ORIGINAL ARTICLE

Physical Therapy Journal of Indonesia (*PTJI*) 2026, Volume 7, Number 1: 89-94
E-ISSN : 2722-6034 ; P-ISSN : 2722-0125

Cross-cultural adaptation and psychometric evaluation of the Indonesian Wolf Motor Function Test for stroke rehabilitation

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Received: 2025-09-16
Accepted: 2025-12-30
Published: 2026-03-19

ABSTRACT

Background: Stroke is a leading cause of mortality and long-term disability worldwide, emphasizing the need for standardized motor assessment tools in rehabilitation. This study aimed to translate and culturally adapt the Wolf Motor Function Test (WMFT) into Indonesian and evaluate its psychometric properties in subacute stroke patients.
Methods: A methodological design was employed, consisting of forward translation, back-translation, expert panel review, pretesting, and psychometric evaluation. A total of 25 subacute stroke patients were recruited using purposive sampling. Inter-rater reliability, intra-rater reliability, and internal consistency were assessed using the Intraclass Correlation Coefficient (ICC) and Cronbach's alpha. Construct validity was examined through correlations with the Fugl-Meyer Assessment for Upper Extremity (FMA-UE).
Results: The Indonesian version of the WMFT (I-WMFT) demonstrated excellent reliability. Inter-rater ICC values ranged from 0.895 to 1.000, while intra-rater ICC values ranged from 0.796 to 0.997. Cronbach's alpha values ranged from 0.799 to 1.000, indicating strong internal consistency. Construct validity was supported by significant correlations with the FMA-UE ($r = 0.899$ for functional ability and $r = -0.828$ for movement time), confirming that the I-WMFT accurately reflects upper extremity motor performance.
Conclusion: The I-WMFT is a reliable, valid, and culturally appropriate instrument for assessing upper limb motor function in Indonesian subacute stroke patients. Its availability enhances objective clinical evaluation and supports evidence-based rehabilitation practices in Indonesia.

Keywords: cross-cultural adaptation, reliability, stroke, subacute phase, validity, Wolf Motor Function Test.
Cite This Article: Setiawan., Chaiyawat, P., Tretriluxuna, J., Riewpaiboon, A. 2026. Cross-cultural adaptation and psychometric evaluation of the Indonesian Wolf Motor Function Test for stroke rehabilitation. *Physical Therapy Journal of Indonesia* 7(1): 89-94. DOI: 10.51559/ptji.v7i1.361

INTRODUCTION

Stroke remains a major contributor to global mortality and disability, accounting for more than 6.6 million deaths annually and significantly impacting disability-adjusted life years.[1] The WHO Rehabilitation 2030 initiative emphasizes the need to strengthen rehabilitation systems through standardized and culturally appropriate assessment tools to ensure equitable care across countries.[2] Many widely used motor assessments were originally developed in Western contexts, making cultural adaptation essential for application across diverse populations. Indonesia faces similar challenges, as rising stroke incidence underscores the urgent need for validated instruments that align with global rehabilitation standards.

In Indonesia, the burden of stroke continues to rise, reaching approximately 293 cases per 100,000 population according to the Global Burden of Disease 2019.[2,3] Risk factors appear relatively evenly distributed across provinces,[3] indicating the necessity for standardized national assessment tools to support uniform rehabilitation practice. However, locally validated motor assessments remain limited, creating a gap between international recommendations and clinical realities. This gap hampers accurate evaluation and limits the comparability of rehabilitation outcomes.

Motor impairment of the upper extremity is one of the most common post-stroke deficits, particularly during the subacute phase, a critical period for neural recovery.[4,5] Various rehabilitation approaches, including task-oriented, technology-assisted, and adjunct therapies, have demonstrated effectiveness in improving upper-limb function and have been implemented in Indonesian clinical settings.[6,7] Accurate assessment during this period is essential for guiding treatment decisions and evaluating therapeutic effectiveness. Therefore, reliable performance-based tools are needed to capture clinically meaningful functional changes.

Internationally, instruments such as the Fugl-Meyer Assessment (FMA), Action

Research Arm Test (ARAT), Functional Independence Measure (FIM), and Wolf Motor Function Test (WMFT) are widely used to assess upper-limb motor performance.[8,9] The WMFT is particularly valued for its strong psychometric properties and successful adaptation into several languages, including Portuguese, Persian, Norwegian, and Nepali.[10,11] However, Indonesia currently lacks a culturally adapted and validated version, limiting clinicians' ability to use internationally recognized outcome measures and hindering alignment with global benchmarks and WHO rehabilitation priorities.

Although the Wolf Motor Function Test (WMFT) has been used in several Indonesian studies as an outcome measure in post-stroke rehabilitation, most publications apply the original version without reporting cross-cultural adaptation or psychometric validation in Indonesian populations. Considering Indonesia's cultural and linguistic diversity, cross-cultural adaptation is necessary to ensure semantic, conceptual, and functional equivalence.[12] Aligning local assessment tools with international standards supports WHO Rehabilitation 2030 goals, which emphasize evidence-based practice and standardized outcome measurement. Therefore, this study aimed to translate, culturally adapt, and psychometrically evaluate the Indonesian version of the Wolf Motor Function Test (I-WMFT) for use in subacute stroke rehabilitation.

METHODS

This study employed a cross-sectional observational design to determine the reliability and validity of the Indonesian version of the Wolf Motor Function Test (I-WMFT) among individuals with subacute stroke. The research consisted of two sequential phases: cross-cultural adaptation of the original WMFT and psychometric evaluation of the adapted version. Ethical approval was obtained from the Institutional Ethics Committee of Dr. Moewardi General Hospital, Surakarta, Indonesia (No. RSUD Dr. Moewardi/EC/2020/07001), and the study was registered under TCTR20200207001.

The cross-cultural adaptation followed established guidelines, including forward translation, synthesis, backward translation, expert committee review, and pretesting.[12,13] Clinical and linguistic experts ensured conceptual accuracy and natural language use, while the expert panel reviewed semantic and cultural equivalence. The pre-final version was pilot-tested in four stroke patients to evaluate clarity and feasibility, resulting in minor revisions before finalization. Written informed consent was obtained from all participants, and confidentiality was maintained by assigning numerical identification codes and storing data securely.

A total of 25 individuals with subacute stroke were recruited using purposive sampling from rehabilitation centers in Central Java, Indonesia. Participants were included if they had a CT/MRI- confirmed ischemic or hemorrhagic stroke, a post-onset duration of one to twelve weeks, mild to moderate upper-limb impairment (FMA-UE scores of 31–55), a Modified Ashworth Scale score of ≤ 2, a Mini-Mental State Examination score of ≥ 20, and were aged 80 years. Exclusion criteria included severe movement-related pain, inability to sit independently for at least 30 minutes, and unstable medical conditions.

Two licensed physiotherapists (Rater A and Rater B) independently administered the I-WMFT and the Fugl–Meyer Assessment for Upper Extremity (FMA-UE) to evaluate inter-rater and intra-rater reliability. Assessments were conducted in a counterbalanced order with a 1–2-day interval between sessions. Criterion validity was examined by correlating I-WMFT scores with FMA-UE scores. Sample size estimation followed recommendations for reliability studies,[14] assuming an intraclass correlation coefficient (ICC) ≥ 0.75, 80% statistical power, and α = 0.05. A minimum of 22 participants was required; 25 were recruited to account for potential attrition (**Table 1**).

Table 1. Sample size estimation for intraclass correlation analysis (Bujang and Baharum (2017)[15]

Observations per subject	Expected ICC	Required sample size (power 80%)	Required sample size (power 90%)
2	0.2	152	210
2	0.3	66	91
2	0.4	36	50
2	0.5	22	30
2	0.6	15	20
2	0.7	10	13
2	0.8	7	9
2	0.9	5	6

ICC: intraclass correlation coefficient; α = 0.05.

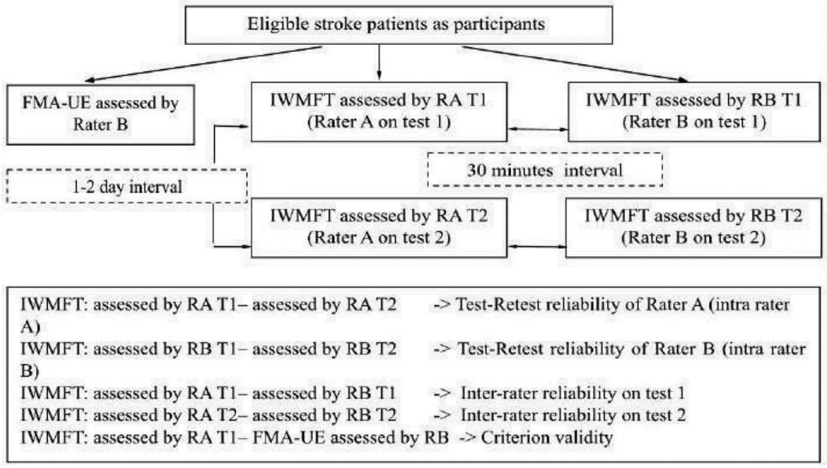

Figure 1. Consolidated standards of reporting trials (CONSORT) diagram and testing procedure.

Data were analyzed using SPSS. Descriptive statistics summarized participant characteristics. Reliability was evaluated using $ICC_{2,1}$ for inter-rater reliability and $ICC_{3,1}$ for intra-rater reliability. Values ≥ 0.75 were interpreted as good to excellent reliability. Internal consistency was assessed using Cronbach's alpha. Criterion validity was analyzed using Pearson's correlation for movement time (interval data) and Spearman's rho for functional ability (ordinal data). Correlation coefficients ≥ 0.40 were considered acceptable.[15,16]

The overall study flow, including recruitment, eligibility screening, and testing sequence, is illustrated in **Figure 1.**

RESULTS

All 25 participants completed the assessment protocol without adverse events, indicating that the Indonesian version of the Wolf Motor Function Test (I-WMFT) was feasible to administer in clinical rehabilitation settings. Participant demographic and clinical characteristics are presented in **Table 2**.

The sample consisted predominantly of middle-aged adults (mean age 60.9 ± 9.9 years), with a higher proportion of males (64%) and left-sided hemiparesis (72%). Participants were assessed during the subacute recovery phase (mean onset 6.8 ± 1.7 weeks) and demonstrated mild to moderate upper-limb impairment, as indicated by FMA-UE scores (43.5 ± 8.6). Muscle tone was generally within mild ranges, and cognitive function was largely preserved. Overall, the sample exhibited adequate variability for psychometric analysis.

The I-WMFT demonstrated excellent inter-rater and intra-rater reliability for both movement time and functional ability (**Figure 2**). Intraclass correlation coefficients (ICCs) for Movement Time reached 1.00, and all reliability coefficients exceeded commonly accepted thresholds for excellent reliability (**Tables 3** and **4**). Internal consistency was high, with Cronbach's alpha values ranging from 0.79 to 1.00.

Criterion validity was supported by strong correlations between I-WMFT scores and the Fugl–Meyer Assessment for Upper Extremity (FMA-UE). Movement

Table 2. Participant demographics and clinical characteristics (*n* = 25)

Variable	Mean (SD) / Frequency	Description
Age	60.9 (9.9)	Years
Sex	16/9	Male/Female
Affected side	18/7	Left/Right
Stroke onset	6.8 (1.7)	Weeks post-stroke
MMSE score	25.8 (1.7)	Range: 0–30
FMA-UE score	43.5 (8.6)	Range: 0–66
MAS score	1.9 (0.3)	Range: 0–5

FMA-UE, Fugl–Meyer assessment–upper extremity; MAS, modified ashworth scale; MMSE, mini-mental state examination; SD, standard deviation.

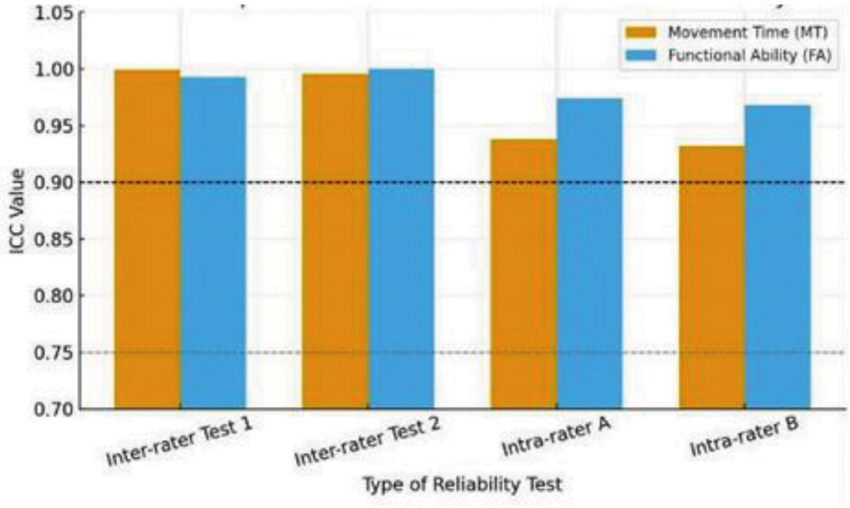

Figure 2. Intraclass correlation coefficient (ICC) comparison between movement time and functional ability.

Table 3. Inter- and intra-rater reliability of the Indonesian Wolf Motor Function Test (movement time)

Reliability parameter	Inter-rater Test 1 ICC (2,1)	Inter-rater Test 2 ICC (2,1)	Intra-rater A ICC (3,1)	Intra-rater B ICC (3,1)
ICC range	0.951–1.000	0.895–1.000	0.796–0.995	0.796–0.997
Total ICC	0.999	0.996	0.938	0.932
Cronbach's α	0.951–1.000	0.899–1.000	0.798–0.996	0.799–0.997

ICC, intraclass correlation coefficient

Table 4. Inter- and intra-rater reliability of the Indonesian Wolf Motor Function Test (functional ability)

Reliability Parameter	Inter-rater test 1 ICC (2,1)	Inter-rater test 2 ICC (2,1)	Intra-rater A ICC (3,1)	Intra-rater B ICC (3,1)
ICC Range	0.724 – 0.991	0.761 – 1.000	0.741 – 0.968	0.697 – 0.963
Total ICC	0.888 – 0.993	0.896 – 1.000	0.803 – 0.974	0.795 – 0.968

ICC, intraclass correlation coefficient

Table 5. Criterion validity between Indonesian Wolf Motor Function Test (I-WMFT) and Fugl–Meyer Assessment–Upper Extremity (FMA-UE) scores

Variable comparison	Correlation test	Correlation coefficient (*r*)	*P*-value	Direction
I-WMFT movement time (test 1) vs FMA-UE	Pearson	-0.828	<0.001	Negative
I-WMFT movement time (test 2) vs FMA-UE	Pearson	-0.761	<0.001	Negative
I-WMFT functional ability (test 1) vs FMA-UE	Spearman	0.899	<0.001	Positive
I-WMFT functional ability (test 2) vs FMA-UE	Spearman	0.872	<0.001	Positive

Table 6. Comparison of reliability and validity of the Wolf Motor Function Test across cultural versions

Country / version	Authors (year)	Participants	Inter-rater ICC	Intra-rater ICC	Validity (*r*)
United States (original)	Wolf et al. (2001)	20 chronic stroke	0.95–0.99	0.93–0.97	0.88–0.92
Brazil	Pereira et al. (2011)	24 hemiparetic	0.97–0.99	0.94–0.98	0.87–0.91
Nepal	Adhikari et al. (2016)	30 stroke	0.93–0.98	0.90–0.95	0.82–0.90
Iran (Persian)	Ezzati et al. (2017)	25 stroke	0.83–0.95	0.82–0.94	0.80–0.88
Thailand	Tretriluxana et al. (2009)	26 acute stroke	0.91–0.97	0.89–0.96	0.84–0.90
Indonesia	Present study (2025)	25 subacute stroke	0.93–1.00	0.80–0.99	0.83–0.90

ICC, intraclass correlation coefficient; *r*, correlation coefficient.

Time showed strong negative correlations with FMA-UE scores, whereas Functional Ability demonstrated strong positive correlations, all correlations were statistically significant (Table 5, Figure 3).

Comparative analysis indicated that the psychometric performance of the I-WMFT was comparable to, and in some domains exceeded, the findings reported for other culturally adapted WMFT versions (Table 6).

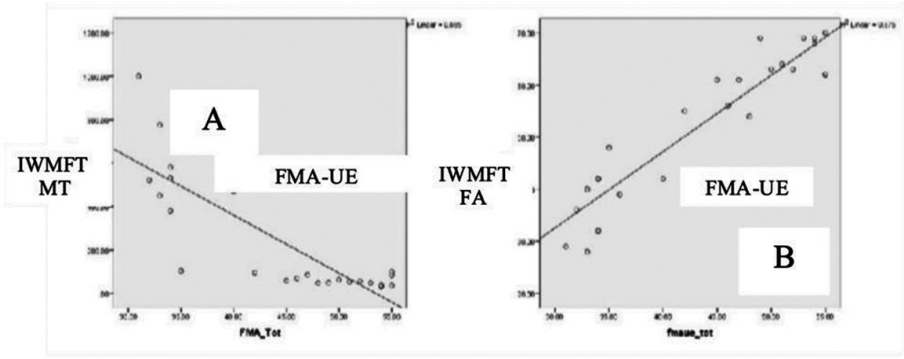

Figure 3. Scatter plot correlations demonstrating the criterion validity. A: Indonesian Wolf Motor Function Test (IWMFT) movement time and FMA-UE Motor Function; B: IWMFT Functional Ability and Fugl–Meyer Assessment–Upper Extremity (FMA-UE) motor function.

DISCUSSION

The demographic and clinical characteristics of participants reflect national and regional stroke epidemiology in Indonesia and Southeast Asia, supporting the ecological validity of the findings. Assessment during the subacute phase is particularly relevant, as this period represents a critical window for enhanced neuroplasticity and motor recovery.[15,16] Contemporary neurorehabilitation models emphasize the interaction between spontaneous biological recovery and task-specific training during this phase. The presence of heterogeneous motor impairment levels strengthened the psychometric evaluation by enabling assessment across a broad performance spectrum, thereby minimizing ceiling and floor effects.[17,18] Similar heterogeneity has been documented in rehabilitation cohorts from East Asia and Europe.[15,19]

The excellent reliability observed in this study aligns with international validation studies conducted in Brazil,[20] Iran,[21] Nepal,[22] and Thailand,[11] all of which reported ICC values above 0.80. The high reliability may be attributed to the use of standardized administration procedures performed by experienced physiotherapists, a factor known to improve rater agreement.[23,24] Movement Time demonstrated slightly higher stability than Functional Ability, likely due to the more objective nature of timed measures compared with judgment-based scoring.[25,26] This pattern is consistent with

previous psychometric findings. Although high internal consistency confirms construct coherence, very high alpha values may reduce sensitivity to small functional changes, particularly in chronic or community-based populations.[13] This underscores the need for responsiveness testing in future research.

The strong correlations between the I-WMFT and the FMA-UE support the criterion validity of the instrument and confirm that both measures assess overlapping but distinct dimensions of upper-limb recovery.[26,27] These findings are consistent with contemporary recovery models, including interhemispheric competition and bimodal balance-recovery frameworks, which conceptualize motor improvement as the result of coordinated neural reorganization rather than isolated strength gains.[15] The I-WMFT demonstrated psychometric properties comparable to those of other adapted versions, despite previous systematic reviews reporting indeterminate cross-cultural validity for several WMFT translations due to inconsistent methodologies.[13] The rigorous adaptation process used in this study ensured semantic, conceptual, and experiential equivalence in accordance with international guidelines.[17,28,19] Similar methodological rigor has been associated with stable psychometric outcomes in studies from Brazil, Portugal, and Norway.[18,29,30]

Sociocultural factors, including patient motivation, coping strategies, and therapist–patient interaction, may influence task engagement and perceived performance.[31] In Indonesia, hierarchical communication styles and variable access to rehabilitation services may further affect assessment behavior, reinforcing the need for culturally responsive instruments. Clinically, the I-WMFT provides a standardized and reliable tool for monitoring upper-limb motor recovery across rehabilitation settings. Its task-oriented and time-based structure aligns well with emerging digital health applications, including tele-rehabilitation and AI-assisted monitoring.[32,33]

Standardized assessment also enables early identification of functional deficits related to delayed therapy initiation or inequitable service access, thereby supporting evidence-based clinical decision-making and health policy development.[34] This study has several limitations, including its single-center design and modest sample size, which may have inflated reliability estimates due to rater homogeneity. The focus on subacute stroke limits generalizability to acute and chronic populations, and this study did not evaluate responsiveness or minimal clinically important differences. Future studies should include multicenter samples, chronic stroke populations, and longitudinal responsiveness evaluation. Integration with digital measurement technologies and exploration of biological correlates of recovery, such as inflammation and microbiota diversity, represent promising directions.[19] Qualitative studies are also warranted to explore cultural perceptions and patient engagement in motor assessment.

CONCLUSION

This study successfully translated and culturally adapted the Wolf Motor Function Test (WMFT) into Indonesian and confirmed its strong psychometric properties. The Indonesian version (I-WMFT) demonstrated excellent inter-rater, intra-rater, and internal reliability, as well as high construct validity when compared with established motor function assessments. These findings indicate that the I-WMFT accurately measures upper-extremity motor performance in individuals with subacute stroke and maintains equivalence with the original instrument. The I-WMFT can be confidently used by clinicians to monitor patient progress and by researchers to generate standardized and comparable data across studies. Overall, the I-WMFT fulfills its intended purpose as a valid, reliable, and culturally appropriate tool for assessing motor recovery in stroke rehabilitation within the Indonesian context. Future investigations should evaluate its responsiveness and applicability in broader clinical populations.

ETHICAL APPROVAL

This study received ethical approval from the Health Research Ethics Committee of Dr. Moewardi General Hospital, Surakarta, Indonesia. All participants were fully informed about the study's objectives, procedures, potential benefits, and possible risks, and provided voluntary written informed consent prior to participation. The study was conducted in accordance with the principles of the Declaration of Helsinki and current ethical guidelines for health research in Indonesia.

CONFLICT OF INTEREST

The authors certify that there are no financial or non-financial conflicts of interest associated with the conduct of this study or the writing of this manuscript.

FUNDING

The authors received no financial support for this study. All expenses were covered by the investigators.

AUTHOR CONTRIBUTIONS

S conceived the study design, prepared and revised the manuscript, collected and owned the data, and analyzed the data. PC, JT, AR contributed significantly to the study's conception and design, data analysis, interpretation of the findings, and drafting and revising the manuscript. All authors reviewed and approved the final manuscript for publication.

ACKNOWLEDGMENT

The authors thank the Faculty of Physical Therapy, Mahidol University, Thailand, and the Health Polytechnic of Surakarta, Indonesia, for their academic support. Appreciation is also extended to the rehabilitation centers in Central Java for assisting with participant recruitment and data collection. The authors are grateful to the physiotherapists and experts involved in the translation and cultural adaptation process. Special thanks go to all stroke patients who participated in this study.

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