

Intra-observer reproducibility of the feet soles two-point discrimination test in asymptomatic elderly and young individuals

Reprodutibilidade intra-avaliador do teste de discriminação de dois pontos na sola dos pés em idosos e jovens assintomáticos

Priscila G. Franco, Roberta C. D. Bohrer, André L. F. Rodacki

Abstract

Background: The first sign of plantar sensory impairment due to aging and peripheral neuropathies are manifested on the soles of the feet and can result in postural control and balance deficits. The aim of cutaneous sensitivity tests is to assess the skin sensory innervation density such as those of the distal segments. In some studies the two-point discrimination test (TPD) have been applied on the soles of the feet and have proven to accurately distinguish elderly with and without falls events. However, the reproducibility of the test still needs to be determined. **Objectives:** The aim of the present study was to verify the intra-observer reproducibility of the TPD test on the soles of feet in asymptomatic elderly and young individuals. **Method:** The sample was composed of 21 physically active elderly participants (67 ± 5 years; 1.56 ± 0.08 m, 65.3 ± 13.7 kg) and 21 physically active young adults (24 ± 3 years, 1.69 ± 0.09 m, 54.5 ± 9.5 kg). The participants attended two sessions with identical experimental procedures, with an interval of 48 hours between them. The skin sensitivity of the right foot sole was assessed using the TPD test. Intra-observer reproducibility was assessed using Bland-Altman plots. **Results:** Elderly and young participants showed sensitivity variations of 0.71% and 1.53%, respectively. **Conclusions:** These values did not exceed two standard deviations and the TPD test was considered as a reproducible measure for the assessment of feet cutaneous sensitivity in asymptomatic and physically active young and elderly participants.

Keywords: proprioception; touch perception; reproducibility; physical therapy.

Resumo

Contextualização: Os primeiros sinais de comprometimento sensorial plantar decorrente do envelhecimento e de neuropatias periféricas são manifestados na sola dos pés e podem resultar em déficits no controle postural e no equilíbrio. Os testes de sensibilidade cutânea visam a avaliar a densidade da inervação sensorial na pele e têm sido utilizados para avaliação de segmentos distais. Alguns estudos têm aplicado o teste de discriminação de dois pontos (DDP) na sola dos pés e diferenciado idosos com e sem históricos de quedas, porém sua reprodutibilidade ainda precisa ser determinada. **Objetivo:** Verificar a reprodutibilidade intra-avaliador do teste de DDP na sola dos pés em idosos e jovens assintomáticos. **Método:** Participaram do estudo 21 idosos ativos (67 ± 5 anos; $1,56 \pm 0,08$ m; $65,3 \pm 13,7$ kg) e 21 jovens ativos (24 ± 3 anos; $1,69 \pm 0,09$ m; $54,5 \pm 9,5$ kg). Os participantes realizaram duas sessões de testes com procedimentos experimentais idênticos, com intervalo de 48 horas. Foi avaliada a sensibilidade cutânea da sola do pé direito por meio do teste de DDP. Para avaliar a reprodutibilidade intra-avaliador, foi aplicado o teste de Bland-Altman. **Resultados:** Idosos e jovens apresentaram variações de 0,71% e 1,53%, respectivamente. **Conclusões:** Esses valores não excedem dois desvios-padrão, e o teste de DDP foi considerado como uma medida reprodutível para a avaliação da sensibilidade cutânea da sola dos pés de jovens e idosos fisicamente ativos.

Palavras-chave: propriocepção; percepção do tato; reprodutibilidade dos testes; fisioterapia.

Received: 04/19/2012 – Revised: 05/21/2012 – Accepted: 07/01/2012

Universidade Federal do Paraná (UFPR), Curitiba, PR, Brazil

Correspondence to: André Luiz Félix Rodacki, Departamento de Educação Física - Centro de Estudos do Comportamento Motor, Rua Coração de Maria, 92, Jardim Botânico, CEP 80215-370, Curitiba, PR, Brasil, e-mail: rodacki@ufpr.br

Introduction ::::

Proprioceptors provide important internal and external sensory information that are sent to the central nervous system, where they are processed^{1,2}. Cutaneous receptors supply information exclusively on external events, such as the location and characterization of a touch, caress or pain, interfering with motor actions^{3,4}. Cutaneous receptors are found in greater amounts in the glabrous skin – skin areas that are under higher friction and therefore, have thicker layer and do not have hair follicles. In fact, distal areas and glabrous skin, such as the palm of the hand and the sole of the feet, provide significant concentration of cutaneous receptors interacting with the environment^{5,6}.

In the upper limbs, changes of force direction are noticed by cutaneous receptors that help with the adjustment and control of fine motor responses⁷. In the lower limbs, more specifically on the sole of the feet, the perception of pressure contact with the ground have an important influence on the postural control during gait^{3,4} consequently influencing the risk of falls. Plantar cutaneous afferents are responsible for informing the central nervous system about the limits of posterior stability and the perception and control of the heel during a step back⁸. In fact, a better plantar cutaneous sensitivity, promoted by the use of proprioceptive insoles, improve the postural control during disturbances of balance, lateral stability during gait and reduce the incidence of falls^{9,10}. Moreover, the loss of cutaneous sensitivity has been associated with complaints of imbalance in the elderly¹¹.

Cutaneous sensitivity tests aim to evaluate the density of sensory innervation in the skin and have been used for the evaluation of distal segments. The nylon monofilaments is one of the most widely used method to evaluate cutaneous sensitivity. Evaluations performed in lower limbs using this methodology have demonstrated interesting results such as the identification of an association between loss of plantar sensitivity with complaints of imbalance in the elderly¹¹. However, some studies do not report the exact area of the sole on the foot for evaluation^{12,13}. Reproducibility of this test is considered to be good, when performed on the back or on the sole of the foot, by the same examiner^{14,15}.

Another method to evaluate cutaneous sensitivity of the sole of foot is the vibration detection threshold test. The reproducibility of this test is inversely proportional to age, in other words, the test is less reliable when performed in the elderly¹⁶. Additionally, this test requires a more complex apparatus. There is also the PSSD™ (Pressure-Specified Sensory Device), a specific device of pressure sensitivity capable of determining thresholds of cutaneous sensitivity

with more accuracy. This method, although used in several studies in the lower limbs, especially in individuals with diabetic neuropathy¹⁷⁻¹⁹, demands the use of force transducers and registration on a computer.

A classic method for determination of functional tactile sensitivity is the two-point discrimination test (TPD) performed with a rigid instrument with tips arranged in pairs in different distances to be slightly pressed on the evaluated area. The TPD is frequently performed together with the monofilaments test and the perception of vibration test^{8,20} and is included in some assessment protocols for cutaneous sensitivity¹⁸. Among these three methodologies, the TPD is the only one that has not had its reproducibility tested for evaluating the sole of the feet, although it is an easy test for clinical use and have low cost.

During the TPD test, the evaluated individual tries to determine if one or two tips touch the pressed area. The smaller the distance detected between two tips, the higher the innervation density of fibers of slow adaptation and of cutaneous receptors functionally present in the skin²¹. This test is one of the most used to evaluate the sensitivity of the hand after surgeries and orthopedic interventions as its results have been associated with the ability to performing fine motor tasks²².

There are some controversies on the reproducibility of the TPD due to the lack of standardization of the pressure applied during the test. One way to solve this problem is to apply a very light strength on the discriminator during the test (10 g to 15 g), which corresponds to the strength produced by the discriminator's own weight. Moreover, it is important that the pressure on both tips is applied simultaneously, because small differences in the time of application may introduce errors²². There are studies on the reproducibility of the TPD in the upper limbs that indicate excellent results²³⁻²⁵, although one study reported that the TPD is not reliable when assessing asymptomatic individuals²⁶.

The first signs of plantar sensory impairment due to aging and peripheral neuropathies are manifested on the sole of feet. An alteration on this plantar sensory impairment is associated with reduced positioning perception and reduced production of ankle torque, resulting in postural control and balance deficits¹³. In fact, TPD has been found to be able to differentiate elderly with and without history of falls²¹. However, the reproducibility of the test still needs to be determined.

Considering that the sensory information from plantar cutaneous receptors is indispensable for the maintenance of balance and postural control, it becomes quite interesting and relevant for a larger number of studies to evaluate

the use of TPD in the identification of faller and non-faller elderly individuals. Thus, the present study aims to verify the intra-observer reproducibility of the TPD in asymptomatic elderly and young participants.

Method ::::

Twenty one elderly residents of the city of Curitiba, PR, Brazil (67 ± 5 years; 1.56 ± 0.08 m; 65.3 ± 13.7 kg), frequenters of a day center for elderly and 21 young adults (24 ± 3 years; 1.69 ± 0.09 m; 54.5 ± 9.5 kg), students of physical education in the Universidade Federal do Paraná (UFPR), Curitiba, PR, Brazil participated in the study. Fifteen of the 21 seniors were classified as active and six as irregularly active through the International Physical Activity Questionnaire (IPAQ). Among the young, 11 were classified as active and ten as very active through the same questionnaire. None of the participants reported cutaneous sensory impairments, peripheral neuropathies or musculoskeletal complications. Diabetic individuals were not included in the study. All participants signed the informed consent term. The experimental procedures of this study had the approval of the Ethics in Research Committee of UFPR, protocol CEP/SD 986.111.10.08; CAAE 0063.0.091.000-10, on September 22, 2010.

Participants visited the laboratory twice, with an interval of 48 hours. The experimental procedures were identical in the two occasions. All participants, elderly and young, were evaluated by the same examiner on the two occasions. Before the TPD test, participants were maintained in a prone position for a period of approximately 3 minutes in order to allow accommodation of plantar tissues²⁷ and to reduce possible effects of the activities previously performed before the test that could affect the cutaneous sensitivity.

Two-point discrimination test (TPD)

In the TPD test, the cutaneous sensitivity of the sole of the right foot was evaluated, specifically in the area of the first metatarsus, which corresponds to an area of greater feet support during gait²⁸. Heel and forefeet areas were not evaluated due to the higher variability of the skin thickness in these regions. A two-point discriminator was used for all evaluations (Touch-Test TM, model NC12776, measures from 1 to 25 mm, North Coast Medical, Inc., Ireland). (Figure 1). The discriminator was positioned perpendicular to the sole of foot, so that the two tips touch the skin at the same time

in an antero-posterior direction and only the discriminator's own weight was applied on the skin. Participants were asked if one or two tips were touching the evaluated area. Each distance between the tips was tested three times in a random order. The distance considered for analysis was the shortest distance guessed correctly with a minimum of two correct guesses in three tries. The use of the discriminator does not cause pain or discomfort and is considered to be a valid measure of functional sensitivity on the hand. A much wider variation is expected on the feet due to the variation in the thickness of the subjacent tissues²¹.

Statistical analysis

Firstly, the data were analyzed with descriptive statistics. Bland-Altman plots were used to evaluate the reproducibility. Measures for which the intra-observer variation did not exceed two standard-deviations from the mean of the two tests were considered reproducible. All analysis were performed in the *GraphPadPrism* program (GraphPad Software Inc®, version 5.0) using a coefficient of $p \leq 0.05$.

Results ::::

Reproducibility of the TPD test was confirmed for both groups as the variations between the two sessions did not exceeded two standard-deviations. Elderly and young participants showed variations in relation to the mean between sessions of 0.71% and 1.53%, respectively, with a mean difference in the two-point discrimination between the measures (TPD1-TPD2) of -0.9 ± 7.4 for elderly and -2.7 ± 16.9 for young participants.

Figure 2 shows the variation of the TPD test for each group.



Figure 1. Two-point discrimination test.

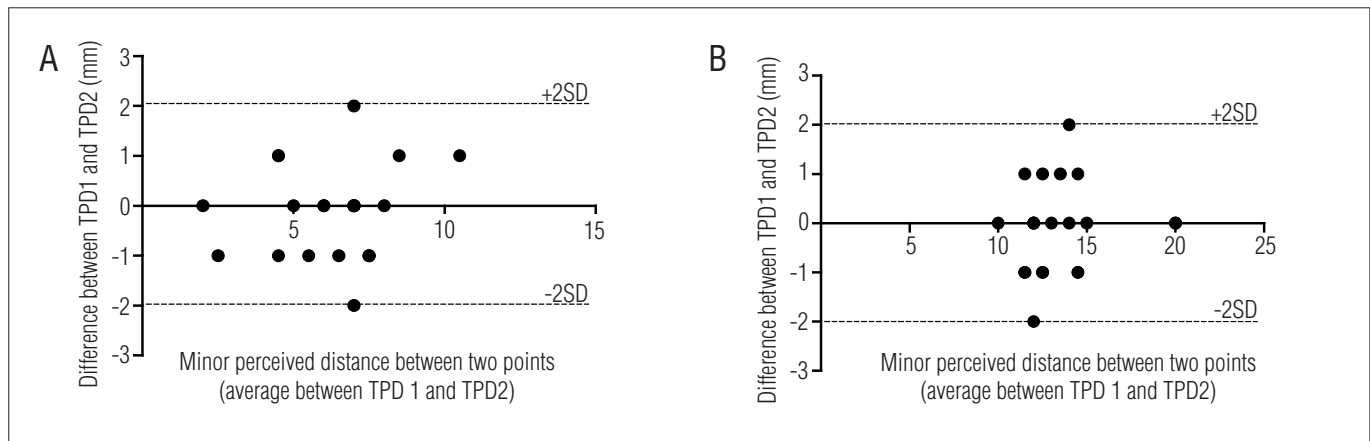


Figure 2. Absolute variation of the TPD test results performed at an interval of 48h for young (A) and elderly (B) volunteers.

Discussion

Cutaneous sensitivity tests are used to detect reduced sensory perception and to diagnose neuropathies and abnormalities of sensory function^{18,30,31}. The TPD test is commonly used to assess upper limbs and airways cutaneous perception in several populations³⁰⁻³³. Nylon monofilaments and the diapason test pitch have been used most often in the sensitivity evaluation of the lower limbs^{11,34-37}. Few studies have used the two-point discriminator for lower limbs, specifically for the sole of the feet^{18,21}.

Although most studies on the reproducibility of the TPD test in upper limbs have demonstrated excellent results^{23-25,38}, there is some evidence that the test may not be as reliable in asymptomatic individuals²⁶. Studies that used this test on the sole of the foot, despite reporting significant results, did not present reproducibility data^{18,21}.

The present study demonstrated that the TPD results between an interval of 48 hours have low variation (0.71% for seniors and 1.53% for young), indicating that this measure is quite reliable when applied to determine the cutaneous sensitivity of the sole of the foot.

Despite the good reproducibility of the test, young participants had twice the variability in the results when compared with elderly. A study that evaluated the reproducibility of the test of cutaneous sensitivity in subjects without impairment of the sensory system through nylon filaments and TPD also found high variation in the results for both methods²⁶. It is possible that, for subjects without proprioceptive impairments, small alterations in the location or in

the application of pressure cause different perceptions due to the good sensibility.

It is possible that subjects with sensory deficits are not capable to differentiate small variations in testing methods and, consequently, have more constant results.

It is important to note that although there are several instruments widely used for the evaluation of postural balance and the prediction of falls, these tests have different focus. For instance, there are functional tests intended at evaluating the maintenance of balance in a global way during the performance of daily tasks, while tests similar to the present study such as nylon monofilaments, vibration and PSSD™ – are characteristically tests of tactile sensitivity (protective or discriminative) that are important in the cause of balance alterations.

The TPD test is an important tool for clinical evaluations, although previous studies²⁶ have not considered the test to be as reliable as nylon monofilaments. However, based on the results of this study, both for young and elderly participants, the TPD test was shown to be reproducible.

Based on the present study, it is possible to conclude that populations with full plantar cutaneous sensitivity have higher variation of results, possibly due to the high discrimination of small pressure variations. Nevertheless, the TPD test on the sole of the feet was considered to have good intra-observer reproducibility for the assessment of active young and elderly participants.

Studies that evaluate the reliability of the TPD test to distinguish faller and non-faller elderly are still needed. Furthermore, inter-observer reproducibility testing of the TPD test are also needed.

References

- Martimbianco ALC, Polachini LO, Chamlian TR, Masiero D. Efeitos da propriocepção no processo de reabilitação das fraturas de quadril. *Acta Ortop Bras.* 2008;16(2):112-6.
- Goble DJ, Coxon JP, Wenderoth N, Van Impe A, Swinnen SP. Proprioceptive sensibility in the elderly: degeneration, functional consequences and plastic-adaptive processes. *Neurosci Biobehav Rev.* 2009;33(3):271-8.
- Santos AA, Bertato FT, Montebelo MIL, Guirro ECO. Effect of proprioceptive training among diabetic women. *Rev Bras Fisioter.* 2008;12(3):183-7. <http://dx.doi.org/10.1590/S1413-35552008000300005>.
- Lin SI. Motor function and joint position sense in relation to gait performance in chronic stroke patients. *Arch Phys Med Rehabil.* 2005;86(2):197-203.
- Cohen H. *Neurociências para fisioterapeutas*. 2ª ed. São Paulo: Manole; 2001.
- Enoka RM. *Neuromechanical basis of kinesiology*. 2ª ed. Illinois, US: Human Kinetics; 1994.
- de Freitas PB, Markovic G, Krishnan V, Jaric S. Force coordination in static manipulation: discerning the contribution of muscle synergies and cutaneous afferents. *Neurosci Lett.* 2008;434(2):234-9.
- Perry SD, McIlroy WE, Maki BE. The role of plantar cutaneous mechanoreceptors in the control of compensatory stepping reactions evoked by unpredictable, multi-directional perturbation. *Brain Res.* 2000;877(2):401-6.
- Palluel E, Olivier I, Nougier V. The lasting effects of spike insoles on postural control in the elderly. *Behav Neurosci.* 2009;123(5):1141-7.
- Perry SD, Radtke A, McIlroy WE, Fernie GR, Maki BE. Efficacy and effectiveness of a balance-enhancing insole. *J Gerontol A Biol Sci Med Sci.* 2008;63(6):595-602.
- Bretan O, Pinheiro RM, Corrente JE. Avaliação funcional do equilíbrio e da sensibilidade cutânea plantar de idosos moradores na comunidade. *Braz J Otorhinolaryngol (Impr.)*. 2010;76(2):219-24.
- Chaiwanichsiri D, Janchai S, Tantisiriwat N. Foot disorders and falls in older persons. *Gerontology.* 2009;55(3):296-302.
- Meyer PF, Oddsson LIE, De Luca CJ. The role of plantar cutaneous sensation in unperturbed stance. *Exp Brain Res.* 2004;156(4):505-12.
- Collins S, Visscher P, De Vet HC, Zuromond WW, Perez RS. Reliability of the Semmes Weinstein Monofilaments to measure coetaneous sensibility in the feet of healthy subjects. *Disabil Rehabil.* 2010;32(24):2019-27.
- Herron ML, Kar S, Beard D, Binfield P. Sensory dysfunction in the great toe in hallux valgus. *J Bone Joint Surg Br.* 2004;86(1):54-7.
- de Neeling JN, Beks PJ, Bertelsmann FW, Heine RJ, Bouter LM. Sensory thresholds in older adults: reproducibility and reference values. *Muscle Nerve.* 1994;17(4):454-61.
- Wood WA, Wood MA, Werter SA, Menn JJ, Hamilton SA, Jacoby R, et al. Testing for loss of protective sensation in patients with foot ulceration: a cross-sectional study. *J Am Podiatr Med Assoc.* 2005;95(5):469-74.
- Carvalho VF, Ferreira MC, Vieira SAT, Ueda T. Limiar de sensibilidade cutânea dos pés em pacientes diabéticos através do pressure specified sensory device: uma avaliação da neuropatia. *Rev Assoc Med Bras (1992).* 2009;55(1):29-34.
- Ferreira MC, Vieira SAT, Carvalho VF. Estudo comparativo da sensibilidade nos pés de diabéticos com e sem úlceras utilizando o PSSD™. *Acta Ortop Bras.* 2010;18(2):71-4.
- van Nes SI, Faber CG, Hamers RM, Harschnitz O, Bakkers M, Hermans MC, et al. Revising two-point discrimination assessment in normal aging and in patients with polyneuropathies. *J Neurol Neurosurg Psychiatry.* 2008;79(7):832-4.
- Melzer I, Benjuya N, Kaplanski J. Postural stability in the elderly: a comparison between fallers and non-fallers. *Age Ageing.* 2004;33(6):602-7.
- Lundborg G, Rosén B. The two-point discrimination test: time for a re-appraisal? *J Hand Surg Br.* 2004;29(5):418-22.
- Dellon AL, Mackinnon SE, Crosby PM. Reliability of two-point discrimination measurements. *J Hand Surg Am.* 1987;12(5 Pt 1):693-6.
- Mackinnon SE, Dellon AL. Two-point discrimination tester. *J Hand Surg Am.* 1985;10(6 Pt 1):906-7.
- Novak CB, Mackinnon SE, Williams JI, Kelly L. Establishment of reliability in the evaluation of hand sensibility. *Plast Reconstr Surg.* 1993;92(2):311-22.
- Rozental TD, Beredjiklian PK, Guyette TM, Weiland AJ. Intra- and interobserver reliability of sensibility testing in asymptomatic individuals. *Ann Plast Surg.* 2000;44(6):605-9.
- Foreman TK, Linge K. The importance of heel compression in the measurement of diurnal stature variation. *Appl Ergon.* 1989;20(4):299-300.
- Perry J. *Gait analysis: normal and pathological function*. 1st ed. Yorba Linda, CA: SLACK Incorporated; 1992.
- Bland JM, Altman DG. Statistical methods for assessing agreement between two methods of clinical measurement. *Lancet.* 1986;1(8476):307-10.
- Tapia IE, Bandler P, Traylor J, Karamessinis L, Huang J, Marcus CL. Upper airway sensory function in children with obstructive sleep apnea syndrome. *Sleep.* 2010;33(7):968-72.
- Premkumar S, Avathvadi Venkatesan S, Rangachari S. Altered oral sensory perception in tongue thrusters with an anterior open bite. *Eur J Orthod.* 2011;33(2):139-42.
- Taylor KS, Anastakis DJ, Davis KD. Chronic pain and sensorimotor deficits following peripheral nerve injury. *Pain.* 2010;151(3):582-91.
- Chassard M, Pham E, Comtet JJ. Two-point discrimination tests versus functional sensory recovery in both median and ulnar nerve complete transections. *J Hand Surg Br.* 1993;18(6):790-6.
- Simoneau GG, Ulbrecht JS, Derr JA, Cavanagh PR. Role of somatosensory input in the control of human posture. *Gait Posture.* 1995;3(3):115-22.
- Lord SR, Menz HB, Tiedemann A. A physiological profile approach to falls risk assessment and prevention. *Phys Ther.* 2003;83(3):237-52.
- Menz HB, Morris ME, Lord SR. Foot and ankle characteristics associated with impaired balance and functional ability in older people. *J Gerontol A Biol Sci Med Sci.* 2005;60(12):1546-52.
- Pham H, Armstrong DG, Harvey C, Harkless LB, Giurini JM, Veves A. Screening techniques to identify people at high risk for diabetic foot ulceration: a prospective multicenter trial. *Diabetes Care.* 2000;23(5):606-11.
- Moberg E. Two-point discrimination test. A valuable part of hand surgical rehabilitation, e.g. in tetraplegia. *Scand J Rehabil Med.* 1990;22(3):127-34.