Indonesian Journal of Global Health Research
Volume 8 Number 4, August 2026
e-ISSN 2715-1972; p-ISSN 2714-9749
https://jurnal2.globalhealthsciencegroup.com/index.php/IJGHR

APPLICATION DISTAL LEG MASSAGE IN DIABETES MELLITUS PATIENT POST LUMBAR SURGERY WITH PERIPHERAL ARTERIAL DISEASE: CASE REPORT

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ABSTRACT

Postoperative lumbar surgery patients with diabetes mellitus are at risk of developing complex neurovascular disorders. Neurological deficits caused by lumbar nerve compression or diabetic neuropathy often result in numbness and tingling in the distal limbs, while impaired peripheral circulation related to diabetes mellitus can delay tissue healing. Distal limb massage is a non-pharmacological intervention that may help improve blood circulation and support peripheral nerve function recovery. To determine the effect of distal limb massage on improving peripheral circulation in post-lumbar surgery patients with diabetes mellitus and peripheral arterial disease (PAD). This descriptive case report with a nursing care approach was conducted from September 13 to 16, 2025, in Room UBK 2 of Welas Asih Hospital. A 46-year-old woman with a lumbar abscess and diabetes mellitus received distal limb massage twice daily for three days (30 minutes/session). Peripheral circulation was assessed using Ankle-Brachial Index (ABI) and plantar temperature before and after intervention and analyzed descriptively. After the intervention, the Ankle-Brachial Index (ABI) increased in the right leg from 1.04 to 1.08 and in the left leg from 0.75 to 0.82. In addition, the average plantar temperature increased by 0.3–0.5°C, indicating improved peripheral perfusion. Distal limb massage demonstrated potential effectiveness in improving peripheral circulation, as reflected by increased ABI values and plantar temperature, and may help reduce numbness and tingling in post-lumbar surgery patients with diabetes mellitus and PAD.

Keywords: ankle-brachial index (ABI); diabetes mellitus; distal limb massage; peripheral circulation; post-lumbar surgery

How to cite (in APA style)
Habeahan, N. K., Kosim, H., & Praptiwi, A. (2026). Application Distal Leg Massage in Diabetes Mellitus Patient Post Lumbar Surgery with Peripheral Arterial Disease: Case Report. *Indonesian Journal of Global Health Research*, *8*(4), 545–552. https://doi.org/10.37287/ijghr.v8i4.1443.

INTRODUCTION

The lumbar region is the part of the spine that has a high degree of mobility and is located between the last thoracic vertebra (T12) and the first sacral vertebra (S1). This structure consists of five vertebrae (L1–L5) that protect the spinal cord and enable the distribution of axial forces. The spinal cord ends at the conus medullaris at the L1–L2 vertebrae, while the cauda equina is a collection of nerve roots that extend through the remainder of the spinal canal. The lumbar spine is composed of bone, cartilage, ligaments, nerves, and muscles that collectively play a role in maintaining the shape and function of the spine. The high mobility of the lumbar region makes this area prone to nerve irritation and pinching, which in certain conditions requires surgical intervention. Spinal surgery is generally performed to treat lower back pain, infection, lumbar radiculopathy, and spinal stenosis after conservative therapy has failed. In emergency conditions such as conus medullaris syndrome, cauda equina syndrome, primary or metastatic cancer, osteomyelitis/discitis, epidural abscess, and trauma, spinal surgery is the first line of treatment (Sassack & Carrier, 2023).

Spinal abscess is a complex pathological manifestation that can appear in extramedullary, epidural, or intradural forms. One form is paravertebral abscess, a critical infection characterized by purulent accumulation around the spine and the potential for significant morbidity. The clinical manifestations of paravertebral abscesses are influenced by the anatomy of the spinal canal and dural sac. The narrow epidural space in the cervical region and the widened space in the

lumbosacral region cause variations in the direction of infection spread. In the anterior canal, the proximity of the periosteum, posterior longitudinal ligament, and dura mater causes the posterior area to be more frequently the site of abscess formation. Infectious agents include bacteria, fungi, and parasites, with Staphylococcus aureus and Mycobacterium tuberculosis being the most common pathogens. Risk factors for paravertebral abscesses include diabetes mellitus, rheumatoid arthritis, multisystem infections, trauma, history of surgery, alcoholism, chronic hepatitis, chronic renal failure, organ transplantation, immunosuppressive conditions, long-term steroid use, chemotherapy, intravenous catheter use, and drug abuse (Abdulghafoor et al., 2024).

The management of paravertebral abscesses is essentially similar to that of other spinal abscesses and requires a multidisciplinary approach, including long-term antimicrobial therapy, supportive care, and surgical intervention when indicated (Ngurah et al., 2025). However, lumbar spine surgery is often associated with neurological deficits. These deficits can arise through several mechanisms, primarily due to mechanical compression of nerve roots, the spinal cord, or the dural sac, as well as nerve root edema, epidural hematoma, or the use of compressive instrumentation (Wang et al., 2020). These conditions make neurological deficits a common complication following lumbar spine surgery (Komatsu et al., 2019). The risk of neurological deficits increases in patients with diabetes mellitus comorbidity. Diabetes mellitus is a metabolic disease characterized by impaired blood glucose regulation, particularly chronic hyperglycemia, which contributes to oxidative stress, cell death, and neuroendocrine pathway dysfunction that contribute to the pathophysiology of neurological disorders (Luna et al., 2021). Additionally, microcirculatory disorders in diabetes mellitus cause reduced perfusion of peripheral nerve fibers, leading to nerve ischemia and neurological deficits manifested as numbness and tingling (Perez-martin et al., 2021).

One non-pharmacological strategy to improve neurological deficit complaints is distal limb massage. Integrative and complementary therapies, including massage, play a role in improving health and supporting the recovery process. The distal limbs are an area prone to circulatory disorders due to the effects of gravity, so massage can help achieve vasodilation to increase blood flow. Massage has also been reported to reduce mild discomfort and increase sensitivity through increased blood flow, skin stimulation, sensation, and joint mobility (Paju et al., 2022). Thai Foot Massage is a deep massage technique using thumb pressure along the meridian lines of the feet and legs combined with toe distraction, and has been reported to stimulate the nervous system and aid nerve myelin sheath function (Chatchawan et al., 2015).

However, research on the effectiveness of distal leg massage in post-lumbar surgery patients with diabetes mellitus comorbidity is still very limited. Therefore, this case study was conducted to explore the potential of distal leg massage in improving blood circulation and reducing complaints of numbness and tingling in post-lumbar surgery patients with diabetes mellitus in the Umar Bin Khattab 2 at Welas Asih Hospital.

METHOD

This study is a descriptive study with a case report design using a nursing care approach in patients after lumbar abscess surgery. The study was conducted over four days, from September 13 to 16, 2025, at the Umar Bin Khattab 2 Inpatient Room of Welas Asih Regional General Hospital. The research subject was a 46-year-old female patient with the initials Mrs. N who underwent debridement and drainage of paravertebral abscess accompanied by lumbar spinal decompression. During the observation period, the patient was in the postoperative day (POD)-1 to POD-3 phase and showed neurological deficits in the form of numbness and tingling in both lower extremities, especially in the distal part.

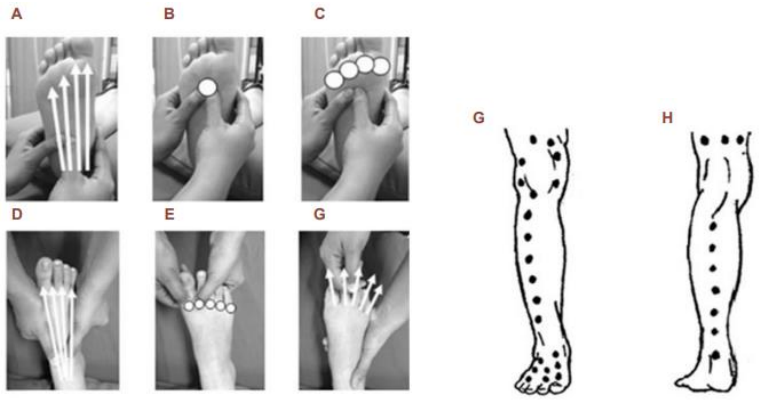
Data collection was conducted using primary and secondary data. Primary data were obtained through direct interviews with the patient and her family as well as clinical observations, which

included physical examination of the lower extremities, sensation, and skin temperature. Secondary data were obtained from the patient's medical records, including laboratory and radiological examination results. The patient had a history of diabetes mellitus since the age of 35, which could potentially aggravate peripheral perfusion disorders and nerve function with clinical findings of decreased sensation and cooler lower extremities.

The intervention provided was Thai Foot Massage as a complementary therapy to improve peripheral circulation and neurological function of the lower extremities. The therapy was performed twice a day, at 08.00 and 15.00, with a duration of 30 minutes per session for three consecutive days according to the Thai Foot Reflexology clinical guidelines (Roubin, 2025). S Before the intervention, the patient underwent a comprehensive screening that included examination of the integrity of the skin of the feet, color, temperature, presence of edema, pressure pain sensation, as well as evaluation of medical history and risk of deep vein thrombosis. Based on these guidelines, the patient's condition was classified as safe and had no contraindications for Foot Thai Massage therapy.

Thai Foot Massage was performed on the soles of the feet (plantar), the backs of the feet (dorsum pedis), the ankles, and the anterior and posterior lower legs with the patient lying supine. The massage technique used light to moderate thumb pressure applied gradually along the three meridian lines of the feet and legs, which include the tibialis anterior and gastrocnemius muscles. Pressure is maintained for 5–10 seconds at each massage point and repeated 3–5 times, combined with gentle pulling of the toes. Each therapy session is divided into 15 minutes for the left foot and 15 minutes for the right foot according to the Foot Thai Massage procedure (Chatchawan et al., 2015).

Pict 1. Thai Foot Massage Procedure



(Chatchawan et al., 2015, page 70)

The results of the intervention were evaluated by comparing the Ankle-Brachial Index (ABI) and plantar temperature before and after the three-day intervention. ABI examination was performed by measuring the systolic pressure of the lower extremities using a digital sphygmomanometer and comparing it with the brachial systolic pressure to assess the level of peripheral perfusion in patients with neurological deficits (Ganesh & Kothiwale, 2016). Plantar temperature was measured using a digital thermometer on the anterior plantar area of both feet to assess temperature changes as an indicator of improved peripheral circulation after the intervention (Chikubu et al., 2025). All research procedures were carried out after the patients and their families provided written consent by signing an informed consent form. This study was conducted in accordance with nursing ethics principles, including autonomy, beneficence, nonmaleficence, veracity, and confidentiality. Nursing care was provided systematically, starting from assessment, nursing diagnosis, planning, implementation, to evaluation as a measure of the success of the intervention provided.

RESULT

Distal massage is one method of mediated vasodilation that can help improve blood circulation and metabolic needs in patients with neurological deficits. This massage can also provide changes in sensory disturbances, reducing numbness and tingling in individuals with decreased blood circulation in the lower limbs (Soe et al., 2025). The massage movements in the distal limb massage intervention stimulate the muscles and small joints in the plantar area, dorsum pedis, and lower limb muscles (gastrocnemius, soleus, tibialis anterior). This area is rich in peripheral sensory nerves and superficial blood vessels, so massage stimulation can improve blood circulation, skin temperature, and sensory sensitivity in the distal extremities.

For this patient, the exercise was performed twice a day. The implementation was carried out for 3 days, starting on September 14, 2025 (POD-1) to September 16, 2025 (POD-3) in the Umar Bin Khattab 2 at Welas Asih Hospital. The measurement tool used was the Ankle-Brachial Index (ABI). The results of the ABI measurements for the right and left legs are shown in Figure 1, and the plantar temperature results are shown in Table 1 as follows:

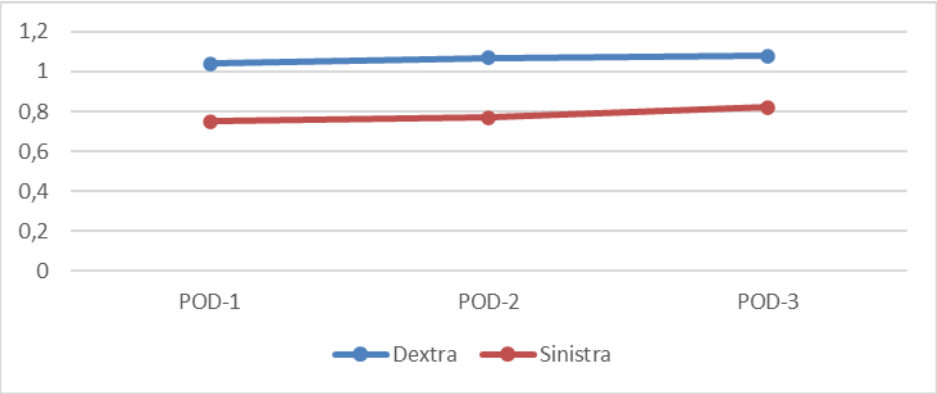


Figure 1. Evaluation of Ankle-brachial Index (ABI) Improvement

According to the results of applying distal leg massage 6 times in 3 days, there was a difference in the Ankle-Brachial Index (ABI) as objective data. The results showed that the increase in ABI was not very significant but improved every day. According to the (Kemenkes Indonesia, 2020) the ABI assessment range of 0.7-0.9 indicates mild PAD, while 0.9-1.30 indicates normal PAD. There was a difference between the left and right legs after the intervention because the left leg was in the mild PAD range from the start. After the distal leg massage intervention, the left leg improved from 0.75 to 0.82. Although there was an improvement, the final result of the distal leg massage intervention remained within the mild PAD range. In contrast, the right leg was in the normal range from the start, with results increasing from 1.04 to 1.08. This increase was not very significant and remained within the normal range. The graph shows a consistent increase in both legs from the first day to the third day, with a more noticeable increase in the left leg compared to the right leg.

Table 1.
Temperature Measurement Result on the Plantar Surface

POD-1			POD-2			POD-3		
Morning	Sinistra	Dextra	Morning	Sinistra	Dextra	Morning	Sinistra	Dextra
Pre	36°C	36°C	*Pre*	36.3°C	36.4°C	*Pre*	35.9°C	36.0°C
Post	36.4°C	36.5°C	*Post*	36.5°C	36.7°C	*Post*	36.2°C	36.4°C
Afternoon	Sinistra	Dextra	Afternoon	Sinistra	Dextra	Afternoon	Sinistra	Dextra
Pre	36.2°C	36.3°C	*Pre*	36.1°C	36.3°C	*Pre*	36.0°C	36.1°C
Post	36.5°C	36.7°C	*Post*	36.2°C	36.4°C	*Post*	36.3°C	36.4°C

According to Chatchawan et al., (2018) plantar temperature can affect blood circulation in the legs. When blood circulation deteriorates, the legs will feel and appear cold, and when blood circulation is good, the legs will feel warm. The results obtained from temperature measurements showed an

increase in plantar temperature in both the left and right legs after distal leg massage intervention. On the first day, the average temperature of the left foot increased from 36.0°C to 36.4°C in the morning and from 36.2 to 36.5°C in the afternoon. A similar increase was seen on the second and third days with a final temperature range of 36.3°C - 36.5°C. This increase in temperature indicates an improvement in peripheral blood circulation and increased tissue perfusion in the distal leg area. These findings are in line with the principles of thermoregulation physiology described by Guyton and Hall, namely that an increase in skin temperature is a response to peripheral vasodilation due to mechanical stimulation, which causes an increase in capillary blood flow and local tissue perfusion after massage (Hall & Guyton, 2011)

DISCUSSION

Decreased peripheral circulation generally occurs due to narrowing or blockage of the arteries, which causes a reduction in the supply of oxygen-rich blood and nutrients to the distal tissues. This condition often leads to neurological deficits characterized by complaints of numbness, tingling, and pins and needles in the distal extremities (Varaki et al., 2018). The clinical findings in patients in this study were consistent with this mechanism, in which patients complained of numbness and tingling in both distal limbs accompanied by signs of peripheral perfusion disorders. To assess peripheral circulation, the Ankle-Brachial Index (ABI) examination was used as an objective indicator. The ABI value is considered normal if the blood pressure in the lower extremities is comparable to the brachial blood pressure, with values of 0.91–1.31 interpreted as normal, 0.70–0.90 as mild peripheral artery disease (PAD), and 0.40–0.69 as moderate PAD (Libya, 2018). In this case, the ABI results showed a normal category in the right leg and mild PAD in the left leg, supporting the presence of peripheral perfusion disorders in the lower extremities.

In addition to postoperative factors, a ten-year history of diabetes mellitus also contributed to the neurological deficit. Diabetes mellitus is a chronic metabolic disorder characterized by persistent hyperglycemia due to insulin resistance or impaired insulin secretion, which can trigger macrovascular and microvascular complications, including diabetic peripheral neuropathy. Chronic hyperglycemia, oxidative stress, and microcirculatory disorders cause peripheral nerve damage, manifesting as decreased sensation, numbness, and tingling in the distal extremities (Khawaja et al., 2018). This condition reinforces the clinical findings in patients and explains why peripheral perfusion disorders and neurological deficits are more prominent.

The intervention results showed an increase in ABI values on the third day, with an increase in the right leg from 1.04 to 1.08 and in the left leg from 0.75 to 0.82. These findings are consistent with reports that Thai foot massage can increase skin blood flow and foot skin temperature, which are indicators of improved local tissue perfusion after mechanical stimulation through massage. Previous research has shown that after one session of foot massage by a therapist, foot skin blood flow and foot skin temperature increased significantly in patients with peripheral neuropathy, reflecting improved microcirculation in the extremities (Chatchawan et al., 2020). In addition, massage of the lower limbs involves large muscles such as the gastrocnemius, soleus, tibialis anterior, and peroneus longus, as well as major blood vessels such as the tibial artery and great saphenous vein. Proximal massage movements help improve venous drainage, reduce blood stasis, and stimulate vasodilation reflexes, thereby contributing to improved peripheral perfusion and reduced numbness due to distal hypoperfusion (Al-fahham & Al-jubouri, 2023).

The Foot Thai Massage procedure in this study was performed according to the technique described by (Chatchawan et al., 2015), with gentle pressure using the thumb on the plantar and dorsum areas of the foot for 5–10 seconds at each point, repeated 3–5 times on each meridian line, and performed for 30 minutes per session. This rhythmic stimulation activates skin mechanoreceptors and peripheral nerves, triggering vasodilation mediated by the sensory nervous system. This mechanism increases micro blood flow and local temperature, thereby supporting improved peripheral

circulation and reducing complaints of numbness and tingling in the distal limbs.

Improvements in peripheral circulation were also reflected in a gradual increase in plantar temperature over the three days of intervention. The increase in plantar temperature indicates a local vasodilation response and increased tissue perfusion due to stimulation of skin mechanoreceptors during massage. According to (Khawaja et al., 2018), an increase in plantar temperature is an indicator of increased microcirculation activity in the lower extremities. Thus, the temperature changes observed in this study reinforce the findings that distal limb massage contributes to improved blood circulation and peripheral sensory function in post-lumbar surgery patients with diabetes mellitus (Ren et al., 2022).

The success of distal leg massage intervention is not only determined by the technique and duration of therapy, but also by the consistency of implementation and patient compliance. Active patient involvement and family support in undergoing the therapy schedule play an important role in maintaining vasodilation effects and improving tissue perfusion continuously. Complementary therapies such as Foot Thai Massage are reported to provide more optimal results when performed regularly and with the assistance of health workers (Paju et al., 2022). Therefore, patient education and continuous nursing follow-up are important aspects in preventing the recurrence of sensory symptoms.

This study has several limitations. The distal limb massage technique used does not yet have a specific protocol for post-lumbar surgery patients, so it still refers to general guidelines for peripheral circulation disorders. In addition, ABI measurements were performed using a digital sphygmomanometer as an alternative to Doppler Ultrasonography, which could potentially affect the accuracy of the results. However, research (Khan et al., 2019) shows that ABI measurements using an automatic oscillometric device with a standard ABI measured using Doppler yield similar results between the two techniques. Therefore, although not the gold standard, the method used in this study is still acceptable for describing changes in peripheral perfusion. Further research with more accurate measurement devices and more standardized massage protocols in post-lumbar surgery patients is recommended to improve the validity and generalizability of the results.

CONCLUSION

Patients with peripheral circulation impairment who received six sessions of distal limb massage (Foot Thai Massage) over three days showed improvement in peripheral circulation. This was indicated by an increase in the Ankle-brachial Index (ABI) in the right distal limb from 1.04 to 1.08 and in the left distal limb from 0.75 to 0.82. In addition, there was an increase in plantar temperature after each intervention session, indicating improved peripheral perfusion and local vasodilation response.

REFERENCES

Abdulghafoor, I., Agha, I., Ibrahim, M. A., Salim, Y. T., Ibrahim, K. W., Mohammed, O. M., & Mohammed, S. J. (2024). Septic paravertebral abscess and inferior vena cava thrombosis complicated by uro-sepsis : Case report. 23(September), 329–333. https://doi.org/10.37897/RJN.2024.3.16

Al-fahham, T. M., & Al-jubouri, M. B. (2023). Effectiveness of Foot Massage on Diabetic Patients ' Peripheral Neuropathy : A Randomized Controlled Trial. 7, 458–469. https://doi.org/https://doi.org/10.59670/ml.v20iS7.4412

Chatchawan, U., Eungpinichpong, W., Plandee, P., & Yamauchi, J. (2015). Effects of Thai Foot Massage on Balance Performance in Diabetic Patients with Peripheral Neuropathy : A Randomized Parallel-Controlled. Medical Science Monitor Basic Resarch, 21, 68–75. https://doi.org/10.12659/MSMBR.894163

Chatchawan, U., Jarasrungsichol, K., & Yamauchi, J. (2020). Immediate Effects of Self-Thai Foot Massage on Skin Blood Flow, Skin Temperature, and Range of Motion of The Foot and Angkle in Type 2 Diabetic Patients. Journal of Alternative and Complementary Medicine, 26(6), 491–500. https://doi.org/10.1089/acm.2019.0328

Chatchawan, U., Narkto, P., Damri, T., & Yamauchi, J. (2018). An exploration of the relationship between foot skin temperature and blood flow in type 2 diabetes mellitus patients : a cross-sectional study. The Journal of Physical Therapy Science, 30(11), 1359–1363. https://doi.org/10.1589/jpts.30.1359

Chikubu, H., Inage, K., Orita, S., Shiga, Y., Inoue, M., & Okuyama, K. (2025). A Study on Subjective Symptoms and Plantar Temperature Imbalance in Lumbar Spinal Stenosis : A Preliminary Study. 17(2). https://doi.org/10.7759/cureus.79388

Ganesh, B. R., & Kothiwale, V. A. (2016). Reliability of ankle brachial index in patients with neurological deficits on ischemic episode of the limbs following Burgers exercises : open labelled clinical trial. International Journal of Research in Medical Sciences, 4(8), 3440–3443. https://doi.org/10.18203/2320-6012.ijrms20162308

Hall, J. E., & Guyton, A. C. (2011). Textbook Of Medical Physiology (12th ed.). Elsevier.

Kemenkes Indonesia. (2020). Pedoman Nasional Pelayanan Kedokteran Tata Laksana Diabetes Melitus Tipe 2 Dewasa. 1–183.

Khan, S. Z., Waris, N., Miyan, Z., Ulhaque, M. S., & Fawwad, A. (2019). Comparison of ankle-brachial index (ABI) measured by an automated oscillometric apparatus with that by standard hand-held doppler in patients with Type-2 diabetes. Pak J Med Sci, 35(4), 1167–1172. https://doi.org/: https://doi.org/10.12669/pjms.35.4.30

Khawaja, N., Shennar, J. A., Saleh, M., Dahbour, S. S., Khader, Y. S., & Ajlouni, K. M. (2018). The prevalence and risk factors of peripheral neuropathy among patients with type 2 diabetes mellitus ; the case of Jordan. Diabetology & Metabolic Syndrome, 1–10. https://doi.org/10.1186/s13098-018-0309-6

Komatsu, J., Sato, K., Iwabuchi, M., Fukuda, H., Kusano, K., Kaneko, K., & Shirado, O. (2019). Recovery of paraplegia following postoperative epidural hematomas in lumbar canal stenosis surgery by closed kinetic chain (CKC) exercises. 0–5. https://doi.org/10.1097/MD.0000000000015670

Libya, N. P. E. (2018). Pengaruh Senam Kaki Diabetik Terhadap Ankle Brachial Index (ABI) pada Pasien Diabetes Melitus Tipe II di UPT Kesmas Gianyar I Tahun 2018 [Poltekkes Denpasar]. http://repository.poltekkes-denpasar.ac.id/id/eprint/1348

Luna, R., Manjunatha, R. T., Bollu, B., Jhaveri, S., Avanthika, C., Reddy, N., Saha, T., & Gandhi, F. (2021). A Comprehensive Review of Neuronal Changes in Diabetics. 13(10). https://doi.org/10.7759/cureus.19142

Ngurah, I. G., Wijaya, P., & Yulian, K. (2025). Paraspinal Abscess Secondary to Spondylodiscitis : A Rare Presentation with Progressive Neurological Deficits and Systemic Infection. Indonesian Journal of Medicine, 10(2), 113–124. https://doi.org/https://doi.org/10.26911/theijmed.2025.10.2.842

Paju, W., Yusuf, R., Nurhidayah, J., Fauzi, A., & Bata, V. A. (2022). The Effect of Foot Massage on Peripheral Neuropathy in Patients With Diabetic Mellitus : A Systematic Review. Malaysian Journal of Medicine and Health Sciences, 18(9), 354–362.

Perez-martin, A., Ennaifer, H., Silva, H., & Knapp, Y. (2021). Mechanisms of Venoarteriolar Reflex in Type 2 Diabetes with or without Peripheral Neuropathy. MDPI, 10 (4), 1–11. https://doi.org/https://doi.org/10.3390/biology10040333

Ren, L., Guo, R., Fu, G., Zhang, J., & Wang, Q. (2022). The efficacy and safety of massage adjuvant therapy in the treatment of diabetic peripheral neuropathy. 101(10), 1–4. https://doi.org/10.1097/MD.0000000000029032

Roubin, S. (2025). Thai Foot Reflexology Guide. In Thai Massage Book. Thai Massage School of Chiang Mai.

Sassack, B., & Carrier, J. D. (2023). Anatomy, Back, Lumbar Spine. Treasure Island (FL). https://www.ncbi.nlm.nih.gov/books/NBK557616/

Soe, S. M., Wanpen, S., Thaweewannakit, T., Peungsuwan, P., & Chatchawan, U. (2025). Short-term Effects of Self-Thai Foot Massage and Foot Care on Balance and Proprioception Among Patients With Diabetic Peripheral Neuropathy. 39(1). https://doi.org/https://doi.org/10.56808/2586-940X.1115

Varaki, E. S., Gargiulo, G. D., Penkala, S., & Breen, P. P. (2018). Peripheral vascular disease assessment in the lower limb : a review of current and emerging non - invasive diagnostic methods. BioMedical Engineering OnLine, 1–27. https://doi.org/10.1186/s12938-018-0494-4

Wang, R., Li, C., Yi, X., Lu, H., Wang, Y., & Li, H. (2020). Causes of lower extremity weaknesses after posterior lumbar spine fusion surgery and therapeutic effects of active surgical exploration. Journal of Orthopaedic Surgery and Research, 15(1), 435. https://doi.org/10.1186/s13018-020-01948-4