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Original Research Article

Tele-assessment of Berg balance scale, timed-up, go and box and block test in patients with chronic stroke: establishing agreement with the face-to-face assessment

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ABSTRACT

Background: The COVID-19 pandemic has triggered rapid adaptive actions in favor of remote interventions and clinical assessment methods. The reliability of functional tests used in remote assessment is limited in patients with chronic stroke. The aim of the study was to assess the inter-reliability of the Berg balance scale, the timed-up and go test, and the box and block test via remote assessment, in patients with chronic stroke.
Methods: Fifteen patients (8 men and 7 women) underwent a home-based teleassessment using a software platform and a center-based face-to-face assessment, on two consecutive days. The assessment order was randomized and conducted by an independent examiner. All participants were instructed regarding the use of the software platform, home equipment preparation, and safety issues
Results: Participants aged 50-70 years (mean 59.6±7.34) with an average of 4.8±2.5 years after stroke and a moderate degree of motor dependence (Barthel scale: mean 83±8.61 units) completed all tests in both assessment procedures without experiencing adverse events. The inter-reliability was moderate for the total BBS score: ICC=0.869 (95% CI: 0.616 to 0.955), excellent for the total time of the TUG: ICC=0.968 (95% CI: 0.907 to 0.989) as well as for the upper right and left arm scores of the BBT: ICC=0.974 (95% CI: 0.922 to 0.991) and ICC=0.966 (95% CI: 0.897 to 0.988), respectively.
Conclusions: Tele-assessment for BBS, TUG, and BBT appears moderate to excellent inter-reliability in functionally independent patients with chronic stroke.

Keywords: Berg balance scale, Box and block test, Reliability, Stroke, Tele-assessment, Timed-up and go test

INTRODUCTION

The use of technology in remote evaluation and rehabilitation intervention has evolved significantly during the last few years, paving the way for the development of telemedicine. Many randomized controlled trials have investigated the benefits of telerehabilitation in post-stroke patients in comparison to traditional rehabilitation methods, showing that telerehabilitation was either equal or superior to traditional rehabilitation, in terms of improvement in daily living activities, psychological status of patients and quality of their life.[1,2]

Although telerehabilitation services have been implemented, a growing concern arises about the potential remote functional assessment in patients with stroke.[1,3-7] Tele-assessment has been demonstrated to be feasible and valid compared to face-to-face assessment in healthy individuals, as well as in patients with chronic heart failure, chronic neurological and respiratory diseases.[2,8-10] The COVID-19 pandemic has triggered rapid adaptive actions in favor of remote interventions, including methods of assessment in most individuals with stroke, raising tele-assessment as a promising solution for reestablishing clinical practice and research beyond the current pandemic. In this context, tele-assessment for upper and lower limb impairments, balance, and gait function may be feasible for patients with stroke, using simple and safe tests similar to those used in other chronic neurological diseases.[11-13] Thus, the aim of the current study was to investigate the agreement between remote assessment and face-to-face evaluation for three functional tests: the Berg Balance Scale (BBS), the Timed up and go test (TUG), and the Box and Block test (BBT), in stroke patients. The primary hypothetical statement was that the use of tele-assessment produces similar results to those achieved during the face-to-face assessment.

METHODS

Participants

This prospective comparative study was performed from January to February 2021. Fifteen non-smoker patients (8 men and 7 women) with left (N=5) and right (N=10) hemiplegia after stroke participated in the study. Participants were recruited from a patient list of the "IASIS" rehabilitation center in the city of Karditsa, Central Greece. The inclusion criteria were: age between 50-70 years old, first stroke that had occurred at least 12 months before recruitment, non-hospitalized, independent mobility, moderate or slight level of dependence (Barthel scale >60 units), and enrollment in an outpatient rehabilitation program. The exclusion criteria were: physician-determined major medical problems (such as musculoskeletal, and pulmonary dysfunction), cognitive impairment with difficulty in understanding written and verbal instructions, and obesity (BMI >35 kg/m^2). All participants were fully informed verbally and via email about the study's aims and procedures, providing written informed consent. The study protocol was carried out in accordance with the Code of Ethics of the World Medical Association (Declaration of Helsinki).[14]

Study design

To test the research hypothesis, participants performed BBS, TUG, and BBT in two experimental conditions, on different consecutive days.[15] Tele-assessment was implemented through video-collaboration software (Vsee, Sunnyvale, California), while the face-to-face assessment was implemented at the "IASIS" rehabilitation center. The Vsee is a secure, high-resolution video-conferencing software with strong data security and video quality features. It was used to establish the two-way telecommunication between physiotherapists and stroke patients at home, enabling the monitoring of patients during the tele-assessment session. The experimental conditions' order was randomized through the use of concealed opaque envelopes. All functional tests were performed between 11.00 am to 2.00 pm in the same order for both experimental conditions (tele-assessment and face-to-face) starting with the BBS, followed by the TUG and BBT, with 15-20 minutes of rest between the tests. All participants were advised to use the same walking aid (if needed), to wear comfortable clothes and footwear for both experimental conditions, and to have a light meal before tests. All the required equipment (e.g., a box for the BBT) was given to the participants by the research team. Before testing in each experimental condition, precise written instructions for each test procedure were handed out to each participant. For those who were randomized to perform the tele-assessment before the face-to-face assessment (N=7), written and pictorial instructions detailing the process for using Vsee software as well as safety instructions were given by an independent physiotherapist (AM) via email, one day before evaluation. For the rest of the participants (N=8), these instructions were given at the end of the face-to-face assessment. All assessments were conducted by the same research physiotherapist (EP), who had over 4 years of clinical experience with stroke patients.

Baseline measurements

For all participants, a full medical history and anthropometric characteristic measurements were taken at the rehabilitation center before entry into the study. Their mobility was assessed using the Barthel scale. This scale demonstrates high reliability between observers (r=0.95) and reliability of repetitive measurements (r=0.89).[16]

Center-based face-to-face assessment

Before evaluation, each participant took a rest for 20-30 minutes to avoid any fatigue due to his/her transportation to the rehabilitation center. During the face-to-face assessment, the examiner supervised the testing procedures, while being in the same room with the participant. The three functional tests were performed under the verbal guidance of the examiner and in line with the recommended guidelines.[17-19]

Home-based remote assessment

During the tele-assessment, the research physiotherapist was geographically located at the "IASIS" rehabilitation center and had no physical contact with the participant. For security reasons and for providing assistance with technical difficulties during the remote assessment an independent physiotherapist was located in a separate room at the patient's home. Before starting the testing, a

laptop was placed on a table by the independent physiotherapist, 150-200 cm away at the side of each participant to fully capture him/her in sitting and standing positions for the BBS and TUG test. For the BBT the laptop remained on one edge of the table and the two-compartment box was placed on the other edge, in order for the research physiotherapist (EP) to have visual contact with the participant and to be able to count the number of the blocks that being transferred from one compartment of the box to the other. The telecommunication platform setup was done by the participant using the instructions that were given by the research physiotherapist. No telephone or remote visual contact was allowed between the two physiotherapists during the tele-assessment. It was agreed that in case of an adverse event, such as loss of balance with a fall or internet signal loss, the assessment procedures would be terminated and the research physiotherapist would ask for assistance from the independent physiotherapist who was located in the patient's home.

The Berg Balance scale

The BBS is one of the most common tests used to assess balance and postural stability in rehabilitation and is a core outcome measure recommended for the assessment of standing balance. It is a 14-item test, with each item covering a different movement task such as reaching, bending, transferring, and standing incorporating most components of postural control such as sitting and transferring safely between chairs; standing with feet apart, feet attaching, in single-leg stance, feet in the tandem Romberg position with eyes open or closed; reaching down to pick and lift something off the floor. Each item is scored along a 5-point scale, ranging from 0 to 4, each grade with a well-established set of criteria. Zero indicates the lowest level of function and four is the highest level of function. The total score ranges from 0 to 56. While BBS has excellent intra and inter-rater reliability when administered face-to-face, few studies have evaluated BBS when administered remotely.[20,21] During the test, the examiner assessed the way of performance but also the time needed for each activity. Time completion of the test was between 20-30 minutes for each participant.

The timed up and go test

The TUG is a simple, valid and reliable clinical test that is frequently used for assessing basic functional mobility in stroke patients.[22] The test consists of consecutive activities such as getting up from a chair, walking 3 meters, turning 180 degrees, walking back to the chair, and sitting down. Time is registered from when the participant arises, walks 3 meters, turns around, walks back, and sits down again. The time to complete these tasks is evaluated by a stopwatch and is recorded as a test score; longer durations are associated with decreased mobility.

The box and block test

The BBT is designed as a method for evaluating and measuring dexterity and grip, handling, and releasing functions. This test is durable, simple, and reliable for the assessment of patients with severe dexterity deficits such as stroke patients.[23] A specially designed box with two compartments is located along the edge of a table standardized in height. Each participant sat at a standardized height chair, in front of the table and the box. In this study, the test was performed firstly with the dominant hand (for all participants the right hand) followed by the left one. During the face-to-face assessment, the test examiner sat across from the participant observing the blocks being transported. A 15-second trial period preceded every assessment. Then, the blocks were returned to their compartment. Immediately afterward, the participant placed his/her hands on both sides of the box and the test began. With the signal, the participant took only one block at a time with the dominant hand, carried the block over the partition, and released it into the opposite compartment. The whole procedure lasted 60 seconds. The procedure was repeated with the non-dominant hand. After completing each test, the examiner counted the blocks before returning them to the compartment. If the participant had transported two or more blocks at the same time, only one was counting. In case the block bounced and fell on the ground, it was counted as a successful trial. If the block or/and the fingers did not exceed the partition, that block was counted as an unsuccessful trial.

Statistical analysis

The Shapiro-Wilk test for normality was used to ascertain that the data for considered variables were normally distributed. Categorical variables were expressed as numbers (and % percentages). Continuous variables were expressed as mean±standard deviation (SD). The sample size was calculated using the G*Power 3.1.9.4 software (University of Dusseldorf, Germany). The "exact" test (Correlation: Bivariate normal model) and the detection of a moderate effect size f=0.7 (two-tailed, alpha level=0.05, power=80%) showed that a total of thirteen patients were required. Assuming a drop-out rate of 15%, the total sample size was estimated at fifteen patients.[24] Inter-reliability was tested using Intra-class Correlation Coefficients (ICC). Interpretations of the ICC were based on Koo & Li's guidelines: ICC values less than 0.5 indicate poor reliability, values between 0.50 to 0.75 indicate moderate reliability, values between 0.75 to 0.90 indicate good reliability and values greater than 0.9 indicate excellent reliability.[25] To explore the level of agreement between the measured variables in the two experimental conditions and to identify possible outliers, Bland-Altman plot analyses were employed.[26] The collected data were processed using the Statistical Package for the Social Sciences software (SPSS version 22.0, IBM Corporation, Chicago, USA). The significance level for all analyses was set at $p<0.05$.

RESULTS

Fifteen chronic stroke patients (8 men and 7 women) with a mean age of 59.6±7.34 years, with an average of 4.8±2.55 years after stroke and a moderate degree of motor dependence (Barthel scale: mean 83±8.61 units), underwent assessment of three functional tests via tele-assessment and face-to-face methods. The baseline characteristics of the participants are presented in (Table 1).

Table 1: Participants' baseline characteristics (n=15).

Variables	Observations
Age (years)	59.6±7.34
Height (cm)	170.4±5.44
BMI (kg/m^2)	25.38±2.35
Interval after stroke onset (months)	56±30
Localization, N (%)	
Right Hemisphere	5 (33)
Left Hemisphere	10 (67)
Barthel score	83±8.61

All participants completed the trials of BBS, TUG, and BBT on each experimental condition and none experienced technical difficulties with setting up the teleconferencing. There were reported no adverse events during both experimental conditions. No additional assistance was given by the independent physiotherapist, who was located in the patient's home during the tele-assessment. The (Table 2) shows the range of data of all assessments, and the inter-reliability (ICC) results of BBS, TUG, and BBT.

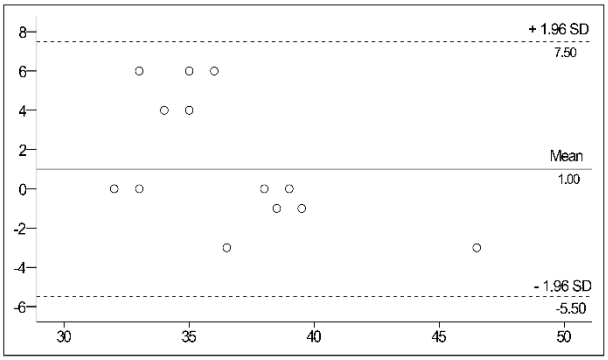

Figure 1: Bland-Altman plots for the Berg Balance Scale. The means on the x axis are the average of two trials and the differences between scores are on the y axis. The solid line represents the mean difference between the face-to-face and the tele-assessment. The dotted lines are the upper and the lower limits of agreement.

A visual inspection of the Bland-Altman plots revealed a good level of agreement between the face-to-face and the tele-assessment for the total score of the BBS (Figure 1), and an excellent level of agreement for the total time of the TUG (Figure 2), as well as for the BBT score (Figure 3), identifying no outliers.

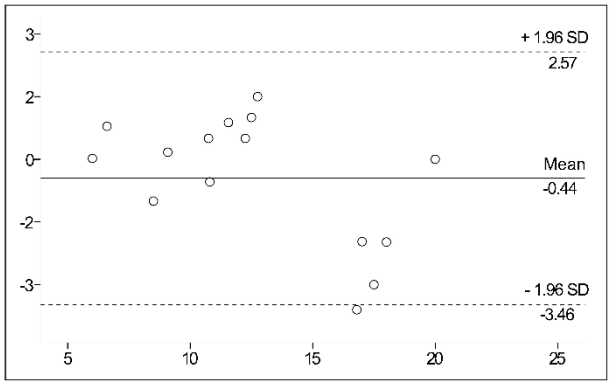

Figure 2: Bland-Altman plots for the Timed Up and Go test. The means on the x axis are the average of two trials and the differences between scores are on the y axis. The solid line represents the mean difference between the face-to-face and the tele-assessment. The dotted lines are the upper and the lower limits of agreement.

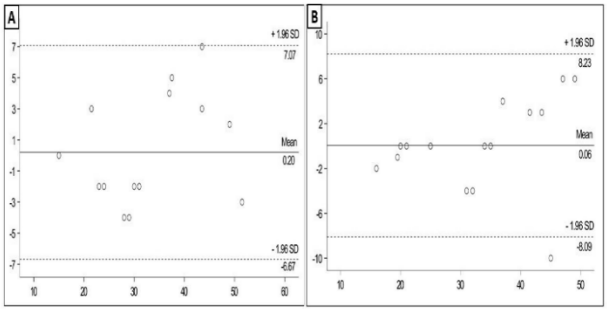

Figure 3: Bland-Altman plots for the Box and Block Test; A) the right arm and B) the left arm. The means on the x axis are the average of two trials and the differences between scores are on the y axis. The solid line represents the mean difference between the face-to-face and the tele-assessments. The dotted lines are the upper and the lower limits of agreement.

DISCUSSION

The present study is the first to investigate the tele-assessment of the BBS, TUG, and BBT in patients with chronic stroke. The results demonstrated good to excellent reliability for all three functional tests between the face-to-face assessment and the tele-assessment (Table 2). During and beyond the COVID-19 pandemic health care providers consider how to meet the rehabilitation needs of people whose health or level of mobility and participation in treatment sessions has been impacted directly or indirectly by the strict long-term social distancing strategies. Thus, the demands for rehabilitation services in patients after stroke are increasing, driving a need for more services to be delivered in homes and communities, especially for those

with chronic stroke.[27] Widely-used functional tests for assessing patients after stroke are applied in clinical settings. However, a small number of studies have examined the upper and lower extremities' functional capability, balance, and posture reliability when these tests are used remotely to assess patients with moderate levels of dependence after stroke.[28-31]

Table 2: Inter-reliability results between the center-based face-to-face and home-based tele-assessment for the BBS, TUG and BBT in patients with chronic stroke (n=15).

Functional test	Center-based face-to-face Assessment (mean±SD)	Home-based tele-assessment (mean±SD)	ICC (95% CI)
BBS	37.4±3.8	36.4±5.6	0.869 (0.616-0.955)
TUG (seconds)	12.4±3.9	12.9±4.7	0.968 (0.907-0.989)
BBT Left hand (number of cubes)	33.13±11.66	33.06±10.42	0.966 (0.897-0.988)
BBT Right hand, (number of cubes)	33.06±11.23	32.86±10.07	0.974 (0.922-0.991)

The BBS is commonly used for the assessment of balance and postural stability and is widely known as a main assessment tool for stroke rehabilitation.[7] Only a few studies have assessed the agreement of the BBS when it is performed remotely, mostly in patients with other neurological diseases or after musculoskeletal injuries (such as arthroplasty and Parkinson's disease).[21,9] Gillespie et al examined the agreement between BBS scores obtained through telerehabilitation (via sessions conducted using Skype) and traditional in-person assessment in patients aged 18–95 years for 20 participants with an average of 50.3 (SD 33.5) days after the stroke.[28] BBS had excellent agreement ICC=0.97 (95%CI: 0.96 to 0.97) between remote and in-person assessment, while in our study we found moderate reliability between the two experimental conditions. Possible contributing causes for these discrepancies in ICC values may be the different methodologies used between studies. In the study of Gillespie et al the examiner had access to participants' cameras using a remote far-end control to view them as they performed the balance assessment tasks. In our study, the laptop was placed by the independent physiotherapist before starting testing for a full capture of his/her whole body while he/she performed the test. These findings may suggest that when comparing remote to face-to-face administration of the BBS the optimal setup placement of the camera is an important issue that may be considered. The agreement of the TUG when it is performed remotely has been previously examined for other patients with chronic diseases,[2,29] as well as in elderly people.[30] This study was the first attempt to assess the TUG in patients with chronic stroke when performed remotely revealing excellent reliability between the tele-assessment and face-to-face assessment. In a recently published study by Guidarelli et al the total time (in seconds) of the TUG revealed good reliability ICC=0.88 (95%CI: 0.74 to 0.94) when performed remotely in middle-aged adults (N=25) with cancer. The authors noted difficulties, mainly in specifying the start and end time of the test (i.e., full stand and full sit).[29] The higher reliability values in our study may be partially explained by the slower walking velocity of the stroke patients that facilitated the accurate capture of the start and the end time of the test from the laptop camera. To the best of our knowledge, there is no previous study examining tele-assessment BBT in stroke patients. In some studies, the BBT has been performed remotely using VR technology in patients with neurological conditions and in healthy subjects.[31-33] However, the virtual task itself may be greatly different from the real test. Cho et al. have noticed some difficulties in using VR technology for performing the test, such as the absence of sensory input (e.g., weight, texture, and pressure) and difficulty with ensuring a recognizable grasping posture. Nevertheless, the study showed good correlations in both non-hemiplegic (r=0.904) and hemiplegic sides (r=0.788) between the BBT and the virtual BBT.[31] Our intervention was well-designed to provide safe remote assessment for patients who were independently mobilized, using videoconference technology through the Vsee platform. The Vsee platform has been previously used for remote assessment of exercise capacity in patients with cystic fibrosis or for the application of a supervised tele-exercise program in children with Cystic Fibrosis.[10,34] In the present study, in order to establish the successful connection of participants with the platform, written instructions detailing the process for using Vsee software were given via email, one day prior to evaluation. In this way, we successfully managed to ensure the seamless performance of all tests without technical problems. Our study aimed to assess the reliability of three functional tests used in remote assessment and thus to provide practice recommendations in the new era of telehealth services. However, researchers and healthcare professionals should be aware of the factors that influence tele-assessment to ensure accurate and competent assessments (e.g., technological glitches, patient and provider acceptance, and comfort with the use of technology).

Limitations

This study entailed several limitations. Firstly, the study involved a sample of patients with stroke aged 50 to 65 years old who had moderate motor dependence. This

approach may limit the generalizability of these findings to patients with a broader range of stroke severity with more severe motor dependency and to older patients. This may affect the external validity of the results. Furthermore, the sample size was relatively small. However, it was calculated using power analysis based on the results from previous studies and it was a realistic group size to find estimates for agreement between the two experimental conditions in the setting of telerehabilitation.[2,31] Lastly, the two assessment methods were not blind for the examiners and someone may consider the results biased. At the time of the study, the research team physiotherapists had previous clinical experience in remote assessment procedures and telerehabilitation and this may mitigate any bias.[35,36] Although written instructions were given to all participants, it was difficult for some of them to properly prepare their space for the tele-assessment. A familiarization session with the examiner before the assessment could be supportive, especially for those patients who are not familiar with the use of technology. Future studies should adopt a large sample size and examine the feasibility of conducting tele-assessment within the home in a broader range of ages and stroke severity.

CONCLUSION

In conclusion, results from our study suggest that functional tests, which are commonly used for face-to-face evaluation of balance, posture, and manual dexterity in patients with chronic stroke, such as the BBS, TUG, and BBT, can be successfully adapted for home-based tele-assessment through video-conferencing. The added value of adapting remote administration in functional tests is the potential opportunity to reach a population for which face-to-face evaluation may not be feasible for multiple reasons.

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