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The Association Between Physical Activity and Lower Extremity Flexibility in Older Adults: A Cross-Sectional Study

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Abstract

Background: Aging is associated with progressive musculoskeletal decline, including reduced lower extremity flexibility, which may impair gait performance, balance, and functional independence among older adults. Physical activity is considered an important modifiable factor for maintaining musculoskeletal function and flexibility in aging populations.

Objective: This study aimed to analyze the association between physical activity level and lower extremity flexibility among community-dwelling older adults in Melinggih Village, Gianyar Regency, Bali, Indonesia.

Methods: This observational analytic study used a cross-sectional design involving 61 older adults aged ≥60 years recruited using purposive sampling. Physical activity level was assessed using the Baecke Physical Activity Questionnaire (BPAQ), while lower extremity flexibility was measured using the Sit and Reach Test (SRT). Data were analyzed using Spearman's rank correlation test with $p<0.05$.

Results: Most participants demonstrated moderate physical activity levels (70.5%). The mean BPAQ score was 8.98±1.37, while the mean SRT score was 0.46±4.36 cm. Spearman correlation analysis showed a significant positive association between physical activity level and lower extremity flexibility ($r=0.680$; $p<0.001$). The findings indicate a moderate-to-strong clinically relevant association between habitual physical activity and flexibility performance among older adults.

Conclusion: Physical activity level was significantly associated with lower extremity flexibility among older adults. Regular physical activity may contribute to maintaining flexibility and functional mobility; however, causal relationships cannot be established due to the cross-sectional design.

Keywords
Aged; Motor Activity; Flexibility; Range of Motion, Articular; Cross-Sectional Studies

Introduction

Population aging has become a major global public health challenge due to the increasing proportion of older adults worldwide.[1] Aging is associated with progressive physiological decline affecting multiple body systems, particularly the musculoskeletal system, resulting in decreased muscle mass, reduced muscle strength, impaired joint mobility, and increased connective tissue stiffness. These degenerative changes contribute to functional limitations, reduced mobility, and decreased quality of life among older adults.[2] Age-related musculoskeletal decline may also impair balance control, gait performance, and the ability to perform activities of daily living independently.[3] Consequently, maintaining physical function has become an important component of healthy aging strategies.[4]

In Indonesia, the older adult population continues to increase annually, reflecting demographic transition and improvements in healthcare services and life expectancy.[5] However, increased longevity is frequently accompanied by higher prevalence of physical disability, mobility impairment, and dependency among older adults.[1] Previous studies have shown that functional decline in older adults is strongly associated with increased fall risk, reduced gait efficiency, decreased postural stability, and impaired participation in daily activities.[6] Falls among older adults remain an important public health concern because they may lead to fractures, hospitalization, long-term disability, and reduced independence.[7] In Gianyar Regency, Bali, previous reports indicated that falls among community-dwelling older adults were associated with impaired physical performance and reduced balance confidence.[8] These findings suggest the importance of identifying modifiable factors associated with physical function in older populations.

One important component of physical function in older adults is lower extremity flexibility.[1] Flexibility refers to the ability of muscles and joints to move through an adequate range of motion without excessive restriction.[9] Lower extremity flexibility is essential for performing functional movements such as walking, bending, standing up from sitting positions, climbing stairs, and maintaining postural balance. Reduced flexibility may contribute to abnormal movement patterns, decreased gait performance, limited mobility, and increased risk of falls among older adults.[10] In addition, aging-related reductions in collagen elasticity, muscle extensibility, and joint lubrication may further decrease lower extremity flexibility and functional performance.[2] These physiological changes may eventually contribute to sarcopenia-related disability and reduced functional independence among older adults.[11]

Physical activity is considered an important modifiable factor influencing musculoskeletal health and functional capacity in aging populations.[12] Physical activity is defined as any bodily movement produced by skeletal muscles that requires energy expenditure.[13] Regular physical activity has been associated with improved cardiovascular fitness, muscle strength, balance, flexibility, and mobility among older adults.[14] Conversely, insufficient physical activity may accelerate age-related decline in musculoskeletal function and increase the risk of disability and dependency. Previous studies have demonstrated that physically active older adults tend to exhibit better flexibility, postural control, and functional mobility compared with sedentary individuals.[15] Physical activity involving repeated movement and joint mobilization may promote adaptive responses in muscles and connective tissues, helping preserve muscle extensibility, tissue elasticity, and joint range of motion.[16] Furthermore, habitual physical activity

may improve circulation, neuromuscular coordination, and connective tissue compliance, thereby supporting flexibility performance in older adults.[17]

Several studies have investigated the relationship between physical activity and physical function among older adults; however, evidence specifically examining lower extremity flexibility remains limited, particularly in community-based older adult populations in Indonesia.[18] Most previous studies focused primarily on balance, muscle strength, or general physical performance rather than flexibility as a distinct musculoskeletal component. In addition, variations in cultural background, occupational activity, and lifestyle patterns among older adults may influence physical activity behavior and flexibility outcomes.[19] Rural older adults in Bali commonly participate in household activities, agricultural work, religious ceremonies, and community-based social activities that may contribute differently to habitual physical activity patterns compared with urban populations.[14,19]

Melinggih Village, located in Payangan District, Gianyar Regency, Bali Province, has a growing older adult population with varying levels of physical activity and functional capacity. Community-based elderly exercise programs are regularly conducted in this area through local banjar activities; however, information regarding lower extremity flexibility among older adults remains limited. Understanding the relationship between physical activity level and lower extremity flexibility is important for developing evidence-based physiotherapy interventions aimed at maintaining mobility, preventing functional decline, and promoting healthy aging among community-dwelling older adults.[20]

Therefore, this study aimed to analyze the association between physical activity level and lower extremity flexibility among older adults in Melinggih Village, Gianyar Regency, Bali, Indonesia. This study hypothesized that higher physical activity levels would be associated with better lower extremity flexibility among older adults. This study was exploratory in nature.

Methods

This study employed an observational analytic design using a cross-sectional approach to examine the association between physical activity level and lower extremity flexibility among community-dwelling older adults. A cross-sectional design was selected because it allows assessment of the relationship between variables at a single point in time and is appropriate for exploratory community-based research involving aging populations. Data collection was conducted between March and April 2026 in Melinggih Village, Payangan District, Gianyar Regency, Bali Province, Indonesia. Melinggih Village is a rural area in Bali where older adults commonly engage in household, agricultural, religious, and community-related activities that may contribute to habitual physical activity patterns. Community-based elderly exercise activities are routinely conducted through local banjar programs, and data collection was performed at the village community hall (Bale Banjar).

Participants were recruited using purposive sampling based on predetermined eligibility criteria. A total of 71 older adults were initially screened for eligibility. Ten individuals were excluded due to a history of spinal injury, severe lower extremity pain, or Mini Mental State Examination (MMSE) scores below 24. Consequently, 61 participants fulfilled the inclusion criteria and completed the study procedures, resulting in a response rate of 85.9%. The use of purposive sampling may increase the risk of selection bias because participants were recruited from community-based exercise activities, potentially resulting in a relatively healthier and more active study population.[21] However, this sampling technique was considered appropriate to ensure that participants fulfilled the required physical and cognitive conditions for the assessment procedures.

The inclusion criteria consisted of older adults aged ≥60 years, permanent residents of Melinggih Village, willingness to participate by signing written informed consent, and MMSE scores ≥24 indicating normal cognitive function. Participants were excluded if they had severe neurological disorders, severe visual or hearing impairment, severe pain or movement limitation affecting testing procedures, or severe musculoskeletal disorders involving the spine or pelvis. Severe musculoskeletal disorders were operationally defined as conditions causing substantial pain, restricted movement, or inability to safely perform the Sit and Reach Test (SRT) based on participant interviews and direct observation during screening procedures. Participants who required walking aids were also excluded to minimize mobility-related confounding factors. The participant recruitment and screening process is summarized below for conversion into a STROBE-based flowchart (Figure 1).

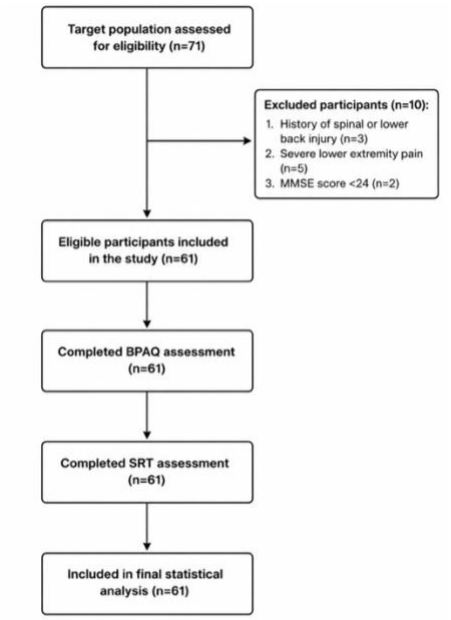

Figure 1. STROBE Flowchart of Participant Recruitment and Selection Process

Sample size estimation was performed for correlation analysis using a minimum expected correlation coefficient of r=0.35 derived from previous studies investigating flexibility and physical activity in older adults.[22] With a 95% confidence level and 80% statistical power, the minimum required sample size was calculated to be 61 participants using correlation sample size estimation formulas. However, software-based power analysis was not performed and should be considered in future studies.[22]

The independent variable in this study was physical activity level, whereas the dependent variable was lower extremity flexibility. Potential confounding variables identified in this study included age, sex, body mass index (BMI), musculoskeletal condition, and comorbidities. However, adjusted statistical analysis was not performed because of the limited sample size and statistical power.

Physical activity level was assessed using the Baecke Physical Activity Questionnaire (BPAQ), which consists of occupational activity, sports activity, and leisure-time activity domains. The BPAQ is a standardized self-reported questionnaire widely used to evaluate habitual physical activity levels in adult and older adult populations. Previous studies demonstrated acceptable validity and reliability of the BPAQ, with Intraclass Correlation Coefficient (ICC) values ranging from 0.78 to 0.87.[23] Participants with BPAQ scores <7.5 were categorized as having low physical activity levels, whereas scores ≥7.5 were categorized as moderate physical activity levels based on score distribution and previous community-based studies involving older adults. Categorization was performed to facilitate interpretation of activity level distribution among participants, although numerical data were also analyzed continuously during correlation analysis.[23]

Lower extremity flexibility was assessed using the Sit and Reach Test (SRT), which is a standardized flexibility assessment commonly used to evaluate hamstring and lower back flexibility.[15] Participants were instructed to sit with both knees fully extended and reach forward maximally along the measurement scale without flexing the knees. The assessment was performed while participants wore their usual footwear condition to maintain comfort and safety during testing procedures. Standardized verbal instructions were provided before testing, and each participant performed two testing trials**.** The best score from the two trials was recorded in centimeters (cm) to improve measurement consistency and reduce random measurement error. The use of repeated trials in flexibility testing has been recommended to improve reliability and minimize performance variability.[24]

Before data collection, all participants underwent cognitive screening using the MMSE to ensure adequate comprehension of study instructions and questionnaires. Eligible participants subsequently completed the BPAQ questionnaire through interviewer-assisted administration to minimize misunderstanding and incomplete responses among older adults. Following questionnaire completion, lower extremity flexibility assessment using the SRT was performed individually by the researcher. The assessor received prior training regarding standardized measurement procedures to improve intra-rater consistency and reduce measurement bias. Standardized verbal instructions and testing procedures were applied equally to all participants. In addition, flexibility assessment was performed during daytime community exercise sessions to reduce potential diurnal variation in flexibility measurements.

Descriptive statistics were used to summarize participant characteristics and study variables. Numerical data were presented as mean ± standard deviation (SD), median, and interquartile range (IQR), whereas categorical data were presented as frequencies and percentages. Normality testing was conducted using the Kolmogorov–Smirnov test. The results demonstrated that BPAQ scores were normally distributed (p=0.200), whereas SRT scores showed non-normal distribution (p=0.006). Therefore, non-parametric statistical analysis was considered appropriate. Scatter plot visualization was used to assess the relationship pattern between variables before correlation analysis. Data screening procedures indicated no extreme outliers requiring exclusion. The association between physical activity level and lower extremity flexibility was analyzed using Spearman's rank correlation test with a significance level of $p<0.05$. Correlation strength was interpreted using Evans classification criteria.[25]

Potential sources of bias were also considered during the study process. Recall bias and social desirability bias may have occurred because physical activity level was assessed using a self-reported questionnaire. To minimize measurement bias, interviewer-assisted administration, assessor training, and standardized testing procedures were implemented consistently throughout data collection.

This study received ethical approval from the Ethics Committee of the Faculty of Medicine, Universitas Udayana, Indonesia, with ethical clearance number 0982/UN14.2.2.VII.14/LT/2026 dated March 5, 2026. Written informed consent was obtained from all participants before data collection. Participants were informed regarding study procedures, confidentiality of data, and their right to withdraw from the study at any time without consequences. The authors declared no conflict of interest, and this study received no external funding.

Results

A total of 61 community-dwelling older adults from Melinggih Village, Payangan District, Gianyar Regency, Bali Province were included in this study. All participants fulfilled the eligibility criteria and completed the study procedures without missing data. Prior to statistical analysis, participant screening and recruitment procedures were conducted systematically to ensure that participants met the required cognitive and physical conditions for questionnaire administration and flexibility assessment.

The demographic and clinical characteristics of participants are presented in Table 1 to provide an overview of participant distribution and baseline study variables. The majority of participants were female (54.1%), while male participants accounted for 45.9% of the study population. The mean participant age was 63.82±3.25 years, with an age range of 60–72 years. All participants demonstrated normal cognitive status based on MMSE screening, with a mean MMSE score of 28.18±2.05.

Assessment of physical activity level using the BPAQ demonstrated that most participants had moderate physical activity levels. A total of 43 participants (70.5%) were classified into the moderate physical activity category, whereas 18 participants (29.5%) had low physical activity levels. The mean BPAQ score was 8.98±1.37, with a median score of 9.10 and an interquartile range (IQR) of 2.00. Lower extremity flexibility assessed using the SRT showed that 38 participants (62.3%) achieved SRT scores ≥0 cm, while 23 participants (37.7%) demonstrated SRT scores <0 cm. The mean SRT score was 0.46±4.36 cm, with scores ranging from −14.10 cm to 6.90 cm. The median SRT score was 0.90 cm with an IQR of 5.70, indicating variability in flexibility performance among participants.

Table 1. Characteristics of Participants

Variable	Category	n	%	Mean ± SD	Median (IQR)	Min–Max
Sex	Male	28	45.9	–	–	–
	Female	33	54.1	–	–	–
Age (years)	≥60	61	100	63.82±3.25	63.00 (4.00)	60–72
Cognitive status (MMSE)	Normal (≥24)	61	100	28.18±2.05	28.00 (2.00)	24–30
Physical activity level (BPAQ)	Low (<7.5)	18	29.5	8.98±1.37	9.10 (2.00)	6.20–12.20
	Moderate (≥7.5)	43	70.5	–	–	–
Lower extremity flexibility (SRT)	<0 cm	23	37.7	0.46±4.36	0.90 (5.70)	−14.10–6.90
	≥0 cm	38	62.3	–	–	–

Note: MMSE = Mini Mental State Examination; BPAQ = Baecke Physical Activity Questionnaire; SRT = Sit and Reach Test; SD = standard deviation; IQR = interquartile range.

Before correlation analysis was performed, normality testing was conducted to determine the distribution pattern of the study variables and to identify the most appropriate statistical approach for data analysis. The results of the Kolmogorov–Smirnov test demonstrated that BPAQ scores were normally distributed (p=0.200), whereas SRT scores showed non-normal distribution (p=0.006). Therefore, non-parametric statistical analysis using Spearman's rank correlation test was considered appropriate.

Table 2. Normality Test Results

Variable	Statistic	df	p-value
Physical activity level (BPAQ)	0.078	61	0.200
Lower extremity flexibility (SRT)	0.137	61	0.006

Note: Kolmogorov–Smirnov test; df = degrees of freedom.

To further evaluate the relationship pattern between study variables, scatter plot analysis and flexibility distribution plots were assessed prior to correlation analysis. The scatter plot demonstrated a positive linear tendency between BPAQ scores and SRT scores, indicating that participants with higher physical activity levels generally exhibited better lower extremity flexibility. In addition, visual inspection of the distribution plots suggested variability in flexibility performance among participants without evidence of extreme skewness or clustering patterns. Data screening procedures identified no extreme outliers requiring exclusion from the analysis.

The main analytical findings are presented in Table 3, which summarizes the correlation analysis between physical activity level and lower extremity flexibility among older adults. Spearman's rank correlation analysis demonstrated a statistically significant positive association between physical activity level and lower extremity flexibility ($r=0.680$; $p<0.001$). Based on Evans classification criteria, the correlation coefficient indicated a moderate-to-strong positive relationship between variables. The findings indicate a statistically significant association between physical activity level and lower extremity flexibility, with physically active older adults tending to demonstrate better flexibility performance.[26]

Table 3. Spearman Rank Correlation Analysis

Variable	r	p-value
Physical activity level and lower extremity flexibility	0.680	<0.001

Note: r = Spearman correlation coefficient.

Participants categorized as having moderate physical activity levels generally demonstrated higher SRT scores compared with participants with low physical activity levels. The observed relationship indicates that physically active older adults tended to exhibit greater lower extremity flexibility and better movement performance. However, because this study used a cross-sectional design, causal relationships between physical activity level and lower extremity flexibility could not be established.

Additional analyses such as subgroup analysis based on sex or age category and adjusted correlation analysis controlling for potential confounding variables were not performed because of limited sample size and statistical power. Similarly, sensitivity analysis was not conducted in the present study.[27]

Discussion

This study demonstrated a significant positive association between physical activity level and lower extremity flexibility among community-dwelling older adults in Melinggih Village, Gianyar Regency, Bali, Indonesia. Older adults with higher physical activity levels tended to exhibit better lower extremity flexibility, as reflected by higher Sit and Reach Test (SRT) scores. The correlation coefficient obtained in this study ($r=0.680$) indicated a moderate-to-strong relationship based on Evans classification criteria, suggesting that physical activity may represent an important modifiable factor associated with musculoskeletal function in aging populations. The magnitude of the observed correlation also indicates clinically meaningful relevance because flexibility plays an important role in maintaining mobility, gait performance, and independence among older adults.[28]

The observed association may be explained by physiological adaptations occurring within the musculoskeletal system during habitual physical activity. Aging is characterized by progressive reductions in muscle elasticity, collagen extensibility, connective tissue compliance, and joint lubrication, which contribute to decreased flexibility and movement efficiency.[2] Repeated movement during physical activity may stimulate tissue remodeling, improve circulation, preserve muscle extensibility, and maintain joint mobility, thereby helping counteract degenerative musculoskeletal changes associated with aging.[3] Furthermore, regular physical activity may improve neuromuscular coordination and connective tissue elasticity, which support functional movement patterns and flexibility performance in older adults.[29]

The findings of the present study are consistent with previous studies reporting that physically active older adults generally demonstrate superior flexibility, balance, and functional mobility compared with sedentary populations. Wicaksono et al. reported that lower extremity flexibility was positively associated with balance performance and movement function in older adults.[18] Similarly, Malka and Hanţiu demonstrated that recreational physical activity improved trunk and hamstring flexibility among older adults during the COVID-19 pandemic period.[6] These findings collectively suggest that regular movement and mobility-related activities may contribute to preserving musculoskeletal flexibility and reducing functional decline in aging populations.

Lower extremity flexibility is an important component of functional independence because it supports efficient gait performance, postural control, and activities of daily living.[1] Adequate flexibility of the hip, knee, and ankle joints facilitates walking, transitional movements, stair negotiation, and balance maintenance. Reduced flexibility may lead to compensatory movement patterns, impaired mobility efficiency, and increased fall risk.[13] In addition, impaired lower extremity flexibility has been associated with decreased dynamic balance, reduced movement confidence, and sarcopenia-related disability among older adults.[12] Therefore, the positive association identified in this study has important clinical implications for physiotherapy interventions and healthy aging programs targeting community-dwelling older adults.

The findings of this study also highlight the importance of promoting regular physical activity within rural older adult populations. Older adults living in Melinggih Village commonly participate in agricultural work, household activities, religious ceremonies, and community-based social activities involving repetitive lower extremity movement. These habitual activities may partially contribute to maintaining flexibility and mobility among participants. Differences in occupational demands and sociocultural activities between rural and urban populations may influence physical activity behavior and musculoskeletal outcomes.[19] Consequently, physical activity interventions for older adults should consider local community characteristics and lifestyle patterns to improve program effectiveness.[30]

Although this study demonstrated a statistically significant association between physical activity level and lower extremity flexibility, the findings should be interpreted carefully. The cross-sectional design only identifies associations between variables and

does not establish causal relationships. It is possible that physically active older adults develop better flexibility over time; however, reverse association may also occur, where older adults with better flexibility are more capable of engaging in physical activity. Therefore, the present findings should not be interpreted as evidence that physical activity directly causes improvements in flexibility.

Several methodological limitations should also be considered. First, the use of purposive sampling may increase the risk of selection bias and limit external validity.[31] Participants were recruited from community-based exercise activities, which may result in a relatively healthier and more active sample compared with the general older adult population. Second, physical activity level was assessed using a self-reported questionnaire, which may be affected by recall bias and social desirability bias among older adults. Participants may overestimate or underestimate their habitual physical activity levels during questionnaire administration. This condition may potentially contribute to overestimation of the observed correlation between physical activity and flexibility performance.[32]

Third, several potential confounding factors, including body mass index (BMI), osteoarthritis, comorbidities, nutritional status, and educational background, were not specifically analyzed in adjusted statistical models because of the limited sample size and statistical power. Subgroup analysis based on sex or age category was also not performed because of limited participant distribution within each subgroup. Consequently, the findings should be interpreted as preliminary evidence requiring further confirmation in larger studies.

Another limitation involves the relatively small sample size and the geographically specific study setting. Participants were recruited exclusively from a rural community in Gianyar Regency, Bali, which may limit generalizability to urban older adult populations with different lifestyle patterns, occupational demands, and physical activity behaviors. Therefore, applicability of the findings to urban elderly populations should be interpreted cautiously. Future studies involving larger and more heterogeneous populations are needed to evaluate whether the observed association remains consistent across different demographic and clinical characteristics. Longitudinal or prospective cohort studies are also recommended to clarify temporal relationships and explore potential causal pathways between physical activity and flexibility in older adults.[21]

Despite these limitations, this study has several strengths. Standardized and widely used instruments were employed to assess physical activity and flexibility, including the Baecke Physical Activity Questionnaire (BPAQ) and Sit and Reach Test (SRT). In addition, measurement procedures were standardized through assessor training and uniform verbal instructions to reduce measurement bias. The study also contributes community-based evidence regarding lower extremity flexibility among Indonesian older adults, particularly within rural settings where epidemiological data remain limited.

Overall, the findings suggest that maintaining regular physical activity may play an important role in preserving lower extremity flexibility and functional mobility among older adults.[1] Community-based physiotherapy interventions emphasizing safe, structured, and sustainable physical activity may therefore help support healthy aging, maintain independence, and reduce functional decline among community-dwelling older adults.[20]

Conclusion

This study demonstrated a significant positive association between physical activity level and lower extremity flexibility among community-dwelling older adults in Melinggih Village, Gianyar Regency, Bali, Indonesia. Older adults with higher physical activity levels tended to exhibit better lower extremity flexibility, indicating that habitual physical activity may contribute to maintaining musculoskeletal function and mobility in aging populations.

The findings highlight the importance of promoting regular physical activity among older adults as part of community-based physiotherapy and healthy aging programs. Maintaining physical activity may help preserve flexibility, support functional independence, improve movement efficiency, and reduce the risk of mobility limitations associated with aging.

However, because this study used a cross-sectional design, causal relationships between physical activity level and lower extremity flexibility could not be established. The findings should therefore be interpreted as associative rather than causal evidence. Future studies involving larger and more diverse populations, as well as longitudinal or prospective study designs, are recommended to clarify causal pathways and evaluate the influence of additional factors such as body mass index, comorbidities, nutritional status, and demographic characteristics on flexibility outcomes in older adults.

Clinical Implications

The findings of this study suggest that regular physical activity may play an important role in maintaining lower extremity flexibility and functional mobility among older adults. Community-based physiotherapy programs emphasizing structured and sustainable physical activity may therefore be beneficial in supporting healthy aging and preventing functional decline among community-dwelling older adults. In addition, flexibility-oriented exercise programs may be integrated into elderly community health activities to improve mobility performance and reduce movement-related limitations in aging populations.[20]

Author Contribution

Maria Fatima Nadila Dhone Niki: Conceptualization, Methodology, Software, Validation, Formal Analysis, Investigation, Resources, Data Curation, Writing – Original Draft, Writing – Review and Editing.
Made Hendra Satria Nugraha: Methodology, Writing – Review and Editing, Supervision.
Sayu Aryantari Putri Thanaya: Methodology, Writing – Review and Editing, Supervision.

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Conflict of Interest Statement

The authors declare no conflict of interest related to this study.

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Ethics Statement

This study received ethical approval from the Ethics Committee of the Faculty of Medicine, Universitas Udayana, Indonesia, with ethical clearance number 0982/UN14.2.2.VII.14/LT/2026 dated March 5, 2026.

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