

DIABETIC FOOT: A SCOPING REVIEW OF NEUROSENSORIC DISORDERS – THERMOGRAPHY

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ABSTRACT

Background: Diabetic foot is a chronic complication that can be detrimental and has an impact on the quality of life of diabetic patients. Neurosensory examination of skin temperature using a thermograph can help prevent diabetic foot. **Objective:** to identify the neurosensory examination of skin temperature using infrared thermographs in addressing the risk of diabetic foot. **Design:** The design in this study is Scoping review. **Methods:** A journal search was conducted using the keywords "infrared thermography, screening or assessment, diabetic foot, and meta-analysis" to collect relevant articles published in the last ten years from four databases (ProQuest, PubMed, ScienceDirect, and Google Scholar). The inclusion criteria were: nurses, patients, diabetic foot, assessment, full-text articles, studies focusing on nursing issues, and written in English. Four journal articles were selected and analyzed using PICO. **Results:** Four meta-analysis articles on neurosensory examination of skin temperature sensitivity using a thermograph have a p value < 0.05, which can support clinical nursing for monitoring diabetic foot prevention. **Conclusion:** Examination of skin temperature sensation using a thermograph can be used as a method for neurosensory assessment in monitoring nursing care for structural integrity problems in the physiological changes of the diabetic foot.

INTRODUCTION

Diabetic foot is a complication of chronic diabetes mellitus which can lead to hospitalization rather than other chronic complications (Alaa, Bolton, Di Angelantonio, Rudd, & Van der Schaar, 2019). Diabetic feet can also increase mortality, morbidity, high cothatf care, decreased quality of morend amputations (Floris et al., 2021). The most common risk factors for amputation are neuropathy, peripheral arterial disease, traumalife, foot deformities (Fernandez & Shaw, 2020). Globally, the prevalence of diabetic patients who have diabetic feet is 6.3%, in Asian cotrauma,s it is 5.5% and those who have amputatons in China are 19.03% (Yin, Man, Ye, Liu, & Ma, 2021). The prevalence of diabetic patients in America who have diabetic foot ulcers is 2.5%, and 60% have amputations (Bandyk, 2018)

The American Diabetes Association (ADA) and Brazilian Diabetes Society (SBD) guidelines recommend that all patients with diabetes receive at least one foot assessment annually to identify risk factors for ulceration or amputation. Diabetic foot examination should include inspection of skin color, nails, foot structure and gait, neurological assessment, and vascular assessment (Bandyk, 2018), One of the assessments of diabetic feet is to assess neurosensory sensations by detecting the patient's foot temperature using an infrared thermograph (Rai, Sonne, Song, & Kim, 2022). Foot temperature assessment consists of a liquid crystal thermograph, cutaneous temperature discrimination, electrical contact thermometry, and an infrared thermograph (Lahiri, Bagavathiappan, Jayakumar, & Philip, 2012). An infrared thermograph is a thermal image that provides information about the distribution of

skin temperature. Peripheral neuropathy and the risk of ulceration are related to increased temperature in the plantar region (Hernandez et al., 2017). An abnormal body temperature is a natural indicator of a disease. Infrared thermography is a digital technology that can be used as a diagnostic method in orthopedics, vascular disorders, rheumatic inflammation, trauma, postoperative pain, fractures, and complications in diabetic feet (Zheng et al., 2022).

Assessment of foot temperature using an infrared thermograph can be an indication of abnormal physiological processes associated with several health conditions (Nogueira et al., 2021). Infrared thermography is a technology for detecting radiation in the infrared range of the electromagnetic spectrum that uses a thermal sensor to capture thermal radiation by emitting or reflecting it onto the skin (Karlidag-Dennis, Hazenberg, & Dinh, 2020). Based on the description above, the authors are interested in analyzing the use of infrared thermographs in diabetic foot neurosensory examination, which can assist nurses in providing nursing care.

Objective

The aim of this scoping review was to identify the use of infrared thermographs in the neurosensory assessment of diabetic foot skin temperature.

Methods:

This study is a scoping review that is used as a prelude to a systematic review of studies related to the use of infrared thermographs in neurosensory examination of diabetic foot skin temperature. The stages in carrying out a systematic review that must be carried out are a focus review with eligibility criteria, making a search strategy, identifying literature and selecting with the PRISMA flowchart, and data extraction, as follows:

1. Focus review with eligibility criteria

The journal search included articles published in the 10-year period between 2013 and 2023. The literature review focused on quantitative studies and full-text articles, with a focus on infrared thermographs. Articles selected using writing in English were considered for analysis.

2. Search Strategy

Recent articles on the use of infrared thermographs in neurosensory examination of skin temperature in diabetic feet were obtained from the PubMed, ProQuest, Scienndirect, and Google Scholar databases. The keywords used in the search were "infrared thermography, screening or assessment, diabetic foot, and meta-analysis" to identify the use of infrared thermographs in neurosensory examination of diabetic foot skin temperature. From the search, 12 titles were obtained from ProQuest, 8 titles from Scienndirect, 14 titles from PubMed, and 193 titles from Google Scholar. A total of 227 articles were found.

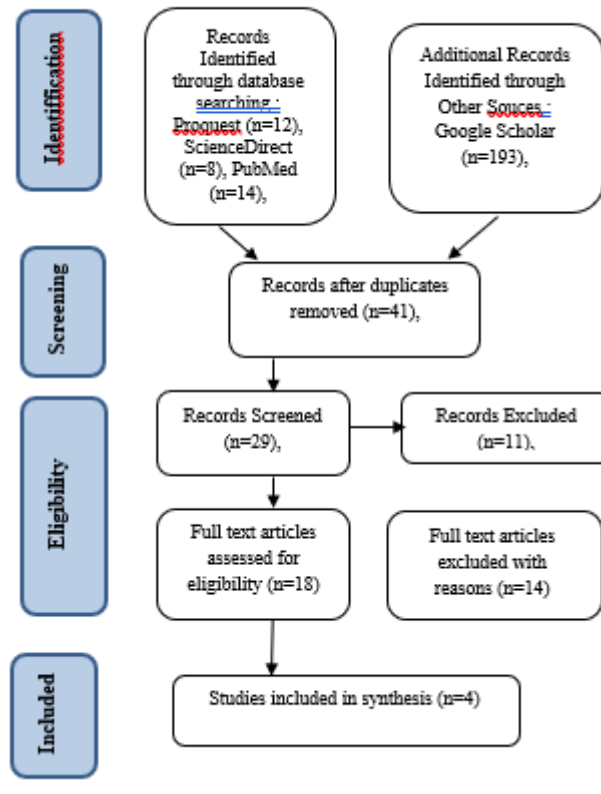
3. Selection of studies based on the PRISMA flowchart

Analysis of articles in the database was performed using article selection criteria based on the PICO approach (P = type 2 diabetes mellitus patients; I = interventions made using infrared thermographs; C = 0; O = expected outcome related to diabetic foot skin temperature assessment) with a PRISMA flowchart (Figure 1). 23 articles were deleted from 227 articles due to filtering results of academic journal articles; 186 articles out of 204 were excluded because they were not suitable. Document type: article and evidence-based health care, and the final search process resulted in four relevant articles.

4. Data Extraction

This search resulted in four main articles, which became the focus of analysis in the 2013–2023 period. The article compares a control group with an intervention group in a clinical trial.

Figure 1 PRISMA Flow diagram



RESEARCH METHODS

This research uses qualitative methods with a literature review approach. Literature review is a systematic, explicit and reproducible method for identifying, evaluating and synthesizing research works and thoughts that have been produced by researchers and practitioners. The step in writing this review literature begins with the selection of topics. Perform a library or source search to gather relevant information from Google Scholar, CINAHL, Proquest, Ebsco, or National Library databases. Determine keywords or keywords for journal searches. After the data is collected, it is processed, analyzed and conclusions drawn.

RESULTS AND DISCUSSION

Results

Meta-analysis Clinical trial Author and Years	Country	Patient Type	P value	Sample size	Outcome
Houghton <i>et al.</i> , 2013	Perth, Australia	Diabetic patients who are at high risk of developing ulcers	0,005	84	The use of infrared thermography is an important tool in the prevention of ulceration of the diabetic foot which can support the role of self-care in preventing foot ulceration.
Ena, <i>et al.</i> , 2021	USA & Norway	T2DM patients at high risk of developing foot ulcers (History of neuropathy, foot deformity or previous ulcer)	0,16	462	The use of an infrared thermometer can be added as a standard of care to reduce the incidence of foot ulcers in at-risk patients with a 95% confidence value.
Berner <i>et al.</i> , 2021	Italia	Healthy patient	0,0095	133	The use of infrared thermography can be used as an alternative technology for preoperative investigations with sensitivity values ranging from 73.7 - 100%
Araujo <i>et al.</i> , 2022	Brazil	T2DM patients at high risk of foot ulceration	0,08	828	Monitoring skin temperature in diabetic feet with the use of infrared thermography can contribute to clinical nursing & to interprofessional practice by identifying ulcerative processes, avoiding lower extremity amputations, improving individual quality of life and reducing health care burdens.

Discussion

The skin is an integumentary system that functions to maintain homeostasis in the internal environment and protect it from the external environment (Upadhyaya *et al.*, 2017). Damage to blood vessels, nerves, and increased collagen in skin tissue can cause integumentary system disorders (Prakasa, 2020). Examination of impaired skin integrity in diabetic feet is one of the early signs of metabolic disorders in diabetic patients (Murphy, Birn, & Bandettini, 2013). Neurosensory assessment of skin temperature using an imaging system can provide an overview of the spread of leg skin temperature to the skin structure so that it can provide information about widespread infections such as abscesses, myositis, and gangrene that cannot be assessed by clinical examination (Escudero-Sanchez *et al.*, 2020).

Neurosensory assessment of skin temperature with the use of infrared thermographs is an imaging technology tool that can detect complications associated with diabetic feet (Hernandez *et al.*, 2016). Assessment of skin temperature on diabetic feet using an infrared thermograph is a radiation detector in the infrared range of the electromagnetic spectrum that uses a thermal sensor to capture thermal radiation emitted or reflected to the skin (Karlidag-Dennis *et al.*, 2020). Assessment of foot temperature using an infrared thermograph can be an indication of abnormal physiological processes associated with several health conditions (Nogueira *et al.*, 2021). Examination of skin temperature using an infrared thermograph has several advantages, namely that it is safe and does not require physical contact so that it can recognize pathological situations, especially in diabetic feet (Ilo, *et al.*, 2020). The use of infrared thermographs can diagnose the presence of infection (Hazenber *et al.*, 2014), prevent injuries in disturbed areas (Astasio-Picado, Martínez, Nova, Rodríguez, & Gómez-Martín, 2018), assess clinical percentages and severity of perfusion (Traina *et al.*, 2021), assess differences in skin temperature (Chanjuan Liu *et al.*, 2015), and detect the onset of ischemic disorders (Staffa, Bernard, & Kubicek, 2016) in diabetic foot.

Foot assessment should begin as soon as the patient is diagnosed with diabetes (Dutra *et al.*, 2020). Delays in early identification and management of diabetic foot can lead to complications, so it

is necessary to prevent and treat diabetic foot with the approach of a multidisciplinary team of experts, including specialist doctors, specialist nurses, and community nurses (Das, 2020). Examination and inspection of the skin to determine signs of neuropathy in the legs and feet, especially on the dorsal, plantar, medial, lateral, and posterior surfaces; examination of toenails; the presence of skin can show whether the skin is peeling, macerating, or cracking. Palpate the pulse bilaterally in the dorsalis pedis, posterior tibial, popliteal, and superficial femoral arteries (Alexiadou & Doupis, 2012).

Neurosensory assessment of skin temperature with the use of infrared thermographs can be used by nursing staff or patients at home (Bozkurt et al., 2011). Infrared thermographs can also detect local temperature differences, spot color, and a higher mean temperature in diabetic feet, which are at high risk for neuropathy and neuroischemia. Infrared thermographs can also be useful as an initial screening for diabetic feet (Ilo, Romsis, & Makela, 2020). Neurosensory examination of skin temperature using an infrared thermograph requires specialist health workers who are able to operate this tool. Neglect, fatigue, and sensory overload can affect errors in diagnosing skin integrity disorders when using a thermograph (Cruz et al., 2020). Neurosensory examination using an infrared thermograph also requires a safe and comfortable environment with a room temperature of 21 - 24°C (Zenunaj et al., 2021). Changes in skin temperature are physiological indicators that can provide an overview of disease or injury and provide information about interactions between limbs and their environment (Soares et al., 2019).

The human body temperature can adapt when subjected to temperature changes caused by internal and external environmental factors. Vasodilation and vasoconstriction are the body's compensation for maintaining a constant body temperature and protecting skin integrity. If the body's physiological response is disrupted, the skin is unable to maintain balance, and the immunological function is disrupted, resulting in impaired skin integrity (Mifsud et al., 2022). One of the nursing model theories that focuses on individuals as holistic beings who can interact with their environment is Levine's conservation theory model (Alligood, 2017). Each individual has an internal and external environment; the internal environment includes the physiological and pathological aspects of the patient, as do changes in the external environment. Nursing practice involves human interaction with individuals who are unable to adapt (Alligood, 2021). The role of nurses is needed to help patients adapt to returning to a state of homeostasis in their social, personal, and biological environments (Michaelson, 2013).

Environmental factors in the form of temperature, humidity, and uncontrolled air flow on the skin surface can affect the structure and function of the skin, which can increase damage to the structural integrity, so that nursing actions are needed to detect inflammation before damage occurs to the skin tissue. Infrared thermograph assessment is an assessment that uses skin temperature as an indicator of skin tissue damage (Mifsud et al., 2022), so infrared thermographs can be used as an instrument in monitoring to prevent physiological changes in diabetic feet. Neurosensory assessment on infrared thermographs is very suitable for use by nurses to reduce workload and increase work efficiency. Infrared thermography is a technology that uses a low-cost infrared camera to detect changes in skin temperature (Cai et al., 2021). Advances in patient care technology can provide changes to nursing practice that can extend the patient's quality of life (Lewis et al., 2017).

CONCLUSION

Assessment of skin temperature on diabetic feet using a thermograph is an instrument that can be used as monitoring in nursing practice with structural integrity problems to prevent the risk of diabetic foot.

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