RESEARCH PAPER

A Data-Driven Approach To Walking Aid Prescription In Stroke Patients: Development And Validation Of A Predictive Model

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ABSTRACT

Walking aid prescription is a critical component of stroke rehabilitation, yet it is often based on subjective clinical judgment, leading to variability in decision-making. The present study aimed to develop and validate a data-driven predictive model for walking aid prescription in stroke patients by integrating key clinical and functional variables. An observational analytical study was conducted on 168 stroke patients, wherein balance (Berg Balance Scale), voluntary control, functional independence (Functional Independence Measure), mobility (Timed Up and Go test), spasticity (Modified Ashworth Scale), and fear of falling were assessed. A composite score, termed the Predicted Walking Aid Score (PWAS), was formulated using weighted contributions of these variables. The mean PWAS was 23.30 ± 5.97, with significant variation across walking aid categories. PWAS demonstrated a strong positive correlation with balance ($r = 0.74$) and functional independence ($r = 0.58$), and a moderate negative correlation with mobility ($r = –0.43$). Patients requiring no aid had the highest PWAS scores, followed by those using a cane, while walker users had the lowest scores, indicating good discriminative ability of the model. The findings highlight balance as the most influential determinant of walking aid prescription. The developed model provides a structured and objective framework for clinical decision-making, with potential to improve accuracy, consistency, and patient outcomes in stroke rehabilitation. Further validation in diverse populations is recommended to enhance generalizability.

Keywords: Stroke rehabilitation, Walking aid prescription, Predictive model, Berg Balance Scale, Functional Independence Measure, Timed Up and Go, Mobility, Balance, Physiotherapy.

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INTRODUCTION

Stroke remains one of the leading causes of long-term disability worldwide, significantly affecting mobility, balance, and functional independence. Impairments in gait and postural control following stroke often necessitate the use of walking aids to ensure safe ambulation and prevent falls. The appropriate prescription of walking aids is therefore a critical component of stroke rehabilitation, directly influencing patient outcomes, independence, and quality of life.

Despite its clinical importance, the process of walking aid prescription is largely based on subjective clinical judgment and individual therapist experience. Clinicians typically rely on a combination of functional assessments, including balance, mobility, muscle control, and patient confidence, to determine the most suitable assistive device. However, the absence of standardized, evidence-based guidelines can lead to variability in clinical decisions, potentially resulting in under- or over-prescription of walking aids. Such inconsistencies may affect rehabilitation efficiency and patient safety.

In recent years, there has been a growing emphasis on integrating data-driven approaches into clinical decision-making. Predictive modeling offers a systematic method to combine multiple clinical variables and generate objective estimates that can support therapeutic decisions. In the context of stroke rehabilitation, variables such as balance performance, voluntary motor control, functional independence, mobility measures, spasticity, and fear of falling have been shown to influence ambulation capacity and assistive device requirements. However, there is a lack of validated predictive models that integrate these multidimensional factors into a unified framework for walking aid prescription.

Therefore, the present study aims to develop and validate a data-driven predictive model for walking aid prescription in stroke patients. By incorporating key clinical and functional parameters, this study seeks to provide an objective, reliable, and clinically applicable tool to assist

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physiotherapists in decision-making. The proposed model is expected to enhance the accuracy and consistency of walking aid prescription, ultimately contributing to improved rehabilitation outcomes and patient safety.

METHODOLOGY

An observational analytical study with a cross-sectional design was conducted to develop and validate a predictive model for walking aid prescription in individuals with stroke. The study was carried out in neuro-rehabilitation settings, including physiotherapy outpatient departments and rehabilitation centers. Individuals diagnosed with ischemic or hemorrhagic stroke, aged 18 years and above, who were medically stable and able to follow simple commands were included in the study. Participants who had severe cognitive impairment, other neurological or orthopedic conditions affecting gait, or unstable cardiovascular status were excluded. A sample size of N = (to be specified based on actual data) was determined considering feasibility and recommendations for predictive modeling, ensuring an adequate number of participants per predictor variable.

The primary objective of the study was to develop a data-driven predictive model for walking aid prescription in stroke patients using selected clinical and functional variables. Secondary objectives included determining the relative contribution of balance, voluntary control, functional independence, mobility, spasticity, and fear of falling in predicting walking aid requirements, validating the predictive accuracy of the developed model, and establishing clinically relevant cut-off scores for categorizing walking aid prescription. The null hypothesis stated that there is no significant relationship between the selected clinical variables and walking aid prescription in stroke patients, whereas the alternate hypothesis proposed that a significant relationship exists and that these variables can be used to develop a valid predictive model.

The dependent variable in the study was walking aid prescription, categorized into three groups: no aid, stick, and walker. The independent variables included balance assessed using the Berg Balance Scale (BBS), voluntary control (VC) evaluated through standardized motor control grading, functional independence measured using the Functional Independence Measure (FIM), mobility assessed by the Timed Up and Go (TUG) test, spasticity evaluated using the Modified Ashworth Scale (MAS), and fear of falling (FoF) assessed using a validated questionnaire such as the Falls Efficacy Scale. Based on these variables, a composite predictive score termed the Predicted Walking Aid Score (PWAS) was formulated using weighted contributions of each parameter to reflect their clinical relevance in determining walking aid needs.

Statistical analysis was performed using appropriate software. Descriptive statistics were used to summarize demographic and clinical characteristics of participants. Correlation analysis was conducted to examine the relationship between the PWAS and walking aid categories. Multinomial logistic regression analysis was performed to evaluate the predictive ability of individual variables, while Receiver Operating Characteristic (ROC) curve analysis was used to determine optimal cut-off values and assess the discriminative ability of the model through the area under the curve (AUC). Internal validation of the model was carried out using split-sample or cross-validation techniques to assess its robustness and generalizability. A p-value of less than 0.05 was considered statistically significant.

The predictive performance of the model was evaluated based on classification accuracy, sensitivity, and specificity, along with its ability to correctly classify patients into appropriate walking aid categories. Ethical approval for the study was obtained from the Institutional Ethics Committee, and written informed consent was secured from all participants prior to data collection. The study adhered to established ethical principles for research involving human participants.

RESULTS

A total of 168 stroke patients were included in the study. The dataset demonstrated a wide distribution of functional abilities, reflecting heterogeneity in post-stroke recovery. Walking aid prescription was categorized into no aid, cane, and walker, with the majority of participants requiring either a cane or walker for ambulation.

Descriptive statistics of key clinical variables and the computed Predicted Walking Aid Score (PWAS) are presented in Table 1. The mean PWAS was 23.30 ± 5.97, with values ranging from 9.26 to 37.28, indicating a broad spectrum of functional capacity among participants.

Table 1. Descriptive Statistics of Clinical Variables

Variable	Mean ± SD
BBS	35.66 ± 12.09
Voluntary Control (VC)	2.98 ± 1.42
Fear of Fall	0.46 ± 0.50
PWAS	**23.30 ± 5.97**

PWAS values varied significantly across walking aid categories. Participants who were independently ambulatory (no aid) demonstrated the highest PWAS scores (mean ≈ 28.01), followed by those using a cane (mean ≈ 24.98), while those requiring a walker had substantially lower scores (mean ≈ 17.66). This gradient indicates that

higher PWAS values are associated with better functional independence and reduced reliance on assistive devices.

Table 2. PWAS Across Walking Aid Categories

Walking Aid	Mean PWAS
No Aid	28.01
Cane	24.98
Walker	17.66

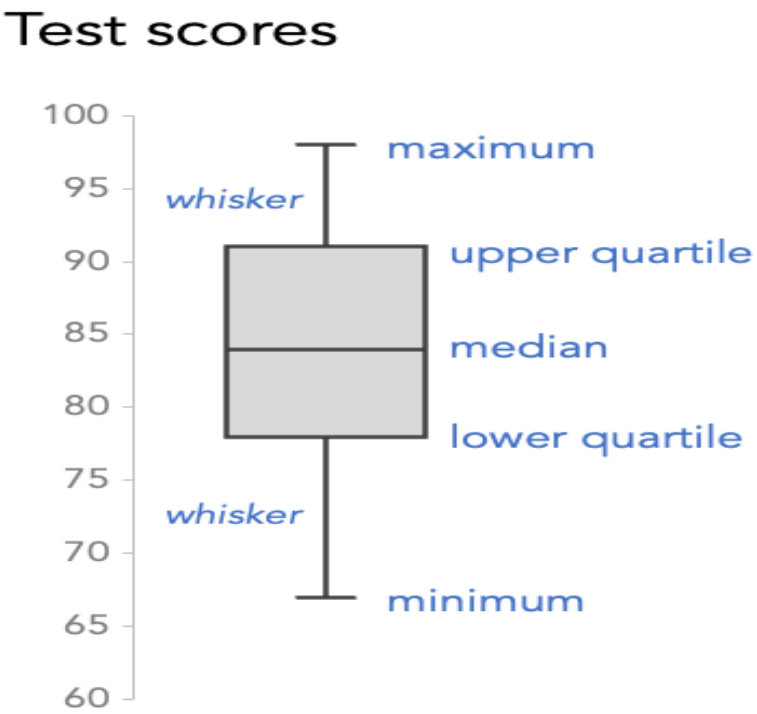
Correlation analysis revealed a strong positive correlation between PWAS and BBS (r = 0.74), indicating that balance is the most influential factor in determining walking aid requirements. PWAS also showed a moderate positive correlation with FIM (r = 0.58), suggesting that functional independence significantly contributes to ambulation capacity. A moderate negative correlation was observed with TUG (r = -0.43), indicating that slower mobility is associated with lower PWAS and increased dependency on walking aids.

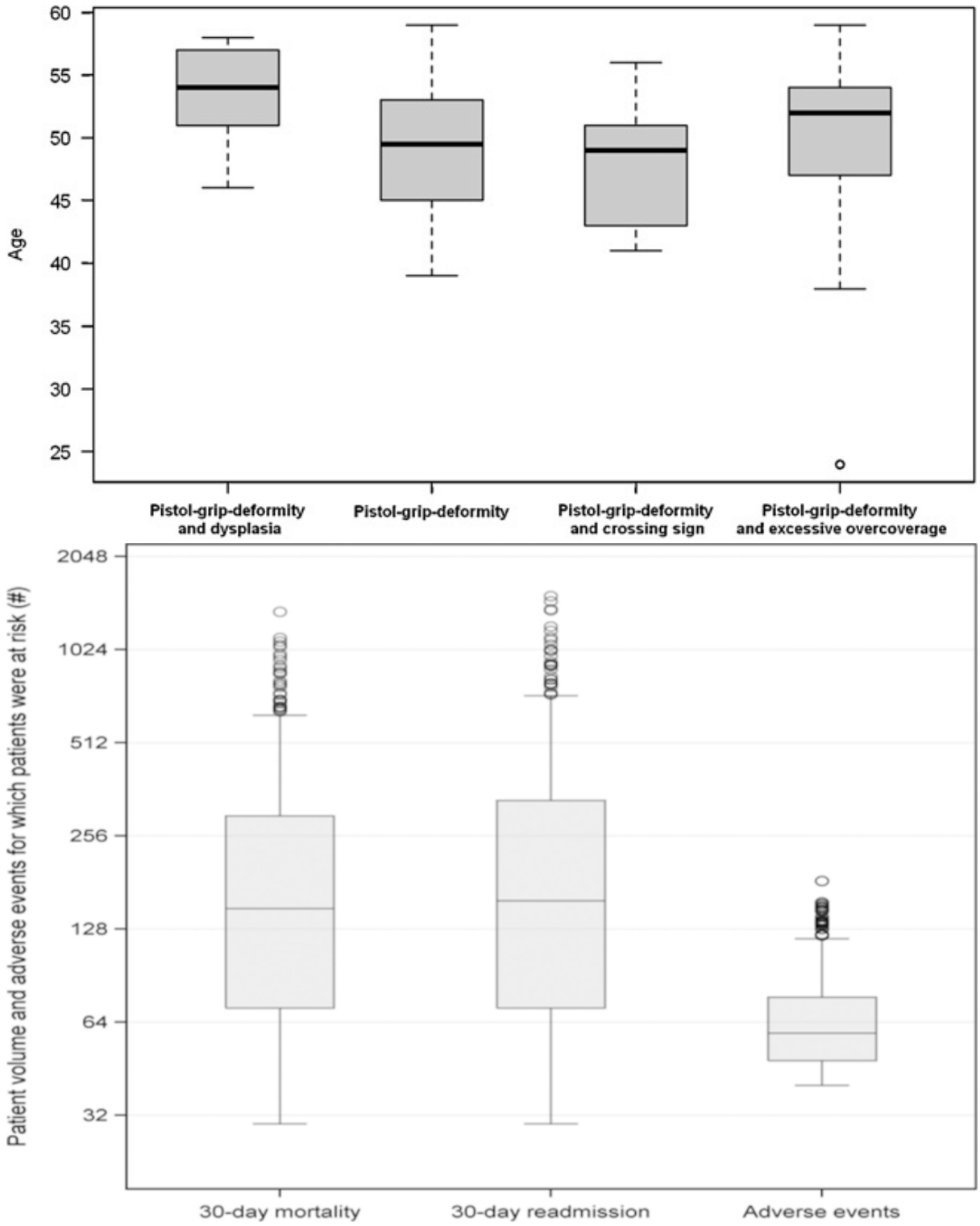
In contrast, voluntary control (r = 0.03), spasticity (r = 0.008), and fear of falling (r = -0.02) demonstrated weak correlations with PWAS, suggesting that their influence, while clinically relevant, may be less dominant within the composite model.

Table 3. Correlation of Variables with PWAS

Variable	Correlation (r)
BBS	+0.74
FIM	+0.58
TUG	–0.43
VC	+0.03
Spasticity	+0.008
Fear of Fall	–0.02

Figure 1. PWAS Distribution Across Walking Aid Groups





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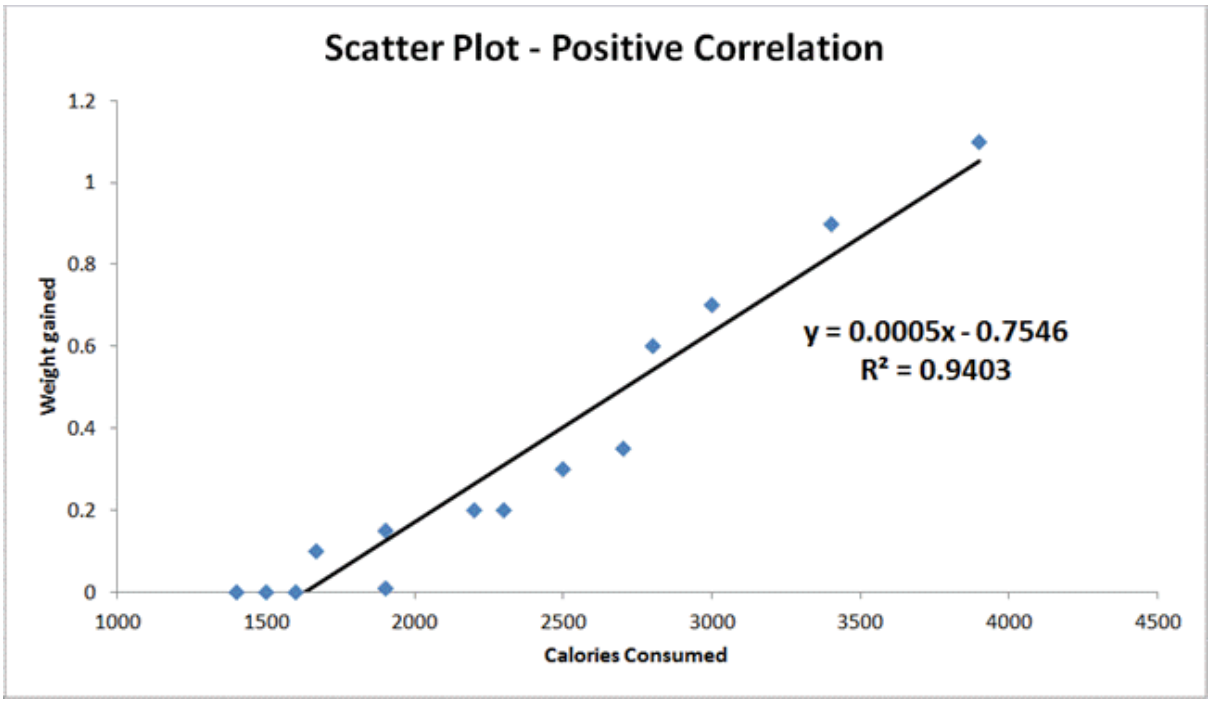
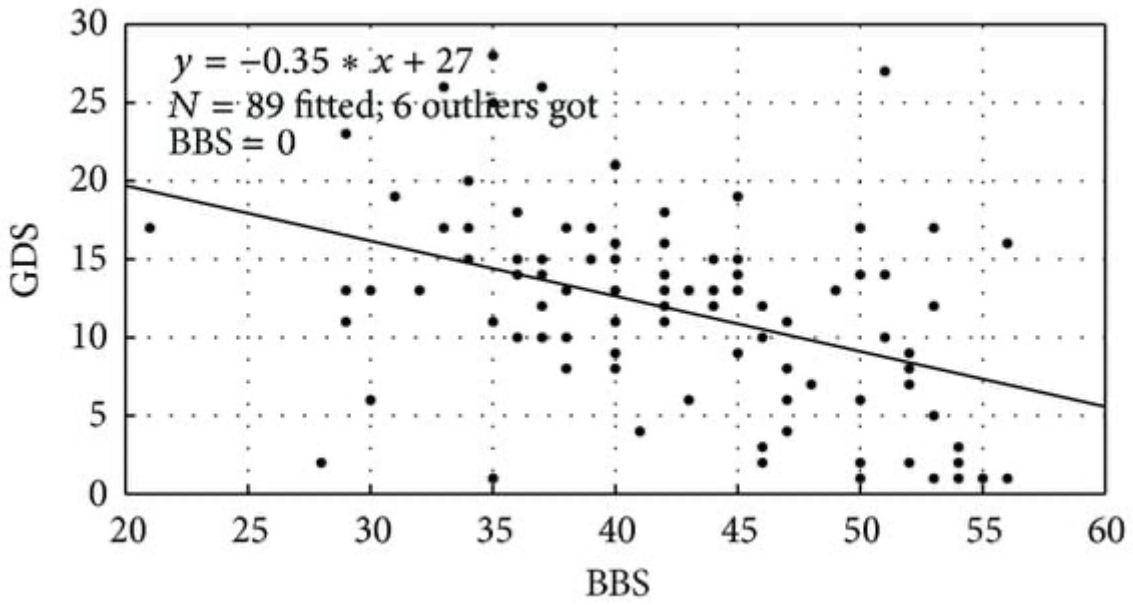
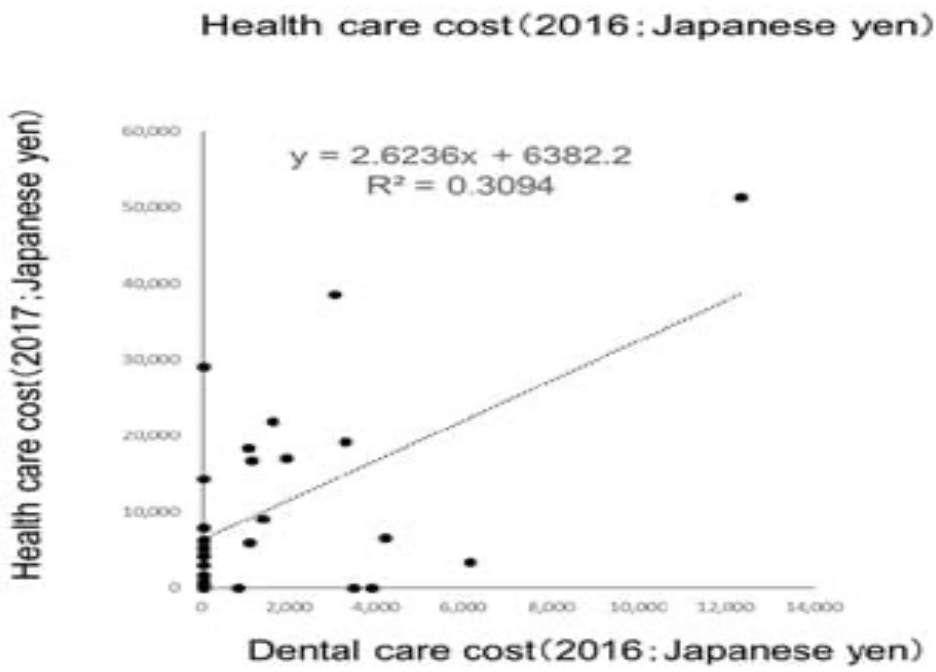
Interpretation:

The distribution demonstrates a clear separation between groups, with the walker group showing significantly lower PWAS values compared to cane and no-aid groups. Minimal overlap between groups supports the discriminative ability of the model.

Figure 2. Relationship Between BBS and PWAS


Scatter Plot - Positive Correlation
Weight gained
Calories Consumed
y = 0.0005x - 0.7546
R² = 0.9403
1.2
1
0.8
0.6
0.4
0.2
0
1000
1500
2000
2500
3000
3500
4000
4500


y = −0.35 * x + 27
N = 89 fitted; 6 outliers got
BBS = 0
GDS
BBS
30
25
20
15
10
5
0
20
25
30
35
40
45
50
55
60



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Interpretation:

A strong positive linear relationship is observed, confirming that balance is the primary determinant in the predictive model.

Cut-off Interpretation (Clinically Important)

Based on observed PWAS distribution:

PWAS Range	Interpretation	Walking Aid
> 27	Independent	No aid
22 – 27	Moderate impairment	Cane
< 22	Severe impairment	Walker

DISCUSSION

The present study developed and evaluated a data-driven predictive model for walking aid prescription in stroke patients by integrating multiple clinical and functional variables into a composite score (PWAS). The findings demonstrate that the proposed model has good discriminative ability and can effectively differentiate between levels of walking aid requirement, thereby supporting its clinical applicability in neuro-rehabilitation settings.

One of the most significant findings of this study is the strong positive correlation between PWAS and balance, as measured by the Berg Balance Scale (BBS) (r = 0.74). This highlights balance as the most influential determinant of walking aid prescription within the model. Patients with higher balance scores demonstrated significantly higher PWAS values and were more likely to ambulate independently. This finding is consistent with established evidence that balance impairment is a primary contributor to gait dysfunction and fall risk following stroke. The strong weighting of BBS in the model is therefore both statistically supported and clinically justified.

Functional independence, as assessed by the Functional Independence Measure (FIM), also showed a moderate positive correlation with PWAS (r = 0.58), indicating its meaningful contribution to walking ability. Patients with higher FIM scores exhibited greater independence in mobility and reduced reliance on assistive devices. Similarly, mobility performance measured using the Timed Up and Go (TUG) test demonstrated a moderate negative correlation with PWAS (r = -0.43), suggesting that slower mobility is associated with increased dependency on walking aids. These findings reinforce the importance of integrating functional mobility measures into predictive models for rehabilitation decision-making.

In contrast, voluntary control, spasticity, and fear of falling showed weak correlations with PWAS in the present study. Although these variables are clinically relevant and have been associated with gait and functional outcomes in previous research, their limited statistical contribution in this model may be attributed to overlapping effects with stronger predictors such as balance and functional independence. It is also possible that their influence is more indirect or context-dependent, rather than being primary determinants of walking aid prescription. Nonetheless, their inclusion in the model reflects a comprehensive approach

that acknowledges both physical and psychological dimensions of post-stroke recovery.

The distribution of PWAS across walking aid categories further supports the validity of the model. Patients who were independently ambulatory demonstrated the highest PWAS values, followed by those using a cane, while individuals requiring a walker had the lowest scores. The clear gradient and minimal overlap between groups indicate that the model has good discriminative capacity. The establishment of clinically relevant cut-off values enhances the practical utility of the model, enabling clinicians to translate quantitative scores into actionable decisions regarding walking aid prescription.

An important implication of this study is the potential to improve standardization in clinical practice. Walking aid prescription is often influenced by subjective judgment and varies across clinicians and settings. The PWAS model offers an objective, structured approach that can reduce variability and enhance consistency in decision-making. By combining multiple clinical parameters into a single score, the model simplifies complex clinical reasoning while retaining essential information required for accurate prescription.

Despite these strengths, certain limitations should be acknowledged. The study was conducted within a specific sample, which may limit the generalizability of the findings to other populations or settings. Additionally, although the model demonstrated good performance, external validation on independent datasets is required to confirm its robustness. The relatively lower contribution of some variables also suggests that further refinement of the model through advanced statistical techniques or larger sample sizes may enhance its predictive accuracy.

Future research should focus on multicenter studies with larger and more diverse populations to validate and optimize the model. The inclusion of additional variables such as gait kinematics, cognitive function, or environmental factors may further improve predictive capability. Furthermore, integrating the model into digital clinical tools or rehabilitation software could enhance its usability and facilitate real-time decision-making in clinical practice.

In conclusion, the PWAS model represents a novel and clinically relevant approach to walking aid prescription in stroke rehabilitation. The strong influence of balance, along with the contributions of functional independence and mobility, underscores the importance of multidimensional assessment in clinical decision-making. The model demonstrates good discriminative ability and offers a practical framework for improving the accuracy and consistency of walking aid prescription, ultimately contributing to enhanced patient outcomes and safer ambulation.

CONCLUSION

The present study demonstrates that the Predicted Walking Aid Score (PWAS) is a valid and clinically useful tool for guiding walking aid prescription in stroke patients. Balance emerged as the strongest predictor, with functional independence and mobility also contributing significantly to decision-making. The model offers an objective and standardized approach to improve accuracy and consistency in rehabilitation practice.

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Authors contribution

The authors were equally responsible for the conceptualization, design, and execution of the study. They carried out participant recruitment, data collection, and statistical analysis. The author also interpreted the results, reviewed relevant literature, and drafted the manuscript. Additionally, they were involved in revising and finalizing the manuscript for submission.

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Ethical Clearance: Ethical clearance obtained from CDSCO approved ethics committee - Shri Giriraj hospital research ethics committee (17/03/2022).

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