



# Cold immersion recovery responses in the diabetic foot with neuropathy

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PERIODE 2 MEI 2023 – 3 JUNI 2023

# IDENTITAS JURNAL

- **Judul** : Cold Immersion Recovery Responses in the Diabetic Foot with Neuropathy
- **Tahun** : 2008
- **Penerbit** : International Wound Journal
- **Penulis** : Manish Bharara, Vijay Viswanathan, Jonathan E Cobb



## Cold immersion recovery responses in the diabetic foot with neuropathy

Manish Bharara, Vijay Viswanathan, Jonathan E Cobb

Bharara M, Viswanathan V, Cobb JE. Cold immersion recovery responses in the diabetic foot with neuropathy. *Int Wound J* 2008;5:562–569.

### ABSTRACT

The aim of this article was to investigate the effectiveness of testing cold immersion recovery responses in the diabetic foot with neuropathy using a contact thermography system based on thermochromic liquid crystals. A total of 81 subjects with no history of diabetic foot ulceration were assigned to neuropathy, non neuropathy and healthy groups. Each group received prior verbal and written description of the test objectives and subsequently underwent a comprehensive foot care examination. The room temperature and humidity were consistently maintained at 24°C and less than 50%, respectively, with air conditioning. The right foot for each subject was located on the measurement platform after cold immersion in water at 18–20°C. Whole-field thermal images of the plantar foot were recorded for 10 minutes. Patients with diabetes with neuropathy show the highest 'delta temperature', that is difference between the temperature after 10-minute recovery period and baseline temperature measured independently at all the three sites tested, that is first metatarsal head (MTH), second MTH and heel. This clinical study showed for the first time the evidence of poor recovery times for the diabetic foot with neuropathy when assessing the foot under load. A temperature deficit (because of poor recovery to baseline temperature) suggests degeneration of thermoreceptors, leading to diminished hypothalamus-mediated activity in the diabetic neuropathic group.

**Key words:** Cold immersion • Diabetic foot • Liquid crystal thermography • Recovery rate • Thermometry • Ulcer

### Key Points

- diabetic foot is the most commonly occurring complication of diabetes mellitus
- despite technological advances in the prevention and treatment of diabetic foot complications, the incidence remains unacceptably high
- prevention of foot ulcers by identifying individuals at high risk represents the most effective way of reducing the incidence of lower limb amputation in diabetic patients

### INTRODUCTION

Diabetic foot is the most commonly occurring complication of diabetes mellitus. The term 'diabetic foot' refers to complications of the foot specific to the diabetic, distinctive underlying factors, which include peripheral neuropathy

and peripheral vascular disease (PVD). Details related to the important socioeconomic consequences of the diabetic foot disease are widely published (1). Despite technological advances in the prevention and treatment of diabetic foot complications, the incidence remains unacceptably high. Prevention of foot ulcers by identifying individuals at high risk represents the most effective way of reducing the incidence of lower limb amputation in diabetic patients (2–4).

Current methods for determination of the risk of foot ulceration are the assessment of circulation, neuropathy and foot pressure. These methods are widely used clinically as well as in the research domain. Patients with long-



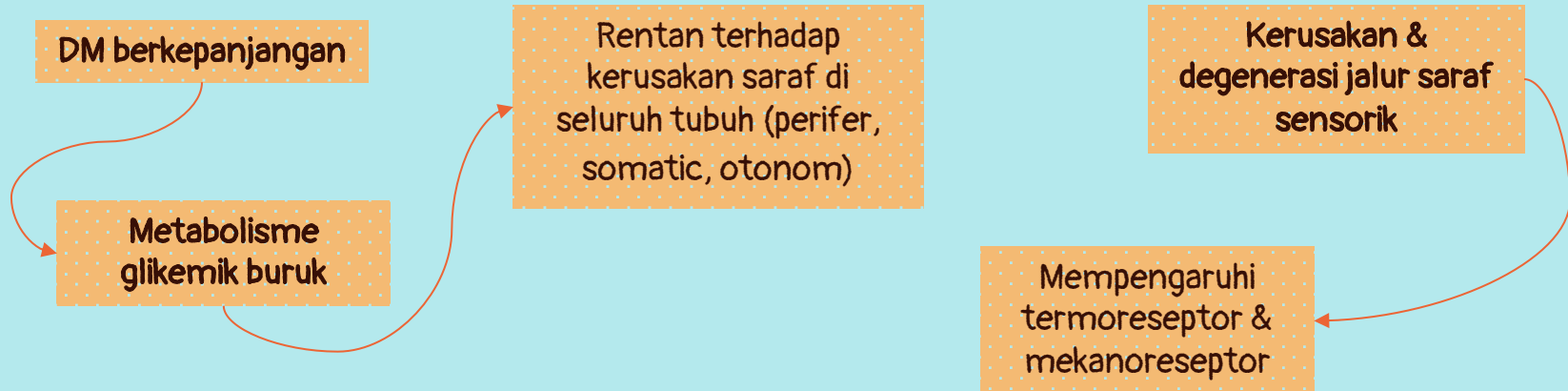
01

# PENDAHULUAN



# PENDAHULUAN

- Komplikasi DM yg plg srg tjd adalah kaki diabetik
- 'Kaki Diabetik' mengacu pd komplikasi kaki khusus untuk diabetes, faktor khas yang mendasarinya meliputi **neuropati perifer & penyakit PD perifer (PVD)**
- Pencegahan efektif ulkus kaki pd DM → Identifikasi individu yang berisiko tinggi, shg dpt mengurangi kejadian **amputasi ekstremitas bawah** pasien DM



# PENDAHULUAN

## Termometer

Alat penilaian sederhana yang telah terbukti menjadi alat pemantauan dirumah yang berguna untuk mencegah terjadinya ulkus kaki diabetik & amputasi pada pasien yg berisiko tinggi

Pengukuran dinamis (laju pemanasan, suhu pemulihan maksimum, tingkat variasi suhu di lokasi anatomi & jeda waktu)

berguna untuk menilai respons terhadap rangsangan termal

## Tujuan Penelitian

mengidentifikasi keefektifan pengujian respons pemulihan perendaman dingin pada kaki diabetik dengan neuropati menggunakan sistem termografi kristal cair (LCT)



# 02

## DESAIN DAN METODE PENELITIAN



# METODE PENELITIAN

- Penelitian ini melibatkan 81 subjek dalam 3 kelompok penelitian yang dilakukan di MV Hospital for Diabetes and Diabetes Research Center di Chennai (India).
- **Kriteria inklusi** → Pasien DM tipe 2 yg beragam (durasi minimum 12 bulan)
- **Kriteria eksklusi** → Pasien dengan ulserasi kaki aktif, PVD, kelainan bentuk kaki Charcot atau cacat fisik apapun

## 3 Kelompok Penelitian

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graph LR; A[3 Kelompok Penelitian] --> B[Pasien diabetes dengan neuropati]; A --> C[Pasien diabetes tanpa neuropati]; A --> D[Kontrol sehat];
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Pasien diabetes dengan neuropati

Pasien diabetes tanpa neuropati

Kontrol sehat

# METODE PENELITIAN

**Table 1** Summary of the composition of study group for the clinical study

Patient group/parameters	Diabetic with neuropathy	Diabetic without neuropathy	Healthy
Number of subjects	28*	23*	30
Male/female	24/4	15/8	8/22
Age (years), mean $\pm$ SD	57.92 $\pm$ 7.08	50.35 $\pm$ 9.79	32.43 $\pm$ 7.3
Duration of diabetes (years), mean $\pm$ SD	14.75 $\pm$ 6.8	9.45 $\pm$ 5.8	n/a
Glycosylated haemoglobin (%), mean $\pm$ SD	9.01 $\pm$ 1.81	8.79 $\pm$ 1.82	n/a
Body mass index (kg/m <sup>2</sup> ), mean $\pm$ SD	25.24 $\pm$ 3.77	25.31 $\pm$ 3.48	25.07 $\pm$ 4.16

\*A total of 30 subjects per group were included in the clinical study. Two (male) neuropathic diabetic subjects and seven (three male/four female) non neuropathic diabetic subjects were excluded from the final analysis, as they were either recently diagnosed with diabetes or had duration of diabetes less than 12 months.  
n/a = Not applicable.

Rerata usia kelompok diabetes neuropatik adalah 58 tahun (41-71 tahun)

Rerata usia kelompok diabetes non neuropatik adalah 50 tahun (33-63 tahun)

Rerata usia kelompok kontrol sehat adalah 32 tahun (20-51 tahun)

dipilih dari departemen rawat jalan Rumah Sakit MV & pertemuan dijadwalkan untuk pasien rawat inap dengan mempertimbangkan tes diagnostik rutin lainnya

dipilih dari antara staf rumah sakit/ anggota keluarga pasien yg mendampingi



# Protokol Penelitian

Evaluasi menyeluruh kaki subjek

Inspeksi visual kaki yg diikuti dgn tes neuropati sensorik menggunakan *monofilamen Semmes-Weinstein 10-g* dan tes ambang batas persepsi getaran (vibration perception threshold VPT) menggunakan *biothesiometer*.

Tes dilakukan pd 5 lokasi di kaki & ambang batas VPT untuk neuropati adalah 30 V

Ketidakpekaan terhadap *monofilamen nilon 10-g* bertingkat di tiga/ lebih lokasi

Neuropati Klinis

# Protokol Penelitian

## Prosedur Pengujian Termal

dimulai dengan waktu **istirahat 20 menit** agar suhu plantar seimbang dengan suhu ruangan. Suhu & kelembapan ruangan dipertahankan secara konsisten pada suhu **24°C** dengan AC.

Istirahat → pasien **duduk di kursi dgn kaki rata di tanah** kemudian suhu kaki plantar diukur menggunakan **termometer digital** pd kepala metatarsal pertama (MTH) & **tumit** setiap sebelum tes.

pasien **berdiri di platform pengukuran** & disarankan untuk **menghindari gerakan** selama durasi tes.

# Protokol Penelitian

## Tes Perendaman dingin

kaki pasien diletakkan di bak air bersuhu 18-20°C selama 3 menit.

Perendaman selama >3 menit (atau 180 detik) dapat mengubah sifat elastis kulit, yaitu pada **pendinginan** (elastisitasnya berkurang karena kontraksi) dan pada **pemanasan** (kulit menyebabkan relaksasi)



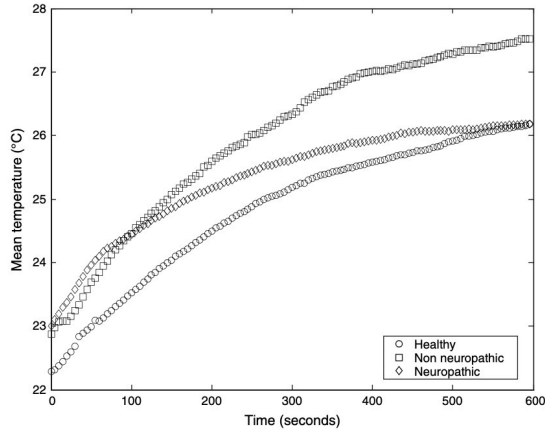


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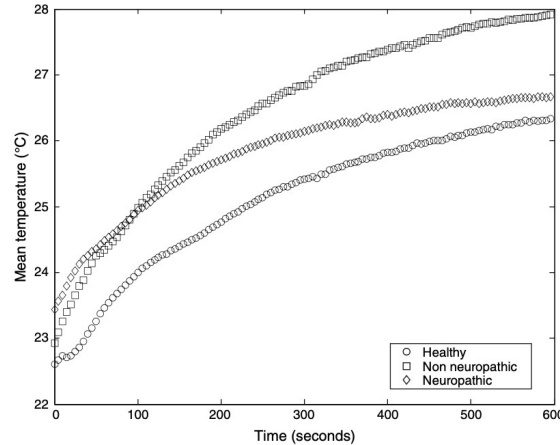
# HASIL PENELITIAN



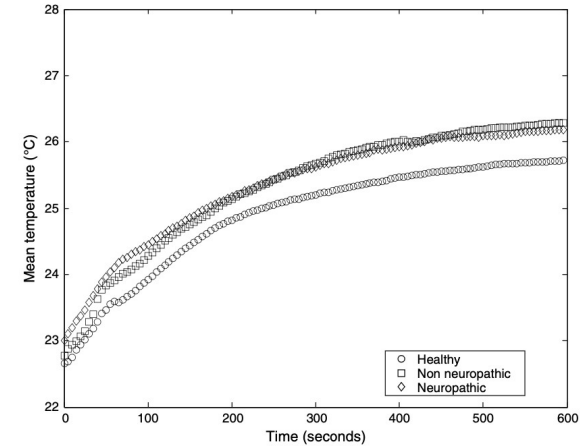
# HASIL



**Figure 1.** Mean temperatures (°C) following cold immersion under the first metatarsal head for all three study groups: healthy non diabetic patients, diabetic patient with neuropathy and diabetic patients without neuropathy.



**Figure 2.** Mean temperatures (°C) following cold immersion under the second metatarsal head for all three study groups: healthy non diabetic patients, diabetic patients with neuropathy and diabetic patients without neuropathy.



**Figure 3.** Mean temperatures (°C) following cold immersion under the heel for all three study groups: healthy non diabetic patients, diabetic patients with neuropathy and diabetic patients without neuropathy.

Suhu rata2 (°C) pada 3 tempat yg diamati, yaitu MTH pertama, MTH kedua, dan tumit.

Semua angka menunjukkan distribusi temperatur sementara selama 10 menit pemulihan setelah perendaman dingin.

# HASIL

**Table 2** Preclinical temperatures measured at the first MTH using digital thermometer prior to the clinical tests using LCT system\*

Study group	Baseline	Cold immersion recovery
Neuropathic	28.93 (1.8)	22.20 (1.06)
Non neuropathic	29.17 (1.18)	22.00 (1.17)
Healthy	28.45 (1.52)	21.94 (0.77)

LCT, liquid crystal thermography; MTH, metatarsal head.

\*The mean temperatures (°C) and standard deviation are shown for all study groups.

menyajikan suhu praklinis yg diukur pada MTH pertama untuk semua kelompok studi menggunakan **termometer digital** sebelum dilakukan uji klinis menggunakan sistem LCT.

# HASIL

Menyajikan suhu rata2 yang diukur menggunakan LCT pada awal & akhir tes dasar serta awal & akhir tes perendaman dingin

**Table 3** Summary of the mean temperature measurement at all regions of interest for three study groups\*

Study group	Baseline	Cold immersion recovery	
Neuropathic			
Start	26.67 (1.41)	23.01 (1.01)	First MTH
End	29.65 (1.84)	26.19 (1.40)	
Start	26.75 (1.54)	23.43 (1.13)	Second MTH
End	29.68 (1.82)	26.67 (1.4)	
Start	26.71 (1.23)	23.01 (1.01)	Heel
End	29.01 (1.43)	26.19 (1.4)	
Non neuropathic			
Start	26.54 (1.6)	22.87 (1.1)	First MTH
End	30.26 (2.36)	27.17 (3.38)	
Start	26.63 (1.44)	22.924 (0.94)	Second MTH
End	30.2 (2.21)	27.91 (3.06)	
Start	26.21 (1.48)	22.78 (0.87)	Heel
End	28.66 (1.73)	26.11 (1.48)	
Non diabetic healthy			
Start	26.11 (1.02)	22.29 (0.47)	First MTH
End	28.64 (1.77)	26.18 (2.2)	
Start	26.12 (1.05)	22.61 (0.83)	Second MTH
End	28.78 (1.8)	26.34 (2.00)	
Start	25.90 (1.27)	22.66 (0.84)	Heel
End	28.01 (1.39)	25.72 (1.40)	

MTH, metatarsal head.

\*Mean temperatures (°C) and standard deviation at the start and end of baseline and cold immersion recovery tests are listed.

# HASIL

Menyajikan 'suhu delta', yaitu perbedaan rata2 suhu kulit antara suhu akhir setelah pemulihan 10 menit & suhu akhir setelah 5 menit uji baseline pd 3 lokasi yang diminati untuk 3 kelompok penelitian

**Table 4** Delta temperatures at the first MTH, second MTH and heel for all study groups

	Healthy (°C)	Non neuropathic (°C)	Neuropathic (°C)
First MTH	1.46	3.09	3.46
Second MTH	2.44	2.29	3.01
Heel	2.29	2.55	2.82

MTH, metatarsal head.





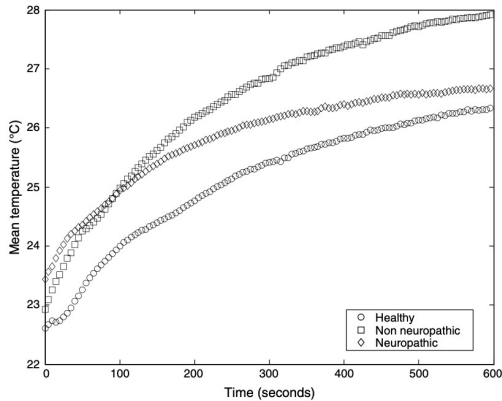
# 04 DISKUSI



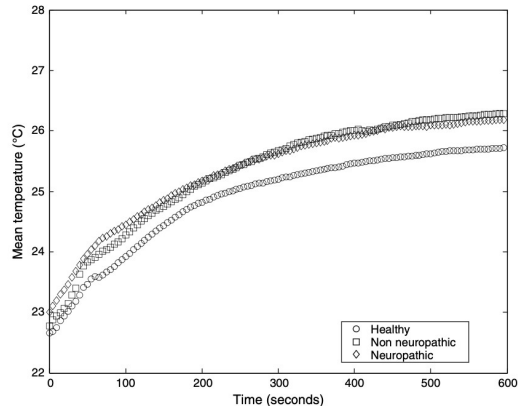
## DISKUSI

- Rangsangan termal (suhu) ke jaringan plantar akan menghasilkan rekrutmen aliran shunt termoregulasi yang dimediasi oleh hipotalamus untuk mempertahankan homeostasis.
- Pada kelompok diabetes, kemampuan ini terganggu karena degenerasi termoreseptor dan neuropati. Neuropati sensorik & neuropati otonom dapat memengaruhi perfusi ke ekstremitas bawah dan suhu.

# DISKUSI



**Figure 2.** Mean temperatures (°C) following cold immersion under the second metatarsal head for all three study groups: healthy non diabetic patients, diabetic patients with neuropathy and diabetic patients without neuropathy.



**Figure 3.** Mean temperatures (°C) following cold immersion under the heel for all three study groups: healthy non diabetic patients, diabetic patients with neuropathy and diabetic patients without neuropathy.

Tingkat respons pemulihan yang cepat untuk kelompok sehat & non neuropatik → menunjukkan bahwa respons termoreseptor masih baik.

2 kelompok tsb → menunjukkan pemulihan yang baik setelah 10 menit untuk mencapai ke suhu dasar

Respons pemulihan pada tumit relatif lebih lambat → dikarenakan oleh adanya jaringan adiposa yang menyediakan insulasi termal



# 05

## KESIMPULAN



## KESIMPULAN

- Konsistensi dalam pengukuran suhu dan variasi waktu di 3 lokasi pengukuran selama respons pemulihan perendaman dingin merupakan indikasi yang berguna untuk pola yang terkait dengan diabetes dan neuropati selanjutnya, yang mungkin secara klinis asimtomatik tetapi terlihat saat menguji respon termoreseptor.
- penelitian ini membuktikan bahwa waktu pemulihan yang buruk untuk kaki diabetik dengan neuropati. Selain itu, defisit suhu (krn pemulihan yg buruk ke suhu dasar) menunjukkan adanya degenerasi termoreseptor yg menyebabkan berkurangnya aktivitas yang dimediasi hipotalamus pada kelompok diabetik neuropati.

# ANALISIS PICO

01

## Population

81 subjek dalam 3 kelompok penelitian yang memenuhi kriteria (Pasien DM tipe 2 dengan durasi minimal 12 bulan dan pasien tanpa ulserasi kaki aktif, PVD, kelainan bentuk kaki Charcot atau cacat fisik apa pun)

02

## Intervention

Dilakukan tes perendaman dingin dengan kaki pasien diletakkan di bak air bersuhu 18-20°C selama 3 menit kemudian **evaluasi respons suhu setelah 10 menit** pemulihan perendaman dingin

# ANALISIS PICO

03

## Comparison

Kelompok penelitian terbagi atas pasien diabetes dengan neuropati sebanyak 28, pasien diabetes tanpa neuropati sebanyak 23 dan kontrol sehat sebanyak 30.

04

## Outcome

Respon pemulihan perendaman dingin yg buruk ke suhu dasar pada kelompok pasien diabetes dengan neuropati.

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## REFERENCES

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# Terima Kasih

