Reliability of Infrared Thermography Images in the Analysis of the Plantar Surface Temperature in Diabetes Mellitus

Natália C.M. Silva, PhD,[a] Hirlaine A. Castro,[b,c] Leonardo C. Carvalho, PhD,[b,c] Érika C.L. Chaves, PhD,[c] Ludmila O. Ruela, MSc,[c] and Denise H. Iunes, PhD[b,c]

Abstract

Objective: The purpose of this study was to evaluate the intraexaminer and interexaminer reliability of image assessment of infrared thermography of the plantar surface of people with diabetes mellitus.

Methods: Fifty-one participants with diabetes were included. The interexaminer reliability (test) consisted of measuring the temperature of the plantar surface by 2 evaluators who separately performed the analysis of thermographic images. The intraexaminer reliability (retest) consisted of the revaluation of the images by a single evaluator 10 days after the first analysis.

Results: The analysis of intrareliability and interreliability indicated excellent levels of correlation (intraclass correlation coefficient >0.75, 95% confidence interval >0.70) in the plantar surface points analyzed.

Conclusion: Infrared thermography image evaluation identified intrareliability and interreliability for temperature analysis of the plantar surface of people with diabetes mellitus. However, further studies need to be conducted to assess validity and its application in health care. (J Chiropr Med 2017;xx:1-6)

Key Indexing Terms: *Body Temperature; Diabetic Foot; Lower Limbs; Reproducibility of Results*

Introduction

Infrared thermography is based on the emission of infrared radiation from a particular object or region as seen through a thermographic camera.[1-3] This instrument enables the detection of the heat distribution on the surface and at the same time allows the measurement of peripheral temperature.[2-4] After capturing the image, one can obtain a record of temperature gradients in colorful hues and enable the computational analysis of the quantification and interpretation of the image.[3] This method allows the measurement of the average temperature, the temperature difference and thermal recovery rate.[5] Researchers interested in investigating the use of infrared thermography in health care have reported the benefit of the method in the evaluation of musculoskeletal disorders, diabetic neuropathy, and vasculopathy.[1,3,4,6-10] Other studies have been conducted to test the use of thermography in detecting problems related to gynecology and obstetrics, neonatology, cardiology, nephrology, neurology, and dermatology.[4,6,7,11-13] This method has been used to diagnose disease and monitor various clinical conditions.[1,4,10] The detection of small changes in temperature in specific regions may suggest corresponding changes in the physiology, which contributes to the screening, diagnosis, and treatment of various diseases.[1,6-10]

Body temperature, mediated by sensory innervation and peripheral circulation, is directly influenced by room temperature.[11] In the presence of local lesions, impairment occurs in perception and thermal regulation, which promotes metabolic and physiological changes in an organism.[11,12] In this sense, a person with diabetes mellitus presents with damage in peripheral nerves and blood vessels and has a reduction in lower limb temperature.[12,13] This can be explained by the involvement of regulatory mechanisms: neurovegetative and motor mechanisms of blood vessels, resulting in the reduction of vasomotor function and lifting or lowering the temperature of the feet.[14] Acquired

[a] School of Nursing of the University of São Paulo/EERP-USP, São Paulo, Brazil.
[b] Course of Physiotherapy, Federal University of Alfenas, Alfenas, Brazil.
[c] Nursing School, Federal University of Alfenas, Alfenas, Brazil.
Corresponding author: Natália C. M. Silva, PhD, Rua Joviano Naves, Número 342, Apartamento 302, Bairro Palmares, Belo Horizonte, Minas Gerais, Brazil 311155710. Tel.: 55 031 993040364. (e-mail: *naty_chantal@hotmail.com*).

Paper submitted May 5, 2016; in revised form October 19, 2017; accepted October 19, 2017.
1556-3707

https://doi.org/10.1016/j.jcm.2017.10.006

neuropathy exposes the individual to a higher probability of complications in different body regions, especially in the extremities, and increased risk of developing skin lesions, resulting in high costs of hospitalization and medical expenses.[15]

Infrared thermography, as a noninvasive method, measures changes in the peripheral body temperature,[8,10,16] maps body temperature,[11] and tracks changes that decrease or increase body temperature.[1,2,3,8] However, because it is a new methodology in health care, its applicability and effectiveness as a method of evaluation need further testing.[4] Few studies have reported the intrarater and interrater reliability of this instrument.

Therefore, the purpose of this study was to assess the intrarater and interrater reliability of infrared thermography in the analysis of the plantar surface temperature of people with diabetes mellitus.

Methods

This was a cross-sectional study. A test–retest design was used to evaluate the intraexaminer and interexaminer reliability of the temperature measured by the infrared thermography. This study was part of a larger project titled "The Use of Reflexology Feet as Treatment for Patients With Diabetes Mellitus." This was approved by the Ethics Committee of the Federal University of Alfenas, Minas Gerais, Brazil (CAAE: 07183512.1.00005142).

Population and Sample

Fifty-one participants with type 2 diabetes mellitus from 2 primary health care units participated. The following were inclusion criteria: diagnosis of the disease for at least 5 years, minimum age of 18 years old, both sexes, infrequent medical monitoring for diabetes control in 2 primary health care units. Exclusion criteria were presence of ulcers, presence of amputations of the lower limbs, uncontrolled hypertension, thrombosis, presence of burns, and fever.

The following guidelines were given to the participants before the examination: Avoid alcohol 24 hours before the examination, caffeine and cigarettes 2 hours before the examination, vigorous sports activities on examination day, and the use of lotions or powders on your feet on examination day.[17,18] All participants gave consent to participate.

Photographic Record

For thermographic recording, the participants were positioned supine with bare feet and held that position for 15 minutes. This amount of time was used because it is the time required for the body heat to come into balance with the environment and produce stable recordings.[19] During this period, participants avoided touching their feet, and all electronics that could compromise the evaluation were removed. The testing environment was thermally controlled at a constant temperature of 23°C.[17,20] To obtain stable interpretations of plantar temperature and to prevent that the temperature of other parts of the body interfering on the photographic record, the feet were thermally insulated by a uniform backdrop.[18] This uniform backdrop consisted in a box with 2 openings for the feet.

All participants had their feet photographed with an infrared thermal camera (FLIR, model E60, Wilsonville, Oregon), with emissivity set to 0.98.[4] According to the manufacturer, this device enables measurement of temperatures ranging from −120°C to 650°C. The equipment was positioned on a tripod at a standardized height of 0.95 m from the ground and at a distance of 0.98 m from the participants' feet, which provided a picture without distortion. All photographic records were performed by a single observer who was familiar with the camera.

Reliability of Infrared Thermography

To assess intraexaminer reliability, a single evaluator analyzed thermographic images of the 18 points shown in Figures 1A and 1B on 2 different occasions. Respecting an interval of time for the data storage was not possible. The first evaluation was conducted on the day the images were captured by the thermographic camera, and the second evaluation was conducted after 10 days. The Quick Report Software Version 1.1 (FLIR Systems) that was provided by the camera's manufacturer was used for these analyses.

To assess interrater reliability, the image analysis was performed by 2 different evaluators in different locations and with different computers. Therefore, there was no exchange of information between examiners that could interfere with the assessments. Results were recorded separately to avoid the comparison of data during the analysis.

Statistical Analysis

We calculated sample size using G*Power Software Version 3.1.7 (Christian-Albrechts-Universität Kiel, Kiel, Germany) that estimated the need for 12 participants for a power of 0.80. The intraexaminer result concordance was analyzed by means of the intraclass correlation coefficient (ICC), assessing the measure consistency by each rater in 2 evaluations, whereas the interexaminer result concordance was analyzed by means of ICC, considering the between-rater concordance at the 2 time intervals for 1 measure assessed. The interpretation of the ICC was according to Fleiss (<0.40, poor correlation; 0.40-0.75, moderate correlation; >0.75, excellent correlation).[21] The 95% confidence interval (CI) was calculated, with values >0.70 being considered excellent.[22,23] The calculation of the standard error of measurement (SEM) was performed using the following formula: $SEM = SD \times \sqrt{(1 - ICC)}$, wherein SD corresponds to the standard deviation.[24] Minimum detectable change (MDC) was calculated with the following formula: MDC = z score level of confidence × SD