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Investigation of the Validity and Reliability of the Tele-Assessment of Balance and Mental Status in Individuals with Stroke

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Abstract

Objective: With tele-rehabilitation increasingly becoming a commonly preferred approach, it has gained importance to investigate whether assessment scales traditionally used in face-to-face settings are valid and reliable when applied via tele-assessment, in order to ensure the remote and long-term sustainability of rehabilitation processes. The aim of this study was to investigate the validity and reliability of the tele-assessment of balance and mental status in individuals with stroke using the Berg Balance Scale (BBS), Mini-Mental State Examination (MMSE), Mini-BESTest, Montreal Cognitive Assessment (MoCA), Tandem Flamingo Test, and Romberg Stance Test. *Methods:* A total of 20 individuals with stroke were included in the study, with a mean age of 54.85 ± 15.42 years; 16 were male (80%) and 4 were female (20%). All participants were at stage 3 or higher for both upper and lower extremities according to the Brunnstrom staging system. The order of assessments (tele-assessment first or face-to-face assessment first) and the allocation of the two physiotherapists conducting the assessments were randomized based on the order of application. The BBS, MMSE, MoCA, Mini-BESTest, Tandem Flamingo Test, and Romberg Stance Test were administered to the participants using both tele-assessment and face-to-face assessment methods. Video recordings were obtained during tele-assessment, and a third evaluation was performed three weeks later by the same physiotherapists using these recordings. *Results:* Excellent agreement was observed between tele-assessment and face-to-face assessment, as well as between face-to-face assessment and video-based evaluation, for the MoCA, MMSE (excluding the orientation subscale), BBS, Mini BESTest, and the Tandem-Flamingo and Romberg Stance Tests (ICC> 0.90). For the orientation subscale of the MMSE, good agreement was found (0.894). Additionally, asynchronous tele-assessment conducted via video recordings three weeks later demonstrated excellent agreement with both face-to-face assessment and synchronous tele-assessment (ICC> 0.90). *Conclusion:* The findings indicate that the BBS, MMSE, Mini-BESTest, MoCA, Tandem Flamingo Test, and Romberg Stance Test are valid and reliable tools for the tele-assessment of balance and mental status in individuals with stroke. However, it is recommended that greater caution

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be exercised when conducting measurements using single-task and time-based tests, such as the Tandem Flamingo and Romberg Stance Tests, during tele-assessment.

Keywords: *stroke, balance, mental health, tele-assessment, validity*

Introduction

Stroke can be defined as a generalized or focal neurological impairment of sudden onset, lasting longer than 24 hours or resulting in death within this period, for which no cause other than vascular origin can be identified [1].

Stroke is among the leading causes of mortality and disability worldwide. According to data from the Global Burden of Disease research program, stroke ranks second among causes of death due to non-communicable diseases [2]. Studies indicate that more than one million individuals experience a stroke annually in Europe, and approximately four hundred thousand people die as a result of stroke each year [3].

Common post-stroke symptoms include hemiparesis or hemiplegia, speech impairments, loss of balance, central facial palsy, and disturbances in mental status and perception [4].

Balance impairments are considered a primary cause of disability following stroke [5]. Previous studies have reported prolonged stance phase during gait in individuals with stroke. A loss of symmetrical weight transfer is observed, accompanied by a reduction in the duration of stable standing. Both static and dynamic balance are impaired after stroke [6].

Approximately 80% of stroke survivors experience cognitive and mental impairments [7]. Stroke-related cognitive dysfunctions may hinder the reacquisition of lost motor abilities. Consequently, mental problems may act as a barrier to functional independence in individuals with stroke [8].

Restoring functional abilities to patients is essential for achieving maximum quality of life and overall health status, and physiotherapy and rehabilitation play a crucial role in this process [9]. Despite the well-established effectiveness of rehabilitation, difficulties in accessing treatment make it challenging for patients to obtain optimal benefits [10].

When considering disadvantages related to access to treatment, factors such as regional limitations in healthcare services, inadequate socioeconomic status of patients, an imbalance between demand and service provision, and resulting delays in accessing treatment become prominent [11]. During pandemic periods such as COVID-19, face-to-face rehabilitation processes were disrupted, and online applications came to the forefront. It is evident that tele-rehabilitation emerged in response to this need, aiming to make treatment more accessible to patients through the use of technology [12, 13, 14].

Assessment and intervention programs in rehabilitation are inseparably related, resembling two sides of the same coin. The planning, updating, and monitoring of the effectiveness of interventions are only possible through systematic assessment. Therefore, tele-assessment appears as an integral component of tele-rehabilitation practices. Many assessment methods used in face-to-face clinical settings can also be applied in tele-assessment environments. However, an important question arises as to whether assessment tools developed for face-to-face evaluation yield equivalent measurement outcomes when used under tele-assessment conditions. Based on this rationale, the present study aimed to investigate the validity and reliability of the tele-assessment of balance and mental status in individuals with stroke.

Methods

This study was conducted by including patients who were diagnosed with stroke by neurologists, referred to us, and receiving treatment at the Hatay Private Akvaryum Rehabilitation Center. Written informed consent was obtained from all participants. The study was approved by the Hatay Mustafa Kemal University Non-Interventional Clinical Research Ethics Committee (approval number: 12/01/2023-T2-K20; date: 12.01.2023). A total of 20 patients, 80% of whom were male, who were registered at the relevant private special education and rehabilitation center, met the inclusion criteria, and agreed to participate in the study were included.

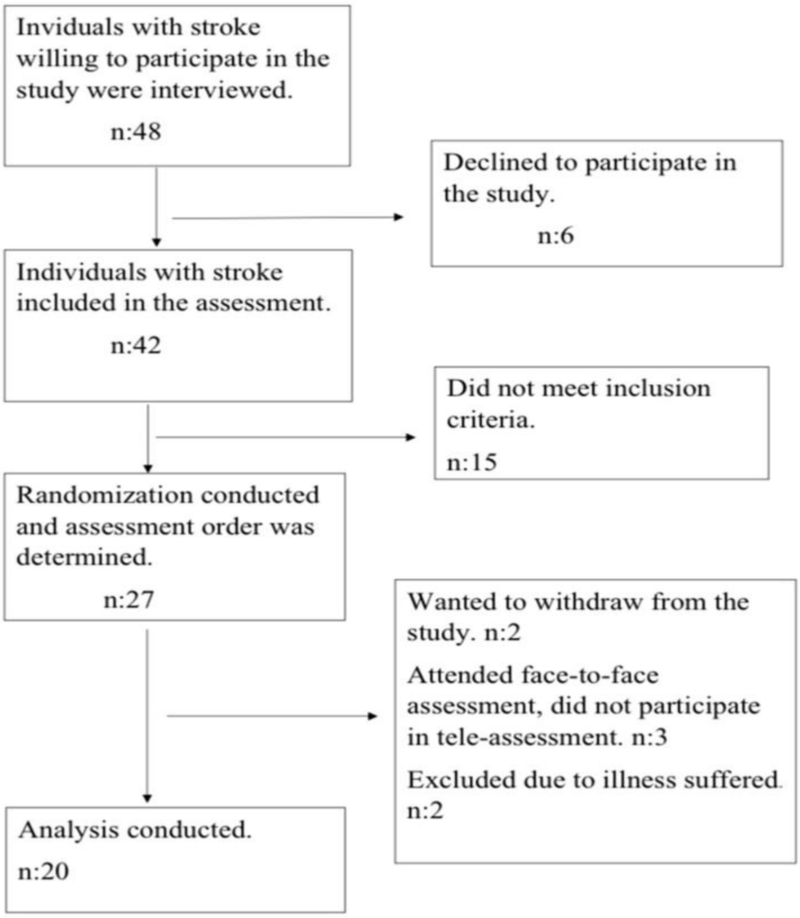

Figure-1. Study Flow Diagram

Inclusion Criteria

- Being between 18 and 75 years of age
- Scoring 18 points or higher on the Mini-Mental State Examination (MMSE)
- Ability to speak and understand Turkish
- Having access to a computer and the internet
- Being at stage 3 or higher for both upper and lower extremities according to the Brunnstrom staging system

Exclusion Criteria

- Having a neurological disease other than stroke
- Having an orthopedic condition affecting mobility
- Having visual or hearing impairments

Randomization Process

The 20 patients included in the study were randomized according to the order of enrollment using a simple randomization method. Patients with odd numbers were first assessed face-to-face by the first physiotherapist and subsequently underwent tele-assessment conducted by the second physiotherapist. Patients with even numbers were first assessed via tele-assessment by the first physiotherapist and then evaluated face-to-face by the second physiotherapist.

To increase measurement consistency and intra-rater reliability, tele-assessments were recorded via the video conferencing application used during the session. These recordings were re-evaluated three weeks later by the same physiotherapist who performed the initial tele-assessment, and each patient was assessed for a third time. In this manner, physiotherapists were blinded to each other's assessment results throughout the study.

Assessment Methods

Prior to the study, participants' demographic information was recorded. For the study session, which lasted a total of 60 minutes, both face-to-face and tele-assessments were conducted to evaluate mental status and balance using the following instruments, respectively: the Mini-Mental State Examination (MMSE), Montreal Cognitive Assessment (MoCA), Romberg Stance Test, Flamingo Stance Test, Tandem Stance Test, Mini-BESTest, and Berg Balance Scale (BBS).

During the tele-assessment phase, participants were asked to have a caregiver present to assist with camera positioning when necessary and to ensure patient safety. Tele-assessment sessions were conducted via Google Meet or Zoom, according to participants' preferences. Participants were informed about video recording prior to this phase, and written informed consent was obtained. These video recordings were evaluated asynchronously.

Romberg Stance Test

The Romberg Stance Test is used to assess static balance. The individual stands with the feet positioned shoulder-width apart and raises the shoulders to 90 degrees of flexion with the elbows in extension. The participant is then asked to maintain this position with eyes closed for a minimum of 30 seconds. To successfully complete the test, the individual must remain standing without exhibiting any postural reactions (e.g., stepping or swaying). If balance is lost before 30 seconds, the duration until balance disruption is recorded [15].

Flamingo Stance Test

For this test, the individual stands upright with the hands positioned at waist level. The participant is asked to lift one foot and place it against the knee of the standing leg. The duration for which the individual can maintain single-leg stance with eyes closed is recorded. This test provides information regarding static balance. Maintaining the position for more than 30 seconds is considered a successful performance [16].

Tandem Stance Test

The individual stands upright with the heel of one foot placed directly in front of the toes of the other foot. The arms are positioned alongside the body. The participant is asked to maintain this position without support for a total of 30 seconds. If balance is disrupted before 30 seconds (e.g., arm abduction or trunk sway), the time until balance loss is recorded. Participants who maintain the position for more than 30 seconds without eliciting postural reflexes (normative value >30 seconds for young adult patient groups) are considered successful. This test is used to assess static balance [17].

Mini-Mental State Examination (MMSE)

The MMSE evaluates language, memory, recall, orientation, and attention/calculation under five domains. Scoring ranges from 0 to 30 points. A score of 25 or higher is considered normal, while scores below 10 indicate severe impairment [18]. The scale was originally developed by Folstein et al. in 1975, and its Turkish validity and reliability were established in 2016 [18, 19]. Scores below 18 indicate cognitive impairment. In studies requiring mutual cooperation, patients with MMSE scores of 18 and above have been included [20].

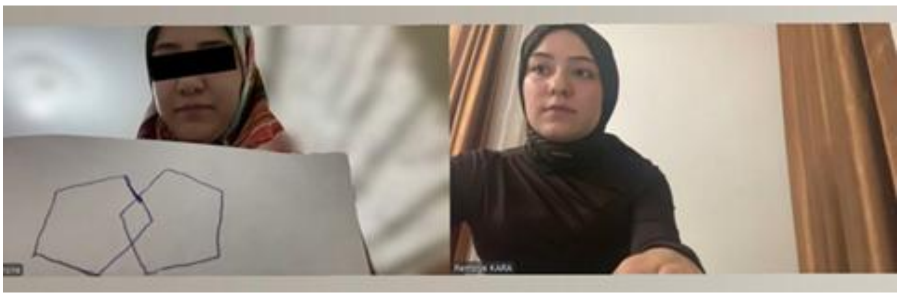

Figure 2. MMSE Tele-Assessment Procedure

Montreal Cognitive Assessment (MoCA)

The Montreal Cognitive Assessment is a rapid screening tool used for the detection of mild cognitive impairment. The scale consists of several tasks, including clock drawing, copying a given figure, correctly following an alternating letter–number sequence, and naming animals shown in pictures. Scoring ranges from 0 to 30 points, with scores of 21 points and above considered within the normal range [21]. The scale was first developed by Nasreddine et al. in 2005. Its Turkish validity and reliability were established by Selek et al. in 2010 in patients with Parkinson's disease and by Özdilek et al. in 2014 in patients with Alzheimer's disease [21,22,23].

Mini Balance Evaluation Systems Test (Mini-BESTest)

The Mini Balance Evaluation Systems Test is one of the scales accepted as a standard for balance assessment. It provides information on both dynamic and static balance through a total of four subcategories and 14 assessment tasks. The test evaluates various balance components, such as standing balance with eyes open and closed, rising onto the toes, and single-leg stance. The maximum achievable score is 28, with higher scores indicating better balance performance. The Turkish validity and reliability of the Mini-BESTest in individuals with stroke were established by Göktaş et al. in 2020 [24].

Berg Balance Scale (BBS)

The Berg Balance Scale, first developed by Berg et al. in 1995, assesses balance across 14 items. Each item is scored on a scale ranging from 0 (minimum) to 4 (maximum). The total score ranges from 0 to 56, with higher scores associated with better balance performance [25]. The Turkish validity and reliability of the scale were established in 2008 [26].

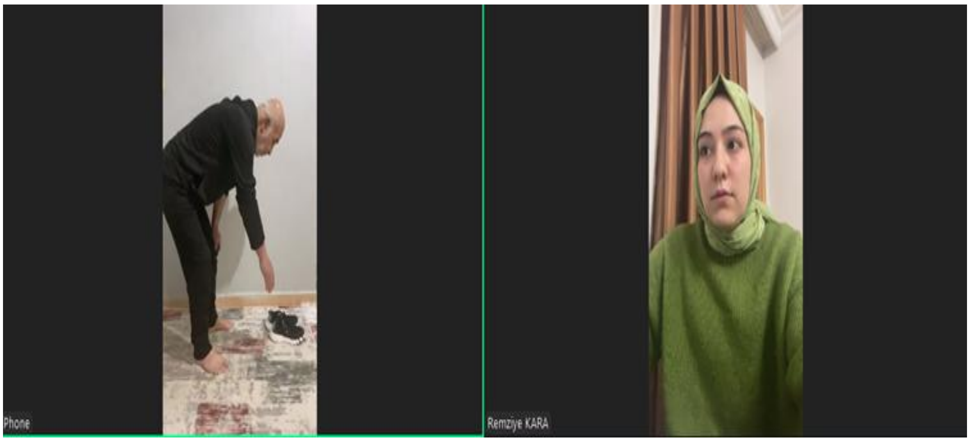

Figure 3. BBS Tele-Assessment Procedure

Brunnstrom Staging

This system, first described by Brunnstrom in 1966, classifies all extremities of the patient into six stages according to stroke prognosis. Stage 1, the lowest level, represents the flaccid stage. Stage 6, the highest level, indicates the presence of isolated movements and corresponds to the highest level of functional performance. In Stage 3, where spasticity reaches its maximum level, voluntary flexion movements of the hip, ankle, and knee joints can be performed in the sitting position and during standing for the lower extremity. For the upper extremity, voluntary control of synergies is present starting from Stage 3 [27].

Statistical Analysis

Parametric methods were used for measurement values showing a normal distribution. In accordance with parametric methods, the *Independent Samples t-test* (t-table value) was used to compare measurement values between two groups with independent variables.

For measurement values that did not show a normal distribution, non-parametric methods were applied. Accordingly, the *Mann–Whitney U test* (Z-table value) was used to compare measurement values between two groups with independent variables, while the *Friedman test* (χ^2-table value) was used to compare measurement values among three or more groups with dependent variables.

The *Cochran's Q test* was used to examine the relationships among three or more dependent categorical variables. *Pearson's chi-square (χ^2) cross-tabulation* was used to analyze relationships between two independent categorical groups. For all statistical tests, the level of statistical significance was set at $p < 0.05$.

The intraclass correlation coefficient (ICC) was used to assess test–retest reliability. ICC values range from 0 to 1, with values closer to 1 indicating a higher level of measurement consistency. ICC values were interpreted as follows: values below 0.50 indicate poor reliability; values between 0.50 and 0.75 indicate moderate reliability; values between 0.75 and 0.90 indicate good reliability; and values above 0.90 indicate excellent reliability [28].

Results

The mean age of the participants was determined to be 54.85 ± 15.42 years, and 8 individuals (40.0%) were within the 50–64 age group. Of the participants, 16 (80.0%) were male and 4 (20.0%) were female. According to Body Mass Index (BMI), 16 individuals (80.0%) were classified as overweight. It was found that 12 participants (60.0%) were high school graduates and 14 participants (70.0%) were smokers (Table 1).

Among the individuals with stroke included in the study, 11 participants (55.0%) had left-sided hemiplegia, and all participants were right-side dominant. According to Brunnstrom staging, 8 participants (40.0%) were at Stage 6 for the lower extremity, and 9 participants (45.0%) were at Stage 5 for the upper extremity. It was observed that 12 participants (60.0%) did not use any assistive device, while 5 participants (25.0%) used a tripod cane. A total of 15 participants (75.0%) had at least one chronic disease, and 9 participants (45.0%) had hypertension only (Table 2).

Table 1. General Distribution of the Sociodemographic Characteristics of the Study Participants

Veriable (N=20)	N	%
Age Classification [X± S.D.→54.85±15.42 (years)]		
<50	6	30
50-64	8	40
≥65	6	30
Sex		
Female	4	20
Male	16	80
BMI [X± S.D.→26.89±2.92 (kg/m^2)]		
Normal Weight (18.5-24.9 kg/m^2)	2	10
Overweight (25.0-29.9 kg/m^2)	16	80
Obesity (≥30 kg/m^2)	2	10
Educational attainment		
Literate	4	20
Primary education	1	5
High school	12	60
University	3	15
Smoking status		
Non-smoker	6	30
Current smoker	14	70

Table 2. General Characteristics of the participants

Affected side	N	%
Right	9	45
Left	11	55
Dominant side		
Sağ	20	100
Brunnstrom recovery stages (lower extremity)		
4.	8	40
5.	4	20
6.	8	40
Brunnstrom recovery stages (upper extremity)		
3.	6	30
4.	3	15
5.	9	45
6.	2	10
Use of assistive devices		
No	12	60
Yes	8	40
Type of assistive device used		
Crutch	3	15
Tripod	5	25
Chronic disease		
No	5	25
Yes	15	75
Type of chronic disease		
Hypertension	9	45
Diabetes + Hypertension	6	30
Assessment priority		
Face-to-face assessment first	10	50
Tele-assessment first	10	50

It was determined that the MMSE (excluding the orientation subscale), BBS, MoCA, Flamingo-Tandem and Romberg Stance Tests, and all subdomains of the Mini-BESTest demonstrated excellent agreement (ICC> 0.90). The orientation subscale of the MMSE showed good agreement (0.894) (Table 3).

Table 3. Examination of the Inter-Session Agreement of Successful Stance Duration in the Tandem, Romberg, and Flamingo Tests, and the Results of BBS, MoCA, Mini-BESTest, and MMSE

Intraclass Correlation Coefficient (ICC)*		**Face-to-Face Assessment – Tele-assessment**	**Face-to-Face assessment – Video recorded assessment**	**Tele-assessment – Video recorded assessment**
Tandem Stance Test (s)	***R***	0.991	0.991	1.000
	p	<0.001	<0.001	<0.001
MMSE total score	***R***	0.983	0.983	1.000
	p	<0.001	<0.001	<0.001
MMSE (orientation)	***R***	0.894	0.894	1.000
	p	<0.001	<0.001	<0.001
MMSE (registration)	***R***	1.000	1.000	1.000
	p	<0.001	<0.001	<0.001
MMSE (attention and calculaton)	***R***	1.000	1.000	1.000
	p	<0.001	<0.001	<0,001
MMSE (delayed recall)	***R***	0.916	0.916	1.000
	p	<0.001	<0.001	<0.001
MMSE (language)	***R***	0.947	0.947	1.000
	p	<0.001	<0.001	<0.001
BBS	***R***	1.000	1.000	1.000
	p	<0.001	<0.001	<0.001
MoCA	***R***	1.000	1.000	1.000
	p	<0.001	<0.001	<0.001
Romberg Stance Test (s)	***R***	0.991	0.991	1.000
	p	<0.001	<0.001	<0.001
Flamingo Stance Test (s)	***R***	0.989	0.989	1.000
	p	<0.001	<0.001	<0.001
Mini BESTest	***R***	0.997	0.997	1.000
	p	<0.001	<0.001	<0.001

*****The intraclass correlation coefficient (ICC) was used.

No statistically significant differences were observed among face-to-face, tele-assessment, and video-based evaluations for the MMSE, BBS, MoCA, and Mini BESTest, including all subdomains ($p > 0.05$). The three assessment methods were found to be comparable with respect to the specified parameters (Table 4).

However, for the Tandem, Flamingo, and Romberg Stance Tests, statistically significant differences were observed in the total duration of successful stance (seconds) across the three assessment methods ($\chi^2 = 20.000$; $p < 0.001$). To determine the source of the significant difference, pairwise comparisons with Bonferroni correction were conducted, revealing significant differences between the results of face-to-face assessment and both tele-assessment and video-recorded assessment. Specifically, the successful stance duration (seconds) in all three tests was significantly higher during face-to-face assessment compared to tele-assessment and video-recorded assessment (Table 4).

Table 4. Comparison of Test Results Across Tele-Assessment, Face-to-Face Assessment, and Video-Recorded Assessment

Veriable (N=20)	Face-to-Face Assessment (1)		Tele Assessment (2)		Video Recorded Assessment (3)		Statistical Analysis* Probability
	X±S.D.	Median [IQR]	X±S.D.	Median [IQR]	X±S.D.	Median [IQR]	
Tandem Stance Test total score (s)	22.05±7.16	20.0 [15.0]	21.20±7.72	17.5 [15.8]	21.20±7.72	17.5 [15.8]	χ^2=20.000 p<0.001 [1-2,3]
MMSE total score	26.65±3.33	28.0 [7.3]	26.30±3.84	28.0 [7.3]	26.30±3.84	28.0 [7.3]	χ^2=4.000 p=0.135
MMSE (orientation)	9.70±0.65	10,0 [0.0]	9.60±0.68	10.0 [1.0]	9.60±0.68	10.0 [0.0]	χ^2=4.000 p=0.135
MMSE (registration)	3.00±0.00	3.0 [0.0]	3.00±0.00	3.0 [0.0]	3.00±0.00	3.0 [0.0]	χ^2=0.000 p=1.000
MMSE (attention and calculaton)	3.05±1.82	3.0 [3.5]	3.05±1.82	3.0 [3.5]	3.05±1.82	3.0 [3.5]	χ^2=0.000 p=1.000
MMSE (delayed recall)	2.65±0.67	3.0 [0.8]	2.55±0.82	3.0 [0.8]	2.55±0.82	3.0 [0.8]	χ^2=4.000 p=0.135
MMSE (language)	8.20±1.01	9.0 [2.0]	8.05±1.23	9.0 [2.0]	8.05±1.23	9.0 [2.0]	χ^2=4.000 p=0.135
BBS	42.85±12.10	46.0 [24.5]	42.85±12.10	46.0 [24.5]	42.85±12.10	46.0 [24.5]	χ^2=0.000 p=1.000
MoCA	24.95±3.14	24.0 [4.0]	24.95±3.14	24.0 [4.0]	24.95±3.14	24.0 [4.0]	χ^2=0.000 p=1.000
Romberg Stance Test total score (s)	19.90±9.41	13.0 [18.0]	18.70±9.91	10.0 [20.0]	18.70±9.91	10.0 [20.0]	χ^2=20.000 p<0.001 [1-2,3]
Flamingo Stance Test total score (s)	15.25±9.90	13.0 [18.8]	13.90±9.91	10.0 [15.0]	13.90±9.91	10.0 [15.0]	χ^2=20.000 p<0.001 [1-2,3]
Mini BESTest	23.00±3.86	22.0 [8.8]	22,90±3,97	22.0 [9.0]	22.90±3.97	22.0 [9.0]	χ^2=4.000 p=0.135

*For data that do not have a normal distribution, the Friedman test (X^2-table value) statistics were used to compare the measurement values of three or more dependent groups.

The assessment order, in which face-to-face evaluation was conducted prior to tele-assessment, had no significant effect on the face-to-face results of the MMSE, Tandem Stance Test, BBS, MoCA, Romberg Stance Test, Flamingo Stance Test and Mini BESTest. Additionally, no statistically significant differences were observed in the face-to-face measurement parameters according to assessment order (p> 0.05) (Table 5).

The effect of conducting face-to-face assessment first versus tele-assessment first on face-to-face results was examined. No significant effect was observed on the classification categories of the Flamingo Stance Test, Romberg Stance Test, Tandem Stance Test, BBS and MMSE face-to-face results. Accordingly, no statistically significant differences were found in the measurement parameters of the face-to-face assessments based on the order of assessment (p> 0.05). (Table 6)

Table 5. The Effect of Conducting Face-to-Face Assessment First on Face-to-Face and Tele-Assessment Results

<u>Face-to-Face Assessment</u>	Face-to-Face assessment first (n=10)		Tele-assessment first (n=10)		Statistical Analysis* Probability
	X±S.D.	Median [IQR]	X±S.D.	Median [IQR]	
Tandem Stance Test (s)	23.40±7.63	27.5 [15.0]	20.70±6.76	18.5 [15.0]	Z=-0.550 p=0.583
MMSE total score	27.30±3.46	29.0 [5.0]	26.00±3.23	28.0 [6.0]	Z=-1.129 p=0.259
MMSE (orientation)	9.70±0.67	10.0 [0,3]	9.70±0.67	10.0 [0.3]	Z=0.000 p=1.000
MMSE (registration)	3.00±0.00	3.0 [0.0]	3.00±0,00	3,0 [0.0]	Z=0.000 p=1.000
MMSE (attention and calculation)	3.70±1.89	5.0 [2.5]	2.40±1.58	3.0 [2.3]	Z=-1.802 p=0.072
MMSE (delayed recall)	2.70±0.67	3.0 [0,3]	2.60±0.69	3.0 [1.0]	Z=-0.449 p=0.654
MMSE (language)	8.20±1.03	9.0 [2.0]	8.20±1.03	9.0 [2.0]	Z=0.000 p=1.000
BBS	44.60±12.55	51.0 [24.8]	41.10±12.03	37.0 [24.8]	Z=-0.613 p=0.540
MoCA	25.50±3.47	24.0 [7.0]	24.40±2.83	25.0 [6.0]	Z=-0.781 p=0.435
Romberg Stance Test (s)	20.90±9.63	21.5 [18.3]	18.90±9.59	12.5 [18.5]	Z=-0.599 p=0.549
Flamingo Stance Test (s)	16.60±11.28	15.0 [25.0]	13.90±8.71	13.0 [17.3]	Z=-0.462 p=0.644
Mini BESTest	23.70±4.05	23.0 [8.3]	22.30±3.73	21.5 [7.5]	t=0.802 p=0.433

* For data with a normal distribution, the 'Independent Sample-t' test (t-table value) statistics were used to compare the measurement values of two independent groups. For data without a normal distribution, the 'Mann-Whitney U' test (Z-table value) statistics were used to compare the measurement values of two independent groups.

Table 6. The Effect of Performing Tele-Assessment or Face-to-Face Assessment First on Test Classification Results

Face-to-face assessment Veriable (N=20)		Face-to-face assessment first (n=10)		Tele-assessment first (n=10)		Statistical Analysis* Probability
		N	%	N	%	
Tandem Stance Test	Maintained stance for 30 s	5	50	3	30	χ^2=0.833
	Failed to maintain for 30 s	5	50	7	70	p=0.361
MMSE Classification	Mild cognitive impairment	2	20	3	30	χ^2=0.267
	Normal cognitive status	8	80	7	70	p=0.606
BBS Classification	Moderate risk	4	40	5	50	χ^2=0.202
	Low risk	6	60	5	50	p=0.653
MoCA Classification	Mild cognitive impairment	6	60	5	50	χ^2=0.202
	Normal cognitive status	4	40	5	50	p=0.653
Romberg Stance Test	Maintained stance for 30 s	5	50	5	50	χ^2=0.000
	Failed to maintain for 30 s	5	50	5	50	p=1.000
Flamingo Stance Test	Maintained stance for 30 s	3	30	1	10	χ^2=1.250
	Failed to maintain for 30 s	7	70	9	90	p=0.264

*Cross-tabulations with the Pearson chi-square (χ^2) test were used to examine the relationships between two independent categorical groups.

Discussion

According to the results of our study, the tele-assessment scores and face-to-face assessment scores of the BBS, Mini-BESTest, MoCA, and MMSE (excluding the orientation subscale) demonstrated excellent intraclass correlation, with no statistically significant differences observed between the two methods. In contrast, although the Flamingo, Tandem, and Romberg Stance Tests, which are used to assess static balance, also demonstrated excellent intraclass correlation, statistically significant differences were found between face-to-face and tele-assessment results. This discrepancy was primarily due to a tendency for face-to-face assessment scores to be higher than tele-assessment scores. Based on these results, the BBS, Mini-BESTest, MoCA, MMSE, Flamingo-Tandem, and Romberg Stance Tests can be reliably used for the tele-assessment of balance and cognitive status in post-stroke individuals; however, static balance tests may systematically yield lower scores in tele-assessment compared to face-to-face assessment.

Tele-assessment methods can generally be categorized into two approaches: synchronous and asynchronous. Synchronous assessments involve real-time interaction between the patient and the evaluator using phone or video conferencing, while asynchronous assessments rely on pre-recorded videos or messages sent by the patient via email or other platforms. Each approach has advantages and limitations. Synchronous methods may be affected by internet connectivity issues, potentially biasing the results, whereas asynchronous methods may face limitations in guidance and verification of accuracy [29]. In our study, to observe the impact of synchronous and asynchronous assessment, video recordings were obtained during tele-assessment, and a third evaluation was conducted using these recordings. Results showed excellent agreement between synchronous tele-assessment and video-based evaluation, indicating no superiority between the two approaches.

In a 2025 study by Önal et al., the BBS was evaluated using different tele-assessment methods (synchronous and asynchronous) and compared with face-to-face assessment. Their findings indicated high agreement between tele-assessment and face-to-face results, suggesting that BBS tele-assessment is a feasible alternative, although larger sample sizes were recommended [30]. Unlike that study, our study included randomization between physiotherapists to control for inter-rater variability. This approach confirmed excellent agreement even when different evaluators conducted the assessments, supporting the validity and reliability of BBS tele-assessment.

In a study examining tele-assessment of balance in patients with knee osteoarthritis, the Timed Up and Go Test, 30-Second Chair Stand Test, and Single-Leg Stance Test were applied. The Single-Leg Stance Test demonstrated excellent agreement, consistent with our findings for static balance tests [31]. However, in our study, stroke patients tended to perform better during face-to-face assessment compared to tele-assessment in timed stance tests, highlighting the need for careful measurement and attention when using such tests in tele-assessment.

Challenges associated with tele-assessment include potential distractions in the patient's environment, which are harder to control remotely, complicating standardization of results. For populations at risk of falling or pediatric groups, support from caregivers is crucial during tele-assessment [32, 33]. The observed differences between face-to-face and tele-assessment results in the Tandem, Romberg, and Flamingo Tests may reflect these limitations. Patients may feel more secure in the presence of a healthcare professional, reducing fear of falling and improving task focus.

Technical limitations, such as limited internet connectivity or unstable electricity supply in rural areas—one of the target populations for tele-assessment—may affect measurement outcomes [32]. Since the Tandem, Flamingo, and Romberg Tests measure single tasks based on seconds, these tests are more susceptible to technical disruptions. Therefore, careful measurement and patient supervision are essential when using single-task, time-based assessments in tele-assessment.

Carotenuto et al. (2021) investigated the effectiveness of tele-administered neuropsychological assessment in patients with Alzheimer's disease and reported that the Mini Mental State Examination (MMSE) demonstrated a high level of consistency, with only statistically insignificant minor differences [34]. Consistent with the literature, our study found excellent agreement across all MMSE subdomains and total scores, except for the orientation subscale. In the orientation subscale, two patients scored one point lower in the tele-assessment compared to the face-to-face assessment. The item identified as problematic was the question *"What is today's date?"*. This discrepancy is attributed to patients having a clearer recollection of the day of their clinic visit.

Previous studies have investigated the effectiveness of the Montreal Cognitive Assessment (MoCA) in distinguishing mild cognitive impairment in individuals aged over 60 years through tele-assessment and have reported results consistent with face-to-face evaluation [35]. In line with the literature, our study demonstrated that tele-assessment of mental status using the MoCA in post-stroke individuals showed excellent agreement with face-to-face assessment.

No prior studies were identified evaluating the Mini-BESTest in tele-assessment. In our study, the Mini-BESTest demonstrated excellent agreement between tele-assessment and face-to-face assessment. Based on these results, the Mini-BESTest can be considered valid and reliable for tele-assessment of balance in post-stroke individuals.

Conclusion

This study demonstrates that tele-assessment is a reliable alternative to face-to-face assessment for evaluating balance and cognitive function in individuals after stroke. Multi-item and functional measures, including the BBS, Mini-BESTest, MoCA, and MMSE, showed excellent agreement between assessment methods, supporting their validity for remote use. Although static balance tests also demonstrated high reliability, they tended to yield lower absolute scores during tele-assessment, indicating the need for cautious interpretation of time-based static balance measures. Overall, tele-assessment offers a feasible and valid approach for post-stroke evaluation when appropriate assessment protocols are applied.

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