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Assessment of time required to reach plantar thermal acclimatisation in patients with diabetes.

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Abstract

Diabetic foot ulceration is a severe complication of diabetes that is preventable through early detection of pre-ulcerative changes. Infrared thermography is a non-invasive technique used to identify abnormal plantar temperature patterns associated with diabetic foot risk. Current guidelines recommend a minimum 15-minute acclimatisation period before imaging; however, acclimatisation duration remains variable in practice, and existing recommendations are based on absolute skin-temperature stabilisation rather than plantar asymmetry, a lack of standardisation identified as a barrier to the clinical adoption of diabetic-foot thermography. This prospective repeated-measures methodological study characterised plantar thermal acclimatisation in 41 adults with diabetes undergoing routine foot screening in a controlled clinical setting. Plantar thermal images were acquired every 30 seconds over a 15-minute period. Stabilisation was assessed using categorical inter-foot asymmetry (a temperature difference greater than 2.2°C), absolute plantar temperature, and inter-foot temperature difference. Categorical inter-foot asymmetry was stable from the initial measurement in 75% of participants, with a median stabilisation time of 0 seconds. Inter-foot temperature difference measures also stabilised immediately, with median and 75th percentile values of 0 seconds across all regions, whereas approximately 75% of participants reached stability in absolute temperature measures within 3.5 minutes. These findings suggest that clinically relevant asymmetry stabilises earlier than absolute temperature, providing evidence to re-examine fixed acclimatisation periods and informing more practical, clinically aligned protocols for diabetic foot screening.

INTRODUCTION

According to the World Health Organization (WHO), an estimated 830 million adults worldwide are living with diabetes [1]. These individuals face a significant risk of developing a wide range of complications, among which diabetic foot ulceration (DFU) is one of the most prevalent and clinically severe [2, 3]. Epidemiological evidence suggests that approximately one in three individuals living with diabetes will experience a DFU at some point in their lives, with reported rates of around 40% of recurrence within the first year [4, 5]. In addition to its clinical burden, diabetic foot disease constitutes the largest component of diabetes-related healthcare expenditure [5]. A growing body of evidence demonstrates that both diabetic foot ulcers and their associated amputations are largely preventable, as preventive foot care and early treatment shown to be clinically effective and cost saving in reducing severe outcomes [5, 6].

Infrared thermography (IRT) is a non-invasive, contactless imaging modality that detects infrared radiation emitted from the skin surface to generate a visual map of temperature distribution [7]. IRT offers an indirect assessment of superficial blood flow and inflammation, since areas of increased perfusion or metabolic activity manifest as localized heat. Unlike anatomical imaging (e.g., MRI or X-ray) thermography visualizes physiological changes that often precede structural damage [8, 9]. These capabilities have established IRT as a valuable tool across diverse medical disciplines, including monitoring neovascularization in oncology, assessing peripheral vascular disease, identifying inflammatory processes in sports medicine, and evaluating tissue viability in complex wound care [10].

Particularly, infrared thermography research in the diabetic foot dates back to the late 1960s, with minimal activity until a substantial expansion in the last decade, reflecting continued interest and new developments

[11]. In this context, the primary clinical value of thermography lies in its ability to facilitate early detection of diabetic foot abnormalities through the analysis of plantar temperature patterns, asymmetries in contralateral regions, and localized thermal changes over time [12, 13]. Alterations in skin temperature may reflect impaired perfusion due to peripheral vascular disease, inflammatory responses, or tissue injury caused by repetitive mechanical stress, which often remains unnoticed in the presence of diabetic peripheral neuropathy [14]. Accordingly, the application of thermal imaging in diabetic foot care is based on the premise that abnormal plantar temperature distributions are closely associated with the development of diabetic foot complications, including ulceration [15–19]. In particular, inter-foot temperature asymmetry exceeding approximately 2.2°C has been shown to predict pre-ulcerative conditions [15–19].

Conducting infrared thermography requires adherence to standardized protocols to ensure that temperature measurements are accurate and reliable. Accordingly, professional bodies such as the American Academy of Thermology (AAT), the International Academy of Clinical Thermology (IACT), and the Thermographic Imaging in Sports and Exercise Medicine (TISEM) consensus have published guidelines outlining best practices for thermographic imaging [20–22]. These guidelines provide recommendations across multiple domains, including imaging environment, equipment specifications, patient preparation and analysis. A key component of these protocols is the acclimatisation period, defined as the time required for the patient's skin surface temperature to reach thermal equilibrium with a controlled ambient environment [20–22]. Collectively, the guidelines recommend a minimum acclimatisation period of 15 minutes for thermographic imaging across a wide range of medical and sports applications [20–22]. Despite this, acclimatisation duration is not standardised in practice, with studies reporting equilibration periods ranging from 5 and up to 60 minutes across diverse clinical and experimental contexts [23]. This lack of standardisation in acclimatisation protocols has been identified as a barrier to the clinical adoption of diabetic-foot thermography [24].

The recommended 15-minute acclimatisation period may have been influenced by early standardisation work in medical infrared thermography. In a foundational protocol paper in 2002, Ring and Ammer suggested that approximately 15 minutes, with 10 minutes as a minimum, was sufficient to allow skin temperature stabilisation under controlled conditions [25]. By citing earlier thermography studies that adopted similar conditioning periods, this work likely contributed to the establishment of this timeframe as a conventional standard through protocol inheritance. Studies that have empirically measured acclimatisation time have reported varying recommended durations, including 8, 10, 15, and 16 minutes [26–29]. However, across these investigations, a consistent methodological approach was used, whereby thermal stabilisation was defined based on the mean absolute skin temperature within a predefined region of interest (ROI), with acclimatisation considered complete once this mean temperature reached a plateau [26–29].

Notably, despite recommending a 10-minute acclimatisation period, Marins et al. found that all ROIs in men stabilised within approximately 2 minutes, while women exhibited longer and heterogeneous acclimatisation patterns across body regions [26]. However, plantar foot regions were not included among the ROI in this study, leaving foot-specific acclimatisation dynamics unexamined. Accordingly, the present study aims to characterise acclimatisation time for the plantar foot. Furthermore, given that clinical interpretation of diabetic foot thermography is driven by relative temperature asymmetries this study also investigates the effect of acclimatisation duration on inter-foot temperature asymmetry.

STUDY AIM AND OBJECTIVES

Primary Aim

To determine the time required for thermal stabilisation using clinically relevant temperature metrics.

METHODS

Study Design

This was a single-centre, prospective, repeated-measures methodological study conducted at King Salman Hospital in Riyadh, Saudi Arabia. A total of 41 adult patients with a diagnosis of diabetes mellitus undergoing routine diabetic foot screening were recruited. Thermographic data were collected between October and November 2025. This study was conducted and reported in accordance with the Strengthening the Reporting of Observational Studies in Epidemiology (STROBE) guidelines [30].

Ethical Considerations

The study was conducted in accordance with the principles of the Declaration of Helsinki (2013). Ethical approval was obtained from the Ministry of Health (MOH) Ethics Board, Research Ethics Committee, General Directorate of Research and Studies, King Saud Medical City Institutional Review Board (IRB registration: H1RI-17-Sep25-01). All participants received detailed information about the study and provided written informed consent prior to enrolment, including consent for the use of their data for publication. Participants were offered gift cards as an incentive for participation.

Participants

Adult patients with a diagnosis of diabetes mellitus (type 1 or type 2), aged 18 years or older, and undergoing routine diabetic foot screening were eligible for inclusion.

Exclusion criteria included the presence of active foot ulceration, acute foot infection, prior lower-extremity amputation, Charcot neuroarthropathy, or any other condition likely to confound thermographic assessment of diabetic foot risk. Patients who were unable to provide informed consent were also excluded.

Eligible participants were identified during routine diabetic foot screening clinics and invited to attend a scheduled appointment for thermographic imaging.

Data Collection

Thermographic data were collected using a standardised imaging protocol informed by the American Academy of Thermology (AAT) guidelines [20], with the exception of the acclimatisation duration. Data collection took place in a temperature-controlled clinical environment at King Salman Hospital, Riyadh, Saudi Arabia. To ensure consistent imaging conditions, ambient room temperature was maintained between 21°C

and 24°C throughout all imaging sessions. All data were acquired by trained healthcare professionals following the standardised imaging procedure [20].

Thermal images were acquired using the TFScan thermal imaging system (Amplifai Health LTD, Saudi Arabia) incorporating a FLIR ONE Edge Pro camera (FLIR Systems, Sweden). The device was positioned at a fixed distance of one metre from the participant and aligned perpendicular to the plantar surface of both feet. Upon arrival, participants were instructed to remove shoes and socks, sit comfortably on a hospital bed, and keep their feet stationary for the duration of the imaging protocol. Thermographic images were captured at 30-second intervals over a total acclimatisation period of 15 minutes. For each image, temperature data were extracted from predefined plantar regions of interest corresponding to the angiosome territories of the lateral calcaneal artery (LCA), medial calcaneal artery (MCA), lateral plantar artery (LPA), and medial plantar artery (MPA). For each foot and region, maximum, minimum, and mean temperatures were recorded. Inter-foot thermal asymmetry was calculated by comparing corresponding regions between the left and right feet. All thermographic analyses were performed using the TFScan software platform (AmplifAI Health Ltd., Saudi Arabia).

In parallel with thermographic imaging, demographic and clinical data were collected by trained healthcare professionals using a structured questionnaire. Collected variables included age, sex, anthropometric measurements (height, weight), lifestyle factors (smoking status), and diabetes-specific characteristics (type of diabetes and duration since diagnosis). Additional clinical information included the presence of cardiovascular comorbidities, peripheral artery disease, diabetic neuropathy, diabetes-related complications (retinopathy, chronic kidney disease), Loss of protective sensation (LOPS) related symptoms (unsteadiness during walking, pain or tenderness, numbness, and tingling or prickling sensations), foot-specific conditions (onychomycosis, gangrene, Charcot neuroarthropathy), and the most recent HbA1c value.

Statistical Analysis

Statistical analyses were performed using R version 4.2.2 (R Foundation for Statistical Computing, Vienna, Austria). Baseline demographic, clinical, and thermographic variables were summarised using appropriate descriptive statistics. The primary analysis assessed temporal changes in inter-foot thermal asymmetry and absolute plantar temperature during the 15-minute acclimatisation period. The stabilisation criteria applied to each metric are illustrated schematically in Fig. 1.

Inter-foot thermal asymmetry was defined as the presence of a plantar region exhibiting a temperature difference greater than 2.2°C compared with the corresponding region on the contralateral foot. For the categorical asymmetry variable, stabilisation was defined as the earliest time point at which the asymmetry status (presence or absence of asymmetry) became constant and remained unchanged for the remainder of the recording period (Fig. 1a).

For absolute plantar temperature measures, stabilisation was assessed using a reference-value approach applied to each time series. For each variable, a reference temperature was defined as the mean of the final five measurements obtained during the recording period. Stabilisation time was defined as the earliest time point at which the temperature entered and remained within a predefined tolerance range of ± 5% of the

reference value for the remainder of the recording (Fig. 1b). Stabilisation times were determined separately for whole-foot mean temperature and for each angiosome-level plantar region, on a per-participant basis.

For inter-foot temperature difference measures, stabilisation was assessed using a reference-value approach applied to each time series. For each variable, a reference value was defined as the mean of the final five measurements obtained during the recording period. Stabilisation time was defined as the earliest time point at which the delta value entered and remained within a predefined absolute tolerance range of ± 1.0°C relative to the reference value for the remainder of the recording (Fig. 1c). Stabilisation times were calculated separately for whole-foot and angiosome-level delta measures on a per-participant basis.

Repeated-measures analysis of variance (ANOVA) was used to evaluate within-subject changes in thermographic measures over time. To identify the point at which thermal measurements stabilised, time-series curve fitting approaches were employed to model temperature trajectories and determine when changes plateaued. Missing data, where present, were handled using multiple imputation methods to minimise bias and preserve the integrity of the dataset.

Schematic illustration of the stabilisation criteria applied to categorical asymmetry, absolute plantar temperature, and inter-foot temperature difference measures.

RESULTS

Participant

A total of 41 participants were included in the final analysis. The mean age was 51.2 ± 15.8 years, with a slightly higher proportion of males (56%) than females (44%). Participants had a mean body mass index of 28.5 ± 7.7 kg/m². The majority had type 2 diabetes (75.6%), with a mean diabetes duration of 13 ± 8.7 years and a mean HbA1c of 8.5 ± 2%. Cardiovascular disease was present in 46.3% of participants, while diabetic retinopathy, neuropathy, and peripheral artery disease were reported in 19.5%, 14.6%, and 12.2% of participants, respectively. Symptoms consistent with Loss Of Protective Sensation (LOPS) prevalent in the past two weeks were common, including walking imbalance (46.3%), numbness (41.5%), tingling (39%), and burning pain (29.2%). The detailed demographic and clinical characteristics of the participants are summarized in Table 1.

Table 1. Demographic and clinical characteristics of participants (N=41)

Characteristic	Value
Age, Mean (SD)	51.2 (15.8)
Sex	
Female, n (%)	18 (44)
Male, n (%)	23 (56)
Height (cm), Mean (SD)	163.8 (9.1)
Weight (kg), Mean (SD)	76.3 (22.2)
Body mass index (kg/m^2), Mean (SD)	28.5 (7.7)
Diabetes Type	
Diabetes Type 1, n (%)	10 (24.4)
Diabetes Type 2, n (%)	31 (75.6)
Diabetes duration (years), Mean (SD)	13.0 (8.7)
Glycated Haemoglobin HbA_{1c} (%), Mean (SD)	8.5 (2.0)
Comorbidities	
Cardiovascular Diseases, n (%)	19 (46.3)
Retinopathy, n (%)	8 (19.5)
Neuropathy, n (%)	6 (14.6)
Peripheral Artery Disease, n (%)	5 (12.2)
Chronic Kidney Disease, n (%)	2 (4.9)
Poor Glucose Control, n (%)	5 (12.2)
Symptoms of Loss Of Protective Sensation in the past two weeks	
Walking Imbalance, n (%)	19 (46.3)
Burning Pain, n (%)	12 (29.2)
Tingling, n (%)	16 (39)
Numbness, n (%)	17 (41.5)

Asymmetry

Across the participants, the median stabilisation time for thermal asymmetry was 0 seconds, reflecting that 31 of the 41 participants showed no change in asymmetry status from the initial measurement onward. The mean stabilisation time was 94.4 seconds (SD 231.3 seconds), with values ranging from 0 to 870 seconds. Percentile analysis, as illustrated in Figure 1, demonstrated that stabilisation occurred rapidly for the majority of participants, with 80% stabilising within 60 seconds. Stabilisation times increased progressively in the

upper tail of the distribution, reaching 270 seconds at the 90th percentile, with prolonged stabilisation confined to a smaller subset of participants.

Absolute variables

Across all absolute plantar temperature measures, stabilisation times were concentrated at early time points for most participants, with median values at or close to zero seconds for both whole-foot and regional measurements. Across variables, the 75th percentile of stabilisation time was generally within 3.5 minutes of recording, indicating early temperature stabilisation for the majority of participants. Table 2 provides detailed stabilisation times for each plantar region, showing that while stabilisation occurred rapidly for most participants, regional heterogeneity contributed to longer stabilisation times in a limited subset. As illustrated in Figure 2, the majority of observations clustered within the initial minutes, whereas a smaller proportion of participants exhibited delayed stabilisation across several plantar regions.

Table 2. Stabilisation times in seconds for absolute plantar temperature measures across whole-foot and angiosome-level regions using a ±5% threshold (N=41). (a) Mean Foot Temperature. (b) lateral plantar artery. (c) medial calcaneal artery. (d) lateral calcaneal artery. (e) medial plantar artery.

Variable	Median	Mean (SD)	75th %ile	90th %ile	95th %ile
Left MFT[a]	0	84.8 (142.9)	127.5	216.0	313.6
Right MFT	15	96.8 (145.6)	180.0	240.0	313.6
Left LPA[b]	75	119.3 (160.6)	157.5	312.0	484.6
Right LPA	45	121.6 (159.0)	210.0	246.0	400.0
Left MCA[c]	0	63.8 (99.4)	97.5	183.0	273.0
Right MCA	45	92.3 (128.1)	150.0	210.0	391.5
Left LCA[d]	45	92.3 (127.2)	150.0	243.0	301.5
Right LCA	60	111.8 (151.5)	180.0	273.0	372.0
Left MPA[e]	0	95.3 (152.7)	150.0	219.0	484.5
Right MPA	15	95.3 (144.5)	157.5	240.0	313.6

Delta variables

Across all inter-foot temperature difference measures, stabilisation times were similarly concentrated at early time points for most participants, with median values of 0 seconds across whole-foot and angiosome-level delta measures. For the majority of variables, the 75th percentile of stabilisation time occurred from the initial measurement, indicating that relative temperature differences stabilised quickly for most participants. Table 3 presents detailed stabilisation times for each delta measure, showing that while stabilisation was rapid in most cases, a limited number of participants exhibited prolonged stabilisation times. As shown in Figure 3,

stabilisation times were tightly clustered at early time points, with delayed stabilisation restricted to the upper tail of the distribution across selected regions.

Table 3. Stabilisation times in seconds for inter-foot temperature delta measures across whole-foot and angiosome-level regions (N = 41). (a) Mean foot temperature delta. (b) Lateral calcaneal artery delta. (c) Medial calcaneal artery delta. (d) Lateral plantar artery delta. (e) Medial plantar artery delta.

Variable	Median	Mean (SD)	75th %ile	90th %ile	95th %ile
MFT[a] delta	0	12.0 (54.7)	0	0	9.0
LCA[b] delta	0	34.5 (97.6)	0	183.0	244.5
MCA[c] delta	0	18.0 (82.2)	0	0	13.5
LPA[d] delta	0	22.5 (87.5)	0	3.0	127.5
MPA[e] delta	0	5.3 (33.2)	0	0	0

DISCUSSION

Principal Findings

This study examined plantar foot thermographic acclimatisation with a specific focus on how acclimatisation time affects inter-foot temperature asymmetry. Overall, stabilisation occurred rapidly for most participants across categorical asymmetry, absolute temperature, and inter-foot delta measures, while a smaller subset demonstrated longer acclimatisation times.

For categorical asymmetry, 75% of participants showed a stable asymmetry status from the initial measurement (0 seconds), indicating that the presence or absence of a clinically relevant inter-foot temperature difference (≥ 2.2 °C) was established early in most cases. The remaining participants exhibited changes over time, with stabilisation extending up to 870 seconds (14.5 minutes) in the most extreme case. Absolute plantar temperature measures showed a similar pattern: median stabilisation times were between 0 and 75 seconds for whole-foot and angiosome-level regions, with approximately 75% of participants stabilising within the first 3.5 minutes, while a limited subset required longer. Inter-foot temperature delta measures also stabilised early for most participants (median 0 seconds across regions), with prolonged stabilisation confined to a small number of cases.

Notably, to our knowledge, this study is the first to characterise foot-specific thermographic stabilisation dynamics through an asymmetry-focused lens. Prior thermographic acclimatisation studies had examined whole-body or regional skin temperatures but did not include plantar foot regions [26–29]. We extend this literature by providing granular data on the plantar angiosomes and, critically, by evaluating stabilisation in terms of clinically relevant inter-foot asymmetry. This approach is novel and directly aligned with diabetic foot ulcer screening practice. Our results reveal that although absolute plantar temperatures and foot-to-foot

differences undergo initial fluctuations post-exposure, the determination of whether a pathological asymmetry exists is usually apparent almost immediately and remains constant in the majority of cases.

Interpretation of Findings

The early temperature stabilisation observed in most participants is physiologically plausible. Following removal of shoes and socks, the feet are rapidly exposed to ambient conditions, and initial thermal transients are likely to occur within the first few minutes. As peripheral structures, the feet may exhibit prompt vasomotor responses when uncovered, allowing skin temperatures to approach a new steady state relatively quickly under controlled conditions.

Despite this overall pattern, some angiosome-level variability was observed, with certain plantar regions stabilising at different rates. This heterogeneity may reflect local differences in perfusion, tissue composition, skin thickness, pressure distribution, or diabetes-related microvascular dysfunction. Prolonged stabilisation in a small subset of participants likely reflects physiological and environmental factors, such as recent physical activity, footwear characteristics, or prior thermal exposure, that can delay equilibration through persistent alterations in blood flow.

Importantly, even when absolute temperatures or delta measures continued to adjust, inter-foot temperature differences generally remained stable. This suggests that bilateral thermoregulatory responses tend to occur in parallel, resulting in ongoing changes in absolute values while preserving a relatively constant temperature gap between feet. Such behaviour is consistent with normal thermoregulation, whereas clinically meaningful unilateral inflammatory changes would be less prone to short-term fluctuation.

Clinical Rationale for Focusing on Asymmetry

Prior work has shown that side-to-side temperature differences in healthy individuals are typically small, with differences up to approximately 0.83°C often reflecting physiological changes or measurement noise, whereas diabetic patients without complications exhibited mean asymmetries between 1.1°C and 1.8°C across similar regions [31]. Accordingly, diabetic foot screening does not rely on absolute skin temperature but on the inter-foot temperature difference, with a contralateral asymmetry greater than 2.2°C serving as the established threshold for pre-ulcerative risk [15–19]. Because asymmetry is a relative measure, it is intrinsically robust to global thermal drift: when both feet cool or warm in parallel during exposure to ambient conditions, the between-foot difference is preserved even while absolute values continue to change. The clinically actionable signal is therefore expected to stabilise before absolute temperatures do, which is precisely the pattern observed in this study. Anchoring acclimatisation requirements to the stability of the asymmetry metric, rather than to absolute-temperature plateau, aligns the protocol with the actual decision rule used in diabetic foot risk stratification.

Comparison with Guidelines and Prior Literature

Current thermography guidelines generally recommend a 15-minute acclimatisation period before imaging [20–22]. Our findings shed new light on this guideline. We observed that for most individuals, particularly with respect to asymmetry, waiting the full 15 minutes may be more than necessary, as the critical diagnostic information (presence of a hotspot) was usually evident almost immediately. In fact, by 3 to 4 minutes into the acclimatisation period, the majority of participants had reached stability. This suggests that the standard 15-

minute duration is a conservative safety margin, likely chosen to cover virtually all possible scenarios and body regions. For the specific purpose of detecting inter-foot abnormalities, our results indicate that lengthy equilibrium times are often not required.

This aligns with Majano et al's recent pilot where they reported that during a 10-minute acclimatisation period, thermal asymmetry showed no meaningful change for most muscle groups [32]. The authors argued that acclimatisation may be unnecessary when the clinical aim is primarily asymmetry screening in many regions [32]. Although plantar foot regions were not included in their analysis, this interpretation closely parallels our observations in the diabetic foot.

In contrast, Sun et al. examined plantar temperature dynamics using inferential stability criteria and recommended a 10-minute acclimatisation period for clinical thermographic assessment [28]. Their findings support a conservative fixed duration when the primary endpoint is absolute plantar temperature, particularly at the subregional level. Methodologically, Sun et al. defined stabilisation as statistical non-difference across time points, whereas our approach quantified stabilisation at the individual level using continuous sampling and predefined stability criteria. This allowed us to characterise both rapid stabilisation in the majority and the presence of a long upper tail. Taken together, this suggests that apparent differences in recommended acclimatisation times reflect variation in anatomical targets and stabilisation definitions. Our work extends the literature by distinguishing between physiological equilibration of absolute temperatures and the earlier stabilisation of clinically relevant inter-foot asymmetry.

Implications for Practice and Future Directions

A prolonged acclimatisation requirement may have workflow consequences in routine diabetic foot screening. In clinical settings, extended waiting periods can reduce throughput and lengthen appointments, creating bottlenecks that could limit scalability. For clinicians, this additional time increases perceived workload and can reduce the practical feasibility of thermographic screening, while for patients it introduces waiting and inconvenience that may diminish acceptability. Together, these factors can undermine satisfaction and act as barriers to sustained adoption in real-world practice. In this context, our findings suggest that shorter acclimatisation periods have the potential to reduce time burden, improve workflow fit, and support wider uptake, provided diagnostic integrity is maintained.

Building on these findings, several avenues for future research are recommended. Validation in larger, multi-centre cohorts and across diverse environmental and clinical settings to establish generalisable reference ranges for plantar thermographic acclimatisation. Identifying clinical or demographic predictors of prolonged stabilisation, such as peripheral arterial disease, neuropathy, or recent activity, would help clarify which patients are more likely to require longer conditioning. Further work is also needed to evaluate the clinical and operational impact of varying acclimatisation duration, including whether shorter intervals preserve diagnostic concordance for asymmetry detection and improve workflow efficiency. Finally, as technology advances, we envision incorporating our results into evidence-informed guidelines and updated protocols that might endorse a shorter or flexible acclimatisation period.

Strengths and Limitations

This study was conducted in a real-world clinical setting among patients with diabetes, enhancing its relevance to routine practice, and employed high-resolution thermal imaging at 30-second intervals across predefined plantar angiosomes to capture detailed temporal and regional stabilisation patterns. The use of multiple complementary stabilisation definitions provides a clinically grounded assessment of acclimatisation dynamics, and the specific focus on the plantar foot addresses an important gap in the existing thermography literature. Standardised acquisition under controlled ambient conditions further supports internal validity. However, the single-centre design, and the uncalculated and small sample size may limit generalisability to other settings or climates. Acclimatisation was capped at 15 minutes in line with current guidance, precluding assessment beyond this window in a small subset of participants. Exclusion of individuals with active foot ulcers or acute infection limits extrapolation to advanced diabetic foot disease, and potential influences of patient characteristics or pre-imaging factors could not be fully explored.

CONCLUSION

This study shows that plantar thermographic stabilisation in people with diabetes occurs earlier than implied by conventional fixed acclimatisation protocols, particularly when assessment is focused on clinically relevant inter-foot asymmetry. In 75% of the participants, asymmetry status was established from the initial measurement and remained stable thereafter, while absolute plantar temperature measures generally stabilised within 3.5 minutes. These findings suggest that the diagnostic signal most relevant to diabetic foot screening stabilises earlier than absolute temperature-based measures. Taken together, the results support re-examining plantar thermography protocols through an asymmetry-centred lens and provide an empirical basis for exploring shorter, more practical acclimatisation approaches that could improve workflow efficiency while preserving diagnostic integrity.

Declarations

Ethics Approval and Consent to Participate

The study was conducted in accordance with the principles of the Declaration of Helsinki (2013). Ethical approval was obtained from the Ministry of Health (MOH) Ethics Board, Research Ethics Committee, General Directorate of Research and Studies, King Saud Medical City Institutional Review Board (IRB registration: H1RI-17-Sep25-01). All participants received detailed information about the study and provided written informed consent prior to enrolment, including consent for the use of their data for publication. Participants were offered gift cards as an incentive for participation.

Consent for publication

Not applicable.

Availability of data and materials

The datasets generated and analysed during the current study are not publicly available due to institutional and ethical restrictions but are available from the corresponding author on reasonable request, subject to approval by the relevant ethics committee.

Competing interests

MFA and MA are employees and shareholders of Amplifai Health.

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Authors' contributions

MA, HI, FA and MFA conceived the study. MA, HI, OMA, MFA and RA designed the methodology and OMA and RA supervised data collection. MA, FA and HI performed the data analysis. MFA, OMA, RA and HI wrote the manuscript and MA, FA and HI prepared figures 1-3. All authors contributed to manuscript revision, read, and approved the final version.

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Figures

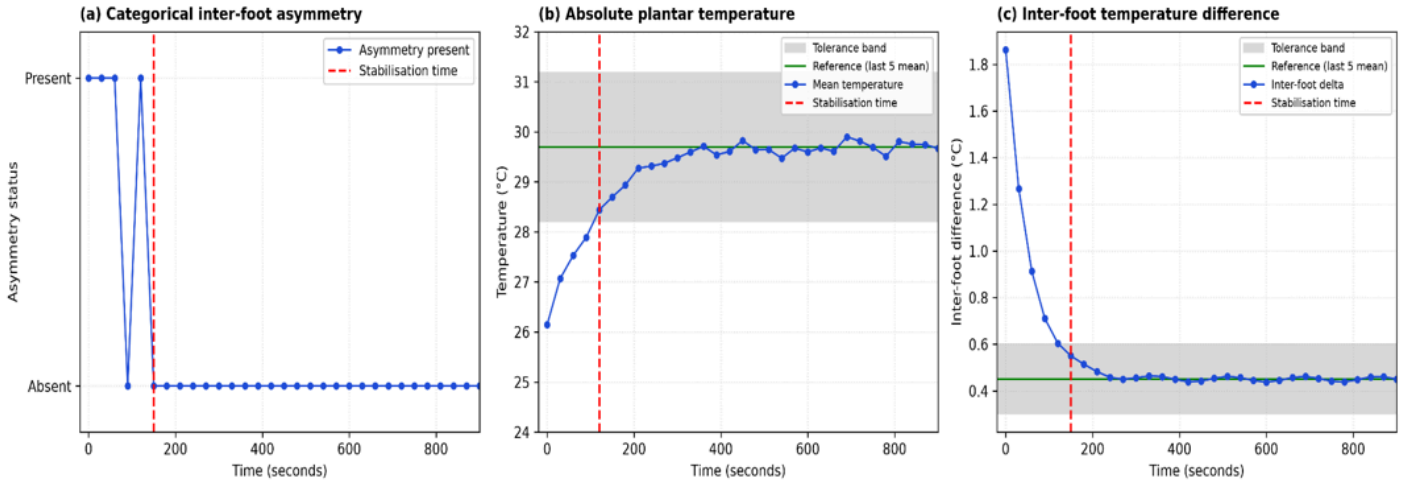


Figure 1

Schematic illustration of the stabilisation criteria applied to categorical asymmetry, absolute plantar temperature, and inter-foot temperature difference measures.

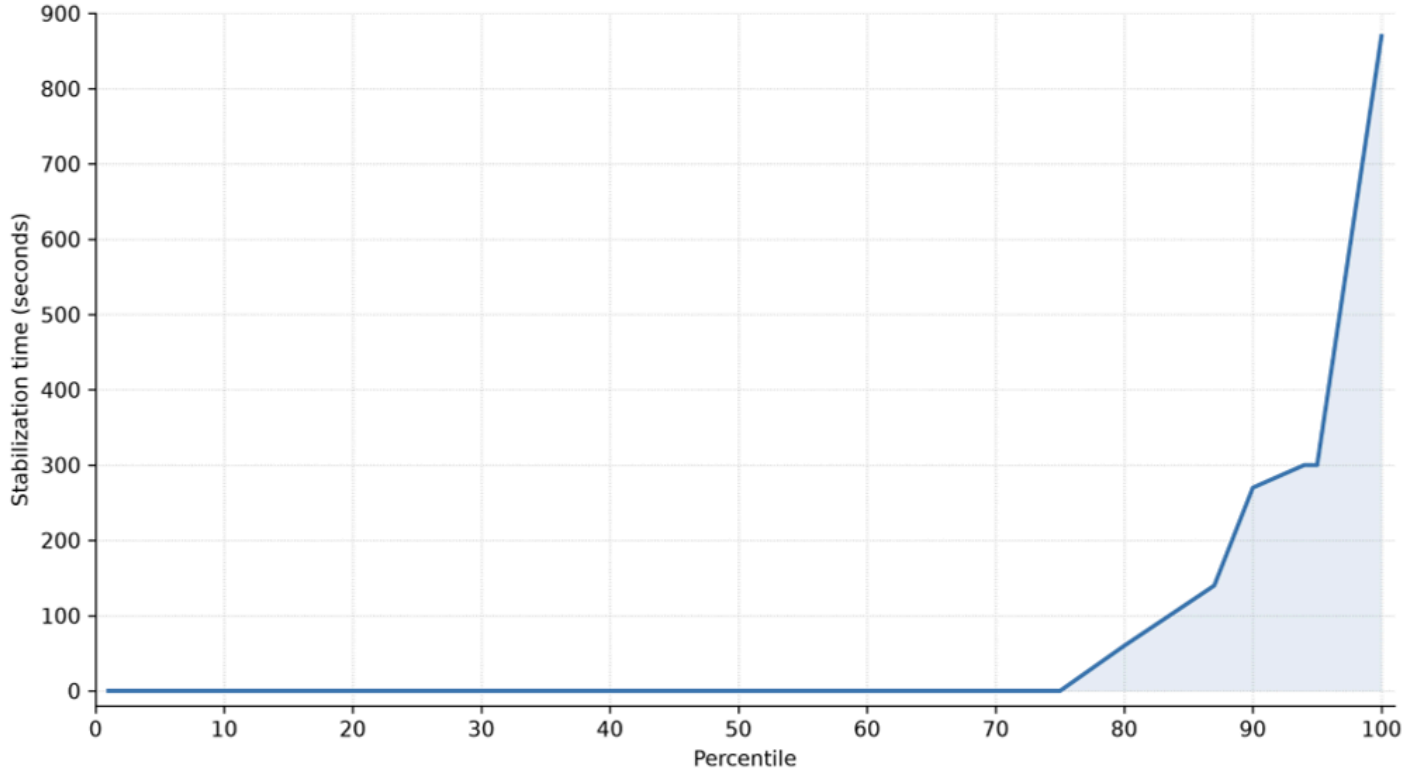


Figure 2

Percentile distribution of stabilisation time for foot thermal asymmetry across participants

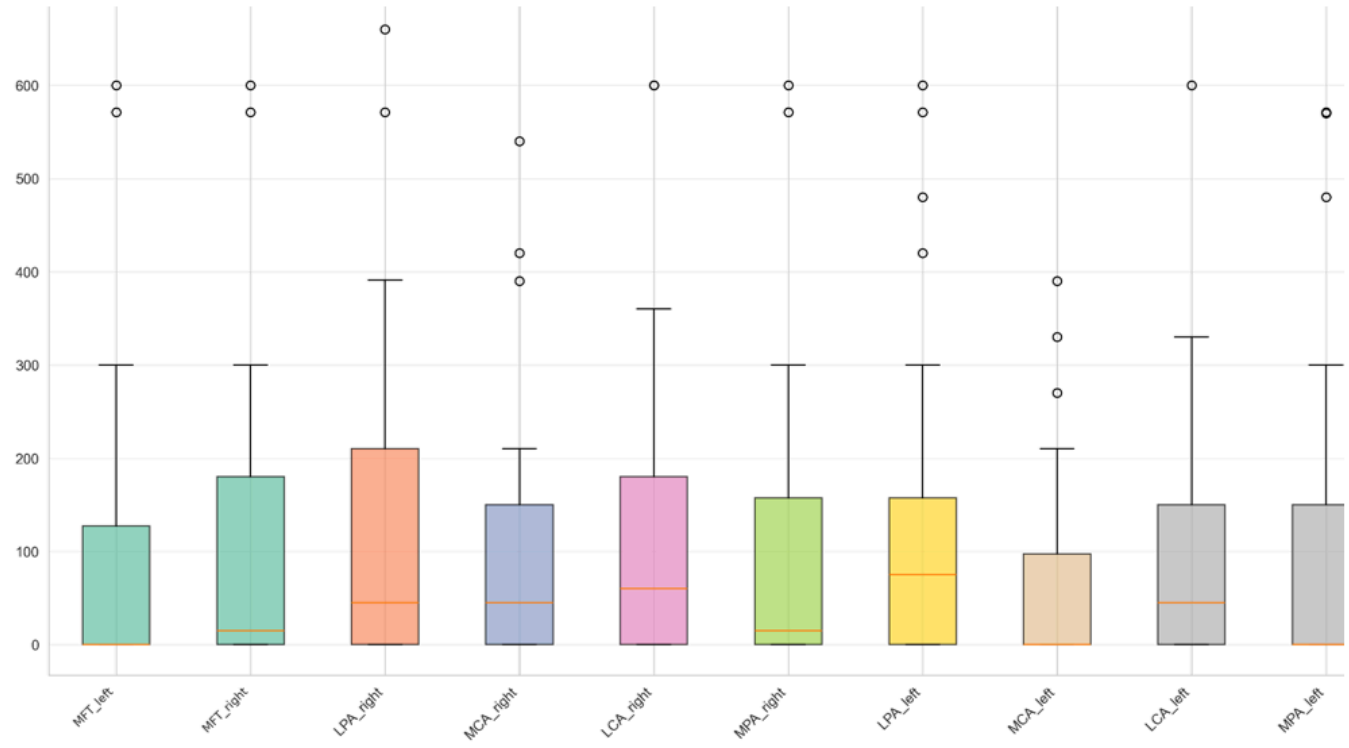


Figure 3

Boxplot distribution of stabilisation times for absolute plantar temperature measures across whole-foot and angiosome-level regions

Fig. 4

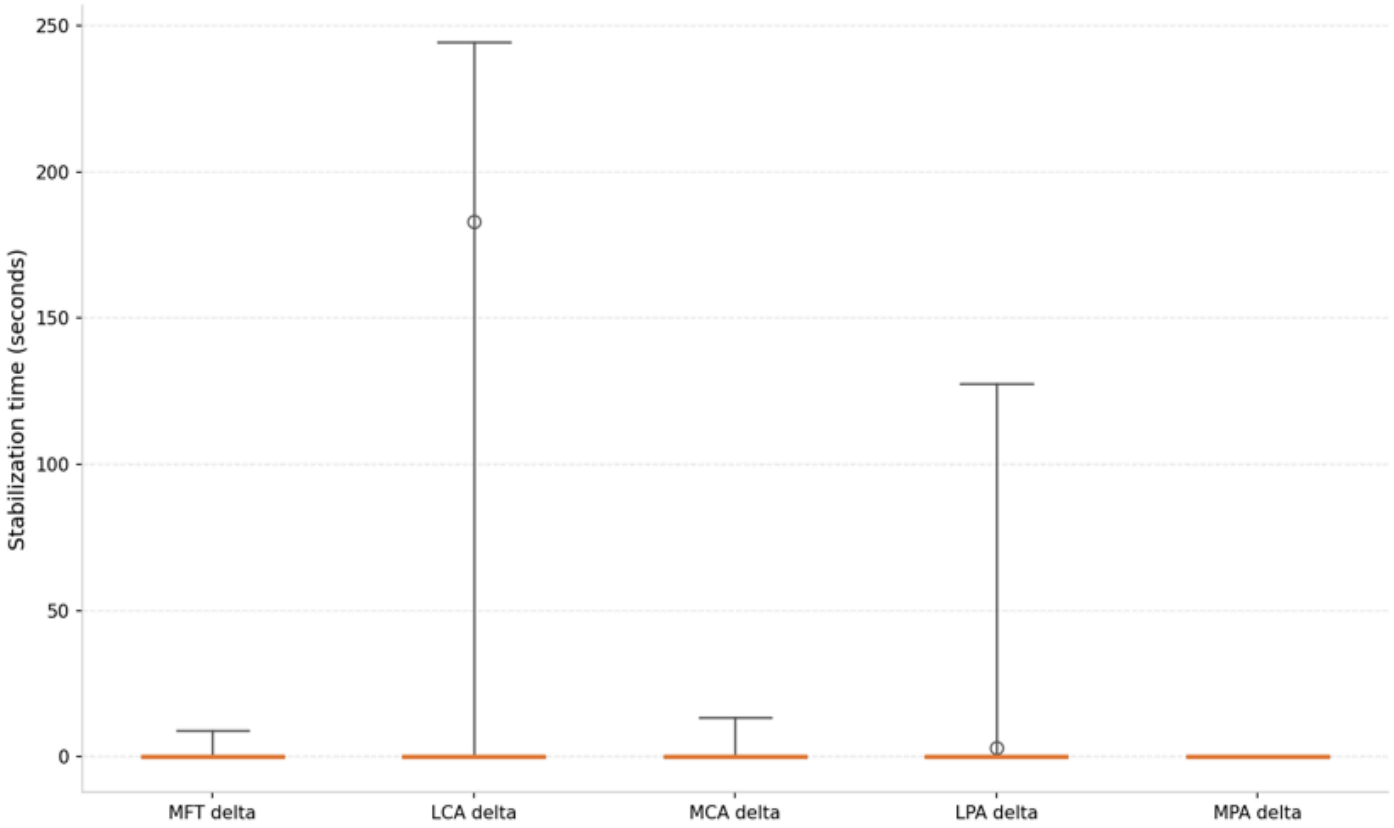


Figure 4

Boxplot distribution of stabilisation times for inter-foot temperature delta measures across whole-foot and angiosome-level regions

Supplementary Files

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- STROBEchecklistv4combined.docx