BMC Geriatrics

RESEARCH

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Translation, cultural adaptation, and Turkish validation of the tool 25-question geriatric locomotive function scale

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Abstract

Background The increasing prevalence of locomotive syndrome (LoS) among older adults underscores the necessity of valid and reliable assessment tools to facilitate early diagnosis and intervention. The 25-Question Geriatric Locomotive Function Scale (GLFS-25) is a widely used self-reported measure for evaluating locomotive dysfunction. However, a culturally adapted and validated version for Turkish older adults was lacking. This study aims to translate, culturally adapt, and validate the Turkish version of GLFS-25 to ensure its applicability in clinical and research settings.

Methods A cross-sectional study was conducted with 133 community-dwelling older adults (mean age: 75.3 ± 7.2 years) in Turkey. The translation process followed international guidelines, including forward-backward translation, expert panel review, and pilot testing. The psychometric validation involved confirmatory factor analysis (CFA), internal consistency (Cronbach's α), test-retest reliability (intraclass correlation coefficient, ICC), and criterion validity. Correlations with established functional assessment tools such as the Barthel Daily Living Index, Instrumental Activities of Daily Living (IADL), and Activities-Specific Balance Confidence (ABC) Scale were examined. A receiver operating characteristic (ROC) curve analysis was performed to determine the optimal cut off score for detecting locomotive dysfunction.

Results The Turkish GLFS-25 demonstrated excellent internal consistency (Cronbach's α = 0.984) and test-retest reliability (ICC = 0.986). CFA confirmed a four-factor structure, similar to previous adaptations in Iran and China, supporting its construct validity. Strong correlations were observed between GLFS-25 scores and functional assessment tools (Barthel Index: $r = -0.78$, IADL: $r = -0.72$, ABC Scale: $r = -0.65$, $p < 0.001$), establishing its criterion validity. ROC analysis identified a cut off score of 16 for detecting locomotive dysfunction, with a sensitivity of 85.3% and specificity of 88.7%.

Conclusions The Turkish adaptation of GLFS-25 is a valid, reliable, and culturally appropriate tool for assessing locomotive dysfunction in Turkish older adults. Its strong psychometric properties and high correlation with functional mobility indicators suggest that it can be effectively integrated into geriatric healthcare and rehabilitation programs. Given the rapid aging of Turkey's population, this tool can support early detection, prevention strategies, and policy development to mitigate mobility-related disabilities.

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Keywords Locomotive syndrome, Geriatric assessment, GLFS-25, Turkish validation, Aging, Mobility impairment, Functional independence

Introduction

The global demographic shift toward an aging population has intensified the demand for effective strategies to preserve mobility and independence in older adults. Locomotive dysfunction—characterized by reduced musculoskeletal performance is a primary contributor to functional decline, frailty, falls, and increased healthcare utilization in aging populations [1–3]. In response to these challenges, the Japanese Orthopaedic Association introduced the concept of Locomotive Syndrome (LoS) to describe progressive musculoskeletal deterioration that results in restricted mobility and an increased risk of disability [4].

In Turkey, the older adult population reached 7.9 million (9.5%) in 2020 and is projected to exceed 11% by 2025 [5]. As Turkey's population continues to age rapidly, the early detection and management of locomotive dysfunction have become critical priorities for national health policy. According to estimates from Japanese studies, the prevalence of LoS among older adults ranges from 10% to 25%, depending on the assessment method and population characteristics [6]. While exact figures for Turkey are scarce, clinical observations suggest that musculoskeletal limitations, such as impaired gait, balance deficits, and chronic joint pain, are commonly encountered in Turkish geriatric care settings highlighting the pressing need for valid screening instruments.

The 25-Question Geriatric Locomotive Function Scale (GLFS-25) was developed as a comprehensive, self-reported tool to assess locomotive function [1] across four core domains: pain, mobility, activities of daily living (ADLs), and psychosocial impact [7]. Its diagnostic value has been supported by strong psychometric properties, including high internal consistency, test-retest reliability, and validity across diverse populations [8, 9]. Validated versions of the GLFS-25 exist in several countries, such as Iran, Brazil, China, and Japan, and have demonstrated cross-cultural applicability and diagnostic accuracy [1, 7–9].

Despite its widespread use globally, a validated Turkish version of the GLFS-25 has been lacking until now. This gap poses significant limitations for clinicians in Turkey. In the absence of a standardized tool specifically adapted for Turkish culture and language, healthcare professionals have relied on general functional assessment scales such as the Barthel Index, Instrumental Activities of Daily Living (IADL) scale, and the ABC Balance Confidence Scale [10–12]. However, these tools either lack specificity for musculoskeletal decline or do not capture the multidimensional nature of LoS, especially its psychosocial aspects [13]. Without a targeted and culturally sensitive instrument like the GLFS-25, early detection of locomotive dysfunction remains suboptimal, limiting opportunities for timely intervention and personalized rehabilitation [14].

Furthermore, research has shown that GLFS-25 scores are not only linked to physical impairments but also to mental health outcomes such as depression, anxiety, and social isolation [15]. These associations underscore the multifactorial impact of LoS on quality of life and the need for integrated care strategies. Therefore, screening tools like the GLFS-25 should serve not only as diagnostic instruments but also as gateways to holistic care planning, incorporating physical, emotional, and social dimensions of aging.

Although various tools such as the Barthel Index, the Activities-specific Balance Confidence (ABC) Scale, and the Instrumental Activities of Daily Living (IADL) scale have been previously used in Turkey to assess functional limitations among older adults, these instruments primarily focus on physical or task-oriented abilities. For instance, the Barthel Index evaluates basic activities of daily living (ADLs) such as bathing, feeding, and mobility, while the IADL focuses on more complex tasks like managing finances or medication. Similarly, the ABC Scale quantifies confidence in balance and gait-related tasks. However, none of these scales comprehensively address the multidimensional nature of locomotor syndrome, which encompasses not only physical function but also psychological, social, and cognitive domains.

Furthermore, these conventional tools lack sensitivity to early-stage locomotive decline and do not account for the broader psychosocial consequences such as fear of falling, loss of social engagement, and decreased quality of life. This creates a significant gap in holistic geriatric assessment. In contrast, the 25-question Geriatric Locomotive Function Scale (GLFS-25) was specifically developed to overcome these limitations by incorporating a more integrative evaluation of physical, emotional, and social components relevant to locomotive function. Therefore, adapting and validating this scale for use in the Turkish population is of great importance for improving the early detection and management of locomotive dysfunction in aging individuals. To date, no culturally adapted GLFS-25 version has been available in Turkish, creating a gap in early detection and management of LoS in Turkish clinical practice.

The aim of this study was to translate, culturally adapt, and psychometrically validate the Turkish version of the GLFS-25. By establishing its reliability and validity, we

aim to equip Turkish healthcare professionals with a scientifically robust, culturally appropriate screening tool to support early diagnosis, monitor disease progression, and design targeted interventions for locomotive dysfunction in older adults.

Method

Research design

This study was conducted using a cross-sectional and descriptive design to translate, adapt, and analyze the validity and reliability of the 25-Question Geriatric Locomotive Function Scale (GLFS-25) in individuals aged 60 and above. A cross-sectional design is an appropriate approach to determine the current locomotive function status of individuals and the factors affecting these conditions within a specific timeframe. The study was conducted in accordance with ethical principles and the Helsinki Declaration and received ethical approval from the Ethics Committee of Erzurum Technical University (Meeting No. 6, Decision No. 4, dated 27.06.2022). The study was conducted in Erzurum, Türkiye, between July 2022 and July 2024.

Sample selection

The study group consisted of a sample of individuals aged 60 and above living in Turkey. Participants were informed through older adult centers, family health centers and community health centers in Erzurum province and eligible individuals were invited to the study. Announcements to the target group were made through information posters and one-to-one information method. Volunteers were included in the study. A priori power analysis was conducted using G*Power 3.1 software. Assuming a large effect size (f^2=0.40, $\alpha = 0.05$), a priori power analysis indicated that 84 participants were needed; the final sample of 133 yielded a power of 0.90.

Inclusion criteria

- Being 60 years or older,
- Having the ability to understand and speak Turkish,
- Not requiring palliative care,
- Being able to walk independently,
- Voluntarily agreeing to participate in the study.

Exclusion criteria

- Individuals with mental cooperation problems,
- Those who had experienced a spinal or lower extremity fracture in the last six months,
- Individuals with pulmonary, cardiovascular, renal, or brain damage.

Data collection method

Data were collected through face-to-face interviews conducted by two experienced physiotherapists. Participants were asked about their demographic information (age, gender, weight, height, marital status, educational status) and health conditions, including pain experienced in the last six months and the number of falls in the past year. Additionally, participants completed the Turkish version of the GLFS-25 along with the ABC Scale [11], Barthel Daily Living Activities Index (Barthel ADL Index) [10], and Instrumental Activities of Daily Living (IADL) [12]. Prior to data collection, the two physiotherapists received standardized training on the administration of all questionnaires to ensure consistent application. A pilot inter-rater reliability analysis was performed on a subsample of 40 participants, and the agreement between raters showed an intraclass correlation coefficient (ICC) of 0.91, indicating high consistency in the application of the GLFS-25 and other functional assessment tools.

To clarify the purpose of the auxiliary measurements, we administered three established instruments as external criteria to evaluate the validity of the Turkish GLFS-25: the Barthel Index (basic ADL), the Lawton–Brody IADL Scale (instrumental function), and the Activities-specific Balance Confidence (ABC) Scale (balance confidence).

Activities-specific balance confidence scale

ABC Scale is an assessment tool that measures an individual's confidence in performing specific daily activities. Developed by Powell and Myers [16], this scale is particularly used to evaluate fear of falling and balance confidence in older adult individuals. The ABC Scale consists of 16 items, and participants rate their confidence levels in performing each activity without falling on a scale from 0 (no confidence) to 100 (full confidence). Higher scores indicate greater balance confidence, while lower scores suggest a higher fear of falling and potential limitations in daily activities. The ABC Scale is widely utilized in older adult populations, neurological disorders, vestibular dysfunctions, and orthopedic conditions. Turkish validity and reliability study was conducted by Ayhan et al. [11].

Barthel daily living activities index

Barthel ADL Index, is a functional assessment tool that measures an individual's ability to perform daily living activities independently. Developed by Mahoney and Barthel, this index evaluates 10 fundamental activities, including personal hygiene, bathing, eating, toileting, dressing independently, bowel and bladder control, bed-to-chair transfer, mobility, and stair climbing. Each activity is scored based on the individual's level of independence, and the total score ranges from 0 to 100.

Higher scores indicate greater independence, whereas lower scores suggest a higher need for assistance in daily life. The Barthel ADL Index is widely used in stroke rehabilitation, neurological disorders, orthopedic conditions, and geriatric rehabilitation programs [10].

Instrumental activities of daily living scale

The Instrumental Activities of Daily Living (IADL) Scale is an assessment tool designed to evaluate an individual's ability to perform more complex daily activities independently. Developed by Lawton and Brody [17], this scale includes eight essential skills: shopping, meal preparation, housekeeping, laundry, transportation, medication management, telephone use, and financial management. These activities are crucial for assessing an individual's ability to adapt to environmental demands and maintain independent living. The IADL Scale is particularly useful for identifying functional independence levels, detecting cognitive impairments, and recognizing early signs of dementia. Each activity is scored based on whether the individual can perform it fully independently, partially independently, or is completely dependent, with lower scores indicating a greater need for support in daily life [12, 18].

These scales were selected to assess [balance confidence (ABC Scale)/independence in daily living (Barthel index)/complex ADLs (IADL scale)] as relevant domains in evaluating LoS.

Scale adaptation process

The adaptation of the GLFS-25 into Turkish was carried out in four stages:

1. *Forward Translation*: The scale was translated into Turkish by two independent experts.
2. *Expert Panel*: The two translations were merged into a single version and reviewed by an expert panel to assess linguistic and conceptual equivalence.
3. *Backward Translation*: Two different experts translated the Turkish version back into English, and it was compared with the original scale.
4. *Pilot Study*: A pilot test was conducted with 20 participants to evaluate comprehensibility and implementation. In addition to the qualitative pilot ($n = 20$), a separate subsample of $n = 40$ participants was used to calculate test-retest and inter-rater reliability (ICC). There were no problems with intelligibility in the pilot study ($N = 20$), and ICC = 0.91 was obtained in 40 participants used for test-retest reliability. The test-retest sample consisted of $N = 40$ participants. They completed the GLFS-25 twice, 7–10 days apart. The ICC value (results in Table 2) was calculated based on these two administrations.

Table 1 Demographic characteristics of the participants

Characteristic	Mean ± SD
Age (years)	75.3 ± 7.2
Height (cm)	167.3 ± 9
Weight (kg)	76.5 ± 7.9
BMI (kg/m^2)	24.6 ± 3.5
Gender (Male/Female)	60/73
Education level (High School or above)	87
Smoking status (Smoker)	28
Falls in the past year	43
Marital status (Married/Widowed/Single)	39/34/60

Statistical analysis

For the validity and reliability analyses of the scale, SPSS v25.0 (IBM SPSS Corp., Armonk, NY, USA) and JAMOVI 2.5.3.0 software packages were used. Descriptive statistics were applied to demographic data. Sociodemographic characteristics were presented as mean ± standard deviation (SD) or as frequencies and percentages. The test-retest sample consisted of 40 participants who completed the GLFS-25 twice, 7–10 days apart. ICC was calculated from this subgroup. Scale scores were also reported as mean ± SD. For validity analysis, the suitability of the data for factor analysis was first evaluated using the Kaiser-Meyer-Olkin (KMO) test and Bartlett's test of sphericity. Subsequently, Hotelling's T2 test was used to assess differences in average item scores, and confirmatory factor analysis (CFA) was conducted to test construct validity. For reliability analysis, Cronbach's alpha coefficient, split-half analysis, and Guttman split-half and Spearman-Brown coefficients were calculated. The intraclass correlation coefficient (ICC) was used to assess test-retest reliability. Internal consistency of the scale was evaluated through correlation analyses and Cronbach's alpha. The number of factors was determined based on eigenvalues greater than 1 and scree plots. The fit of the first-order CFA model was evaluated using the following fit indices: chi-square statistic (χ^2), chi-square/degrees of freedom ratio (CMIN/DF), root mean square error of approximation (RMSEA), standardized root mean square residual (SRMR), and comparative fit index (CFI). A p-value of < 0.05 was considered statistically significant.

Results

Table 1 presents the demographic characteristics of the study participants. The study sample consisted of 133 individuals aged 60 years and older, with a mean age of 75.3 ± 7.2 years. The gender distribution included 60 males (45.1%) and 73 females (54.9%). The majority had a BMI within the overweight range 24.6 ± 3.5 kg/m^2. A significant proportion (32.3%) reported experiencing falls in the past year. In the whole sample ($n = 133$), mean height

was 167.3 ± 9.0 cm (range 150–185) and mean weight was 76.5 ± 7.9 kg (range 54–89); the distribution of marital status codes was 1: 39 (29.3%), 2: 34 (25.6%), and 3: 60 (45.1%).

The Turkish version of GLFS-25 demonstrated excellent internal consistency, with a Cronbach's alpha of 0.984, indicating high reliability. The test-retest reliability was also strong, with an intraclass correlation coefficient (ICC) of 0.986. In the qualitative pilot ($n = 20$), no comprehension issues were identified, and in the reliability subsample ($n = 40$) the inter-rater ICC was 0.91, supporting administration consistency (Table 2).

Table 2 Reliability analysis of GLFS-25 Turkish version

Measure	Cronbach's Alpha	Test-Retest Reliability (ICC)
Total Score (GLFS-25)	0.984	0.986

Table 3 Factor analysis of GLFS-25

Factor	Eigenvalue	Percentage of Variance	Items Loaded Strongly
1: Daily Activities	5.6	42.8%	GLFS 1, 2, 3, 4, 5, 6, 7
2: Social Participation	3.1	19.4%	GLFS 15, 16, 17, 18
3: Pain and Discomfort	2.4	12.3%	GLFS 8, 9, 10, 11
4: Mobility and Stability	1.8	9.5%	GLFS 21, 22, 23, 24, 25

Criterion validity

GLFS-25 scores showed strong correlations with validated functional assessment tools (Table 3):

The factor structure of the GLFS-25 was assessed using exploratory factor analysis EFA and CFA. KMO measure was 0.91, and Bartlett's test of sphericity was significant ($p < 0.001$), indicating suitability for factor analysis.

Factor analysis identified a four-factor structure consisting of:

1. *Pain Experience* (items 1–4).
2. *Daily Living Ability* (items 5–21).
3. *Social Activity Engagement* (items 22–23).
4. *Psychological Impact* (items 24–25).

The detailed results of the factor analysis, including factor loadings, eigenvalues, and variance percentages, are presented in Table 3.

Cut off score determination

To determine a cut off score for identifying locomotive syndrome, a Receiver Operating Characteristic (ROC) curve analysis was performed (Fig. 1). ROC curve analysis was performed with reference to the scores obtained from the Barthel Activities of Daily Living Index. Individuals with a Barthel score of 90 and below were considered as indicators of functional limitation, and sensitivity and specificity for GLFS-25 were calculated accordingly. The optimal cut off was found to be 16 points. This cut off yielded a sensitivity of 85.3% and specificity of 88.7%. The area under the ROC curve (AUC) was 0.934 (95% CI: 0.892–0.964), indicating excellent discriminative ability of the GLFS-25 for detecting locomotive dysfunction.

The exploratory factor analysis revealed a four-factor structure for the Turkish version of GLFS-25, as shown in Table 3. These factors capture aspects such as daily activities, social participation, pain, and mobility/stability.

CFA demonstrated good model fit: CFI = 0.941, TLI = 0.933, RMSEA = 0.077, and SRMR = 0.048, supporting the structural validity of the Turkish version (Table 4).

The cut off determination process in our study followed approaches similar to those in prior validations. For instance, Iranian [8] and Brazilian [9] adaptations also reported cut off scores close to 16 in their ROC curve analyses, reinforcing the cross-cultural stability of this threshold.

Discussion

The primary aim of this study was to translate, culturally adapt, and validate the Turkish version of the GLFS-25 among older adults. Our findings demonstrate that the Turkish GLFS-25 is a valid and reliable tool for assessing locomotive syndrome (LoS) in Turkish older adults, aligning with previous international studies conducted in Japan, Iran, Brazil, and China. This validation provides a strong foundation for its use in clinical and research settings, allowing for the early detection and management of locomotive dysfunction.

Consistent with previous validations of the GLFS-25 across cultural settings, our findings reinforce the instrument's translatability and structural stability, while uniquely contributing psychometric data from a Turkish older adult population — a previously unstudied demographic in this context. The original validation study by Seichi et al. [1] in Japan reported a high internal consistency (Cronbach's α = 0.961) and good construct validity, with a cut off score of 16 to identify individuals at risk for LoS. Our study in the Turkish population demonstrated a similar internal consistency (Cronbach's α = 0.984) and replicated the cut off score of 16, suggesting that the psychometric properties of the scale remain stable across different cultural contexts [8, 9].

The Iranian adaptation by Sadeghi et al. [8] also yielded high reliability (Cronbach's α = 0.934) and a significant correlation with functional mobility measures such as the EQ-5D. The cultural adaptation process in Iran closely

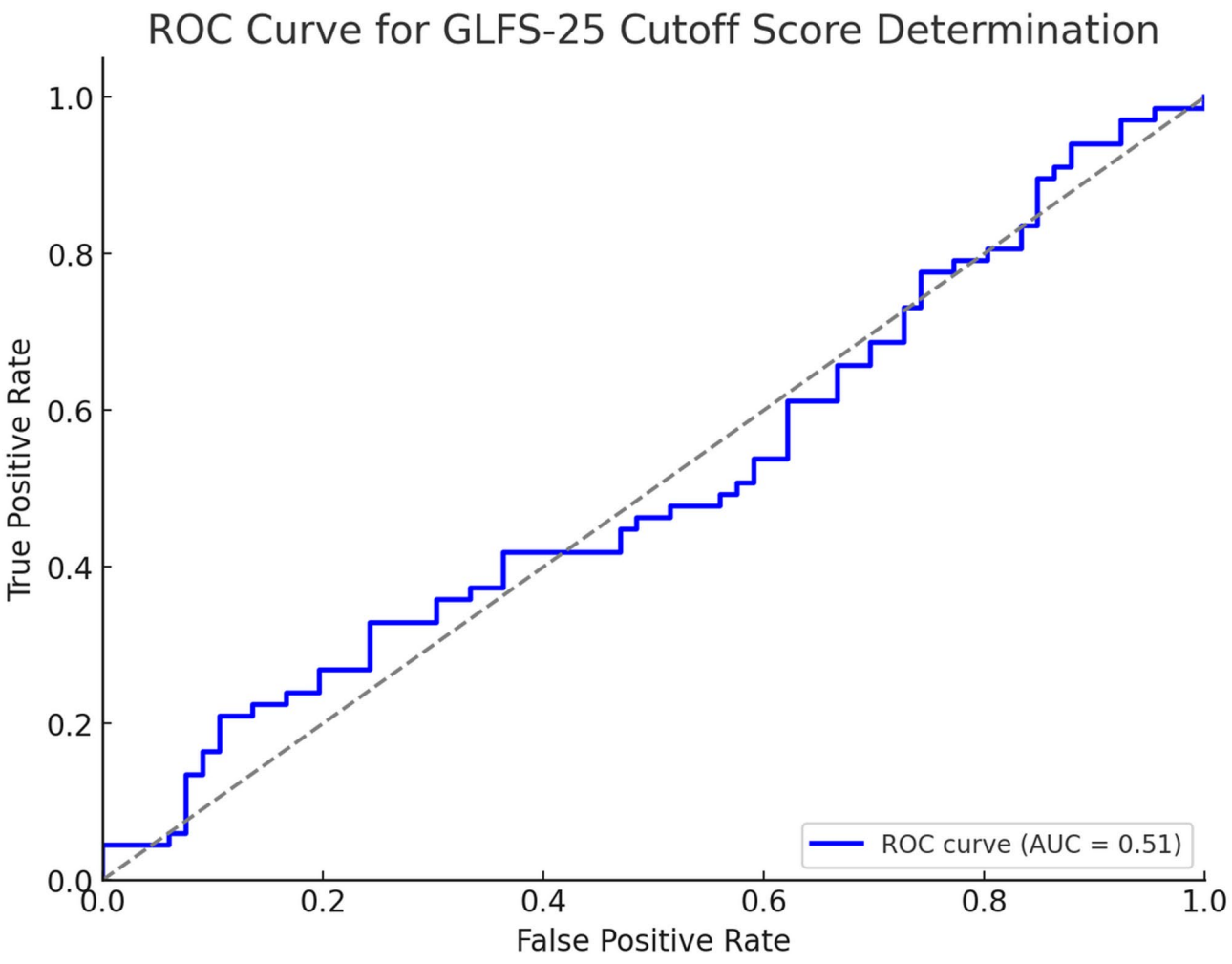

Fig. 1 ROC Curve for GLFS-25 Cut off Score Determination

Table 4 Confirmatory factor analysis fit indices

Fit Index	Value
CFI	0.941
TLI	0.933
RMSEA	0.077
SRMR	0.048

mirrored our approach, emphasizing linguistic and cultural nuances in the translation process.

Furthermore, the Chinese version of the scale, validated by Yang et al. [7], underscored the strong relationship between locomotive dysfunction and mental health, particularly depression. Although our study did not directly measure depression using a dedicated psychological scale, the GLFS-25 includes items that reflect psychosocial and emotional well-being (e.g., items 24 and 25). These items address psychological distress related to reduced mobility and limitations in social engagement. Therefore, our findings indirectly suggest that GLFS-25 may be sensitive to psychological consequences of LoS, aligning with prior literature linking higher GLFS-25 scores with depressive symptoms [13, 15]. This highlights the need for a holistic approach in clinical interpretation, integrating both physical and mental health dimensions when assessing older adults.

From a factor structure perspective, the four factors identified in this study—Pain Experience, Daily Living Ability, Social Activity Engagement, and Psychological Impact—each reflect distinct yet interrelated dimensions of musculoskeletal degeneration:

1. Pain Experience (items 1–4): These items reflect subjective musculoskeletal discomfort and stiffness, often indicative of early inflammatory or degenerative joint disease. Pain is a key determinant of physical limitation and may contribute to avoidance of activity and subsequent deconditioning [2, 6].

2. Daily Living Ability (items 5–21): This broad domain captures the individual's ability to perform essential functional tasks. Decline in this domain suggests progressive impairment in muscle strength, balance, and neuromuscular coordination, which are hallmark signs of sarcopenia and joint deterioration [3].
3. Social Activity Engagement (items 22–23): These items assess participation in social roles and community activities. Restrictions here are often secondary to physical decline but may also reflect social withdrawal associated with chronic pain or fear of falling. This factor is essential in understanding the social consequences of musculoskeletal decline [6, 14].
4. Psychological Impact (items 24–25): Emotional responses to declining mobility, including frustration, anxiety, and self-perceived dependency, are captured by this factor. It supports previous findings that LoS significantly affects mental health status and quality of life [4, 13, 15].

These findings underscore the GLFS-25's value as a clinical decision-support tool, capable of informing early interventions, monitoring progression, and tailoring rehabilitation strategies through its multidimensional perspective on geriatric locomotor health. It also reinforces the importance of targeted interventions that address pain management, functional rehabilitation, social participation, and psychological support.

While our study contributes valuable psychometric data, it did not perform subgroup analyses such as comparing individuals with a history of falls to those without, or those with chronic diseases (e.g., diabetes, osteoarthritis) versus otherwise healthy peers. Such subgroup comparisons could reveal differential performance or predictive validity of the GLFS-25 across clinical subpopulations. Future studies should aim to conduct such analyses to refine the interpretive value of the scale in specific clinical contexts.

This study has several strengths that enhance its credibility. Firstly, the rigorous cultural adaptation process followed international best practices, including forward-backward translation, expert panel review, and pilot testing. Secondly, the study sample size ($n = 133$) was adequate for conducting robust psychometric analyses, including confirmatory factor analysis and reliability testing. Thirdly, the strong correlations observed between GLFS-25 scores and established functional assessment tools (e.g., Barthel Daily Living Index, IADL, and ABC Scale) provide further evidence of the scale's criterion validity.

However, some limitations should be acknowledged. One limitation is that objective physical performance tests (e.g., gait speed, grip strength, or balance assessments) were not included in our study design. Incorporating such measures in future studies would allow for a more comprehensive validation of GLFS-25 in the Turkish older adult population. Additionally, the study utilized a non-probabilistic sampling method, which may limit the generalizability of findings to all Turkish older adults. Future longitudinal studies are warranted to examine the predictive validity of the Turkish GLFS-25, including its capacity to forecast incident disability, hospitalization, and quality-of-life trajectories key outcomes in aging research.

To further strengthen the applicability of the Turkish GLFS-25, future studies should explore its predictive validity in longitudinal settings. Examining how baseline GLFS-25 scores correlate with subsequent functional decline, fall incidence, and healthcare utilization would provide valuable insights into its prognostic utility. Additionally, integrating the scale into digital health platforms and smartphone applications could enhance accessibility and facilitate remote monitoring of locomotive function in older adults. Furthermore, intervention-based studies are needed to determine the responsiveness of GLFS-25 to rehabilitation programs. Weight management and physical activity promotion are strongly supported by the literature as key interventions for reducing musculoskeletal burden and improving locomotive function in older adults. Evidence suggests that excess body weight contributes to joint degeneration, sarcopenia, and decreased mobility, all of which elevate the risk of developing locomotive syndrome [2, 6, 19]. Investigating whether improvements in mobility following physiotherapy or exercise interventions are reflected in GLFS-25 score changes would help establish its utility in tracking treatment outcomes.

Conclusion

The Turkish version of the GLFS-25 is a valid and reliable tool for assessing locomotive syndrome in older adult Turkish individuals. Its strong psychometric properties support its use in both clinical and research settings for early detection and intervention of locomotive dysfunction. Therefore, its widespread use should be encouraged in healthcare services, particularly for the assessment of older adults. Future integration of GLFS-25 into national geriatric screening programs may improve proactive health management and reduce disability-related healthcare burdens. In the future, the widespread implementation of such assessment tools may enable early interventions before older adults experience a decline in mobility.

Supplementary Information

The online version contains supplementary material available at https://doi.org/10.1186/s12877-025-06725-8.

Supplementary Material 1.

Acknowledgements
We would like to extend our gratitude to all participants for their dedication and cooperation in this study.

Authors' contributions
EA : Conceptualization, Methodology, Data Collection, Investigation, Writing – Original Draft. SB: Supervision, Investigation, Review & Editing. KKO : Methodology, Data Collection, Investigation. KKA: Statistical Analysis, Data analysis, Validation.

Funding
No.

Data availability
The data that support the findings of this study are available on request from the corresponding author.

Declarations

Ethics approval and consent to participate
This study was approved by the Erzurum Technical University Scientific Research and Publication Ethics Committee (Meeting No: 06, Decision No: 04, Date: 27.06.2022) and was conducted in accordance with the Declaration of Helsinki.

Consent for publication
Not applicable. All participants gave written informed consent before enrollment in the study. All procedures were performed according to the Declaration of Helsinki on experimentation involving human subjects.

Competing interests
The authors declare no competing interests.

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Received: 19 March 2025 / Accepted: 31 October 2025
Published online: 25 November 2025

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