Development, Reliability, and Validity of the Telerehabilitation Usability Questionnaire in Neurological Diseases

Nörolojik Hastalıklarda Telerehabilitasyon Kullanılabilirlik Anketinin Geliştirilmesi, Güvenilirliği ve Geçerliliği

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ABSTRACT

The purpose was to develop Telerehabilitation Usability Questionnaire (TrUQ) and evaluate its validity and reliability in neurological diseases.

Ninety-five people with Multiple Sclerosis (MS), Parkinson's disease (PD), and stroke participated in this study. Content validity was assessed by an expert panel of 5 physiotherapist experienced in telerehabilitation. Construct validity was investigated using Confirmatory Factor Analysis (CFA) and Explanatory Factor Analysis (EFA). Test-retest reliability and Internal consistency were used to evaluate the reliability.

A three-factor structure was determined based on EFA. Accordingly, three factors correspond to three subscales, on the TrUQ: system availability, exercise feasibility, and telerehabilitation security. Furthermore, the model fits well according to CFA results: χ^2/df = 1.573, CFI = 0.925, IFI = 0.929, GFI = 0.909, and RMSEA = 0.078. The questionnaire was proven to have an acceptable reliability level (Cronbach's alpha= 0.712) and it was found that all items were necessary. Finally, a 10-item version was obtained, and TrUQ was shown to have acceptable test–retest reliability (ICC=0.645)

TrUQ is a valid and reliable questionnaire can be used to measure usability of the telerehabilitation systems in MS, PD, and stroke. Adaptation to different languages and diseases is recommended to be widely applicable.

Key words: Stroke, Multiple sclerosis, Parkinson's disease, Telerehabilitation, Usability

Trial registration: Clinical Trials.gov NCT05970939

ÖZ

Bu çalışmanın amacı, Telerehabilitasyon Kullanılabilirlik Anketini (TrKA) geliştirmek ve nörolojik hastalıklarda geçerliliğini ve güvenilirliğini değerlendirmektir.

Çalışmaya Multipl Skleroz (MS), Parkinson hastalığı (PH) ve inme olan toplam 95 katılımcı dahil edilmiştir. İçerik geçerliliği, telerehabilitasyon konusunda deneyimli 5 fizyoterapistten oluşan bir uzman paneli tarafından değerlendirilmiştir. Yapı geçerliliği, Doğrulayıcı Faktör Analizi (CFA) ve Açıklayıcı Faktör Analizi (EFA) kullanılarak incelenmiştir. Güvenilirlik için iç tutarlılık ve test-tekrar test güvenilirliği kullanılmıştır.

EFA, TrKA'nın üç alt ölçekle ilişkili üç faktör yapısına sahip olduğunu ortaya koymuştur: sistem kullanılabilirliği, egzersiz uygulanabilirliği ve telerehabilitasyon güvenliği. CFA sonuçları, modelin iyi bir uyum sergilediğini göstermiştir: χ^2/df = 1.573, CFI = 0.925, IFI = 0.929, GFI = 0.909, RMSEA = 0.078. Anket kabul edilebilir bir güvenilirlik sergilemiş (Cronbach's alpha= 0.712) ve tüm maddelerin gerekli olduğu bulunmuştur. Sonuç olarak, 10 maddelik bir versiyon oluşturulmuş ve TrKA'nın test-tekrar test güvenilirliğinin kabul edilebilir olduğu tespit edilmiştir (ICC=0.645).

TrKA, MS, PH ve inmede telerehabilitasyon sistemlerinin kullanılabilirliğini değerlendirmek için geçerli ve güvenilir bir araçtır. Daha geniş bir kullanım alanı için farklı dillere ve hastalıklara uyarlanması önerilmektedir.

Anahtar kelimeler: İnme, Multipl skleroz, Parkinson hastalığı, Telerehabilitasyon, Kullanılabilirlik

Gazi University Ethics Commission approved the study (date.: 20/06/2023, numbered: 2023-815)

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INTRODUCTION

Neurological diseases rank as the leading cause of disability the worldwide.[1] Multiple sclerosis (MS), stroke, and Parkinson's disease (PD) are among the most common neurological diseases, non-traumatic causes of mobility disability brought about by damage within the central nervous system.[2] There are an estimated approximately 2.5 million people with MS, 6.8 million stroke patients, and over 6 million people with Parkinson's disease (PD) worldwide.[2,3] Although MS, stroke, and PD have different causes and neurological aspects, they generally lead to motor, sensory, and/or cognitive impairments, resulting in restrictions on people's activities and participation.[4]

The incorporation of pharmacologic and rehabilitation interventions is required to manage the diseases and associated manifestations over time in MS, stroke, and PD.[2,5-7] For acute and chronic patients, with neurological diseases, early access to rehabilitation is important for diseases related symptom recovery and long-term continuity of care.[1] Exercise training as a rehabilitation intervention among these groups commonly is used.[2,8] Exercise training has been shown in previous studies to improve the quality of life of patients by positively affecting the treatment of disease-related disorders.[2,9,10]

Despite these positive developments, many neurological patients may have difficulty coming to the rehabilitation clinic due to various factors such as disease-related disorders, fatigue and related problems, geographical location, time constraints, transportation difficulties, health insurance coverage, and financial burden.[11,12] Therefore, alternative methods such as telerehabilitation are needed to overcome these and similar barriers to clinical exercise.[13]

Telerehabilitation is an umbrella term defined as rehabilitation delivered to patients who have difficulty accessing due to economic, geographical, or physical inadequacies to benefit from rehabilitation services remotely via call-based, videoconference-based, web-based, or mobile application-based.[14] The main advantages of telerehabilitation are long-term patient education and rehabilitation, making changes in the exercise programs remotely, and saving time and financial costs associated with transportation.[11,13] Telerehabilitation-based exercise training is an innovative and potential alternative to face-to-face clinical interventions, and it improves balance, muscle strength, mobility, hand function, aerobic capacity, quality of life, and decreased fatigue in neurological rehabilitation.[13,15-17]

The usability of telerehabilitation methods is essential for unlocking the potential clinical benefits of this technology. Particularly, weak internet connections, the requirement for technological knowledge, and expensive equipment affect patients' participation and the usability of telerehabilitation.[18] In light of this, the patient's acceptance of telerehabilitation methods and usability level should be evaluated.[19] The usability can be assessed through observation, questionnaires, interviews, and various recording methods.[20]

A review of the literature revealed the existence of questionnaires that assess the usability of remotely delivered medical services, such as telemedicine and telehealth.[21-25] These questionnaires include questions evaluating the usability of remotely delivered medical systems, such as "I follow my doctor's advice better since working with the telemedicine system"[22] and "Using the telehealth system, I could see the clinician as well as if we met in person".[21] The System Usability Scale (SUS) is a standardized questionnaire developed by John Brooke to quickly assess a user's subjective perception of a computer system's usability.[23,24] SUS evaluates only computer systems, whereas telerehabilitation is not limited to computer-based applications.[24] Telerehabilitation can be conducted through various platforms, including such as messaging, videoconferencing, integrated systems, and mobile applications.[14] Moreover, none of these previous studies investigated the psychometric properties of the questionnaires and include usability of exercise interventions with telerehabilitation. Given these factors, there is a clear need for valid and reliable tools to comprehensively assess usability in telerehabilitation.

The purpose of this study was to develop, the validity, and reliability of a new usability instrument, the Telerehabilitation Usability Questionnaire (TrUQ) in neurological rehabilitation. The TrUQ is intended to evaluate the usability of various telerehabilitation systems, including videoconferencing, computer-based integrated systems, and the new generation of mobile telerehabilitation applications.

MATERIALS AND METHODS

Participants

Ninety-five participants (35 MS, 37 PD, and 23 stroke) took part in this study. The inclusion criteria were (1) age>18 years, (2) having a diagnosis of MS, stroke, and PD, and (3) having received at least one week of physiotherapy sessions with telerehabilitation via call, messaging, or videoconference at their home. The exclusion criteria were (1) having any additional neurological problems, postural hypotension, cardiovascular, vestibular, or musculoskeletal disorders, (2) having insufficient visual and hearing function to perceived cues, and (3) a Mini-Mental State Examination score less than 24.

For the study sample size, the aim was to recruit a minimum of five participants per question included in the analysis. Since the questionnaire consisted of 10 items, a minimum of 50 participants was required.[26]

Ethical Aspects of the Research

The study protocol was approved by the Local Ethics Commission, ensuring adherence to ethical standards and regulatory requirements. Before the initiation of participant recruitment, the study was prospectively registered on ClinicalTrials.gov. All individuals who participated in the study provided written informed consent, which was obtained following a comprehensive explanation of the study's objectives, procedures, potential risks, and benefits.

Questionnaire development

Development of the TrUQ consisted of four phases: (1) literature review, (2) item development, (3) construct development, and (4) examination of reliability.

Firstly, the researchers identified existing questionnaires that have been widely used in evaluating telemedicine, telehealth, and computer/information technology from a literature review. In the field of these areas, the following questionnaires were identified: The Telehealth Usability Questionnaire (TUQ),[21] The Telemedicine Satisfaction and Usefulness Questionnaire (TSUQ),[22] The System Usability Scale (SUS).[24] These questionnaires primarily evaluate three key factors of usability: usefulness, patient satisfaction, and the quality of interaction between the patient and clinician via telemedicine technology. Items in questionnaires are designed specifically for telemedicine or telehealth systems. The main difference in telerehabilitation is the integration of exercise implementation with the system and the provision of feedback from the therapist. These factors also should be questioned to determine the usability of telerehabilitation. In addition to the literature review, open-ended questions regarding the usability and feasibility of the system were asked to patient groups and therapists applying telerehabilitation, contributing to the development of the item pool.

Second, item development: A usability item pool, consisting of 51 questions in total, questioning satisfaction with telerehabilitation in terms of general solution of technical problems, feasibility of exercises, therapist/system feedback, learnability, usefulness, and time and money saving of the system were identified. The items in the TrUQ were formulated using simple sentences to ensure clear understanding. In addition, the study aimed to develop a survey that would not bore or confuse participants and that they could fill out quickly. The researchers reviewed the entire question pool to remove or combine items with similar meanings. Additionally, questions that did not question directly usability were removed from the pool (e.g. my data is saved during telerehabilitation). Finally, the researchers created a 10-item questionnaire. The next step involved scaling the items. A 5-point Likert scale was used in the questionnaire. In this study, questionnaire items were scored from 1 (strongly disagree) to 5 (strongly agree).

The next step involved determining face validity and content validity to develop items. Face validity was obtained by receiving feedback about the questionnaire from a number of researchers with experience in telerehabilitation. Content validity was analyzed to explain the extent to which the items in the questionnaire covered usability. An expert panel of five physiotherapists with telerehabilitation experience evaluated the questions for clarity and alignment with the content. Using the Lawshe method, each expert rated each item as essential, useful but not essential, or not essential. The panel agreed that 10 items with a high content validity ratio remained on the scale. While all the items were expressed positively, only the third item was expressed negatively to minimize the "halo" effect. In addition, an expert in survey development was consulted to improve the structure and layout of the questionnaire and a pilot group of ten patients was used to assess the intelligibility of the developed questionnaire.

The final phase of the study entailed an evaluation of the scale's internal consistency and test-retest reliability. Following the development of the questionnaire, it was administered to patients with MS, PD, and stroke who had undergone a minimum of one week of physiotherapy sessions via telerehabilitation. Internal consistency was assessed by examining the coherence among the scale's items. To determine test-retest reliability, the TrKA was re-administered to 30 participants after a one-week interval to evaluate the stability of the measurements over time.

Data Analysis

Statistical analysis was carried out in SPSS Statistics (version 23.0; SPSS, Inc. Chicago, IL) and IBM AMOS. Mean and standard deviation were used as descriptive statistics for numerical data. Categorical data was summarized with frequency and percentages. The content validity was assessed by using content validity ratios. The construct validity was assessed with Explanatory Factor Analysis (EFA) and Confirmatory Factor Analysis (CFA). $x2/df \leq 2$, p-value for chi-squared test≥ 0.05, Comparative Fit Index (CFI)≥ 0.90, Incremental Fit Index (IFI)≥ 0.90, Goodness of Fit Index (GFI)≥ 0.90, Normed Fit Index (NFI)≥ 0.90, and Root Mean Square Error of Approximation (RMSEA)≤ 0.05 were considered acceptable in CFA. Bartlett's test of sphericity, Kaiser-Meyer-Olkin (KMO) value, and factor loadings were included as results of EFA. Bartlett's test of sphericity was used to test whether the correlation matrix is different from the identity matrix. KMO was used to evaluate sample size adequacy. The sample size was deemed sufficient if KMO exceeded 0.80. Cronbach's alpha was used to investigate the internal consistency of the scale. Intraclass Correlation Coefficient (ICC) was used to evaluate the test-retest reliability. Cronbach's alpha and ICC values greater than 0.70 were determined to be sufficient in terms of reliability. Item analyses were conducted to evaluate each item individually. A t-test comparing the top and bottom 27% groups was also performed to demonstrate item discrimination of items.[27]

RESULTS AND DISCUSSION

A total of 95 patients were recruited the Turkish version of the Telerehabilitation Usability Questionnaire (TrUQ). The participant characteristics is shown in Table 1.

Tablo 1. Participants Characteristics

Variables		People with MS (n=35)	People with PD (n=37)	People with Stroke (n=23)
Age (years) (mean±SD)		39.68±9.08	61.05±9.60	52.34±12.28
BMI (kg/m²) (mean±SD)		24.96±4.74	27.46±4.95	25.59±3.28
Gender, F/M (female %)		31/4 (88.6%)	15/22 (40.5%)	8/15 (34.8)
Education n (%)	Primary school	2 (5.2)	4 (10.8)	7 (30.4)
	Middle school	3(8.6)	7 (18.9)	1 (4.3)
	High school	5 (14.3)	7 (18.9)	5 (21.7)
	University	25 (71.5)	19 (51.4)	10 (43.5)
EDSS ambulation score n (%)	**0**	4 (11.4)	-	-
	1	10 (28.6)	-	-
	1.5	6 (17.1)	-	-
	2	2 (5.7)	-	-
	2.5	6 (17.1)	-	-
	3	4 (11.4)	-	-
	3.5	1 (2.9)	-	-
	4	2 (5.7)	-	-
H&Y stage n (%)	**1**	-	9 (24.3)	-
	2	-	20 (54.1)	-
	3	-	8 (21.6)	-
mRS	**1**	-	-	1 (4.3)
	2	-	-	12 (52.2)
	3	-	-	10 (43.5)

BMI: Body mass index, EDSS: expanded disability status scale, F: Female, H&Y: Hoehn and Yahr, M: Male, mRS: Modified Rankin Score, MS: Multiple sclerosis, PD: Parkinson's Disease, SD: standard deviation

Construct Validity

The construct validity was used to evaluate factor analysis. The correlation matrix of the items was acceptable (Bartlett's test of sphericity chi-square= 268.55, p<0.001) and the sample size was adequate (KMO=0.710). EFA was performed by using principal components analysis. Direct Oblimin rotation was applied to ensure that the items were grouped under certain factors (Figure 1).

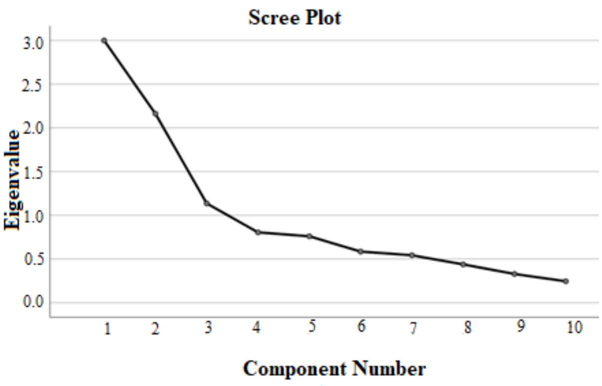

Figure 1. Scree plot from EFA analysis

The ideal number of factors was determined as three using the eigenvalue number greater than 1 and the scree plot approaches. Accordingly, the first factor has items I1, I2, I3, I4, and I7 and their factor loadings are 0.737, 0.652, 0.859, 0.843, and 0.474, respectively. The second factor consists of items I5, I8, and I9 and the factor loadings are 0.772, 0.758, and 0.863, respectively. The third factor comprises items I6 and I10, with factor loadings of 0.792 and 0.825, respectively. The total variance explained by the three-factor structure is 62.97%. The three factors correspond to three subscales, on the TrUQ: system availability (5 items), exercise feasibility (3 items), and telerehabilitation security (2 items).

Furthermore, this structure was reassessed by using CFA (Figure 2). The model fits well in terms of the following fit indices: χ^2/df = 1.573, CFI = 0.925, IFI = 0.929, GFI = 0.909, and RMSEA = 0.078. These results indicate that the CFA provides sufficient support for the verification of the model based on the fit indices.

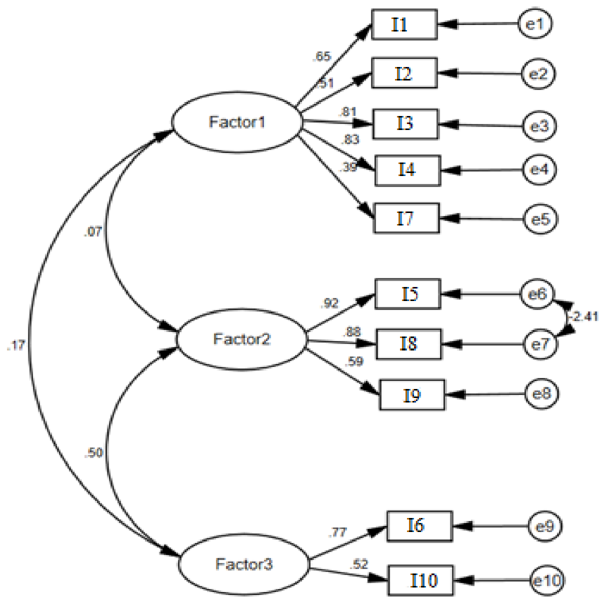

Figure 2. CFA Model and Standardized Estimates

Reliability

The internal consistency and test-retest reliability of the scale were investigated. In addition, item analysis results are given in Table 2. Cronbach's alpha of the total scale was found to be 0.712. In terms of factors, Cronbach's alpha was found to be 0.754 for the first factor, 0.719 for the second factor, and 0.55 for the third factor. There are varying opinions on acceptable values for Cronbach's alpha. While values between 0.70 and 0.95 are generally considered acceptable, some sources suggest a broader range of 0.45 to 0.98, acknowledging that Cronbach's alpha can be influenced by the number of items in the scale.[28,29] A considerable increase in Cronbach's alpha of the total scale (0.712) as a result of removing a specific item suggests that the relevant item can be removed from the questionnaire. Cronbach's alpha increased after item 2 was removed, but the increase was very minor (0.003). Therefore, the item was not removed. Also, all items can be regarded as distinctive based on the findings of the t-test comparing the top and bottom 27% groups. The scale was administered to 30 subjects again to assess consistency over time. ICC was found 0.658, 0.802, 0.505, and 0.645 for the total score, the first factor, the second factor, and the third factor, respectively. An ICC value below 0.50 indicates poor, between 0.50-0.75 indicates moderate, between 0.75-0.90 indicates good, and between 0.90-1.00 indicates excellent fit.[30]

Table 2. Descriptive Statistics and Item-Total Statistics for Each Item

	Mean	Std. Deviation	Scale Mean if Item Deleted	Scale Variance if Item Deleted	Corrected Item-Total Correlation	Cronbach's Alpha if Item Deleted	t (Top 27%-Bottom 27%)
I1	4.589	0.555	39.305	12.874	0.544	0.670	6.929*
I2	3.779	1.103	40.116	11.784	0.310	0.715	5.674*
I3	4.074	0.970	39.821	11.063	0.518	0.660	7.307*
I4	4.011	0.893	39.884	11.359	0.531	0.658	6.563*
I5	4.516	0.666	39.379	13.493	0.289	0.702	4.356*
I6	4.411	0.737	39.484	13.274	0.286	0.704	3.983*
I7	4.516	0.697	39.379	12.642	0.448	0.678	5.026*
I8	4.726	0.448	39.168	13.971	0.352	0.697	5.401*
I9	4.632	0.527	39.263	13.749	0.339	0.697	5.715*
I10	4.642	0.544	39.253	14.106	0.232	0.709	3.479*

*: $p<0.05$

The use of telerehabilitation-based exercise interventions has grown gradually in neurological rehabilitation.[13] The TrUQ was developed to address the rapidly advancing technology in telerehabilitation today. Usefulness reflects users' perceptions of how similar the telerehabilitation system is to traditional clinical exercise training.[21] A usability measure that exhibits the attributes of usefulness, ease of use and learnability, interface quality, and interaction quality in telerehabilitation is needed. The TrUQ was determined to include these attributes and ensure psychometric robustness, building on the most effective measures currently available in telehealth, information technology, and computer systems.

Content validity was ensured through a review of recent studies and interviews with therapists experienced in telerehabilitation. Although it is argued that as low as three individuals per item is acceptable for factor analysis,[31] as a general rule, at least five subjects are required for each item in the questionnaire. Moreover, the appropriateness of using factor analysis was assessed by performing Bartlett's test of sphericity and the Kaiser–Meyer–Olkin (KMO) measure of sampling adequacy in this study. A Bartlett's test of sphericity was a value of less than 0.001, indicating that the data were suitable for factor analysis. The result of the KMO measure of sampling adequacy (KMO=0.710) also indicated that the sample size was adequate to conduct the procedure. Both EFA and CFA were used to determine the construct validity. Additionally, the model also showed fit well in terms of fit indices (χ^2/df = 1.573, CFI = 0.925, IFI = 0.929, GFI = 0.909, and RMSEA = 0.078) and CFA results were considered sufficient for verification. The total variance explained by the three-factor structure is 62.97%. The three factors correspond to three subscales, on the TrUQ; system availability, exercise feasibility, and telerehabilitation security.

Our other outcome was reliability analysis in this study. The internal consistency and test-retest reliability of the scale were investigated to examine reliability. The final version of the questionnaire had a good level of internal consistency and acceptable test-retest reliability, so the TrUQ met the reliability criteria.

Recently, exercise interventions through telerehabilitation have been used in neurological groups that require long-term rehabilitation for many different healthcare purposes, such as providing treatment, monitoring, or educating.[13] Testing the usability of telerehabilitation methods can be a guide in determining the feasibility of exercise interventions.

The used general questionnaires related to usability evaluation were the SUS, TUQ, TSUQ, and the mHealth App Usability Questionnaire (MAUQ). TUQ is most frequently used, evaluates the satisfaction and usability of telehealth services such as videoconferencing systems, computer and mobile-based systems, and collects the opinions of both patients and doctors.[21] While TUQ provides a general evaluation of telehealth, it does not directly ask about the usability of physiotherapy via telerehabilitation. The SUS, which consists of 10 items, is used to determine the perceived usability of computer systems. Previous studies reported that SUS was generally used in industrial usability studies.[32] This survey only questions the usability of the computer systems and does not include questions specific to telerehabilitation, such as the feasibility of exercises used in telerehabilitation and communications with the therapist.[24] Therefore, SUS may be inadequate to assess both other telerehabilitation methods and the usability of exercise interventions. Although the TSUQ was developed many years ago, it has been infrequently used in telemedicine studies.[22] This may be attributed to two main reasons: (1) it was specifically designed for telemedicine services targeting diabetes patients, and (2) The majority of questions measure satisfaction rather than usability. Questions in the survey content, such as "*I follow my doctor's advice better since working with the telemedicine system*", are designed for doctors and telemedicine services; telerehabilitation and physiotherapists are not questioned.[22] MAUQ evaluates only one parameter like SUS. It includes questions that evaluate mobile applications such as *"I like the interface of the app*". Differently from these questionnaires, the TrUQ questionnaire developed in this study consists of questions for patients receiving physiotherapy with telerehabilitation and aims to question usability with telerehabilitation in terms of usability of exercise, usefulness, learnability, and various telerehabilitation methods.

CONCLUSION AND RECOMMENDATIONS

Our development process and accompanying analyses have demonstrated that the TrUQ is a reliable, robust, and versatile measurement tool in MS, PD, and stroke patients. TrUQ is based on the best usability questionnaires available and can respond to the latest technology changes in telerehabilitation. Additionally, this questionnaire incorporates exercise, patient, and therapist needs in physiotherapy through telerehabilitation and addresses all of the relevant dimensions of usability. Since the TrUQ used in this study is the Turkish version, reliability and validity tests need to be conducted in other languages and for different diseases in the future studies. Its more widespread use in telerehabilitation studies will serve as a critical step in evaluating the effectiveness of this scale.

Limitations

This study has some limitations. Firstly, we included the three neurological disease groups in the study, so our results cannot be generalized to other neurological diseases. Secondly, patients who received telerehabilitation via telephone, messaging, or videoconferencing, which requires little equipment and is easy to implement, were included in this study. Advanced telerehabilitation tools using virtual reality or sensors may affect usability, so it may be necessary to test the validity and reliability of the current survey on more advanced telerehabilitation systems.

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Author Contributions

KE: Methodology; writing-original draft; supervision; formal analysis; conceptualization; writing-review and editing; visualization; investigation. SE: Writing-original draft; methodology; visualization; writing-review and editing. FS: Writing-review and editing; visualization. CO: Writing-review and editing; methodology; visualization. MK: Formal analysis; conceptualization; writing-review and editing; visualization. AGG: Supervision; writing-review and editing; writing—original draft; methodology. All authors read and approved the published version of the article.

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