

Electrical Therapy Combined with Exercise for Pain in Grade 1 HNP: A Quasi Experimental Study

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Abstract

Background: Herniated nucleus pulposus (HNP) can cause low back pain and radicular symptoms. The added benefit of exercise combined with electrical therapy remains unclear.

Objective: To determine whether adding hamstring stretching and quadriceps strengthening to electrical therapy reduces pain more than electrical therapy alone in patients with Grade 1 HNP.

Methods: This quasi-experimental pretest-posttest study included 30 participants aged 40–60 years with Grade 1 HNP, assigned to electrical therapy (n = 15) or electrical therapy plus exercise (n = 15). Pain was assessed using the Visual Analogue Scale. Within- and between-group changes were analyzed using t tests, with ANCOVA used to adjust posttest scores for baseline pain.

Results: Pain changed from 5.45 ± 0.66 to 5.28 ± 0.65 in the electrical therapy group ($p = 0.264$) and from 6.17 ± 0.71 to 4.10 ± 0.79 in the combination group ($p < 0.001$). After adjustment, posttest pain differed significantly between groups ($F = 48.547$, $p < 0.001$, partial $\eta^2 = 0.643$), with an adjusted mean difference of 1.656 (95% CI 1.158–2.154; $p < 0.001$).

Conclusion: Adding hamstring stretching and quadriceps strengthening to electrical therapy was associated with greater pain reduction than electrical therapy alone in patients with Grade 1 HNP. Findings should be interpreted considering the nonrandomized allocation and small sample size.

Keywords

Herniated Disc; Transcutaneous Electric Nerve Stimulation; Exercise Therapy; Pain Measurement

Introduction

Herniated nucleus pulposus (HNP), also referred to as herniated intervertebral disc, is a spinal disorder characterized by displacement of the nucleus pulposus through the annulus fibrosus, with potential irritation or compression of neural structures. It is an important contributor to low back pain and radiculopathy and is frequently encountered in musculoskeletal and rehabilitation services. The present study focused on Grade 1 HNP, for which conservative management is commonly considered before more invasive treatment is contemplated.¹

Physiotherapy management aims to reduce pain, preserve mobility, improve neuromuscular function, and address factors that may contribute to mechanical loading of the lumbar region.² Electrical modalities such as transcutaneous electrical nerve stimulation (TENS) are commonly used for symptomatic pain management. Therapeutic exercise provides a complementary approach by targeting strength, flexibility, movement control, and functional capacity. Exercise therapy has been reported to reduce pain and improve clinical outcomes in lumbar disc herniation, although substantial heterogeneity remains regarding exercise selection, dosage, and duration.³

Exercise directed toward the lower extremity and lumbopelvic region may be particularly relevant in patients with lumbar disorders.⁴ Quadriceps strengthening can support lower limb function and load distribution, whereas hamstring stretching may improve posterior chain flexibility and lumbopelvic mobility.⁵ The rationale for combining these approaches with electrical therapy is therefore based on the possibility that symptomatic pain modulation and exercise related functional adaptations may address different components of the patient's impairment.⁶ However, evidence specifically evaluating this combination in Grade 1 HNP remains limited.⁷

Pain intensity is a clinically important outcome in HNP because it directly influences activity, treatment tolerance, and perceived recovery.⁸ The Visual Analogue Scale (VAS) is widely used to quantify pain intensity, although its interpretation should be considered within the context of patient characteristics and measurement conditions.^{9,10} Previous clinical studies have described associations between demographic characteristics, physiotherapy response, and pain outcomes in patients with HNP.^{11,12}

Recent evidence also suggests that the effect of TENS may vary according to stimulation parameters and clinical context. A 2026 systematic review and meta-analysis reported inconsistent effects of TENS on chronic low back pain overall, while suggesting that stimulation dose may influence analgesic response.¹³ Exercise based rehabilitation has also received increasing attention, with recent systematic and narrative reviews supporting exercise as an important component of conservative management for lumbar degenerative and disc related conditions.^{3,14,15}

Clinical data from the Medical Rehabilitation Unit of RSUD Benda Kota Pekalongan indicated that 1,182 patients were managed during 2025, with HNP among the five most frequent diagnoses. Secondary data from July through December 2025 identified 90 HNP patients.¹⁶ These local data indicate a relevant clinical burden and support the need for treatment approaches that can be implemented within routine rehabilitation services.

Despite the widespread use of electrical modalities and therapeutic exercise, the authors identified limited evidence directly comparing electrical therapy alone with electrical therapy combined with quadriceps strengthening and hamstring stretching in

patients with Grade 1 HNP.¹⁷ Therefore, this study aimed to determine whether the combination was associated with greater pain reduction than electrical therapy alone among patients aged 40 to 60 years treated at the Medical Rehabilitation Unit of RSUD Bendan Kota Pekalongan. The study hypothesis was that the combination would produce a greater reduction in pain.

Methods

This quantitative study used a quasi-experimental pretest posttest two group design. The study was conducted at the Medical Rehabilitation Unit of RSUD Bendan Kota Pekalongan from 6 April to 16 May 2026. Participants were patients diagnosed with Grade 1 HNP by an orthopaedic specialist and a rehabilitation medicine specialist.

Participants were selected using purposive sampling according to predefined eligibility criteria. Participants were not randomly allocated. Group assignment was based on order of attendance. Patients attending during the first and second weeks were assigned to the electrical therapy group, whereas patients attending during the fourth and fifth weeks were assigned to the combination group. This allocation approach was retained as reported in the original study and represents an important limitation when interpreting between group effects.

Inclusion criteria were Grade 1 HNP diagnosed by an orthopaedic specialist and a rehabilitation medicine specialist, age 40 to 60 years, completion of at least four treatment sessions, and low back pain associated with HNP with a VAS score of 3 to 9. Exclusion criteria were vertebral fracture or severe spondylolisthesis, impaired skin sensation representing a contraindication to electrical therapy, and use of high dose analgesic medication.^{9,18}

The initial sample size was estimated using the Slovin formula, $n = N/(1 + Ne^2)$, with a 5% margin of error, resulting in a minimum sample of 20 participants. The study subsequently enrolled 32 participants, of whom two met the reported dropout criteria, leaving 30 participants for analysis. As supplementary information, a post hoc power assessment was conducted using the observed change in VAS score. The mean change was -0.17 in the electrical therapy group and -2.07 in the combination group, giving a mean difference in change of 1.90 points. Using an assumed pretest posttest correlation of 0.50, the reported Cohen *d* was approximately 2.69. With 15 participants per group, $\alpha = 0.05$, and a two-sided test, the estimated power was reported as greater than 99%. Because this effect size was derived from the observed data and the correlation was assumed rather than directly estimated from the dataset, this post hoc calculation was treated only as supplementary information and not as an *a priori* basis for sample size determination.

Electrical therapy consisted of TENS and infrared radiation (IR). TENS was delivered using a two channel ITO ES 521 unit (ITO Co., Ltd., Tokyo, Japan; CE 0123; Class I, Type BF). Burst TENS was administered at 20 Hz with a pulse duration of 200 μ s and an ON/OFF ratio of 7/6 seconds. The treatment duration was 10 minutes, and current intensity was increased gradually from 0 mA to a comfortable level tolerated by the participant without pain. Surface electrodes were positioned over the treatment area according to clinical indication.

IR was delivered using a Heuser TGS 6.1 ohne Dimmer infrared therapy lamp (Heuser Apparatebau GmbH, Haan, Germany; CE 0297), rated at 900 W, 230 V, and 50/60 Hz, with six infrared lamp elements. The lamp was positioned at least 0.6 m from the skin and perpendicular to the treatment area at approximately 90°. Irradiation was delivered for 15 to 20 minutes according to patient tolerance. IR was used as a superficial heating modality within the reported treatment protocol.

The combination group received electrical therapy with the addition of hamstring stretching and quadriceps strengthening. Hamstring stretching was performed in the supine position. One leg remained extended on the mat while the treatment leg was raised with the knee maintained in extension until a tolerable stretch was reached without pain. The position was held for 15 to 30 seconds, followed by 10 seconds of rest, for 3 to 5 repetitions per leg per session. Treatment was delivered face to face as individual therapy under direct physiotherapist supervision. The reported dose was two sessions per week for two weeks, giving four sessions.

Quadriceps strengthening used a static quadriceps exercise. The participant was positioned supine with the lower limbs extended, and a rolled towel was placed under the popliteal fossa. The participant was instructed to contract the quadriceps by pressing the posterior knee toward the towel while maintaining knee extension without lifting the limb. Each contraction was held for 5 to 10 seconds followed by 10 seconds of rest. Each session consisted of two sets of 8 to 10 repetitions, with one minute of rest between sets. The reported dose was two sessions per week for two weeks, for four sessions in total.

Attendance and completion of each intervention session were recorded on a monitoring sheet. All participants received treatment directly according to the standardized protocol and were supervised by a physiotherapist. Potential confounding was addressed through common eligibility criteria, standardized procedures, comparable treatment frequency and duration, and documentation of baseline characteristics such as age and sex. Participants were instructed to follow the prescribed treatment protocol and avoid additional interventions that could affect pain. Physical activity and other treatments could not be optimally controlled and were therefore considered limitations.

Pain intensity was assessed using the VAS. The VAS was used as the primary outcome because pain reduction was the principal endpoint of the study. Measurements were obtained before and after the intervention period.

Data were analyzed using IBM SPSS Statistics version 25.0. Normality was assessed with the Shapiro Wilk test and homogeneity with Levene's test. Within group pretest to posttest changes were examined using paired *t* tests. Independent *t* tests were used to compare group scores at baseline and posttest. Because baseline pain differed significantly between groups, ANCOVA was used as the principal adjusted analysis, with posttest pain as the dependent variable, intervention group as the fixed factor, and pretest pain as the covariate. Statistical significance was set at $\alpha = 0.05$. Partial eta squared was reported as the effect size, together with the confidence intervals available in the original statistical output.

The study reported ethical approval number 094/IV/EC/P3M/UNTS/2026. The name of the approving institution or ethics committee and the informed consent procedure were not specified in the available manuscript and therefore require completion before submission.

Results

Thirty-two participants with Grade 1 HNP were recruited. Two participants were reported as dropouts, resulting in 30 participants included in the final analysis. The final sample comprised 15 participants receiving electrical therapy and 15 receiving the combination of electrical therapy and exercise. The participant flow is presented in Figure 1.

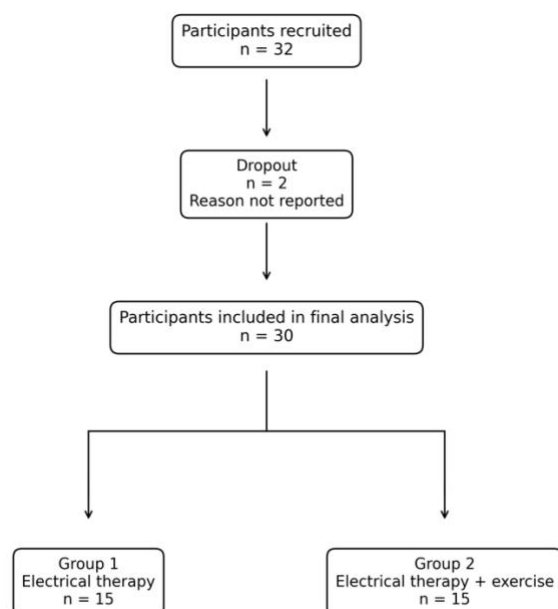


Figure 1. Participant flow. The diagram reflects the recruitment and final analytical sample reported in the manuscript.

The age distribution was identical between groups. In each group, 7 participants were aged 40 to 50 years and 8 were aged 51 to 60 years. Female participants represented 60.0% of the electrical therapy group and 53.3% of the combination group. These characteristics are summarized in Table 1.

Table 1. Participant characteristics by age and sex

Characteristic	Electrical therapy, n (%)	Combination, n (%)
Age 40 to 50 years	7 (46.7)	7 (46.7)
Age 51 to 60 years	8 (53.3)	8 (53.3)
Male	6 (40.0)	7 (46.7)
Female	9 (60.0)	8 (53.3)

Pain categories by age showed that moderate pain was the predominant category before treatment. After treatment, the combination group showed a greater shift toward mild pain, particularly among participants aged 51 to 60 years. The detailed age specific distribution is presented in Table 2.

Table 2. Pain category by age group before and after treatment

Time	Pain category	Electrical 40 to 50	Electrical 51 to 60	Combination 40 to 50	Combination 51 to 60
Pre	Mild	2	1	0	0
Pre	Moderate	5	7	6	8
Pre	Severe	0	0	1	0
Post	Mild	3	2	5	8
Post	Moderate	4	6	2	0
Post	Severe	0	0	0	0

Descriptive pain scores by age are shown in Table 3. In the combination group, posttest mean pain was 4.3 ± 0.9 among participants aged 40 to 50 years and 3.8 ± 0.5 among those aged 51 to 60 years. The corresponding descriptive values for the electrical therapy group were 4.9 ± 0.5 and 5.5 ± 0.5 , respectively.

Table 3. Pain scores by age group

Time	Age	Group	Mean	Median	Mode	SD
Pre	40 to 50	Electrical therapy	5.3	5.4	5.4	0.7
Pre	51 to 60	Electrical therapy	5.5	5.4	4.3	0.6
Pre	40 to 50	Combination	6.3	6.3	5.3	0.8
Pre	51 to 60	Combination	5.9	5.9	5.8	0.5
Post	40 to 50	Electrical therapy	4.9	5.1	5.1	0.5
Post	51 to 60	Electrical therapy	5.5	5.8	5.8	0.5
Post	40 to 50	Combination	4.3	4.1	3.8	0.9
Post	51 to 60	Combination	3.8	4.0	4.1	0.5

Pain categories by sex are presented in Table 4. The distribution showed more female participants in both groups, but the study was not designed to estimate sex specific risk and therefore the descriptive distribution should not be interpreted as evidence that female sex increases HNP pain risk.

Table 4. Pain category by sex before and after treatment

Time	Pain category	Electrical male	Electrical female	Combination male	Combination female
Pre	Mild	1	2	0	0
Pre	Moderate	5	7	6	8
Pre	Severe	0	0	1	0
Post	Mild	2	3	6	7
Post	Moderate	4	6	1	1
Post	Severe	0	0	0	0

Overall pain categories are summarized in Table 5. In the electrical therapy group, moderate pain decreased from 80.0% to 67.0%. In the combination group, moderate pain decreased from 93.3% to 13.3%, while mild pain increased to 86.7% after treatment.

Table 5. Overall pain category before and after treatment

Time	Pain category	Electrical therapy, n (%)	Combination, n (%)
Pre	Mild	3 (20.0)	0 (0.0)
Pre	Moderate	12 (80.0)	14 (93.3)
Pre	Severe	0 (0.0)	1 (6.7)
Post	Mild	5 (33.0)	13 (86.7)
Post	Moderate	10 (67.0)	2 (13.3)
Post	Severe	0 (0.0)	0 (0.0)

Mean pain scores are shown in Table 6. The electrical therapy group changed from 5.45 ± 0.66 at pretest to 5.28 ± 0.65 at posttest, whereas the combination group changed from 6.17 ± 0.71 to 4.10 ± 0.79 .

Table 6. Descriptive pain scores before and after treatment

Group	Time	Mean	Median	Mode	SD
Electrical therapy	Pre	5.45	5.40	5.40	0.66
Electrical therapy	Post	5.28	5.40	5.80	0.65
Combination	Pre	6.17	6.10	5.80	0.71
Combination	Post	4.10	4.10	4.10	0.79

The distributional assumptions were supported by the Shapiro Wilk results, with p values greater than 0.05 for pretest and posttest scores in both groups. Levene's test also indicated homogeneity of variance at pretest and posttest. The detailed results are presented in Table 7.

Table 7. Normality and homogeneity testing

Measure	Electrical statistic	Electrical p	Combination statistic	Combination p
Pretest Shapiro Wilk	0.923	0.217	0.933	0.307
Posttest Shapiro Wilk	0.912	0.144	0.894	0.078
Levene pretest	0.033	0.857		
Levene posttest	0.027	0.870		

Within group analysis showed no statistically significant pretest to posttest change in the electrical therapy group ($p = 0.264$), while the combination group showed a statistically significant change ($p < 0.001$). Because the baseline mean pain scores differed between groups, interpretation of between group effectiveness relied primarily on the adjusted ANCOVA analysis rather than the unadjusted posttest comparison.

Table 8. Within group pretest to posttest comparison

Group	Pretest mean $\pm$ SD	Posttest mean $\pm$ SD	p value
Electrical therapy	5.4533 ± 0.66854	5.2867 ± 0.65232	0.264
Combination	6.1667 ± 0.71780	4.1000 ± 0.79462	<0.001

Paired t test.

Independent t tests showed significant differences between groups at both pretest ($p = 0.009$) and posttest ($p < 0.001$). The baseline difference indicates that direct comparison of posttest means without adjustment may be confounded by the initial pain imbalance. These results are shown in Table 9.

Table 9. Between group comparison of pain scores

Time	p value	Interpretation
Pretest	0.009	Significant difference
Posttest	<0.001	Significant difference

Independent t test.

ANCOVA results are presented in Table 10. The overall model explained 64.8% of the variance in posttest pain ($R^2 = 0.648$; adjusted $R^2 = 0.622$). Pretest pain was significantly associated with posttest pain ($F = 17.743$, $p < 0.001$, partial $\eta^2 = 0.031$, 95% CI 0.00 to 0.22). After controlling for pretest pain, intervention group was significantly associated with posttest pain ($F = 48.547$, $p < 0.001$, partial $\eta^2 = 0.643$, 95% CI 0.47 to 0.75).

Table 10. ANCOVA of posttest pain adjusted for pretest pain

Source	SS	df	MS	F	p	Partial η^2	95% CI
Model	16.429	2	8.215	24.838	<0.001	0.648	0.42 to 0.76
Pretest	5.868	1	5.868	17.743	<0.001	0.031	0.00 to 0.22
Group	16.055	1	16.055	48.547	<0.001	0.643	0.47 to 0.75
Error	8.929	27	0.331				
Total	686.180	30					

Estimated marginal means at the mean pretest pain score further demonstrated the adjusted between group difference. The adjusted mean was 5.512 (95% CI 5.157 to 5.867) for electrical therapy and 3.856 (95% CI 3.506 to 4.205) for the combination group. The adjusted mean difference was 1.656 (95% CI 1.158 to 2.154; $p < 0.001$).

Table 11. Estimated marginal means for posttest pain

Group	Adjusted mean	95% CI	Adjusted mean difference	95% CI	SE	p
Electrical therapy	5.512	5.157 to 5.867	1.656	1.158 to 2.154	0.173	<0.001
Combination exercise	3.856	3.506 to 4.205	-1.656	-2.154 to 1.158	0.170	<0.001

Covariate evaluated at the mean pretest pain score. LSD, least significant difference.

Discussion

The principal finding of this study was that the combination of electrical therapy with hamstring stretching and quadriceps strengthening was associated with a substantially greater reduction in pain than electrical therapy alone. Within group analysis showed no statistically significant change in the electrical therapy group, whereas the combination group demonstrated a significant pretest to posttest reduction. More importantly, because baseline pain differed between groups, the ANCOVA provided the most appropriate primary comparison within the available analysis. After adjustment for pretest pain, the intervention group remained significantly associated with posttest pain, with a partial η^2 of 0.643 and an adjusted mean difference of 1.656 points.

The lack of a statistically significant change within the electrical therapy group should not be interpreted as evidence that TENS or IR can never reduce pain. Rather, the finding indicates that the specific electrical therapy protocol and treatment exposure used in this study did not produce a statistically detectable pretest to posttest change in this sample. This interpretation is compatible with recent evidence suggesting variability in the effectiveness of TENS according to stimulation parameters, clinical population, and treatment dose.¹³ The current protocol used burst TENS at 20 Hz for 10 minutes and IR for 15 to 20 minutes, within a treatment program delivered over four sessions. The relatively limited exposure may have contributed to the observed result.

The combination group showed a larger reduction in pain, from a mean of 6.17 to 4.10. This finding is consistent with the broader literature supporting exercise based rehabilitation for lumbar disc related disorders. A 2025 systematic review and meta analysis reported beneficial effects of exercise therapy on pain and functional outcomes in lumbar disc herniation, while also emphasizing heterogeneity in exercise protocols.³ Recent reviews have similarly described exercise as an important component of conservative rehabilitation for lumbar degenerative disc disease and lumbar disc herniation.^{14,15} The present study adds local clinical evidence concerning a specific combination of hamstring stretching and quadriceps strengthening delivered alongside electrical therapy.

One possible explanation for the larger response is that the exercise component may address functional and biomechanical factors that are not directly targeted by passive electrical modalities.¹⁹ Quadriceps strengthening may support lower limb function and load transfer, while hamstring stretching may improve posterior chain flexibility and lumbopelvic mobility.²⁰ Such changes may complement symptomatic pain modulation. However, the present study did not directly measure muscle strength, flexibility, lumbar biomechanics, disability, or functional capacity. Therefore, these mechanisms should be regarded as plausible explanations rather than demonstrated mediators of the observed pain reduction.

The findings also need to be interpreted in relation to the baseline imbalance. The independent t test indicated a significant difference in pretest pain between groups, with the combination group beginning with a higher mean score. A higher baseline score can influence the magnitude of observed change and may contribute to regression toward the mean.²¹ The use of ANCOVA partially addressed this problem by adjusting posttest pain for pretest pain. The adjusted results continued to show a substantial group effect, which strengthens the evidence for an association between the intervention strategy and lower posttest pain within this dataset. Nevertheless, adjustment cannot fully remove selection bias caused by nonrandom group allocation.

The demographic pattern showed a predominance of participants aged 51 to 60 years and a slightly greater proportion of women in both groups. These descriptive characteristics are broadly compatible with the clinical profile of degenerative spinal disorders, but this study was not designed to estimate demographic risk factors.²² In particular, the greater proportion of women should not be interpreted as evidence that women have a higher risk of HNP pain because sex was neither randomized nor analyzed as a primary explanatory variable.

From a clinical perspective, the findings support consideration of a multimodal rehabilitation approach in which electrical therapy is used as a supportive modality while therapeutic exercise is incorporated to address functional impairments.²³ This interpretation is consistent with recent literature emphasizing exercise based management for lumbar disc related conditions.^{3,14,15} The result does not establish that every combination of electrical therapy and exercise will be superior to electrical therapy alone, because the observed effect may depend on exercise selection, dosage, patient characteristics, and the specific electrical modality used.²⁴

Several methodological limitations should be considered. First, the sample was small, with only 15 participants per group, which limits precision and generalizability. Although the reported supplementary post hoc power calculation suggested very high power based on the observed effect size, post hoc power calculations based on observed data and an assumed pretest posttest correlation should not be interpreted as a substitute for an a priori sample size calculation. Second, group assignment was nonrandom and depended on attendance period, creating potential selection bias and confounding. Third, participants and intervention providers were not blinded, which may introduce performance and detection bias. Fourth, activity level and concurrent treatment exposure were not optimally controlled. Fifth, the study measured pain but did not assess disability, functional performance, muscle strength, flexibility, or longer term follow up.

The strengths of the study include a clearly defined clinical population, a standardized intervention protocol, direct physiotherapist supervision, explicit treatment fidelity monitoring, and the use of ANCOVA to account for the baseline pain imbalance. The detailed TENS, IR, stretching, and strengthening parameters also improve reproducibility. Future research should use randomized allocation, a larger sample, prospectively determined sample size based on an expected effect size, blinded outcome assessment where feasible, standardized monitoring of concurrent treatment and physical activity, and longer follow up. Future trials should also evaluate functional outcomes alongside pain and should examine whether specific exercise doses or electrical stimulation parameters modify the treatment response.

Conclusion

In this quasi-experimental study of patients aged 40 to 60 years with Grade 1 HNP, electrical therapy alone was not associated with a statistically significant pretest to posttest reduction in pain, whereas the combination of electrical therapy with hamstring stretching and quadriceps strengthening was associated with a significant reduction. After adjustment for baseline pain, the combination group had a lower adjusted posttest pain score than the electrical therapy group, with an adjusted mean difference of 1.656 points (95% CI 1.158 to 2.154; $p < 0.001$) and a large partial η^2 of 0.643 (95% CI 0.47 to 0.75). These findings support the use of exercise as an important component of multimodal rehabilitation for Grade 1 HNP, while electrical therapy may be considered a supportive modality.²⁵ Because the study used nonrandomized allocation and a small sample, the findings should not be interpreted as definitive causal evidence. Larger randomized studies with prospectively determined sample sizes, blinded outcome assessment, functional outcomes, and longer follow up are warranted.

Author Contribution

Mahayu Yoga Pradany: Conceptualization; Methodology; Investigation; Data curation; Writing, original draft; Writing, review and editing. Arini Utami: Supervision; Methodology; Writing, review and editing. Mianti Nurriszky Sutejo: Supervision; Writing, review and editing. Muhammad Dwi Kurniawan: Supervision; Writing, review and editing.

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Conflict of Interest Statement

The authors declare no conflict of interest.

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Ethics Statement

This study was approved under Ethical Approval No. 094/IV/EC/P3M/UNTS/2026. The name of the approving ethics committee or institution and the informed consent procedure were not specified in the available manuscript and should be completed before submission.

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