Cloud Publications
International Journal of Advanced Physiology and Allied Sciences
2014, Volume 1, Issue 1, pp. 42-52, Article ID Med-186

Research Article | Open Access

Normative Values of Two-Point Discrimination Test among Students of Princess Noura Bint Abdulrahman University in Riyadh

Safanah Alsaeed, Taibah Alhomid, Hoda Zakaria and Reem Alwhaibi

Physical Therapy Program, Rehabilitation Department, College of Health and Rehabilitation Sciences, Princess Noura Bint Abdulrahman University, Riyadh, Saudi Arabia

Correspondence should be addressed to Safana Alsaeed, safanaalsaeed@gmail.com

Publication Date: 18 October 2014

Article Link: http://medical.cloud-journals.com/index.php/IJAPAS/article/view/Med-186

Abstract Present research was performed to generate normative values using Two-Point Discrimination test (TPD) for skin areas of dominant hand. Various studies revealed that TPD test demonstrate the integrity of tactile stimulation. In this study the test was executed on 270 students of art & design, medical and literary backgrounds of age between 20-23 years which were randomly selected from different colleges of Princess Noura Bint Abdulrahman University in Riyadh. TPD values were determined for distal palmar of the hand and tip of middle finger of their dominant hand parallel to the median nerve, which innervate the area of the hand and perpendicular on the fingertips. The examiner addressed the hand skills or any talent and visual acuity scale of the participants and used Michigan hand outcomes questionnaire (MHQ) to measure their perception of hand function, pain, satisfaction and work performance which was focused on all daily living activities of hand (ADL). To meet objectives of the study, test parameters were considered viz. ADL of one and both hands, overall function of hand, normal work; TPD values of distal palm of hand and tip of middle finger. Normative values of TPD test were obtained from range 2-7 mm among participants in distal palm of dominant hand with 4 mm average and 2-3 mm in the tip of middle finger with 2.6 mm average. Obtained normative values were analyzed statistically and compared with referred values. A plot between average TPD values shown that discriminatory sensations were found better in art and design college students. To measure the visual acuity values visual acuity test 6/6 vision was performed on participated students which represented the normal vision. Plot between values of TPD and visual acuity suggested that decrease level of visual acuity of students has better normative values which were obtained 3.4 mm of distal palm of dominant hand and 2.4 mm on the tip of the long finger. A significant relation between age of students and TPD values were estimated $p<0.015$ and $p>0.01$ for visual acuity. This study estimated that fingertips were the most sensitive part than palm of hand ($p<0.01$).

Keywords *TPD Values; Visual Acuity; Dexterity; Questionnaire; Tactile Sensation; Correlation*

1. Introduction

The nervous system is a complex network of nerves and cells that carry messages to and from the brain and spinal cord to various parts of the body. The nervous system includes both the central nervous system and peripheral nervous system. The central nervous system is made up of the brain and spinal cord and the peripheral nervous system is made up of the somatic and the autonomic nervous systems. The somatic nervous system consists of peripheral nerve fibers that pick up sensory information or sensations from the peripheral or distant organs (those away from the brain like extremities) and carry them to the central nervous system. These also consist of motor nerve fibers that come out of the brain and take the messages for movement and necessary action to the skeletal muscles.

In human body a living organ has its ability to respond to stimuli where thousands of incoming messages are highly evolved and processed simultaneously through human sensory receptors. These sensory receptors respond to stimuli and transmit data about them to the brain. Receptors are located throughout the body including the skin, epithelia, internal organs, skeletal muscles, bones, and joints.

Somatosensory tests are categorized on the basis of type of sensation which body feels like pain, temperature and tactile or touch sensation. The two-point threshold has long been used as a measure of tactile spatial resolution for evaluating outcome from peripheral nerve injury and repair (Jerosch-Herold, 2000). Thus, Two-point discrimination test assesses the ability to perceive two points applied to the skin simultaneously. TPD is a measure of the smallest distance between two stimuli which is applied simultaneously and with equal pressure (Kannathu and Asir, 2013). It is the only quantifiable measure used in the British Medical Research Council (MRC) classification that was developed by Highet in 1954 where Two-point discrimination thresholds were assessed together with locognosia, tactile gnosis, and touch threshold (Jerosch-Herold, 2000). Two point discrimination addresses the sensitivity of overlapping receptive fields on the body surface by generating normative values. These normative values are the minimal separation (in millimeters) at which the patient can distinguish these stimuli and should be recorded in each extremity (Hal Blumenfeld, 2010).

In neurologic examination Two-Point discrimination test is frequently used particularly with hand injuries (Nolan M.F., 1985). Evaluation of extent of injuries to peripheral nerves of hand is easily assessed because normal values for two point discrimination are readily available (Nolan M.F., 1982).

In recent study Kannathu and Asir (2013) applied the discrimination of Two-Point Touch Sense which was estimated through Two-Point Discrimination Test and accepted it one of the feasible methods. They believed this method is mostly useful in evaluating two-point discrimination in upper extremity. To measure two-point discrimination they used aesthesiometer that is a device for measuring the tactile sensitivity of the skin. It consists of a small ruler with two moveable tips coated with vinyl. Coating of vinyl solution protects it from excessive temperature and assists to minimize the impact of temperature on perception of contact. To precede the two-point discrimination test aesthesiometer is generally used which measures the shortest distance that two points of contact on the skin can be distinguished. Thus it forms a part of sensory assessment in human upper extremity (Kannathu and Asir, 2013).

Dellon A.L. (1981) analysed the cutaneous innervation and central somatosensory functions of upper extremity and hand by performing Two-Point Discrimination (TPD) test. TPD is widely used to test the ability of an individual to differentiate touch stimuli at two nearby points on the body at the same time (Nolan, M.F., 1982).

Generally, in TPD test therapist uses both end tips of the rigid instrument may be calipers or reshaped paperclip over touching and slightly pressing the patient's skin with one point or with two points on the skin area to be tested. Before starting the test it is recommended to explain the procedure to the patient with his/her eyes open and must demonstrate the procedure to the patients (WSU Health Care Sciences). In this test two small simple plastic octagon shape instrument embedded with sharp points was used. During the test patient is asked for closing his/her eyes and consistently inform whether the one point or two points was felt. On the response of patient the distance is measured between points without any delay (Walker H.K., et al., 1990). Smallest distance at which two points of contact can be felt and correlates with receptor density, smaller distance means greater receptor density. Mostly, the body parts such as finger, toe, palm, arm, leg, shoulder, tongue etc., are being used in the test.

Two-Point Discrimination values vary according to part of the body since different parts have receptive fields of different sizes (Nolan, M.F., 1983). It has been stated that finger tips and palm of the hand are considered to be the most sensitive parts which perceive the two-point in a small distance when compared to other parts of the body (John Krantz, 2012; Dean S. Louis, 1984; Kannathu and Asir, 2013). Cortical homunculus which is pictorial representation of the anatomical divisions of the primary motor cortex and primary somatosensory cortex shows that hand represents a large area in the brain since it has wide and important function in daily activities of human beings (Marieb, E. and Hoehn, K., 2007).

Normative values measured via two-point discrimination test for palm of the hand has been reported and classified by American Society for Surgery of the Hand in 1983. Accordingly, normal if the distance is less than 6 mm, fair from 6 to 10 mm, poor 11-15 mm, and protective if one point is perceived and the individual is considered anesthetic if no sensation is reported (Susan L. Michlovitz, 2004). The normal value in the fingertips is reported to be around 3 mm (Kenyon and Kenyon, 2009).

2. Objectives

1) To generate the two-point discrimination test values among Princess Nora Bint Abdulrahman University's students.
2) To investigate the factors affecting the two-point discrimination test results.
3) To evaluate the limitations and recommendations of two-point discrimination test.

3. Materials and Methods

3.1. Participants

270 healthy young female students aged between 20-23 years of age participated in this study. 90 students from medical colleges, 90 students from college of art and design and 90 students from literary colleges have participated. Subjects were randomly selected from different colleges at Princess Nora University.

Students were asked about their age, their dominant hand, visual acuity scale and if they have any hand skills or talents. The exclusion criteria in this study were any medical condition or diseases that may influence the results of the test; diabetes, epilepsy, any neurological condition and sensation problems, any recent fracture or injury during the last 10 months, skin conditions like wounds, burns, graft, scare tissue, eczema, erythema of skin, tattoos, fatigue and increasing body temperature.

3.2. Materials

Two-point discrimination test, the purpose of this test is to measure the ability of the subjects to differentiate between one point touch in one point and simultaneous touch in two separate points with

eyes closed. The examiners explained the purpose of the test and demonstrated the technique of testing to the participants, and answered their questions. The two point discriminator tool used in this study consists of a two small simple plastic octagon shape ranged from 1 mm to 25 mm each side, measures a different range of 8 labeled of fixed two point intervals (Figure 2). The interpoint distance was increased or decreased until the volunteers were consistently able to correctly indicate whether one point or two points had touched them simultaneously.

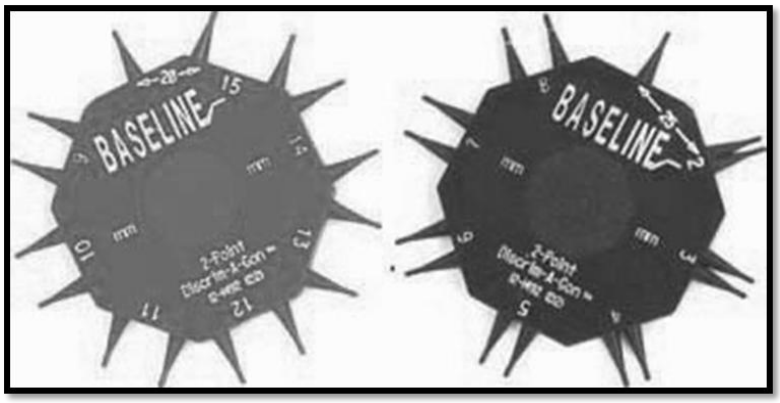

Figure 2: *Two-Point Discriminator Tool*

Michigan hand outcomes questionnaire (MHQ) was also used to measure the participants' perception of hand function, appearance, pain, and satisfaction (Kenyon and Kenyon, 2009). The questionnaire was translated into Arabic language to be used with students who do not understand English. The translated form is reviewed and corrected by three consultant professors in the field of physical therapy. To meet the aim of the study, only three components of the questioner were selected: over all functions of the hand which is graded from 1 to 5, 1 referred to very good and 5 to very poor. Activity of daily living (ADL) which is graded from 1 to 5, 1 not difficult at all, and 5 very difficult; and normal work scores are from 1 to 5, 1 refers to always and 5 never.

3.3. Procedure

Two well-trained senior physiotherapy students applied the two-point discrimination technique on the participants. The test was done on distal surface of the palm of the dominant hand and the fingertip of the middle finger, parallel to the median nerve, which innervates the area of the hand and perpendicular on the fingertips. While applying the test the subjects sat on a chair resting their arms on the table with 90-degree elbow flexion and the examiner's hand under the participant's hand. This position is the most comfortable and relaxed position to apply the test. The hotness or coldness of the participant's hand may influence the result so room temperature kept constant and at comfortable level.

The participants were asked to demonstrate the feeling of light touch, rather than a deep pressure, of one or two points simultaneously. The test was done three times for the participants to confirm the results and the examiner avoid touching the skin point twice during the examination with two minutes rest in between each trial. When performing the test the examiner applied firm and equally distributed pressure through the points. After finishing the test, the participants took their time to answer the questionnaire.

4. Statistical Analysis

Normative values were obtained for palm and finger of hand using TPD test then analyzed statistically and compared with referred values by American Society of Hand Therapists. The data collected followed normal distribution hence they are expressed as mean and standard deviations (X ±SD). F-test (ANOVA) is used to determine the significance of differences in two-point discrimination values obtained. It is the ratio of systematic variance to unsystematic variance therefore higher scores is better. The statistic for ANOVA is called the F statistic, which we get from the F-test.

$$F = \frac{\frac{n_1(\bar{x}_1 - \bar{x})^2 + n_2(\bar{x}_2 - \bar{x})^2 + \ldots + n_I(\bar{x}_I - \bar{x})^2}{I - 1}}{\frac{(n_1 - 1)s_1^2 + (n_2 - 1)s_2^2 + \ldots + (n_I - 1)s_I^2}{N - I}}$$

Where *I* is number of samples taken; (n_1, n_2… n_I) is sample size of each sample; means of the samples is (1, 2… I) and (s_1, s_2… s_I) represents standard deviations of each sample respectively.

Inverse correlation between the visual acuity and a better two point discrimination values was analysed. To measure the visual acuity values visual acuity test 6/6 vision was performed which represented the normal vision. Percentages of average of Michigan hand outcomes questionnaire parameters with percentages of overall function of hands were also analysed.

5. Results

Table 2 reports statistically analysed values obtained from Two-Point Discrimination test for art & design, medical and literary students of colleges of Princess Noura Bint Abdulrahman University. 90 female students of each subject of average age of 21 years participated in this study where Two-Point Discrimination test was executed over palm of hand and middle finger of the participants. The reference values for the discrimination of two-point touch sense for palm and finger of hand were presented in Table 1.

Table 1: *Two-Point Discrimination Test Referred Values for Palm and Finger of Hand*
Source: American Society of Hand Therapists

Classification	Point Measurement
Normal	Less than 6mm
Fair	6 to 10m
Poor	11 to 15mm
Protective	One point perceived
Anaesthetic	No points perceived

The reference values ranges from < 6mm to 10mm represent distances of two points touch sensation and considered normal and fair values while > 11mm are poor values.

Normative values and summary statistics obtained from results of Two-Point Discrimination test demonstrated these values ranged from 2 to 7mm among the participants in the distal palm of dominant hand with 4mm average range while in tip of middle finger normative values were 2 to 3mm recorded with 2.66 average ranges as shown in Table 2. The mean of TPD values for each subject group is represented in graph (Figure 2).

The plotted average TPD values in distal palm of dominant hand and tip of middle finger showed large variability suggesting that discriminatory sensations were found better in art and design college students when compared to values of medical and literary students as shown in Figure 1. Medical college students also showed some better discriminative values than literary college students.

Table 2: *Statistically Analysed Values Obtained from the Arts, Medical, Literary Students of Colleges of Princess Noura Bint Abdulrahman University*

Parameter	Art Students (N= 90) X ±SD	Medical Students (N=90) X ±SD	Literary Students (N=90) X ±SD	F (ANOVA) Test	P Value
TPDT in the distal palm of hand	3.02 ± 1.18	4.01±1.02	4.89±1.27	58.02	0.000
TPDT in the tip of middle finger	2.2±0.46	2.68±0.68	3.06±0.9	97.75	0.000
Overall function of hand	89.28±10.7	93.6±7.86	92.47±7.87	5.7	0.004
ADL of one hand	87.9±10.19	90.5±14.4	88.66±10.5	1.158	0.316
ADL of both hands	94.89±7.57	97.8±4.25	93.4±12.2	6.057	0.003
Normal work	79.4±19.4	87.97±15.4	81.38±18.7	5.04	0.004
GPA	3.8±0.58	4.38±0.51	3.4±0.74	45.5	0.000

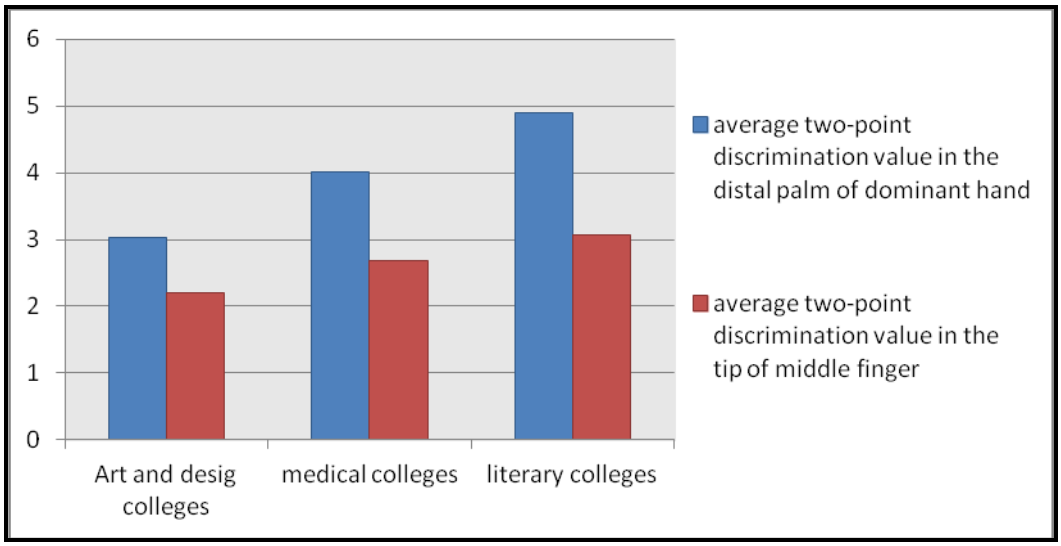

Figure 1: *The Values in the Graph Represent the Mean of TPD for each Subject Group*

There was an inverses correlation between the visual acuity and a better two point discrimination values. To measure this correlation, visual acuity 6/6 vision is analysed side by side on students. A graph is plotted between level of visual acuity and average TPD values in distal palm hand along with tip of long finger which is shown in Figure 2. It suggests that decrease level of visual acuity of students has better normative values comparing with students who have complete visual acuity level. Graph showed that average TPD values for distal palm of dominant hand are 3.4mm and 2.4mm in the tip of the long finger respectively (Figure 2).

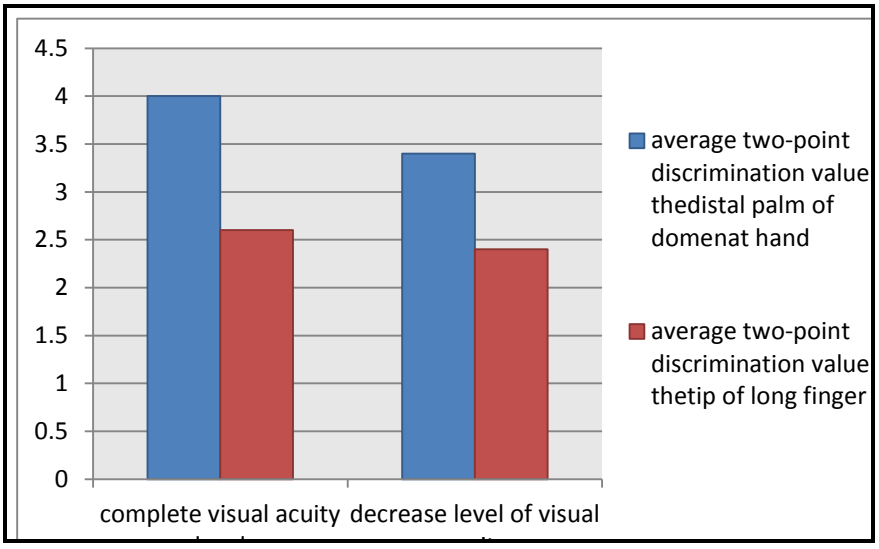

Figure 2: *The Inverses Correlation between Complete Visual Acuity along with Decrease Visual Acuity Levels and Average TPDT Values*

The examiner asked the students for the hand talent skills and answered a Michigan hand outcomes questionnaire, which is focused on hand function of daily living activities. Questionnaire follows the parameters viz. over all functions of hand, ADL of one hand, ADL of both hands and normal work scores for all colleges' students given in Table 1. A graph is plotted between the percentages of average of these parameters with percentages of overall function of hands as shown in Figure 3. On comparison with TPD values, no relation was found between hand outcomes and TPD values however, graph showed that medical college students have higher percentage of hand outcomes comparing to art and literary students. Surprisingly, art and design college students have the lowest percent of hand outcomes.

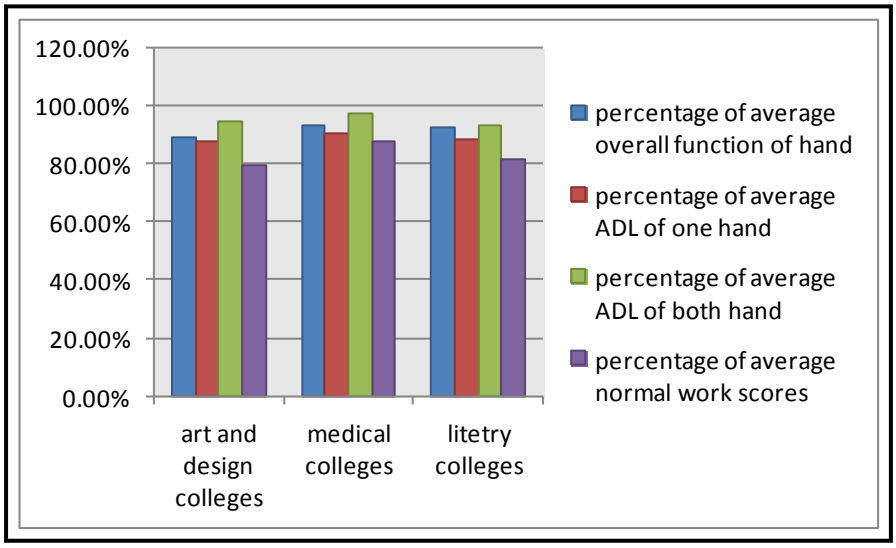

Figure 3: *The Mean Percentage of the Questionnaire Items in the Groups*

Age of students is also considered an important factor for the test and compared with TPD values which estimated a significant relation between them ($p< 0.015$). Visual acuity compared with TPD values estimated a significant relation ($p < 0.01$). It was estimated that fingertips were most sensitive part when compared with palm of the hand because of smallest TPD values (Table 1) ($p < 0.001$).

6. Discussion

The Two-Point Discrimination Test is the most frequently used test for the neurological assessment of the tactile system (Rhee T., et al., 2006). Same human body has diversified factors to respond to parallel stimulation eventually affected TPD test values. It has been reported that age of the patient in test influence the two-point discrimination ability. Sohn and Simons (1980) analysed the influence of age on values and they found that two-point discrimination values increase with age. However, in this study students have age range 20-25 years hence minor changes were accounted.

Lee Dellon et al. (1983) demonstrated four tests related to sensibility to analyse hand function hence evaluated their ability of sensibility to identify objects. Among four tests Lee Dellon et al. (1983) found that the normative values collected using moving two-point discrimination test were the best correlated with patient's ability to identify objects with fingertips ($p< 0.001$). It was reported that the time required to identify those objects were correlated best with the static two-point discrimination test ($p<0.001$). This study suggested that combine use of both TPD tests supply the most precise prediction of functional sensation in hand.

Omar (1980) showed that distribution of heavy callus over the skin could influence the result value where skin texture had also a defect role. Skin temperature is also considered one of crucial factor which has direct impact on the TPD sensitivity therefore Mackworth (1953) demonstrated that Two-Point Discrimination reduces with respect to reduction in skin temperature and increase in the skin temperature showing the improvement in TPD sensitivity.

Zubek et al. (1964) demonstrated that visual deprivation produced tactile acuity enhancement, as assessed by two-point and tactile fusion tasks. Catteneo and Vrschi (2011) also reported that decrease in visual acuity level led to enhancement in sensitive tactile as well as auditory receptors. Goldreich and Kanics (2003) suggested that tactile acuity was enhanced in loss of sight. In this study it has been also shown that decrease in visual acuity level results in better TPD values for palm of hand and tip of long finger. Why hand is chosen to get TPD values? This question is general and may arise in anybodies mind hence one can say hand is a very special organ with unique functions and versatility in human body. It can be known for its dexterity and manipulating our environment (Hausman et al., 2003) consequently parts of hand such as palm, finger, over all functions of hand, ADL of one and both hands corresponding to normal work are considered in this test. Results showed TPD values are found better in Art & Design Colleges students which supports above statement that hand is known for its dexterity because of great mobility of the joints and flexibility at muscles (Moran, 1989). It comes about when each has been through up in different environment and has practiced very different types of motor skills; these repeated experiences results in constantly changing the map of each brain (Schmidt and Lee, 1988) that lead to the cerebral cortex to expand in the somatotopic hand area.

It has been reported that tips of finger are most sensitive part of hand as compare to other parts. This is in agreement with study of Kannathu and Asir (2013) which recently proved that discrimination of the two-point touch sensitivity in finger tips is much more than any other areas in the upper extremity. They found the reason about most sensitivity that increased free nerve endings in the hands.

Michael F. Nolan (1982) evaluated two-point discrimination sensitivity in the hand which demonstrated the discrimination values for area of skin overlying the first dorsal interosseous muscle was 21.0 mm. Skin area covering the volar surface of the tips of the thumb as well as long and little fingers showed of 2.6 mm.

In this study students of Art & Design College perform better hand functions and skills which results in the lowest test values. This happened because of expansion in their cerebral cortex eventually

formation of new maps through constant practicing (Song and Abbott, 2001). Outcomes of questionnaire evaluated that Art & Design students have marked lowest in activities related to their daily living comparing to other participated students. It was predicted that low marks may be due to their nature of work which turned their hands to fatigue and affecting the activity of daily living. Conversely, Medical students having good hand functions lead to normal TPD values. This could be due to perfect knowledge of medical students about how to use the hand in correct manner. Graph of mean of TPD values shown that literary college students test values and hand functions are within normal limits which might be related to general functions of hand.

7. Study Limitations and Recommendations

First limitation in this study was visual acuity data of participated students collected through Questionnaire which is a theoretical method and may lead to non-accurate data. Generally a visual acuity test is an exam that determines how well you can see the details of a word or symbol from a specific distance away and known as Snellen test that provides accurate data.

Second limitation was lesser participation of students that is number of participated students was as small as compare to total number of students in theses colleges of the university. Age of students is prime factor and considerations for this study therefore students of Medicine college could not take part in this study because of age range which was less than 20 years.

Usually first year college students have more curiosity to learn new skills as compare to final year students. Thus, further research is recommended to study TPD test on first year students of different colleges until graduation and follow up the test values to investigate new learning skills and results outcome. Furthermore, it is recommended that new result values must be compared with other cortical sensation tests.

8. Conclusion

Two-point discrimination values for skin areas of the palm of hand and tip of middle finger are presented. Mean values ranged from 2 to 7mm among the participated students in the distal palm of dominant hand and 2 to 3mm in tip of middle finger indicated that Art & Design college students have better normative values because of their better hand functions and skills. Plot between TPD values and parameters suggested that test values obtained were different and depended on nature of colleges, visual acuity and dexterity. Test discriminated two point pressures simultaneously with shortest distance between them and found high in the tip of middle finger while palm of distal hand perceived low pressure. Variations in pressure proposed that tip of fingers are most sensitive part of hand than palm of hand. In future it is recommended to study the test on first year going students because of their more curiosity to learn new skills hence to investigate how age and learning skill may affect TPD results ultimately visual acuity and dexterity based on nature of colleges.

References

Chung, K.C., Pillsbury, M.S., Walters, M.R., and Hayward, R.A. *Reliability and Validity Testing of the Michigan Hand Outcomes Questionnaire*. Journal of Hand Surgery. 1998. 23 (4) 575-87.

Catteneo, Z., and Vrschi, T., 2011: *Blind Vision; the Neuroscience of Visual Impairment*. 1st Ed. United State of America; Stone Sans and Stone Serif. Chapter 2. 12-32.

Dellon A.L. *Evaluation of Sensibility and Re-Education of Sensation in the Hand*. 1981. Baltimore: Williams & Wilkins.

Dean S. Louis et al. *Evaluation of Normal Values for Stationary and Moving Two-Point Discrimination in the Hand.* The Journal of Hand Surgery. 1984. 9 (4) 552–555.

Goldreich, D., and Kanics, I.M. *Tactile Acuity is enhanced in Blindness*. J Neurosci. 2003. 23; 3439-3445.

Hal Blumenfeld. *Primary Sensation-Asymmetry, Sensory Level*. In: Neuroanatomy through Clinical Cases 2nd Ed. 2010. MA, USA: Sinauer Associates, Inc., Publishers.

Jerosch-Herold, C. *Should Sensory Function after Median Nerve Injury and Repair Be Quantified using Two-Point Discrimination as the Critical Measure?* Scand J Plast Reconstr Surg Hand Surg. 2000. 34 (4) 339-43.

John Krantz. Experiencing Sensation and Perception. Pearson Education, Limited. 2012. Chapter 12. 12.

Kenyon, K., and Kenyon, J., 2009: *The Physiotherapist's Pocketbook*. 2nd Ed. New York: Churchill Livingstone. Chapter 2. 191.

Kannathu, S. and Asir John, S. *The Discrimination of Two-point Touch Sense for the Upper Extremity in Indian Adults*. International Journal of Health and Rehabilitation Sciences. 2013. 2 (1) 38-43.

Marieb, E. and Hoehn, K. Human Anatomy and Physiology. 7th Ed. Pearson Benjamin Cummings: San Francisco. 2007.

Martini, Frederic et al., 2007: *Anatomy and Physiology*. Philippines: Pearson Education Asia Pte. Ltd. Chapter 15. 496-498.

Mackworth, N.H. *Finger Numbness in Very Cold Winds*. Journal of Physiotherapy. 1953. 5; 533-543.

Moran, C.A. *Anatomy of the Hand*. Physical Therapy. 1989. 69 (12) 1007-1013.

Nolan, M.F. *Two-Point Discrimination Assessment in the Upper Limb in Young Adult Men and Women*. Journal of the American Physical Therapy Association. 1982. 62 (7) 965-9.

Nolan, M.F. *Limits of Two-Point Discrimination Ability in the Lower Limb in Young Adult Men and Women*. Journal of the American Physical Therapy Association. 1983. 63 (9) 1424-8.

Nolan, M.F. Quantitative Measure of Cutaneous Sensation Two-Point Discrimination Values for the Face and Trunk. Physical Therapy. 1985; 65:181-185

Rhee, T., Neumann, U., and Lewis, J. *Human Hand Modeling from Surface Anatomy*. Association of Computing Machinery Journal. 2006. 6 (15) 27-34.

Omer, G.E., and Spinner, D., 1980: *Sensibility Testing, Management of Peripheral Nerve Problems*. Philadelphia, PA: WB Saunders Co. 3-15.

Schmidt, R.A., and Lee, T.D., 1988: *Motor Control and Learning: A Behavioral Emphasis.* 2nd Ed. Illinois, US: Human Kinetics. Chapter 1. 3-19.

Song, S., and Abbott, L.F. *Cortical Development and Remapping Through Spike Timing-Dependent Plasticity*. Neuron. 2001. 32 (2) 339-350.

Sohn, S.A., and Simons B.P. *Functional Anatomy of the Hand*. In: Acute Hand Injuries: A Multispecialty Approach. Wolfort F.G. (Ed.). Boston, MA: Little, Brown & Co. 1980. 32-42.

Susan L. Michlovitz. *Principles of Hand Therapy.* In: Hand Surgery. 1st Ed. 2004. Philadelphia: Lippincott Williams & Wilkins.

Zubek, J.P., Flye, J. and Aftanas, M. *Cutaneous Sensitivity after Prolonged Visual Deprivation*. Science. 1964. 144; 1591-1593.

WSU Health Care Sciences. *Two Point Discrimination*. Somatosensory Examination and Evaluation Study Guide.

Walker, H.K., Hall, W.D., and Hurst, J.W., 1990: *Clinical Methods: The History, Physical, and Laboratory Examinations*. 3rd Ed. Boston: Butterworths. Chapter 67. 343-349.