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Warm-Water Foot Soaking with Epsom Salt and Lower-Extremity Somatosensory Function after Ischemic Stroke: A Quasi-Experimental Controlled Study

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ABSTRACT

Somatosensory impairment after ischemic stroke can reduce lower-extremity sensitivity, impair balance, and increase fall risk. Evidence for warm-water foot soaking with Epsom salt remains limited. To evaluate its association with lower-extremity somatosensory function after ischemic stroke. This non-randomized quasi-experimental pretest–posttest controlled study included 66 participants allocated sequentially to an intervention group (n = 33) or a usual-care control group (n = 33). Somatosensory function was assessed using the sensory domain of the Fugl-Meyer Assessment for the Lower Extremity. The intervention comprised soaking the feet in 5 L of water at 40 °C with 250 g Epsom salt for 20 minutes, three times weekly for four weeks. Wilcoxon signed-rank and Mann–Whitney U tests were used. Median scores increased from 7.00 to 8.00 in the intervention group ($p < .001$) and remained 7.00 in the control group ($p = .157$). The between-group difference was significant ($p = .038$; $r = 0.256$). The intervention was associated with modest improvement. Non-random allocation and the absence of a warm-water-only arm prevent conclusions about efficacy or a salt-specific effect.

Keywords: Complementary therapy, Epsom salt, Ischemic stroke, Somatosensory function, Warm-water foot soaking

1. Introduction

Stroke remains a major global public health challenge, with case numbers continuing to rise, particularly in low- and middle-income countries (Abtari et al., 2024). The World Health Organization (2025) reports that, based on 2021 estimates, stroke is now the third leading cause of death and disability worldwide, with nearly 93.8 million people living with its long-term consequences and approximately 11.9 million new cases occurring each year. Within Indonesia, the 2023 Indonesian Health Survey (Survei Kesehatan Indonesia/SKI) recorded a national stroke prevalence of 8.3 per 1,000 population (Kementerian Kesehatan Republik Indonesia, 2024), and claims data from the National Health Insurance Program (Jaminan Kesehatan Nasional/JKN) show that Aceh Province recorded 6,078 stroke cases between 2017 and 2022, an incidence rate of 113.93 per 100,000 population (Zainuddin et al., 2025).

Beyond incidence, the more pressing concern for rehabilitation practice is the burden that persists after the acute event. Stroke occurs when cerebral blood supply is interrupted, either through vessel occlusion (ischemic) or bleeding (hemorrhagic), producing tissue ischemia and neuronal damage that can affect both motor and sensory pathways (Seidi et al., 2023). Somatosensory impairment is one of the most disabling of these consequences: reduced sensitivity to touch, pressure, and proprioception in the limbs affected by hemiparesis, particularly the lower extremities, compromises postural control and increases fall risk, and in turn limits patients' mobility, independence in daily activities, and overall quality of life if not properly managed. Despite this burden, rehabilitation options that specifically target sensory recovery remain comparatively limited: conventional physiotherapy and pharmacological approaches largely emphasize motor recovery, and access to structured sensory retraining is often constrained in primary care and community settings, leaving a gap between the scale of the problem and the treatments realistically available to most patients.

In response to these treatment gaps, complementary therapies have drawn growing interest because they are relatively simple to implement, low-cost, and associated with minimal risk of adverse effects (Vakilinia et al., 2020). Hydrotherapy, including foot soaking, is one such approach already used in the rehabilitation of conditions such as neuropathic pain, rheumatoid arthritis, and impaired peripheral circulation (Iłżecka, 2019). Warm hydrotherapy produces local vasodilation and increased peripheral blood flow, which may enhance tissue oxygenation and cellular metabolism (Setiawan et al., 2021), and thermal stimulation more broadly has been reported to support sensory and motor recovery after stroke through repeated afferent stimulation (Wang et al., 2024; Celi-Lalama et al., 2024). Adding Epsom salt (magnesium sulfate) to warm water has been proposed to further enhance this effect, as magnesium ions are thought to modulate synaptic transmission and inhibit NMDA-receptor activity (Shil & Ankar, 2025), although evidence for a distinct, salt-specific effect beyond that of warm water alone is still limited.

Although several studies have examined warm-water or thermal interventions for other post-stroke outcomes, evidence on their effect specifically on lower-extremity somatosensory function in people after ischemic stroke, and in the context of routine care at community health centers, remains scarce. This study addresses that gap by evaluating warm-water foot soaking with Epsom salt on lower-extremity somatosensory function among people after ischemic stroke; because no warm-water-only comparison arm was included, the design cannot isolate the specific contribution of the mineral salt from that of warm water itself. The findings are intended to inform a safe, non-pharmacological intervention that primary healthcare settings can feasibly adopt to support post-stroke sensory recovery.

2. Methods

2.1 Study Design

This study used a quasi-experimental, non-randomized, pre-post control-group design, comparing an intervention group that received warm-water foot soaking combined with Epsom salt against a control group that continued routine care.

2.2 Setting and Ethical Approval

The study was conducted between March and April 2026 across several community health center (Puskesmas) service areas in Bireuen Regency, Aceh Province, Indonesia, following ethical approval from the Health Research Ethics Committee of Universitas Prima Indonesia (Ethical Clearance No. 067/KEPK/UNPRI/II/2026).

2.3 Participants

The population comprised people after ischemic stroke residing within the service areas of the participating community health centers, totaling 81 individuals. Participants were selected using purposive sampling, with inclusion criteria of a confirmed diagnosis of ischemic stroke, ability to maintain a stable sitting position, presence of lower-extremity sensory impairment, age ≥ 18 years, no comorbid disorders or wounds of the lower extremities, ability to communicate and follow instructions, and willingness to provide informed consent. Exclusion criteria were impaired consciousness, severe comorbid conditions affecting the lower extremities, and hypersensitivity or allergy to mineral salt. Of the 81 individuals in the population, 66 met the inclusion criteria and were enrolled, while the remaining 15 declined to participate in the study. Because allocation was not generated or concealed using a formal randomization procedure, this study is reported as non-randomized: participants were allocated to the intervention or control group sequentially according to their day of enrollment, with an equal number (n = 33) assigned to each group.

2.4 Intervention

The intervention was delivered over four weeks, three sessions per week. In each session, participants sat and soaked their feet, from ankle to heel, in 5 liters of warm water at 40 °C mixed with 250 g of Epsom salt (magnesium sulfate; product: Epsom Salt Garam Mandi dan Rendam Kaki), for 20 minutes, in the evening before bed. Each session was directly supervised by the researcher, who monitored and maintained the water temperature throughout using a water thermometer. No adverse effects, such as skin irritation, dizziness, or burns, were reported during the four weeks of intervention. The control group followed identical pre-test and post-test schedules but received only usual care during this period.

2.5 Outcome Measures

Lower-extremity somatosensory function was assessed using the sensory domain of the Fugl-Meyer Assessment for the Lower Extremity (FMA-LE), administered by the researcher. The pre-test was administered 30 minutes before the first session, and the post-test at the end of the fourth week following the final session.

2.6 Statistical Analysis

Normality was tested using the Shapiro–Wilk test, given a sample size below 50 in each group. As the data were non-normally distributed, the Wilcoxon signed-rank test was used to examine within-group differences in somatosensory sensitivity scores before and after the study period, and the Mann–Whitney U test was used to compare the magnitude of change between the intervention and control groups, at a significance level of 0.05.

2.7 Ethical Considerations

Adherence to the intervention protocol, and any medication or concurrent physiotherapy changes during the four-week study period, were not formally monitored or recorded; this is acknowledged as a limitation of the present study (see Section 4). This study was not prospectively registered in a clinical trial registry. Ethical approval was obtained from the Health Research Ethics Committee of Universitas Prima Indonesia (No. 067/KEPK/UNPRI/II/2026). Informed consent was obtained from all participants before enrolment.

3. Results

3.1 Participant Characteristics

Participant characteristics in the intervention and control groups were determined based on age, gender, education, blood pressure, medication adherence, and history of physiotherapy.

Table 1. Demographic and Clinical Characteristics of Participants by Study Group

Participant Characteristics		Intervention Group (n = 33)		Control Group (n = 33)	
		f	%	f	%
Age	19–45 years	9	27.3	12	36.4
	46–60 years	24	72.7	19	57.6
	≥60 years	0	0.0	2	6.1
Gender	Male	16	48.5	12	36.4
	Female	17	51.5	21	63.6
Education	Higher education	13	39.4	8	24.2
	Senior high school	13	39.4	17	51.5
	Junior high school	7	21.2	6	18.2
	Elementary school	0	0.0	2	6.1
Blood Pressure	Normal	0	0.0	0	0.0
	Elevated	0	0.0	0	0.0
	Stage 1 Hypertension	7	21.2	9	27.3
	Stage 2 Hypertension	26	78.8	24	72.7
Medication Adherence	Non-Adherent	10	30.3	10	30.3
	Adherent	23	69.7	23	69.7
Physiotherapy History	None	3	9.1	4	12.1
	1–3 times per month	11	33.3	2	6.1
	3–4 times per month	1	3.0	2	6.1
	1–2 times per week	12	36.4	18	54.5
	3–4 times per week	5	15.2	6	18.2
	>4 times per week	1	3.0	1	3.0

Note: f, frequency.

Based on Table 1, the age characteristics of participants in the intervention and control groups showed that the majority were aged 46–60 years (65.2%). Most participants were female, totaling 38 participants (57.6%), and the most common level of education was senior high school, with 30 participants (45.5%). Based on blood pressure, the majority of participants were classified as having Stage 2 Hypertension, totaling 50 participants (75.8%). Most participants in both groups were adherent to medication therapy (69.7%), and the majority underwent physiotherapy regularly 1–2 times per week (45.5%).

3.2 Within-Group Changes in Lower-Extremity Somatosensory Sensitivity Among People after Ischemic Stroke

Shapiro–Wilk testing showed that pre- and post-test somatosensory sensitivity scores in both groups were non-normally distributed ($p < .05$ for all comparisons), so within- and between-group comparisons used non-parametric tests (Wilcoxon signed-rank and Mann–Whitney U). Differences in lower-extremity somatosensory sensitivity scores before and after warm-water foot soaking with Epsom salt were analyzed for the intervention group, and corresponding pre–post scores were analyzed for the control group, both using the Wilcoxon test (Table 2).

Table 2. Within-Group Changes in Lower-Extremity Somatosensory Sensitivity Before and After the Study Period, by Group

Group	Pre-Test Median (Min–Max)	Post-Test Median (Min–Max)	Z	p-value
Intervention Group (n = 33)	7.00 (4.00–9.00)	8.00 (5.00–10.00)	-5.060	< .001
Control Group (n = 33)	7.00 (4.00–10.00)	7.00 (4.00–10.00)	-1.414	.157

Note: Values are presented as median (minimum–maximum). Within-group p-values were obtained using the Wilcoxon signed-rank test.

3.2.1 Intervention Group

Analysis of the intervention group using the Wilcoxon test showed that the median somatosensory sensitivity score increased from 7.00 (4.00–9.00) before treatment to 8.00 (5.00–10.00) after treatment ($p < .001$), indicating a statistically significant within-group increase in lower-extremity somatosensory sensitivity following the intervention.

3.2.2 Control Group

For the control group, the median somatosensory sensitivity score remained at 7.00 (4.00–10.00) before and after the observation period ($p = .157$), indicating no statistically significant within-group change in the absence of the warm-water foot-soak intervention.

3.3 Between-Group Comparison of Lower-Extremity Somatosensory Sensitivity

Table 3. Between-Group Differences in Lower-Extremity Somatosensory Sensitivity after Ischemic Stroke

	Intervention Mean Rank	Control Mean Rank	U	Z	p-value	r
Lower-Extremity Somatosensory Sensitivity	38.33	28.67	385.000	-2.079	.038	0.256

Note: The between-group comparison was performed using the Mann–Whitney U test; r indicates effect size.

The Mann–Whitney test showed a statistically significant between-group difference ($p = .038$), favoring the intervention group, with a small effect size ($r = 0.256$), indicating that warm-water foot soaking with Epsom salt was associated with a modest improvement in lower-extremity somatosensory sensitivity among people after ischemic stroke relative to usual care.

4. Discussion

The findings indicated that most participants from both study groups were between 46 and 60 years old. This result aligns with previous research conducted by Jessyca and Sasmita (2021), which reported a similar age distribution among stroke patients. Based on these findings, it can be concluded that stroke does not only occur among the elderly but is increasingly found in late adulthood due to unhealthy lifestyles, hypertension,

hyperlipidemia, diabetes mellitus, smoking, and lack of physical activity. Among older adults, decreased vascular function and increased degenerative risk factors also contribute to the occurrence of stroke.

Women represented the majority of participants in the present study, consistent with the broader pattern reported in national stroke epidemiology, in which sex-specific factors such as pregnancy, hypertension during pregnancy, oral contraceptive use, menopause, and hormone therapy are commonly implicated in stroke risk. Additional factors such as obesity, diabetes mellitus, dyslipidemia, atrial fibrillation, and migraine also contribute to stroke risk in women (Yoon & Bushnell, 2023). Senior high school was the most frequently reported level of educational attainment among participants across both study groups. In contrast, Suyanto et al. (2022) found that most stroke patients in their study had attained only elementary school education, a discrepancy that may reflect differences in the demographic characteristics of each study sample. Most participants were also adherent to medication therapy, consistent with Suyanto et al. (2022), who identified medication adherence as an important factor in controlling stroke risk factors such as hypertension, diabetes mellitus, and dyslipidemia, and in preventing recurrent stroke.

The majority of participants attended physiotherapy sessions on a regular basis, ranging from one to two times per week. This is in line with the findings of Nindorera et al. (2025), who suggested that a 45-minute physiotherapy program conducted three times weekly may yield the most favorable outcomes for individuals with chronic stroke, encompassing physiotherapy, occupational therapy, and speech therapy tailored to each patient's specific needs. In this regard, patient adherence to physiotherapy schedules remains a critical determinant in achieving successful post-stroke rehabilitation outcomes.

The main finding of this study was that warm-water foot soaking with Epsom salt was associated with a statistically significant, though modest, improvement in lower-extremity somatosensory sensitivity among people after ischemic stroke compared with usual care (between-group $p = .038$, $r = 0.256$), while the control group showed no significant within-group change. This is broadly consistent with prior work on thermal and hydrotherapy interventions after stroke, which has generally reported small-to-moderate benefits for sensory and motor outcomes rather than large effects (Wang et al., 2024; Celi-Lalama et al., 2024), suggesting that the direction of our findings aligns with the existing literature even though the present effect size was smaller than some previously reported estimates.

A plausible mechanism is that warm-water immersion (40–42°C) transfers heat energy to peripheral tissue, promoting vasodilation and improved peripheral blood flow, which may support the metabolic recovery of peripheral nerve tissue affected by stroke (Setiawan et al., 2021). According to Celi-Lalama et al. (2024), thermal stimulation can activate temperature-sensitive peripheral sensory receptors, generating afferent input that travels through somatosensory pathways to the thalamus and sensory cortex; increased sensory input of this kind has been proposed to promote neuroplasticity and cortical reorganization supporting sensory and motor recovery after stroke (Wang et al., 2024).

The addition of Epsom salt (magnesium sulfate) may provide some additional benefit beyond that of warm water alone: magnesium ions have been proposed to modulate synaptic transmission and inhibit NMDA-receptor activity in ways that could support nerve recovery (Aktaş et al., 2025), and sodium and chloride in the salt solution may influence osmotic pressure at the skin surface (Ozdemir & Can, 2021). However, because this study did not include a warm-water-only comparison arm, these findings cannot establish that Epsom salt contributed an effect distinct from warm water itself, and evidence for a specific, clinically meaningful transdermal-magnesium effect remains inconclusive; this should be regarded as a hypothesis for future, adequately controlled research rather than a demonstrated mechanism.

Although the between-group difference reached statistical significance, the effect size was small ($r = 0.256$), and this modest magnitude should be interpreted with caution rather than presented as strong evidence of clinical benefit. Statistical significance indicates that the observed difference is unlikely to be due to chance, but it does not by itself establish that the improvement is large enough to meaningfully change a patient's function or independence in daily activities. Several factors may explain why the effect observed here was more modest than anticipated, including the relatively short four-week intervention period, the presence of chronic, established neurological deficits that may respond more slowly to sensory stimulation, heterogeneity in stroke severity and duration among participants, and the concurrent physiotherapy that a majority of participants in both groups were already receiving, which may have narrowed the between-group difference attributable to the foot-soak intervention alone.

Compared with other thermal-based interventions after stroke, the present findings are broadly consistent with reports that repeated thermal or sensory stimulation yields measurable but generally modest gains in sensory or motor function (Wang et al., 2024; Celi-Lalama et al., 2024), rather than the larger effects

sometimes seen with more intensive, supervised rehabilitation modalities. This suggests that warm-water foot soaking with Epsom salt may be best positioned as a low-cost, low-risk adjunct to standard rehabilitation rather than a replacement for supervised physiotherapy.

This study has several limitations that should be considered when interpreting its findings. Group allocation was not randomized, which increases the risk of confounding by unmeasured differences between groups; the sample was drawn from a single region with a relatively small size; FMA-LE assessments were performed by the researcher, who also supervised the intervention and was therefore not blinded to group allocation, which may have introduced assessment bias; adherence and adverse-event data were reported only qualitatively rather than through structured tracking; no warm-water-only control arm was included, so the specific contribution of Epsom salt cannot be isolated; the FMA-LE sensory domain is an ordinal measure, and this study did not report a minimal clinically important difference or confidence intervals for the observed change; and no post-intervention follow-up was conducted to assess whether the improvement was sustained. Taken together, these findings should be regarded as an initial association between warm-water foot soaking with Epsom salt and improved lower-extremity somatosensory sensitivity, rather than definitive evidence of efficacy.

For nursing practice, these findings suggest that warm-water foot soaking with Epsom salt may be considered as a simple, low-cost, non-pharmacological adjunct that nurses in primary care and community health settings can incorporate alongside standard post-stroke rehabilitation to support patients' sensory recovery, provided that expectations about the magnitude of benefit remain realistic and that the intervention does not substitute for physiotherapy or other core rehabilitation services.

5. Conclusion

Warm-water foot soaking combined with Epsom salt was associated with a statistically significant, though modest, improvement in lower-extremity somatosensory sensitivity among people after ischemic stroke, whereas the control group showed no meaningful within-group change. Given the small effect size and the non-randomized design, these findings should be regarded as an initial association rather than confirmed evidence of efficacy. Warm-water foot soaking with Epsom salt may nonetheless be considered a safe, simple, and low-cost complementary adjunct that primary healthcare providers, including nurses, could integrate into post-stroke rehabilitation programs to support lower-extremity sensory recovery, alongside, rather than in place of, standard physiotherapy.

Future research should employ a pre-registered, adequately powered, assessor-blinded three-arm randomized controlled trial, comparing warm water with Epsom salt, warm water alone, and usual care, with a larger and more geographically diverse sample, a longer intervention period, and post-intervention follow-up, to produce more conclusive evidence and to isolate the specific contribution of Epsom salt.

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