><td rowspan="4">Over 1st dorsal interosseous muscle</td><td>I.visual condition</td><td>20.60 ± 2.38</td><td>20.91 (19.53-22.04)</td><td rowspan="4">0.001*</td><td rowspan="2">Z</td><td rowspan="2">-0.238[b]</td><td rowspan="2">-3.305[b]</td><td rowspan="2">-2.892[b]</td><td rowspan="2">-2.836[b]</td><td rowspan="2">-2.734[b]</td><td rowspan="2">-0.768[b]</td></tr>
<tr><td>II.visual condition</td><td>20.53 ± 2.31</td><td>21.16 (19.07-22.04)</td></tr>
<tr><td>III.visual condition</td><td>19.80 ± 2.40</td><td>19.58 (18.77-21.08)</td><td rowspan="2">p-value</td><td rowspan="2">0.812</td><td rowspan="2">0.001**</td><td rowspan="2">0.004**</td><td rowspan="2">0.005**</td><td rowspan="2">0.006**</td><td rowspan="2">0.442</td></tr>
<tr><td>IV.visual condition</td><td>19.65 ± 2.51</td><td>19.50 (18.66-21.16)</td></tr>
</table>

*IQR= inter-quartile range, SD: standard deviation, *p <0.05, ** p < 0.00625 (Bonferroni correction)*

of the occlusion method in TPD testing. This was achieved in different ways by different authors. Traditionally, blindfolds or closed eyes were commonly used to block a person's vision. However, in cases of central nervous system dysfunction, such methods may cause anxiety or disorientation if used for an extended period. In such situations, using a small screen or folder as a visual barrier is recommended to limit the amount of visual input (35). In our study, the vision was obscured by four different methods. In the first two methods, the eyes were closed (I and II visual condition), and in the other two methods (III and IV visual condition), the eyes were open during testing. From these four methods, nearly half of the participants felt more comfortable and distinguished two points more easily in the test procedures when their eyes were open (III and IV visual condition). These patients claimed they were distracted, their concentration decreased, and they fatigued quickly while their eyes closed. Also, the distance required to perceive two points as distinct stimuli was smaller in these two test procedures. Smith (2016) recommends sensory evaluations with eyes open, in line with current findings.

The learning effect is a challenge encountered in sensory evaluation. In the study of Meiner et al. (1996), TPD assessments were carried out within 14 days by the same examiner at the same location and time of day, following a standardized procedure. The results showed that thresholds decreased in all conditions across the three testing sites during the second session. This decrease, or in other words, improvement, may result from the change in perception thresholds on the second day of the assessment and may support the existence of a learning effect between the first and second sessions (37). Several studies have also indicated that the learning effect can influence TPD measurements, although these effects are often not clinically significant. Research involving healthy volunteers and patients with multiple sclerosis (MS) has shown slightly enhanced perception in repeated test sessions, suggesting the presence of a learning effect (38,39). In contrast, a study in children with cerebral palsy (CP) indicated that static and moving TPD tests may be less sensitive to learning effect (40). In our study, we tested four different visual conditions on two separate days. The first two visual conditions—where participants either wore a blindfold or kept their eyes closed—were assessed on the first day. The other two conditions—where participants' eyes were open but their vision was obscured by a folder or they were instructed to look away from the evaluated area—were tested on the second day. The improvement in tactile acuity during the last two visual conditions (eyes open) may be attributed to a learning effect present on the second day of evaluation. This represents a limitation of our study. Further research is necessary to determine whether the TPD threshold varies when the order of the visual conditions changes.

CONCLUSION

In our study, we tried to find the most sensitive method for occluding the participants' vision in the TPD test. Although the threshold values of the TPD test were in clinically appropriate ranges in all visual conditions, we suggest performing the TPD test while the participants' eyes are open.

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Ethical Approval: All participants were informed about the aim and methods of the study, and signed an informed consent. The study was conducted in accordance with the Declaration of Helsinki, and the protocol was approved by the Clinical Research Ethics Committee of Kutahya Health Sciences University (Date: 08.08.2018; Decision No: 2018/10-7).

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