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Original Research

Adapting the Multiple Sclerosis Functional Composite for Telehealth Administration Using Videoconference Delivery: Methodological Considerations and Interrater Reliability

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List of abbreviations: MS, multiple sclerosis; NHPT, Nine-Hole Peg Test; PASAT, Paced Auditory Serial Addition Test; Tele-MSFC, Multiple Sclerosis Functional Composite by telehealth videoconferencing; T12.5FWT, timed 12.5-Foot Walk Test; T25FWT, timed 25-Foot Walk Test.

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KEYWORDS
Disability evaluation;
Patient outcome assessment;
Telemedicine;
Telerehabilitation

Abstract *Objective:* To describe the adaptations made and to examine interrater reliability and feasibility of administering a telehealth version of the Multiple Sclerosis Functional Composite (tele-MSFC).
Design: The Multiple Sclerosis Functional Composite (MSFC) is a commonly used, in-person clinical outcome assessment. It is composed of the timed 25-Foot Walk Test (T25FWT), Nine-Hole Peg Test (NHPT), and Paced Auditory Serial Addition Test (PASAT). The MSFC was adapted for videoconference administration as part of a larger clinical trial. One of the adaptations included administering a timed 12.5-Foot Walk Test (T12.5FWT) for participants who did not have adequate space in their homes for the T25FWT. Participants, examiners, and raters completed surveys online about their satisfaction and experience with tele-MSFC.
Setting: Participants underwent the tele-MSFC in their homes using a laptop or smartphone while examiners scored the tele-MSFC in real-time at a remote location.
Participants: Community-dwelling adults (n=61) with mild-to-moderate multiple sclerosis (MS) symptoms.
Interventions: Not applicable.
Main Outcome Measure: Tele-MSFC.
Results: Intraclass correlation coefficients (ICC) assessed interrater reliability between the examiner and 2 independent raters who later scored a recording of the tele-MSFC. Interrater reliability was excellent (ICC>0.90) for all tests, including the T12.5FWT. Participants were highly satisfied with tele-MSFC. However, challenges included adequate space for T25FWT, technical difficulties, and safety and privacy considerations of individuals with moderate impairments who were requested to have their caregivers present during testing.
Conclusion: The tele-MSFC is reliable and feasible to administer with adaptations for community-dwelling adults with mild to moderate MS symptoms. Further validation of T12.5FWT is needed.

The COVID-19 pandemic accelerated the use of telehealth services,[1] broadly defined as "the use of electronic information and telecommunications technologies to support long-distance clinical health care, patient and professional health-related education, public health, and health administration."[2] Telehealth services offer many benefits including the reduced burden of time and travel, the ability to reach people in rural areas, increased patient satisfaction, and the potential to decrease health care costs.[3,4] However, challenges related to regulatory issues, disparities in technology and internet accessibility, and clinical competency need to be addressed.[3-5]

An important aspect of telehealth service delivery is conducting performance-based assessments of physical and mental function in which the evaluator and patient are in separate locations. Adults with chronic disabling conditions, such as multiple sclerosis (MS), can benefit from telehealth assessments to monitor disease progression, treatment responses, and self-management efforts.[6] Mobility impairments, fatigue, pain, compromised immune function, and the cost and time associated with traveling to specialty clinicians provide a strong rationale for administering telehealth assessments for adults with MS. However, adapting in-person assessments for telehealth delivery can influence reliability and validity.[4,7]

The Multiple Sclerosis Functional Composite (MSFC) is a commonly used clinical outcome measure. The MSFC was initially validated as an in-person assessment. It measures 3 clinical dimensions of MS: ambulation (ie, Timed 25-Foot Walk Test, T25FWT), arm/hand function (ie, Nine-Hole Peg Test, NHPT), and cognitive function (ie, Paced Auditory Serial Addition Test, PASAT).[8] Scores on these 3 assessments can be converted to z scores, which are averaged to form a single MSFC score. To respond to the COVID-19 pandemic, we adapted and tested a telehealth version of the MSFC (tele-MSFC) as part of a larger randomized controlled trial.[9] The purposes of this study were (1) to examine interrater reliability between the examiner and 2 independent raters in scoring the tele-MSFC and (2) to explore feedback provided by the examiners, raters, and participants with MS on the feasibility of administering the tele-MSFC.

Methods

Overview

This study was part of a noninferiority, pragmatic, randomized controlled trial to compare 3 modes of delivering the *Packer Managing Fatigue* program.[10] Pre-pandemic, the research team administered the MSFC in-person at baseline to examine performance-based functional status as a moderator/covariate when testing the effects of the *Packer Managing Fatigue* program on primary and secondary outcomes. To continue administering the MSFC during the pandemic, the research team adapted and tested the tele-MSFC among 61 participants with MS. The research team, with input from multiple stakeholders, including occupational therapists,

physiatrists, physical therapists, people with MS, and cyber security experts, adapted the MSFC to be delivered using HIPAA-compliant Zoom. Procedures, including examiner training, safety protocols, and participant instructions, were adapted, manualized, and refined. Procedures for the study were approved by the Institutional Review Board at Case Western Reserve University.

Participants

Inclusion criteria for the clinical trial were a self-reported diagnosis of MS, being at least 18 years of age, having moderate-to-severe fatigue as measured with the Fatigue Severity Scale,[11] and the ability to speak and read English. Individuals were excluded if they could not understand the consent form or were unwilling to perform the study activities outlined in the informed consent. Individuals enrolled in the noninferiority clinical trial at the start of the COVID-19 pandemic were invited to first participate in this feasibility study and then complete the remaining study activities for the noninferiority trial. An additional pre-screening questionnaire was developed and administered as described below to determine appropriate safety precautions for participating in the walking test. Individuals who could not walk still had the option to participate in the noninferiority trial, NHPT, and PASAT.

Procedures

Tele-MSFC adaptations

The MSFC was adapted in several ways to be administered in participants' home environments via Zoom. The adaptations focused on (1) how examiners were trained, (2) the manuals that were provided to examiners and participants, (3) the development of a pre-screening safety questionnaire and technology needs assessment, (4) the administration of a timed 12.5-Foot Walk Test (T12.5FWT) for participants who did not have adequate space in their home for the T25FWT, and (5) the supplies participants would need to be mailed to complete the tele-MSFC. These adaptations were decided upon through an iterative process involving group discussions, practice administrations, and stakeholder feedback. The research team met several times via Zoom to identify potential methodological challenges and develop a plan of solutions. Clinical stakeholders then identified additional challenges and provided feedback on proposed solutions. Protocols and manuals were revised and provided to patient stakeholders for feedback on understanding and feasibility. Table 1 summarizes anticipated challenges and how they

Table 1 Anticipated challenges and planned solutions in administering tele-MSFC

Challenges	Solutions
Safety during the measurement and administration of the T25FWT	(1) Developing a pre-screen for the T25FWT to explore potential fall risk during participation (2) If screening indicated a fall risk, requiring a helper or caregiver present with the participant during the administration of the T25FWT (3) Ensure adequate training of examiners to end the test if safety concerns arise
Accuracy with the measurement of the T25FWT.	Use a pre-measured 25-foot ribbon, which is used for measurement and then removed prior to administration.
Ability of examiners to see start and finish lines.	Use of blue tape and orange cones at start and finish lines.
Lack of available 25-feet distance in the participant's home	Created and tested a 12.5-foot option for delivery with administration/scoring instructions. A third orange cone was included in each kit to acquire the 12.5FT distance marker/timing on all participants.
Potential of dropping pegs on the floor during set up or during NHPT	Provide 2 additional pegs.
Technical difficulties or lack of device/Wi-Fi access	Make devices and hot spots available to participants experiencing technical difficulties or lack of access to technical devices
General MSFC equipment needs for both examiner and participant	A telehealth kit for the MSFC would be shipped to participants
Positioning challenges with webcam to allow for adequate examiner views	Positioning device will be provided as needed; Examiners to practice supporting device positions to attain adequate views
Participant privacy and safety on-line	Explore options and select a safe/secure delivery platform (eg, Zoom for Healthcare)
Additional examiner training needs unique to telehealth delivery	Include in Examiner training, such things as supporting set-up, using Zoom, troubleshooting technology challenges
Unique wording/instructions needs to administer the MSFC via videoconferencing vs usual in-person administration	Develop both an examiner and participant set of instructions to support consistent set-up and administration
Participant being unfamiliar or uncomfortable with Zoom technology	Provide a brief set of instructions for participants, and short videos to instruct on basic Zoom usage

were addressed. Upon integrating the feedback from the stakeholders, the research team then practiced administering the tele-MSFC among themselves to identify and problem-solve any difficulties.

Tele-MSFC training and manuals

Four examiners (ie, 3 individuals with a master's degree and 1 with a bachelor's degree) were trained by an individual with an occupational therapy doctorate degree to administer the tele-MSFC. The 4-hour training consisted of reviewing instructional materials, scoring a Zoom recording of the tele-MSFC, and administrating the tele-MSFC with a peer examiner and trainer. The trainer also periodically monitored the examiner's recordings to ensure consistent and accurate administration. The examiner manual was adapted to include new prompts and checklists to help ensure safety, confirm proper testing set-up, and minimize distractions during testing. The participant manual was developed to provide written instructions and several pictures that reiterated safety precautions, how to set-up the walking test, where to place the webcam, and the importance of minimizing distractions.

Pre-screening questionnaire, length of walking test, and technology need assessment

Prior to administering the T25FWT, examiners used a safety screening protocol to determine whether the T25FWT should be omitted, done in the presence of another adult, or substituted with the T12.5FWT. Table 2 shows the pre-screening questions. If no one was available, the participant could not walk, or felt unsafe, the T25FWT was omitted with the option of still completing the NHPT and PASAT. If the participant met the criteria to perform the T25FWT but did not have enough space in their home, they were given the option to perform the T25FWT outside or perform the T12.5FWT in their home.

Questions were asked to determine whether participants needed to receive a smartphone with a data plan and receive a technical support call prior to administrating the MSFC. If they did not have Wi-Fi, a smartphone with a cellular data plan was sent to the participant and returned after the study. We also asked the following question to determine the amount of technical support the participant would receive: "On a scale of 1 to 10, how confident are you that you can independently use Zoom for a videoconference call, with 1 being not confident at all, and 10 being very confident?" A response of 6 or less led to a recommendation that the participant schedule a time for a technical support phone call prior to completing the tele-MSFC. During the technical support phone call, the research assistant (RA) used a checklist of activities for the participant to perform, including connecting to the internet with their device, logging into Zoom, turning on the camera, positioning the camera, and ensuring the audio was working. The RA was also available during the administration of the tele-MSFC to troubleshoot technology issues.

Tele-MSFC kit

Participants received a telehealth kit by mail, which included the instruction manual, a positioning device to support webcam placement of smartphone, material for the walking test (ie, ribbons of 25 feet and 12.5 feet in length, blue masking tape to mark the start and finish lines, and 3 orange cones), material for the NHPT (ie, a peg board and 11 pegs), and a smartphone with a cellular data plan if needed.

Administration of Tele-MSFC

Before the testing session, participants were asked to use the ribbon in the kit to measure 25 or 12.5 feet and place cones at the start, middle (if 25 feet), and end of the ribbon. Participants were asked to position their webcam so that the examiner could see the entire distance and the participants' feet. For the NHPT and PASAT, participants were invited to set up their webcam so both hands and the peg board could be seen. Participants were asked to set up the tests in rooms that minimized distractions and had adequate space to complete the T25FWT or T12.5FWT without potential safety hazards. Once the examiner verified the set-up requirements, standardized instructions were provided to the participants.

Further refinements

After the first 31 participants, 2 changes were made to the protocol: a change to the safety screening and an addition to the tele-MSFC kit. The eligibility criteria presented in table 2 were expanded to minimize excluding participants from the T25WT. Questions #3, #4, and #5 were removed. Question #6 was modified so the participant did not need someone present if they used a mobility aide. Question #8 was modified so the participant would need someone present during the test if they had fallen at least once during the past 6 months. An audio device (ie, MP3 player) with a recording of PASAT was added to the tele-MSFC kit to ensure the PASAT recording was synchronized to the timing of participant answers and to support a clear auditory recording for the participant. The MP3 player was placed in a sealed envelope and participants were instructed not to open the envelope until the Zoom session.

Data collection

The examiner recorded the time taken to complete each of the T12.5FWT or T25FWT, NHPT, and the number of correct answers on the PASAT in real-time; 2 independent raters later watched a video recording of the session to gather the same data. Raters could replay the recordings as needed. Raters were asked to complete a survey online to document any challenges with scoring the test as well as any challenges they observed during testing. After completing the tele-MSFC, participants were asked via an online survey: (1) How satisfied were you with using videoconferencing (Zoom) to complete the MSFC? (1-10 rating scale); (2) How satisfied were you with the instructions for completing the MSFC? (1-10 rating scale); and (3) Describe the strengths and limitations of completing the MSFC using Zoom (Open-ended response). All data were collected using REDcap, which was set up so raters could not access the scores of other raters and examiners.

Data analysis

SPSS (version 28) was used to conduct the quantitative analysis. Intraclass correlation coefficients (ICC, 1-way random

Table 2 Initial pre-screening questions

Now, I'm going to ask you some questions so we can prepare for the Baseline Assessment.

The first questions are to assess safety for the walking test. There is a risk of falling during this assessment. You can decide not to complete the walking test and still participate in the study.

1. Are you able to walk 25 feet with or without a mobility device? 25 feet is approximately the length of a yellow school bus.
   If yes: proceed to next question
   If no: skip safety questions (participant will skip walk test) and proceed to technology questions.
2. Do you have adequate space in your home where you could safely walk 25 feet in a straight line?
   If yes: proceed to the next question.
   If no: Would you feel comfortable doing the walk test outside on a flat surface if weather permits?
   If yes or no: Do you have adequate space in your home where you could safely walk 12.5 feet in straight line? 12.5 feet is approximately the length of 1 mid-size car.
      Note: Minimum length of is 12.5 feet or willing to walk outside is required. If participant does not have at least 12.5 feet or does not want to walk outside, discontinue safety questions.
3. Can you move throughout your home without leaning on the walls or furniture?
   If yes: proceed to the next question.
   If no: We would like to request that a helper is available while we administer the test. Would you have someone available during the test?
      If yes: proceed to the next question.
      If no: To help ensure safety, we ask that a helper is present. We will skip this portion of the assessment since a helper is not available to you.
4. When you walk around at home, do you need the assistance of another person?
   If no: proceed to the next question.
   If yes: We would like to request that a helper is available while we administer the test. Would you have someone available during the test?
      If yes: proceed to the next question.
      If no: To help ensure safety, we ask that a helper is present. We will skip this portion of the assessment since a helper is not available to you.
5. When you visit your doctor's office, can you go by yourself?
   If yes: proceed to the next question.
   If no: We would like to request that a helper is available while we administer the test. Would you have someone available during the test?
      If yes: proceed to the next question.
      If no: To help ensure safety, we ask that a helper is present. We will skip this portion of the assessment since a helper is not available to you.
6. Do you use mobility aides such as a cane, walker, or wheelchair?
   If no: proceed to the next question.
   If yes: We would like to request that a helper is available while we administer the test. Would you have someone available during the test?
      If yes: proceed to the next question.
      If no: To help ensure safety, we ask that a helper is present. We will skip this portion of the assessment since a helper is not available to you.
7. Are you able to bend over to pick up an object from the floor without leaning on walls or furniture or without losing your balance?
   If yes, proceed to the next question.
   If no, please describe the usual assistance provided. (Document the type of assistance typically provided).
      If no, requires a person to have help setting up the walk test. "We would like to request that a helper is available to set up the test. Do you have someone available who could set up the walk test on the day of the assessment?"
      If no: To help ensure safety, we ask that a helper set up the walk test. We will skip this portion of the assessment since a helper is not available to you.
8. How many times have you fallen in the past 3 months? Record response
   If no falls: proceed to the next question.
   If 1 or more falls: We would like to request that a helper is available while we administer the test. Would you have someone available during the test?
      If yes: proceed to the next question.
      If no: To help ensure safety, we ask that a helper is present. We will skip this portion of the assessment since a helper is not available to you.

If participant doesn't require a helper and/or uses a mobility device: Having someone present while you complete the walking test isn't required, but we suggest having one just as a precaution.

effects)[12] were used to examine interrater reliability between the examiner and rater 1, the examiner and rater 2, and the 2 raters on each trial of the T12.5FWT (seconds to complete), T25FWT (seconds to complete), NHPT (seconds to complete), and PASAT (number correct). An ICC less than 0.5 was considered poor reliability, an ICC between 0.5 and 0.75 was considered moderate reliability, an ICC between 0.75 and 0.9 was considered good reliability, and an ICC greater than 0.90 was considered excellent reliability.[12] The consistency of doubling the time participants completed the T25FWT to complete the first 12.5 feet with the actual time it took to complete the T25FWT was examined with Cohen's d (calculated using the standard deviation of the differences). A Cohen's d less than 0.2 was considered a negligible difference.[13,14] Means and standard deviations were used to describe participants' responses to closed-ended questions on satisfaction. Open-ended survey responses and rater comments were reviewed, categorized, and summarized by a research team member (T.V.) using a thematic analysis approach.[15] Participants' and raters' comments were read several times to generate thematic categories that summarized perspectives on the strengths and limitations of administering the tele-MSFC.

Results

The research sample (n=61) was predominantly women (81%), non-Hispanic white (88%), and had relapsing-remitting MS (70%). About one-third of participants reported using a mobility aid. A further description of the research sample is presented in table 3. Of the 61 participants, 34 (55.7%) completed the T25FWT, and 18 (29.5%) completed the T12.5FWT. The remaining 9 participants could not walk, felt uncomfortable completing the test, or could not have someone present during testing. All participants completed the PASAT and NHPT. No adverse events occurred.

Table 4 shows the ICC for each test of the tele-MSFC. The ICC for T25FWT, the mid-way point of the T25FWT, T12.5FWT, and NHPT were excellent (>.90 for all comparisons). When the examiner played the PASAT recording, ICC was excellent between the 2 raters but moderate to good between the raters and examiner. When the participant played the PASAT recording, ICC was excellent between the 2 raters and the examiner. The mean difference between doubling the time it took participants to complete 12.5 feet with the actual time it took to complete the T25FWT ranged from 0.09 to 0.33 seconds. Cohen's d ranged from -0.07 to -0.220 with 95% confidence interval of -0.56 to 0.28.

Participants were highly satisfied using Zoom (Mean =9.15; Standard deviation =1.23) and the instructions (Mean =9.43; Standard deviation =0.91) to undergo the tele-MSFC.

Tables 5 and 6 summarize the strengths and challenges noted by participants and raters. Participants reported the strengths as having a positive experience with the facilitator, the comfort of one's home setting, and scheduling flexibility. Limitations included difficulties using technology and/or following instructions, having an available helper for support, and the space requirements for the T25FWT. Challenges noted by the examiners included administration or technical difficulties, environmental barriers (eg, physical safety hazards, such as a dog or rug), and participants having

Table 3 Demographic characteristics (n=59)*

Participant Characteristic	M	SD
Age	52.34	11.42
	N	%
Sex		
Men	11	18.60%
Women	48	81.40%
Latinx or Hispanic Origin	0	0%
Racial/ethnic group		
Black or African American	7	11.90%
Non-Hispanic White	52	88.10%
Living community		
Rural	12	20.30%
Suburb	37	62.70%
Urban	10	16.90%
Education		
Partial high school	1	1.70%
High school graduate	2	3.40%
Some college	11	18.60%
Associate degree	6	10.20%
College/University graduate	21	35.60%
Master's degree	15	25.40%
PhD, MD, or equivalent	3	5.10%
Marital status		
Married	35	59.30%
Widowed	3	5.10%
Divorced	11	18.60%
Single	10	16.90%
Employment status		
Working full time (40 or more hours)	20	33.30%
Retired	15	25.40%
Unemployed - on disability insurance	13	22.00%
Part-time (20-39 hours per week)	5	8.50%
Part-time (1-19 hours per week)	3	5.10%
Unemployed - unable to find employment	2	3.40%
Annual household income		
Under $29,000	10	17.00%
$30,000 - $39,999	3	5.10%
$40,000 - $54,999	12	20.30%
$55,000 - $99,999	16	27.20%
Over $100,000	14	23.80%
I do not want to respond	4	6.80%
Type of MS		
Relapsing-remitting	41	69.50%
Secondary progressive	10	16.90%
Primary progressive	7	11.90%
I do not want to respond	1	1.70%
PDDS		
Normal	15	25.40%
Mild disability	9	15.30%
Moderate disability	8	13.60%
Gait disability	7	11.90%
Early cane	11	18.60%
Late cane	2	3.40%
Bilateral support	6	10.20%
Wheelchair/Scooter	1	1.70%

Abbreviation: PDDS, patient determined disease steps.

* Demographic data missing for 2 participants as they did not complete the demographic questionnaire.

Table 4 Mean, standard deviations, and intraclass correlation coefficients (n=61)

	Rater 1 Mean ± SD	Rater 2 Mean ± SD	Examiner Mean ± SD	Rater 1 vs Rater 2 ICC (95% CI)	Rater 1 vs Examiner ICC (95% CI)	Rater 2 vs Examiner ICC (95% CI)
T25FWT (trl#1)	9.38 (10.75)	9.59 (11.02)	9.53 (10.97)	0.999 (0.998-1.00)	0.999 (0.999-1.00)	0.999 (0.999-1.00)
25FWT (trl#2)	8.55 (10.97)	8.64 (11.04)	8.85 (11.04)	0.995 (0.990-0.998)	0.997 (0.993-0.998)	0.997 (0.995-0.999)
Mid-T25FWT (trl#1)	4.78 (5.58)	4.91 (6.03)		0.980 (0.959-0.990)		
Mid-T25FWT (trl#2)	4.41 (4.89)	4.49 (4.91)		0.998 (0.997-0.999)		
T12.5FWT (trl#1)	4.26 (1.33)	4.43 (1.61)	4.49 (1.65)	0.936 (0.841-0.975)	0.934 (0.836-0.975)	0.975 (0.936-0.991)
T12.5FWT (trl#2)	4.17 (1.17)	4.31 (1.50)	4.44 (1.37)	0.920 (0.804-0.969)	0.878 (0.709-0.952)	0.915 (0.791-0.967)
NHPT-D (trl#1)	27.06 (13.27)	27.31 (13.35)	27.75 (17.84)	0.995 (0.992-0.997)	0.944 (0.908-0.966)	0.942 (0.905-0.965)
NHPT-D (trl#2)	24.84 (9.65)	24.94 (9.70)	25.42 (13.91)	0.998 (0.997-0.999)	0.906 (0.849-0.942)	0.907 (0.850-0.943)
NHPT-ND (trl#1)	28.48 (11.96)	28.51 (12.02)	29.04 (15.21)	1.00 (0.999-1.00)	0.986 (0.978-0.992)	0.928 (0.881-0.956)
NHPT-ND (trl#2)	29.37 (21.17)	29.49 (21.12)	29.80 (22.44)	1.00 (1.00-1.00)	0.972 (0.954-0.983)	0.972 (0.954-0.983)
PASAT (Examiner plays MP3)*	37.07 (16.94)	33.86 (17.33)	43.68 (15.20)	0.962 (0.921-0.982)	0.782 (0.585-0.892)	0.655 (0.383-0.823)
PASAT (Participant plays MP3)†	45.97 (11.37)	45.03 (12.48)	46.80 (11.21)	0.978 (0.956-0.989)	0.954 (0.908-0.978)	0.897 (0.798-0.949)

Abbreviations: CI, confidence interval; Mid-T25FWT, Midway point for timed 25-Foot Walk Test (measured in seconds); NHPT-D, Nine-Hole Peg Test for dominant hand (measured in seconds); NHPT-ND, Nine-Hole Peg Test for non-dominant hand (measured in seconds); SD, standard deviation; trl #1, trial number one; trl#2, trial number two.

* 31 participants completed.

† 30 participants completed.

Table 5 Participants' perspective on strengths and limitations

Strengths Coding Summary	Sample Strengths Quote
Positive facilitator experience	*You did great.*
Comfort of home setting	*. . . I actually found it comfortable to be in my own home and take my time.*
Allowed for scheduling flexibility	*It's much more flexible with my schedule.*
Limitations Coding Summary	**Sample Limitations Quote**
User difficulty: Technical trouble (slow connection; working technology)	*Internet is slow so sometimes lose connection or takes a while to go from webpage to webpage or takes longer to load webpage* *The only issue I had was working my own phone*
User difficulty (instructions)	*The instructions considering the cognitive challenges of people with MS.*
Needing an available helper	*Just had to make sure to have someone to help with the video and timing.*
Lack of room	*I had a lack of room to fully complete the verbal and peg tests.*
Length of walk	*The long walk was odd but whatever....*

Table 6 Rater observed testing challenges

Challenge Category	Challenge Category Examples
Administration or technical difficulties	Examiner or participant errors (eg, Setting up the test improperly, not achieving needed camera angles, not using assigned AE (eg, reported AFO), stopwatch improperly set, participant not following (or understanding) instructions) or technical difficulties (eg, Accessing BOX, Zoom, difficulty achieving camera angles, video glitch, using MP3 player)
Environmental factors	Physical safety hazards (cats, dogs, rugs, clutter, Christmas tree in walk path), audio distractions (barking dog, wind chimes), lack of available helper
Physical challenges	Reported co-morbidity (Gout, ulnar nerve inflammation, "bad eyes"), MS factors (mobility challenges), set-up exertion
Difficulty understanding instructions or reported cognitive challenges	Noted difficulty observed with understanding instructions and/or comments reflecting need to repeat instructions. Participant self-reports cognitive challenges.

physical health challenges and/or difficulty understanding instructions. Raters noted in their online survey that they observed examiners providing support on using Zoom, adjusting camera angles and volume, reiterating instructions, and reminding participants to remove pets from the walking path. Family members or caregivers present during the examiner were observed helping the participant access Zoom, adjusting camera angles, and walking alongside the participant during the T25FWT.

Discussion

To our knowledge, this is the first study to examine the feasibility of adapting the MSFC to be delivered via Zoom in a participant's home. We found that the tele-MSFC had excellent interrater reliability, was viewed as acceptable, convenient, and satisfactory by participants, and could be administered safely with precautions. The main challenges to administering the tele-MSFC were the space requirements for the T25FWT, including people with more moderate impairments in the T25FWT, and technical support provisions. Future research should explore test-retest reliability and concurrent validity of the tele-MSFC with the in-person MSFC and Expanded Disability Status Scale (EDSS).[16] Such research could result in a cost-efficient assessment that could be used in telehealth services and decentralized clinical trials to monitor disease progression and the effectiveness of interventions.

Our results are consistent with the literature examining the validity and reliability of telehealth assessments in people with MS. A commonly used in-person assessment of MS-related disability is the EDSS.[16] Kane et al[17] compared the in-person EDSS to a telehealth version of the EDSS (tele-EDSS) conducted in a clinical setting with the examiner in a separate room from the patient. Agreement between the in-person and tele-EDSS were strong, with correlations ranging from 0.96 to 0.97. Bove et al[18] continued validating the tele-EDSS with participants assessed in their homes or private offices. Participants received a kit that included assessment material and a webcam if needed. A caregiver or family member was allowed to be present during the assessment. Pearson correlations between the in-person and tele-EDSS composite scores were between 0.89 and 0.98, with subscale correlations ranging from 0.37 to 0.79. While Kane et al and Bove et al have shown that the tele-EDSS is feasible, there remain lingering concerns that the EDSS relies on subjective ratings of an evaluator and does not adequately evaluate the walking speed and cognitive function.[8,19-21] As a result, the MSFC was developed and validated.[8,22,23]

Adapting in-person assessments for telehealth delivery may help promote diversity, inclusion, and accessibility in clinical trials or clinical practice.[3-5] However, policies and procedures for videoconference delivery may hinder participation in telehealth assessments. Excluding individuals at risk for falling, who do not have home environments conducive to telehealth assessments (eg, space requirements or distractions), or who have cognitive impairments may reduce the risk of adverse events. However, such policies may disproportionately exclude disabled or historically marginalized populations from participating in telehealth assessments.[24] Providing technical support and smartphones with data plans, allowing caregivers to be present during the test, and tailoring tests to someone's functional ability and the amount of space in their home may help facilitate participation in telehealth assessments. However, these provisions will require allocating additional resources and reevaluating the assessment's reliability and validity. One approach to developing time-efficient, reliable, and valid telehealth assessments tailored to individual circumstances is using principles consistent with Item Response Theory (IRT). For example, Kasper et al[25] used IRT to select performance-based physical assessments and self-report questions from the National Health and Aging Trends Study to calculate a composite score of physical capacity that was relevant and valid across a broad range of functional levels in older adults.

Study limitations

Although this study showed the feasibility of the tele-MSFC, there are study limitations that should be considered. The small sample size is a limitation of the study. Many participants could not complete the T25FWT due to inadequate space in their homes or risk of falling and could not have a caregiver present. As such, a protocol was developed for the T12.5FWT to help maximize participation and minimize missing data. However, we acknowledge the limitation of doubling the time for the 12.5FWT to estimate the time for the T25FWT. Doubling the time does not account for differences in gait initiation, termination, and acceleration. Additional research is warranted to validate the ideal distance to measure ambulation when remotely administering the MSFC. Furthermore, we acknowledge the limitations of using the PASAT. Future research is needed to explore the integration of the Symbol Digit Modalities Test within the MSFC.[26-28] Social desirability biases may have influenced feedback from examiners, raters, and participants. Although the in-person MSFC encourages the examiner to walk with the patient if the patient is concerned about falling, having a caregiver present during the tele-MSFC may influence the results in inconsistent ways (eg, walking faster or slower). Until test-retest reliability and concurrent validity have been established, the tele-MSFC should not be used as an endpoint in clinical trials. We also acknowledge the limitation of modifying the protocol during data collection. However, protocol revisions did result in more participants completing the walking test without adverse events and improved interrater reliability.

Conclusions

We identified several challenges and solutions for administering the tele-MSFC. Future research should examine strategies for tailoring telehealth assessments to the home environment, functional level, and preferences/confidence level of participants. The T25FWT may exclude many participants from performing the test at home due to space requirements. Administering 12.5FWT in the home may be more feasible. Using the T12.5FWT and calculating walking speed may be possible solutions. However, these solutions are inconsistent with the validated, legacy version of the

MSFC. To promote safety and inclusion, we found it important to provide technical support, involve family caregivers, and assess the participants' confidence level in safely performing the test.

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