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Effectiveness of physiotherapy modification of Asymmetric-Symmetric Walking exercise on functional balance and independent walking in post-stroke hemiplegic patients

Eficacia de la modificación fisioterapéutica del ejercicio de Marcha Asimétrica–Simétrica sobre el equilibrio funcional y la marcha independiente en pacientes con hemiplejía post-ictus

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SUMMARY

Objective: *Stroke is a leading cause of long-term disability worldwide and often results in hemiplegia and gait impairments. Conventional rehabilitation strategies frequently lack adaptability to the asymmetrical gait patterns observed in post-stroke patients. This study aimed to evaluate the effectiveness of Physiotherapy Modification Asymmetric–Symmetric Walking Exercise (PT-MASWE) in improving functional balance and independent walking among individuals with hemiplegic stroke.* **Methods:** *A one-group pretest-posttest design was employed, involving 60 hemiplegic post-stroke patients at the Physio Sakti Clinic, Makassar. The participants underwent PT-MASWE therapy twice a week for three weeks. The Berg Balance Scale (BBS) was used to assess functional balance and independent walking at baseline, after the third and sixth sessions. Statistical analyses were conducted using Friedman tests, with significance set at $p < 0.05$.* **Results:** *Significant improvements in the BBS scores were observed across all three assessment points. The median BBS scores increased from 9.0 (range, 6-14) at baseline to 27.0 (range, 20-30) after the third session and 54.0 (range, 43-56) after the sixth session ($p < 0.05$). These results indicate a progressive enhancement in balance and postural control following the PT-MASWE intervention.* **Conclusions:** *PT-MASWE is a practical physiotherapeutic approach for improving functional balance and walking ability in patients with hemiplegic stroke. The structured*

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progression from asymmetrical to symmetrical gait training appears to support sensorimotor recovery and functional independence in patients with stroke. Further studies with control groups are required to validate and expand these findings.

Keywords: *Stroke rehabilitation, hemiplegia, independent walking, functional balance, gait recovery.*

RESUMEN

Objetivo: *El ictus es una de las principales causas de discapacidad a largo plazo en todo el mundo y a menudo provoca hemiplejia y alteraciones en la marcha. Las estrategias de rehabilitación convencionales suelen carecer de adaptabilidad frente a los patrones de marcha asimétricos que se observan en pacientes que han sufrido un ictus. Este estudio tuvo como objetivo evaluar la eficacia del Ejercicio de Marcha Asimétrica-Simétrica Modificado por Fisioterapia (PT-MASWE) para mejorar el equilibrio funcional y la marcha independiente en pacientes hemipléjicos posictus.* **Métodos:** *Se empleó un diseño pretest-postest con un solo grupo, compuesto por 60 pacientes hemipléjicos que habían sufrido un ictus y que fueron tratados en la Clínica Physio Sakti de Makassar. Los participantes recibieron terapia PT-MASWE dos veces por semana durante tres semanas. Se utilizó la Escala de Equilibrio de Berg (BBS) para evaluar el equilibrio funcional y la capacidad de marcha independiente al inicio, tras la tercera sesión y después de la sexta sesión. El análisis estadístico se realizó mediante la prueba de Friedman, con un nivel de significación de p< 0,05.* **Resultados:** *Se observaron mejoras significativas en las puntuaciones de la BBS en los tres puntos de evaluación. La mediana de las puntuaciones aumentó de 9,0 (rango 6–14) al inicio a 27,0 (rango 20–30) después de la tercera sesión y a 54,0 (rango 43–56) tras la sexta sesión (p < 0,05). Estos resultados indican una mejora progresiva en el equilibrio y control postural tras la intervención PT-MASWE.* **Conclusiones:** *El enfoque PT-MASWE representa una estrategia fisioterapéutica efectiva para mejorar el equilibrio funcional y la capacidad de marcha en pacientes hemipléjicos posictus. La progresión estructurada del entrenamiento de marcha asimétrica a simétrica parece facilitar la recuperación sensoriomotora y la independencia funcional. Se recomiendan estudios adicionales con grupos control para validar y ampliar estos hallazgos.*

Palabras clave: *Rehabilitación del ictus, hemiplejía, marcha independiente, equilibrio funcional, recuperación de la marcha.*

INTRODUCTION

Stroke is widely recognized as a neurological emergency marked by sudden and focal deficits resulting from vascular injury in the brain, either through ischemic blockage or hemorrhagic rupture (1). Numerous global epidemiological studies have consistently identified stroke as a major cause of mortality and long-term neurological disability, contributing to persistent functional impairment and posing a substantial economic burden on health systems worldwide (2,3). A significant proportion of the global stroke burden is concentrated in low- and lower-middle-income countries, where 87.0 % of stroke-related deaths and 89.0 % of disability-adjusted life years (DALYs) are recorded (4). Since 2016, the number of national stroke clinical quality registries/audits has increased significantly. However, some registries appear to have ceased operation, with the reasons for their discontinuation remaining unclear (5). These findings underscore the global urgency of developing effective, accessible, and sustainable rehabilitation strategies to mitigate the physical and socioeconomic effects of stroke.

In Indonesia, a developing country, the burden of stroke continues to rise, reflecting a significant public health challenge that requires immediate attention. According to the 2018 Indonesian Basic Health Research (Riskesdas), the prevalence of stroke in South Sulawesi Province reached 10.6 %. The highest proportion was observed among individuals aged ≥ 75 years, accounting for 48.2 % of all cases (6). These statistics highlight the considerable impact of stroke, particularly among older adults, who are most vulnerable to acute and long-term complications, such as hemiplegia, mobility impairment, and loss of functional independence.

Hemiplegia, one of the most common post-stroke complications, is characterized by unilateral paralysis contralateral to the affected cerebral hemisphere. This condition is frequently accompanied by gait disturbances, balance dysfunction, muscle stiffness, fatigue, and impaired postural control (7). These deficits compromise motor ability, increase the risk of falls, and hinder patients' ability to regain

independence. Postural instability in stroke survivors is often associated with disrupted integration of multiple sensory systems, including the visual, somatosensory (including proprioception), vestibular, and musculoskeletal systems, which collectively regulate body orientation and adaptive postural responses (8). Previous studies have reported that 16.7 % to 83 % of stroke survivors experience significant balance impairments (9), which may lead to reduced mobility, increased fear of falling, and sedentary behavior, further exacerbating their functional decline and disability (10).

Given these challenges, rehabilitation strategies prioritizing gait and balance recovery are essential for post-stroke patients. Various physiotherapy interventions have been developed to address these issues. One such intervention is Modified Constraint-Induced Movement Therapy (mCIMT), which has been proven effective in improving upper limb function through an intensive, structured, and repetitive approach combined with restriction of the non-paralyzed limb (7). Another approach is the Motor Relearning Program (MRP), which emphasizes task-specific motor retraining, such as balance, standing, and walking, making it relevant for post-stroke rehabilitation (11). Symmetrical gait training, including robot-assisted approaches, has shown promising results in several post-stroke populations (12).

However, each approach has its limitations. mCIMT primarily focuses on upper limb rehabilitation and requires intensive patient participation, which may not be feasible for all stroke conditions (7). Although holistic and task-specific, the MRP does not directly address the restoration of gait symmetry, which is a critical challenge for patients with hemiplegic stroke (11). Symmetrical gait training, including robot-assisted methods, has shown promising outcomes but often lacks adaptability to the asymmetrical movement patterns commonly seen in post-stroke individuals, potentially limiting its effectiveness in promoting functional independence (12).

In clinical practice, many post-stroke patients experience asymmetrical gait patterns, a high risk of falls, and decreased quality of life due to mobility dependence. Therefore, an approach is needed that not only stimulates motor control and balance but also improves explicit walking symmetry (10). The Physiotherapy Modification Asymmetric–Symmetric Walking Exercise (PT-MASWE) is a modified physiotherapy approach developed to address this gap. The PT-MASWE is created using principles from how the nervous system works and is developed in steps, starting from sitting to standing, and includes exercises for balanced stability and both walking types. This approach is tailored to the stroke recovery phase, allowing it to be applied across the subacute-to-chronic recovery phases. To date, there is still limited scientific evidence from prospective studies assessing the effectiveness of PT-MASWE in improving balance and independent walking ability. Therefore, this study was conducted to evaluate the extent to which PT-MASWE can be an effective and efficient alternative intervention for post-stroke hemiplegia.

MATERIALS AND METHODS

Research Design and Participants

This study employed a pre-experimental, one-group pretest-posttest design at the Physio Sakti Clinic in Makassar, Indonesia, from May 2024 to April 2025. Ethical approval was obtained from the Ethics Committee of the Faculty of Nursing, Hasanuddin University (approval no. 212/UN4.18.3/TP.01.02/2025). Participants were adults aged 18–89 years with hemiplegia diagnosed clinically and confirmed using the Medical Research Council (mRC) scale, with muscle strength grades of 2–3 considered eligible. All participants agreed to attend therapy twice weekly for three consecutive weeks and provided written informed consent prior to participation.

The exclusion criteria included vital organ failure (lungs, heart, or kidneys), history of coronary artery bypass graft (CABG) surgery, osteoarthritis, unstable blood pressure (≥160/100 mmHg), cognitive disorders, and refusal to participate. Of the 129 screened patients, 71 met the eligibility criteria and were enrolled in this study. During follow-up, 11 patients discontinued due to incomplete therapy sessions, leaving 60 participants who successfully completed six sessions and were included in the final analysis. The study flow is shown in Figure 1.

The intervention consisted of a modified physiotherapy approach termed *Physiotherapy Modification Asymmetric–Symmetric Walking Exercise* (PT-MASWE), designed to enhance functional balance and independent walking in patients with post-stroke hemiplegia.

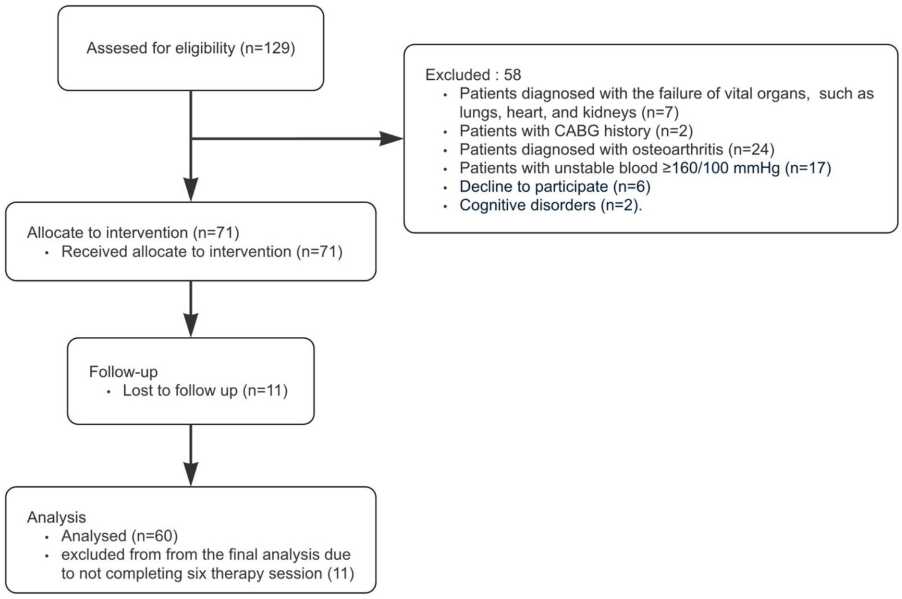

Figure 1. CONSORT Flow Chart of the study procedure.

Assessment and Intervention Procedures

Data collection was conducted in the following stages. First, a pretest was conducted to assess functional balance and independent walking using the Berg Balance Scale (BBS), administered according to the standardized guidelines provided by the Rehabilitation Measures Database of the Shirley Ryan AbilityLab (https://www.sralab.org/rehabilitation-measures/berg-balance-scale) (13). Next, the intervention, which involved physiotherapy-modified asymmetric–symmetric walking exercise (PT-MASWE), was administered twice weekly for three weeks. Upon completion of the intervention, a post-test was conducted by re-evaluating functional balance and independent walking using the BBS to identify changes that occurred after the intervention.

The preparation stage began by ensuring that patients with post-stroke hemiplegia met the eligibility criteria, followed by the measurement of blood pressure. If the blood pressure reached ≥160/100 mmHg, the intervention was not continued to maintain patient safety. The patients then received brief education about the purpose of the intervention and were positioned appropriately in the supine or sitting position.

The basic exercise sequence consisted of four components: *bridging exercise* to stabilize the pelvis and prepare for transition to a sitting position; *quadriceps strengthening exercise* to enhance lower limb strength in preparation for stepping; *bugnet side-lying exercise* to correct posture and maintain trunk alignment; and *standing balance and stabilization exercise* to improve balance and strengthen the hip muscles before gait training. Each exercise was performed in three sets of repetitions.

After completing the basic exercise sequence, the patients proceeded to the core intervention,

namely PT-MASWE, which involved gait training that began with an asymmetric walking pattern and progressively transitioned into a symmetric one. This modification was designed to facilitate sensorimotor integration, improve functional balance, and support the recovery of independent walking ability in patients with post-stroke hemiplegia.

Statistical Analysis

Data analysis was conducted using IBM SPSS 25.0 software, and the Shapiro-Wilk test was used to assess the normality of the distribution. The Friedman test was used to compare functional balance and independent walking at baseline and after the third and sixth sessions. Data are presented as median (min-max), and values were considered significant at $p < 0.05$.

RESULTS

All participants in this study were stroke patients with hemiplegia, with a total of 60 individuals enrolled. Of these, 36 (60 %) patients had hemorrhagic stroke (HS), and 24 (40 %) had non-hemorrhagic stroke (NHS). Regarding comorbidities, 4 (6.7 %) participants had hypertension, 8 (13.3 %) had diabetes mellitus, and 48 (80 %) reported no comorbidities. Based on gender, the majority of respondents were female, comprising 36 (60 %) individuals, while 24 respondents (40 %) were male. The median age of the participants was 59.5 years (range, 27–89 years). Muscle strength, assessed using the Medical Research Council (mRC) scale, showed a median score of 2 (range, 2–3). The median systolic blood pressure was 130 mmHg (range, 130–150 mmHg), and the median diastolic blood pressure was 90 mmHg (range, 90–100 mmHg) (Table 1).

Table 1. Characteristics of Respondents

Subject Characteristics (n=60)	n (%)	Median (Min-Max)
Type of Stroke:		
a. Hemorrhagic Stroke (HS)	36 (60)	
b. Non-hemorrhagic stroke (NHS	24 (40)	
Comorbid:		
Hypertension	4 (6.7)	
Diabetes Mellitus	8 (13.33)	
No Comorbid	48 (80)	
Gender:		
Men	24 (40)	
Women	36 (60)	
Age (Years)	59.5 (27-89)	
Muscle Strength using mRC Scale		2 (2-3)
Systolic Blood Pressure (mmHg)		130 (130-150)
Diastolic Blood Pressure (mmHg)		90 (90-100)

The results of this study showed a significant difference in the median scores of the Berg Balance Scale (BBS) for functional balance and independent walking across three time points: baseline, after the third session, and after the sixth session of the Physiotherapy Modification Asymmetric–Symmetric Walking Exercise (PT-MASWE) intervention ($p<0.05$) (Table 2). At baseline, before the intervention, the median BBS score was 9 (range 6–14). Following the three PT-MASWE sessions, the median BBS score increased to 27, with the lowest and highest scores of 20 and 30, respectively. Further improvement was observed after the sixth session, with the

median BBS score reaching 54 and scores ranging from 43 to 56. These findings indicate that the PT-MASWE intervention contributed to a gradual improvement in the participants' functional balance over time (Figure 2).

Table 2. Berg Balance Scale Level

Functional Balance and Independent walking (n=60)	Median (Min-Max)	p-value
Baseline	9.0 (6-14)	0,0001*
3rd Treatment	27.0 (20-30)	
6th Treatment	54.0 (43-56)	

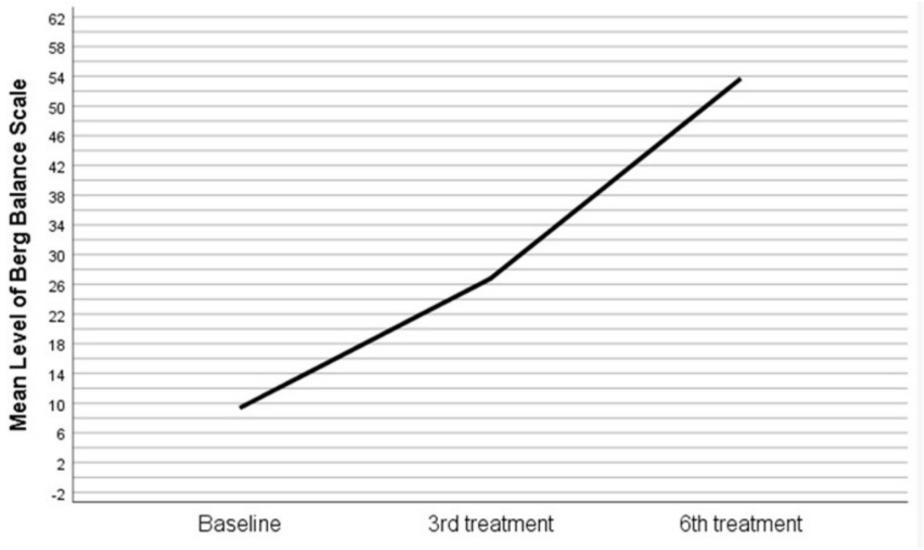

Figure 2. Graphic of Berg Balance Scale Levels.

DISCUSSION

This study revealed that most stroke patients with hemiplegia were women (60 %), with a median age of 59.5 years. These findings contrast with global epidemiological data, which report a slightly higher stroke incidence in men (52.6 %) than in women (47.4 %) (4). The greater proportion of women in this study might be explained by their tendency to experience stroke at older ages, often with greater pre-stroke disability and poorer outcomes (14). Consequently, women are more likely to present with severe impairments, such as hemiplegia, and require intensive rehabilitation.

Regarding stroke type, this study found a predominance of hemorrhagic strokes (60 %), which is higher than both global and Indonesian trends, where ischemic strokes are more common (65.3 % globally and 67.1 % in Indonesia), and hemorrhagic strokes account for only 29 %-30 % of cases (4,15). This discrepancy may reflect the referral hospital setting of the study,

which typically manages more severe cases and underscores the importance of hypertension management, given that uncontrolled blood pressure is the leading risk factor for intracerebral hemorrhage.

The median age of 59.5 years aligns with global estimates, suggesting that over half of all strokes occur in individuals under 70 years of age, with approximately 15 % occurring between 15 and 49 years of age (4). The inclusion of patients as young as 27 years in this study underscores the increasing burden of stroke among younger adults in low- and middle-income countries, which has significant socioeconomic implications (15). Interestingly, only a small fraction of patients reported comorbidities such as hypertension (6.7 %) and diabetes (13.3 %), whereas the majority (80 %) had no documented comorbidities. This contrasts with global evidence that identifies hypertension as the primary modifiable risk factor for stroke, responsible for over half of stroke-related disability-adjusted life years (DALYs) (4). This discrepancy may reflect the underdiagnosis or underreporting of chronic conditions, indicating the need for improved screening and documentation of vascular risks in clinical practice (15).

Overall, the findings of this study provide valuable insights into the local characteristics of patients with stroke, highlighting the predominance of women and hemorrhagic strokes. These results reinforce the importance of integrating sex and age considerations into stroke prevention, management, and rehabilitation. In particular, healthcare systems in developing countries, such as Indonesia, must strengthen the early detection of vascular risk factors, ensure equitable access to care, and adopt rehabilitation programs that are responsive to biological, hormonal, and social differences between men and women.

The main finding of this study was that the Modified Physiotherapy Asymmetric–Symmetric Walking Exercise (PT-MASWE) significantly improved functional balance in patients with hemiplegic stroke. This was demonstrated by a progressive increase in the median Berg Balance Scale (BBS) score from 9 at baseline to 27 after the third session, and further to 54 after the sixth session. This improvement indicates that PT-MASWE is a practical and adaptive rehabilitation approach capable of reactivating neuromuscular mechanisms, enhancing postural control, and restoring gait symmetry in patients with stroke. These findings are consistent with the principles of neuroplasticity, which state that structured and repetitive functional training supports central nervous system reorganization and motor recovery (16). During the critical window of neurological recovery following a stroke, targeted motor stimulation, such as that provided by the PT-MASWE, plays a crucial role in reinforcing newly formed neural pathways and enhancing locomotor ability. This is supported by Liu et al. (17), who demonstrated that balance and core stability training enhanced functional performance in patients with stroke.

Before implementing the PT-MASWE, patients underwent a preparatory exercise program designed to optimize their readiness for gait rehabilitation. The program consisted of four key components: bridging to enhance pelvic stability and core activation, quadriceps strengthening to increase lower-limb power for sit-to-stand and stepping, side-lying exercises to improve trunk alignment and reduce compensatory patterns, and standing balance training to reinforce hip stabilizers and refine postural strategies. Collectively, these exercises facilitate neuromuscular activation and sensorimotor adaptation by enhancing proprioceptive feedback, vestibular responses, and multisensory integration, which in turn promote dynamic balance and gait symmetry (18,19). Additionally, the physical activity embedded in these interventions likely improved cerebral circulation and oxygenation, thereby further supporting functional recovery. By providing a foundation of proximal control and postural stability, this preparatory phase established the physiological conditions necessary for the subsequent asymmetric–symmetric walking training. It reflected a progressive, evidence-based rehabilitation strategy.

The PT-MASWE is a structured, stepwise program that stimulates the transition from asymmetrical to symmetrical gait through the following progressive stages: sit-to-stand, symmetrical standing stabilization, asymmetric gait patterning, and transition to symmetrical walking. Grounded in the principles of Proprioceptive Neuromuscular Facilitation

(PNF) and Sensorimotor Integration (SMI), this approach actively engages both paretic and non-paretic limbs, thereby minimizing compensatory overuse and promoting bilateral movement symmetry (11,20). Compared with other approaches, such as mCIMT (primarily for upper limbs), the Motor Relearning Program (which emphasizes task-specific training but not gait symmetry), and robot-assisted gait training (which often lacks adaptability to individual asymmetries) (7,11,12), PT-MASWE offers a more accessible and context-appropriate strategy for stroke rehabilitation. One of the major advantages of PT-MASWE is its cost-effectiveness. Unlike robotic gait training or intensive inpatient rehabilitation, it requires minimal equipment and can be implemented in community-based or primary health care settings. This accessibility is crucial for low- and middle-income countries (LMICs), where the stroke burden is high and rehabilitation resources are scarce (5,6).

The stable progression of BBS scores over six sessions indicates that the PT-MASWE effectively re-engaged proprioceptive awareness and vestibular responses through a coordinated multisensory stimulation. Clinically, this translates to a reduced fall risk, accelerated gait recovery, and enhanced independence in activities of daily living (ADL), all of which are critical outcomes for successful stroke rehabilitation (21). The cost-effectiveness of PT-MASWE, which requires minimal equipment and is adaptable for use in community or primary healthcare, further enhances its applicability in low- and middle-income countries (LMICs).

Limitations

This study had several limitations. First, the research design employed a pretest-posttest design without a control group; therefore, the results cannot be compared with those of other therapies or natural recovery over time. Second, the sample size was limited to a single clinic in Makassar, making it challenging to generalize the findings to a larger population. Third, the outcome was measured using only one tool (the Berg Balance Scale), without considering other aspects, such as biomechanical analysis or quality of life. Finally, the intervention duration was relatively short (3 weeks), which may not be sufficient to observe the long-term effects of the PT-MASWE.

Future research should involve randomized controlled trials with larger and more diverse samples, as well as stratification by stroke type and sex, to validate the effectiveness of PT-MASWE and clarify its broader applicability.

CONCLUSION

The findings of this study demonstrate that Physiotherapy Modification Asymmetric–Symmetric Walking Exercise (PT-MASWE) significantly improves functional balance and independent walking ability in patients with post-stroke hemiplegia. The structured and progressive approach, from asymmetrical to symmetrical gait training, facilitates sensorimotor integration and enhances postural control. These results suggest that PT-MASWE is a practical and clinically applicable intervention that can be effectively implemented in future routine rehabilitation programs. The observed improvements across sessions support its use as an effective modality for promoting gait normalization and functional independence in patients with stroke. Future studies employing randomized controlled designs are recommended to validate these outcomes further and explore the long-term benefits in diverse stroke populations.

Author Contributions

Prof. Dr. Djohan Aras, S.Ft, Physio, M.Kes, M.Pd contributed to the research concept and design and provided the final approval for the article. Dr. Andi Rizky Arbaim Hasyar, S.Ft, Physio, was responsible for the data analysis and manuscript writing. Aco Tang, S.ST, S.KM, M.Kes: Collection and assembly of data, and critical revision of the article

Ethical Approval

The research procedure was reviewed and approved by the Ethics Committee of the Faculty

of Nursing, Hasanuddin University (Approval No. 212/UN4.18.3/TP.01.02/2025). Written informed consent was obtained from each participant prior to the experiment's commencement.

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Conflict Of Interest. The authors declare that they have no conflicts of interest related to this study.

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