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RESEARCH ARTICLE OPEN ACCESS

Development and Feasibility of a Telerehabilitation Programme Combined with or without Transcranial Direct Current Stimulation tDCS Among Older Adults with Post-Stroke Mild Cognitive Impairment

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Abstract

Objective: Stroke rehabilitation is clinically and economically complex and requires a long-term commitment from patients and their support systems. Therefore, there is a need for an intervention that addresses the cost and accessibility needs of stroke survivors and their caregivers. This study aimed to gain expert consensus on the feasibility of Brunnstrom Movement Therapy (BRS) telerehabilitation for older adult patients with post-stroke mild cognitive impairment.

Methods: A Delphi study was conducted to provide a BRS telerehabilitation programme for older adult patients with post-stroke mild cognitive impairment. The stages involved were literature review, items-modelling, expert review, and video modelling of the consented items. The feasibility of the video was tested among selected patients.

Results: Consensus on the structure and content of the BRS telerehabilitation with and without tDCS was achieved in three rounds. The final telerehabilitation programme comprised eight exercise regimens, including repetition and progression of the exercise programme. The programmes had a good feasibility score among the study participants. The USE questionnaire data revealed high scores for the telerehabilitation programme, with usefulness at 89.28%, ease of use at 88.52%, ease of learning at 93.25%, and satisfaction at 89.80%. When combined with tDCS, the programme's usefulness increased to 93%, ease of use to 90%, ease of learning remained high at 92%, and retention was at 91%.

Conclusion: The BRS telerehabilitation programme was developed for older adult patients with post-stroke mild cognitive impairment, with experts' consensus that it is feasible to use among older adult patients with post-stroke mild cognitive impairment.

Keywords: Stroke; Telerehabilitation; tDCS; Older adults

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Plain English Summary
In this study, we the authors wanted to find out if Brunnstrom Movement Therapy delivered through tele-rehabilitation could be helpful for older adults who have had a stroke and are experiencing mild cognitive impairment. We conducted a Delphi study, involving experts, to design a BRS telerehabilitation program. This program included exercises aimed at improving movement and was tested among selected patients to check its feasibility.
After rounds of literature and expert review, we reached a consensus on the structure and content of the tele-rehabilitation program, which included eight exercise routines. Patients who tried out the program in a pilot study found it feasible and rated it highly in terms of usefulness, ease of use, ease of learning, and satisfaction.
In conclusion, our study suggests that the BRS telerehabilitation program could be beneficial for older adults who have had a stroke and are dealing with mild cognitive impairment, according to this modified Delphi study.

Introduction
Stroke rehabilitation is a complex and challenging process, but utilising brain plasticity through interventions such as exercise and Transcranial Direct Current Stimulation (tDCS) can become a more achievable goal (1, 2). Exercise interventions such as Brunnstrom Movement Therapy may improve brain plasticity endogenously, while tDCS achieve this exogenously, allowing the brain to reorganize itself and reorganise connections to restore lost or damaged neural pathways (3, 4, 5). This has the potential to help the patient regain motor, sensory, and cognitive functions that were lost due to the stroke. Therefore, by combining exercise and tDCS in the stroke rehabilitation process, the patient's brain plasticity may be stimulated more effectively, significantly improving recovery from a stroke (3, 5).
In stroke rehabilitation, exercise interventions are typically prescribed using neurodevelopmental techniques such as Bobath and Bunnstrom Movement Therapies (6). Physiotherapists who prescribe exercise interventions usually consider the patient's capacity and the stage of stroke recovery (6). For these exercise-based interventions to be effective, they need to follow principles of neuroplasticity such as sufficient repetition, transference of learning, task-specific practice and meaningful activities (7). Research has indicated that exercise interventions which adhere to neuroplasticity principles are more successful in helping stroke patients to meet their rehabilitation goals (7, 8). Therefore, when prescribing an exercise intervention, it is essential to consider all of these principles to improve motor recovery among patients with stroke.
The application of telerehabilitation programmes in providing exercise interventions is gaining a lot of interest particularly due to the recent experience of the COVID-19 pandemic and the low number of physiotherapists in monitoring sufficient exercise prescriptions for stroke rehabilitation (1, 9, 10). Telerehabilitation exercises may bridge gaps in exercise prescription for stroke survivors such as a reduction in time taken to exercise, cost-effective and sufficient exercise prescription, as well as an increase in patient's ability to manage their exercise routine independently (9, 10, 11, 12). The majority of the current telerehabilitation programmes for the stroke population are virtual reality programmes making the implementation or application of such programmes challenging in low-resource settings (1). Another issue is that some of these virtual reality interventions do not follow neurorehabilitation principles for stroke such as Brunnstrom Movement therapy and Bobath techniques (1).
Virtual reality components of telerehabilitation come with their challenges and some of these challenges include accessibility to equipment and technology, cost of equipment for home-based exercise, adherence to prescribed exercises and technological technicalities also make virtual reality programmes challenging for older adult stroke survivors in developing nations such as Nigeria. Furthermore, the majority of the available telerehabilitation studies are not only heterogeneous in design and findings, but they are also not designed for older adults with post-stroke mild cognitive impairment. Therefore, these challenges call for more studies designed specifically for older adult stroke survivors with mild cognitive impairment living in developing countries. Moreover, telerehabilitation has the potential to increase patient access to Brunnstrom Movement Therapy by increasing convenience and flexibility for stroke survivors, thus allowing them to be more independent with their exercise programme. However, how Brunnstrom Movement therapy will work and the combination of its items for the telerehabilitation programme to improve stroke symptoms in the cadre of older adult population with post-stroke mild cognitive impairment is not yet known due to the lack of available empirical

evidence. Therefore, there is a need for more studies that focus on the feasibility and efficacy of telerehabilitation programmes in combination with tDCS for older adults with post-stroke mild cognitive impairment living in developing countries. This study developed, gained experts' consensus and tested the feasibility of a Brunnstrom Movement Therapy telerehabilitation programme with or without tDCS for stroke rehabilitation among older adults with post-stroke mild cognitive impairment

Materials and Methods

The development of the telerehabilitation programme followed a reporting standard for Conducting and Reporting of Delphi Studies (CREDES)) guideline and then the feasibility study of how the developed exercise intervention would be accepted in a telerehabilitation programme with or without tDCS among older adults with post-stroke mild cognitive impairment.

Development of the Telerehabilitation Programme

The telerehabilitation programme in this paper is based on Brunnstrom Movement Therapy which is suitable for post-stroke older adults of at least Brunnstrom Recovery Stage 3. The United Nations suggests the age of 65 years or older as the definition of old age. In Nigeria, the age of 60 years is considered as old age for civil servants and the age of 55 years and above is sometimes considered as old age (13, 14, 15). Thus, age 55 is considered for this paper. The CREDES checklist includes the justification; planning and process; definition of consensus; informational input; and prevention of bias on the intended programme to design. This checklist was achieved using a three-round hybrid Delphi technique (16, 17). The first round started with a literature review on the components of the Brunnstrom Movement Therapy and then the generation of items for the Telerehabilitation Brunnstrom Movement Therapy components. The generated items on the Brunnstrom Movement Therapy were collated and experts' opinions on each item were sought for consideration for inclusion into the asynchronous telerehabilitation programme. The items generated after this round were processed into a video demonstrated by healthy participants who modelled the telerehabilitation programme.

In the second round of the Delphi technique, the video and the items collated were presented to a group of experts in a focus group meeting for consensus. The experts' agreement was rated with a content validity index form (18). This Delphi technique round aimed to "get the experts' consensus with the highest item content validity index. The content validity of a given instrument or programme reflects how its items have appropriate contents for the constructs that they measure, in this case, the programme to be developed. This study presents the item content validity index (I-CVI), which expresses the proportion of experts' agreement on each item's relevance (18). An item's I-CVI is the number of reviewers rating either 3 or 4 for an item (moderately relevant or very relevant) divided by the total number of reviewers (18). In addition, the scale level content validity index (S-CVI) was evaluated and it is the percentage of total items deemed content valid by experts. The final stage of the Delphi was a form of feasibility study of the experts' consented items and videos among the population of older adults with post-stroke mild cognitive impairment, pain and at least BRS of 3.

Feasibility and Acceptance of the Telerehabilitation Programme

The telerehabilitation programme (Brunnstrom Movement Therapy videos of the items generated) was assessed for feasibility and acceptance among older adults with post-stroke mild cognitive impairment, pain and at least a BRS of 3. A feasibility study particularly of a randomized control trial is designed to address whether the study can be done (19). Therefore, this study's feasibility goal was to ask whether the telerehabilitation programme of the Brunnstrom Movement Therapy could be used for rehabilitation for older adults with post-stroke mild cognitive impairment. If the programme is good, should the clients proceed to use it, and if so, how should they? Although the CONSORT 2010 extension does not directly apply to internal pilot studies, some of its components were used in this study.

Study design and Participants recruited

The protocol for this main study has been published (15). This study design was a multi-arm parallel-group randomized controlled trial but only the first twelve participants that fell into group 1 (telerehabilitation group) and group 2 (telerehabilitation combined with tDCS) were part of the feasibility study. This is because the telerehabilitation programme with or without tDCS was the one tested for feasibility and acceptance while group 3 was conventional physiotherapy interventions. For the feasibility study specifically, the focus was on the initial twelve participants who fell into group 1 (telerehabilitation group) and group 2 (telerehabilitation combined with tDCS). These groups were selected because the telerehabilitation program, both with and without

tDCS, constituted the interventions being tested for feasibility and acceptance. Group 3, receiving conventional physiotherapy interventions, was not part of the feasibility testing.
By concentrating on these two groups in the feasibility study, we intended to assess the practicability and acceptability of the telerehabilitation interventions before implementing them on a larger scale.

Assessments
Baseline assessments of the patient included the use of a face-numerical Rating Scale (NRS) for pain assessment, Brunnstrom (20). Recovery stage of stroke for motor function, modified Ashworth scale for spasticity (21), Berg balance scale and time up and go test for motor functions. The functional activity question (FAQ) (22), Informant Questionnaire on Cognitive Decline in the. Elderly (IQCODE) (23) and Mini-Mental State Examination (MMSE) (24) tools were used for cognitive functions. The feasibility and acceptance of the telerehabilitation programme were assessed with the Usefulness, Satisfaction and Ease of Use (USE) questionnaire (Appendix 1).

Interventions
Telerehabilitation Programme
The telerehabilitation programme comprised the videos of the generated items of Brunnstrom Movement Therapy post expert consensus. Participants received the recorded videos on the hospital's computer (see Figure 1). The patients were seated on a chair in front of the computer. The first day of the intervention was monitored by the research principal investigator and his trained assistants. This was to enable the participants to be familiar with the intervention procedures. Further information about the telerehabilitation programme is detailed in the published protocol (15).

Figure 1: An image of a participant receiving the telerehabilitation programme

Telerehabilitation Programme combined with the tDCS
The same material for the telerehabilitation-based exercise above plus a tDCS device (see Figure 2). The tDCS device (OMNI Stimulator, Australia) was used (https://www.omnistimulator.com/). The principal investigator/ research assistant mounted the device while the telerehabilitation programme was going on. Further information about the telerehabilitation programme combined with tDCS is detailed in the published protocol (15).

Figure 2: Image of a patient with telerehabilitation plus transcranial direct current stimulation (tDCS) programme

Data analysis

The participants' characteristics and baseline measures were described with descriptive statistics of frequency, percentage and mean. The content validity index (CVI) interpreted from the expert consensus are the experts in agreement which is the sum of the relevant rating by the experts. The universal agreement (UA) was determined by assigning a score of "1" to an item that had 100% expert agreement. The items-CVI was derived using the expert in agreement (proportion of contents that the experts scored 3 or 4) by the total number of the experts. The scale-level content validity index (S-CVI) on the average method was derived as the average of the Items-CVI. Thus S-CVI equals sums of Items-CVI divided by the number of the items. The scale level content validity on the universal agreement method was derived using the sum of the UA by the number of the items.

The Usefulness, Ease of Use, Ease of Learning and Satisfaction of the USE questionnaire were analyzed with descriptive statistics to evaluate the parameter score for the telerehabilitation programme usefulness, ease of use, ease of learning and satisfaction of its use. The comparison of parameter score was derived using the sum score and the total number of respondents, the statement (number of items relating to the parameter tested) and the total likert scale number which was seven.

Results

Delphi

Literature Review

Brunnstrom Movement Therapy items for the Telerehabilitation programme.

The Brunnstrom approach is a neurodevelopmental technique based on the work of Sherrington, Magnus, Jackson, and Twitchell (25). It believes that when the central nervous system is damaged, the recovery usually follows a specific sequence that ranges from a period of flaccid paralysis to a period in which muscle tone increases, becomes spastic, and basic movement reflexes appear. The next stage is when the patient starts to have synergistic movement of some group of muscles, and at this stage, there is also a further increase in spasticity. Finally, the spasticity disappears to allow isolated joint movement and more body coordination that approaches normal or near normal (25).

Brunstrom Movement Therapy (BMT) states that when no motion exists, movement is facilitated using reflexes, associated reactions, proprioceptive facilitation, and/or exteroceptive facilitation to develop muscle tension in preparation for voluntary movement (25). The responses of the patient from such facilitation are combined with the patient's voluntary effort to produce semi-voluntary movement (25). Proprioceptive and exteroceptive stimuli assist in eliciting the synergies. When voluntary effort appears, the patient is asked to perform an isometric contraction. If successful, they are instructed to perform controlled lengthening (eccentric contraction). Finally, a shortening contraction (concentric contraction) and reversal of the movement between the agonist and antagonist are essential to improve the motor outcome. Table 1 shows the experts involved in the items generated for the BMT and Table 2 shows the BMT exercise interventions reviewed for patients with at least BRS of 3.

Table 1: Experts Committee Characteristics

S/N	Expert	Year of Experience
1	PT Ad	14
2	PT Ba	12
3	PT Ay	16
4	PT EL	14

PT Ad= Assistant director of physiotherapy, PT Ba= Chief Physiotherapist, PT Ay and PT EL = Principal physiotherapists

Table 2: List of exercises reviewed for patients with Brunnstrom Recovery Stage (BRS) of at least 3 and expert consensus

BRS Stage 3	BRS Movement Therapy/items rating
Upper limb	Reflex assistance is withdrawn then movement patterns that deviate from basic limb synergy are introduced Range of motion exercises Item 1: Auto-assisted exercises 4,4,4,4 Item 2: Shoulder external rotation during the auto-assisted exercises 4,4,4,4 Item 3: Shoulder elevation 3,4,4,3 Item 4: Chopping Exercises 4,4,4,4 Item 5: Weight-bearing with extended elbow 3,4,3,4 Item 6: The shoulder girdle elevation. Retraction and protraction. 4,4,4,4 **ADL for upper limb** The extensor synergy may be used as follows: Item 7: To stabilize an object between the affected arm and the body. **A jar may be held steady while the unaffected hand unscrews its top**; a handbag or a newspaper may be held under the arm while the unaffected hand opens a door, and so forth. 4,4,4,4 The **flexor synergy** or its components may be utilized for many activities: Item 8: To carry a **coat over the forearm**, elbow flexed, provided the elbow flexor muscles are sufficiently strong 4,4,44 Item 9: To carry **a briefcase or handbag** after the handles have been placed in the hand. The grip of the affected hand, however, can seldom be relied on for any length of time because the grip may loosen if the patient's attention does not remain focused on hand closure. 4,4,44
Hand Section of the UL	Item 10: There is mass grasp but no voluntary finger extension at BRS of 3. The exercises will be meant to improve the fingers' extension via auto-assisted exercise of the hand. 4,4,4,4
Trunk and Lower limb	Item 11: Unilateral contraction of hip flexors 4,4,4,3 Item 12: Activation of the dorsiflexion muscles of the ankle and weight bearing on the affected lower limb 4,4,4,3

Twelve exercise interventions were identified (see Table 2 above) as the exercise interventions suitable for a patient with at least a BRS of 3. The exercise interventions included a range of motion exercises, auto-assisted exercises, shoulder external rotation during the auto-assisted exercises, shoulder elevation, chopping exercise, and weight bearing with an extended elbow as well as shoulder girdle elevation and retraction and protraction for the upper extremity. Some of these exercise interventions also include patient using their flexor and extensor synergy to provide activities of daily living such as stabilizing an object between the affected arm and the body. It was found in the literature that the patient might hold a jar steady while their unaffected hand unscrewed the jar top. Other identified exercise interventions suitable for this cadre of stroke survivors included hand auto-assisted exercises to improve the patient's finger extension, unilateral contraction of hip flexors and activation of the dorsiflexion muscles of the ankle and weight-bearing on the affected lower limb.

Expert Review of the Items Generated and the Expert Focus Group Meeting

The items generated were sent to each expert for further review of the items. During a focus group meeting the items were deliberated on and scored for relevance for a telerehabilitation programme. Experts agreed on upper extremity auto-assisted exercise, shoulder girdle elevation retraction and protraction, chopping, and shoulder external rotation during auto-assisted exercise. Using the paretic hand to stabilize an object on the table while the unaffected hand opens an object is one example of a functional exercise intervention with upper limb extensor synergy (envelope). Upper limb extensor synergy will stabilize an object between the affected arm and the body. The patient will use the strong hand to stretch the paretic fingers into extension, which is expected to break the mass grasp. The exercise recommendation for the lower extremity, which will be performed while the patients are sitting, is the unilateral contraction of their hip flexors and engagement of their ankle dorsiflexor muscle. Table 2 shows (above) the final items generated and the expert rating.

Content Validity Index of the Telerehabilitation Brunnstrom Movement Therapy Items

Content validity reflects how items of an instrument or programme under consideration possess appropriate contents for the constructs that it measures; in this case, the telerehabilitation programme to be provided (18). This study reports the Item content validity index (I-CVI), which expresses the proportion of agreement on the relevancy of each item and the scale level content validity index (S-CVI), which is the proportion of total items judged to be content valid. There was a perfect expert agreement and universal agreement for the proposed telerehabilitation BRS items. The items' content validity index is 100%, which results in a perfect scale-level content validity index as well as a perfect scale-level content validity index based on the universal agreement method (see Table 3 for details).

Table 3: Content Validity Index for the proposed Telerehabilitation program

Items	Exp 1	Exp 2	Exp 3	Exp 4	Experts in Agreement	I-CVI	UA
1	4	4	4	4	4	1	1
2	3	4	4	3	4	1	1
3	3	4	4	3	4	1	1
4	4	4	4	4	4	1	1
5	4	4	4	4	4	1	1
6	4	4	4	4	4	1	1
7	4	4	4	4	4	1	1
8	4	4	4	4	4	1	1
9	4	4	4	4	4	1	1
10	4	4	4	4	3	1	1
11	4	4	4	4	3	1	1
12	4	4	4	4	3	1	1
Proportion relevant	1	1	1	1	S-CVI/Avr	1	
Mean Exprt proportion		1			S-CVI/UA		1
Mean I-CVI	1						
***S-CVI/Avr**	1						
***S-CVI/UA**	1						

*I-CVI: Item content validity index

*S-CVI/Avr: Scale-level content validity index based on the average method

*S-CVI/UA: Scale level content validity index based on the universal agreement method

Items 1 to 12 are the same number as the list generated in Table 1.

Feasibility and Acceptance
The mean age of the participants in this study was 67±7.73 years for the telerehabilitation programme and 68.6 ±7.10 years for the telerehabilitation plus tDCS programme. The majority of the participants in the telerehabilitation group are male while the group of telerehabilitation programmes with tDCS has more female participants. The participants' sociodemographic characteristics and clinical characteristics are detailed in Tables 3 and 4.

Table 4: Sociodemographic Details of the Participants

Variable name	Telerehabilitation program Mean (SD)/Freq (%)	Telerehabilitation plus tDCS program Mean (SD)/Freq (%)
Age	67±7.7	68.6±7.1
Gender:		
Male	9(75%)	5 (41.7%)
Female	3(25%)	7 (58.3%)
Ethnicity:		
Yoruba	10(83.3%)	12(100%)
Igbo	1(8.3%)	
Hausa	1(8.3%)	
Education level:		
None	--------	---------
Primary	3(25%)	3(25%)
Secondary	6(50%)	6(50%)
Tertiary	---------	3(25%)
Postgraduate	3(25%)	---------
Live with:		
Family	12(100%)	12(100%)
None	-----------	-------------
Others	-----------	------------
Tobacco use:		
Never	6(50%)	11(91.7%)
Past	6(50%)	1(8.3%)
Alcohol use:		
No	10(83.3%)	9(75%)
Yes	2(16.7%)	3(25%)
Employment status		
Yes	3(25%)	2(16.7%)
No	9(75%)	10(83.3%)

Freq: Frequency; SD: Standard deviation; tDCS: transcranial direct current stimulation

Table 5: Clinical Characteristics

Variable name	Telerehabilitation program Mean (SD)/Freq (%)	Telerehabilitation plus tDCS program Mean (SD)/Freq (%)
Types of Stroke		
Haemorrhagic	6 (50%)	5(41.7%)
Ischemic	6(50%)	7(58.3%)
Side of Brain affected:		
Right	6 (50%)	8(66.7%)
Left	6(50%)	4(33.3%)
Time of stroke occurrence (days)	144.25±26.3	149.17±23.7

Freq: Frequency; SD: Standard deviation; tDCS: transcranial direct current stimulation

The USE Questionnaire Parameter Score
The usefulness, satisfaction, and ease of use of the telerehabilitation-based exercises were assessed using the Usefulness, Satisfaction, and Ease of Use questionnaire. The parameter scores tested for telerehabilitation and telerehabilitation with tDCS programmes are usefulness, ease of use, ease of learning, and satisfaction. According to

data collected via the USE questionnaire, the telerehab programme's usefulness had a parameter score of 89.28%, and its ease of use had a parameter score of 88.52%. The parameter score for ease of learning was 93.25%, and the parameter score for satisfaction was 89.80. The usefulness of the telerehabilitation programme plus tDCS had a parameter score of 93%, and the ease of use had a parameter score of 90%. The parameter score for ease of learning is 92%, and the parameter score for retention was 91% (see Figure 3).

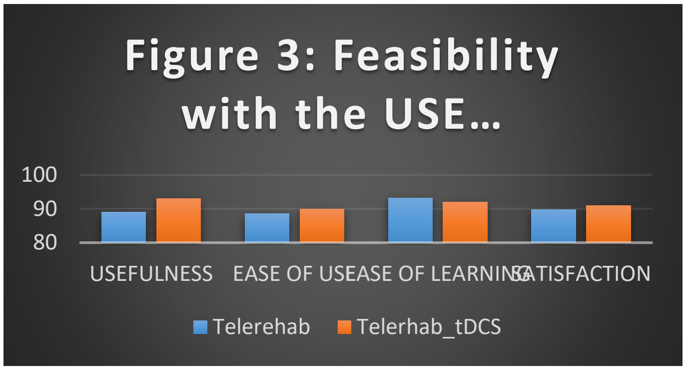

Figure 3: Feasibility with Usefulness, Satisfaction, and Ease of Use (USE) Questionnaire

The telerehabilitation-based exercises programme was evaluated qualitatively among the first 12 participants who met the inclusion criteria of having BRS 3 motor dysfunction and cognitive dysfunction of 18 to less than 24 on the MMSE. A similar feasibility study was carried out for the telerehabilitation-based exercise programme combined with tDCS. The following exercises were difficult to complete, according to the participants' common trends: Stabilize a bottle of coke between the affected arm and the body while the unaffected hand unscrews its top; Carrying a coat over the forearm with the elbow flexed and weight-bearing on the affected lower limb using a chair stand exercise interventions were deemed difficult to perform. The qualitative findings on each of the exercise interventions are presented in Tables 6 and 7.

Table 6: Participants' quotes on the exercise interventions during the telerehabilitation programme

Telerehabilitation Programme (Each of the exercises)	General Comments on the Telerehabilitation Programme
Weight-bearing with extended elbow exercise makes me uncomfortable to do alone and I would suggest it be left out.	The exercise programme is good and I would love to continue with it at home.
I found weight-bearing with an extended elbow difficult to do.	I like the exercise programme.
I do not want to participate in the exercise with bottle opening, it is challenging for me.	I see the exercise programme as what I can do at home.
The exercise of bottle opening appears difficult to do.	I can do the exercise programme alone.
I do not like to do exercise on stabilising a bottle of coke between the affected arm and the body while the unaffected hand unscrews its top.	The exercise is good and it looks like the normal treatment program that I do receive.
I do not feel comfortable carrying a coat over the forearm, elbow flexed and work around. I feel like I want to fall when I perform exercise to carry a coat.	I enjoy the exercise and I would like to continue to use it at home.
I cannot do Weight bearing on the affected lower limb using a chair stand-alone.	The exercise is not hard for me and I would like to use it at home.
Weight-bearing on the affected lower limb using a chair stand is difficult to do without support.	I enjoy most of the exercise intervention like my normal exercise program in the hospital.
I do not want to do Weight bearing on the affected lower limb using a chair stand exercise.	In almost all the exercises, I find it easy to do like the one I do with my physiotherapists.

I do not like to do exercise while stabilising a bottle of coke between the affected arm and the body while the unaffected hand unscrews its top.	I find the exercise programme to be incredibly beneficial, as I can do it at my convenience in the comfort of my home.
I found it difficult to bear weight with my legs extended.	The exercise is not hard for me, and I would like to use it at home. I also appreciate the fact that I can customise the programme to suit my needs and abilities, allowing me to progress at a pace that is comfortable for me.
I find it uncomfortable to do weight-bearing and extended elbow exercises by myself, and I would advise against it.	I find the exercise programme to be very cost-effective, as I can easily repeat it whenever needed without needing to spend additional money

Table 7: Participants' quotes on the exercise interventions during the Telerehabilitation plus tDCS programme

Do Telerehabilitation with the TDCS programme (Each of the exercises)	General comments on Telerehabilitation with the tDCS programme
I do not feel comfortable carrying a coat over the forearm.	I consider the telerehabilitation with tDCS programme to be a fantastic way to maintain physical and mental health and fitness.
I find the bottle-opening exercise to be challenging, so I don't want to do it.	I can complete the telerehab with the TDCS programme on my own time and at my own pace.
The bottle-opening exercise is challenging and can cause a fear of falling, which makes it challenging for me to perform.	I enjoy telerehabilitation with tDCS and want to keep doing it at home. I am also reassured by the fact that I can complete telerehabilitation with tDCS at my own pace and on my own time.
The telerehabilitation with tDCS is easy for me to attend and I would like to have more experience of it.	I am unable to put any weight on the impacted lower limb while standing alone.
When I exercise to carry my coat, I feel like I want to fall.	Telerehabilitation with tDCS provides me with the flexibility to attend on my terms, and the the telerehab program component to complete exercises at a pace that is comfortable for me.
Support is essential for weight bearing on the affected lower limb without a chair stand.	With telerehab and tDCS, I can comfortably do my exercises in a safe environment.
I believe that I need support for weight bearing on the affected lower limb without a chair stand.	Telerehab with tDCS allows patients to perform exercises at a comfortable and safe pace, eliminating fatigue and allowing them to complete activities they would otherwise have difficulty with.
I do not want to use a chair stand exercise to bear weight on the affected lower limb.	Telerehabilitation with tDCS is a great way to maintain physical and mental health and fitness.
Telerehabilitation and tDCS programme allow me to exercise conveniently and at my own pace.	To reduce my fear and to safely bear weight on the affected lower limb, I need support.
I do not want to do the exercise that involves carrying a coat.	With the help of telerehabilitation and tDCS, I can engage with my exercise intervention better.
Telerehabilitation with tDCS provides me with a convenient and effective way to carry out my exercises.	Telerehabilitation with tDCS provides me with a convenient and effective way to carry out my exercises.
To ensure I can bear weight safely, I require a form of support.	Telerehabilitation with tDCS gives me the confidence to exercise more effectively.

Telerehab: telerehabilitation; tDCS: transcranial direct current stimulation

The final BRS exercise interventions suitable for the telerehabilitation programme were eight, including auto-assisted exercises; Chopping (Chop and lift exercise involve patient using both hands in an auto-assisted format and following diagonal movement across midline for upward and downward movement); Shoulder elevation; and shoulder elevation with shoulder external rotation during the auto assisted exercises. For the hand, the fingers extension via auto-assisted exercise of the hand and exercise interventions for the lower extremity are activation of the dorsiflexion muscles of the ankle and unilateral contraction of hip flexors.

Discussion

Experts agreed on twelve exercise interventions suitable for BRS telerehabilitation, but only eight were feasible to combine for use in stroke patients. This type of BRS telerehabilitation exercise for telerehabilitation programmes is similar to the concept of functional training, which aims to improve overall body function and movement patterns by targeting multiple muscle groups simultaneously. By incorporating these exercises into a telerehabilitation programme, patients can improve their strength, flexibility, and range of motion in a convenient and accessible way. Also, this type of exercise is similar to traditional rehabilitation exercises but can be performed with the help of technology, making it more accessible and convenient for patients.

There are several studies on the development of exercise interventions for stroke rehabilitation (26, 27, 28) Fuentes et al. (26) work on the tDCS plus virtual reality exercise was conducted in Spain and Llorens et al. (27) work was also conducted in Spain. A similar study by Lee and Cha (28) work conducted in South Korea. The majority of these exercise interventions are passive and active exercise interventions (27, 28). In telerehabilitation programmes for stroke rehabilitation, auto-assisted exercise and active exercise interventions are the most commonly used exercise intervention means. For instance, a randomized controlled trial conducted by Yao et al. (29) showed that telerehabilitation exercises in the form of virtual reality for stroke rehabilitation, which included upper limb exercises in the form of games (patient hit the target object), were effective in improving functional outcomes and quality of life among stroke survivors. The exercises were delivered via virtual reality gaming and supported by a therapist who provided feedback and guidance.

The exercise combination in this study also involved a group with a combination with the tDCS programme. Contrary to this current study in which mode of exercise interventions involved asynchronous telerehabilitation programme via computer, the majority of the available exercise interventions for stroke rehabilitation on telerehabilitation or in combination with tDCS were on virtual reality programmes (26, 30, 31). For example, a study conducted by Lee (31) in South Korea investigated the effects of telerehabilitation (virtual reality) with tDCS on upper limb function in patients with stroke, which included exercises such as catching virtual balls. The exercise components of the virtual reality programme involved reaching, grasping, and manipulating objects in a simulated environment while standing or sitting while another study by Llorens et al. (30) in Spain investigated the effects of virtual reality exercises on upper extremity function in stroke patients.

On the exercise prescription and progression, there was expert consensus on the recommendation for each participant to receive this new exercise intervention three times a week (45 minutes per session) for a total of 24 treatment sessions over eight weeks. Consensus on the progression was for each participant to perform four repetitions of the exercise in the first two weeks, then an increment of two repetitions every two weeks, all within 12 to 14 rates of perceived exertion. Recent studies have shown that an 8-week telerehabilitation programme for stroke patients can significantly improve upper limb function and quality of life (10, 32, 33). The recommended exercise progression in these programmes typically involves gradually increasing the intensity and duration of the exercises throughout the programme.

In this study, the proposed BRS telerehabilitation items have perfect expert agreement and universal agreement. The content validity index of the items is 100%, resulting in a perfect scale-level content validity index as well as a perfect scale-level content validity index based on the universal agreement method. This finding suggests that all the scale's items are highly relevant and representative of exercise interventions for stroke rehabilitation. It also implies that there is a high level of agreement among experts regarding the scale's content validity.

Using the USE questionnaire, the findings of this study show that both BRS telerehabilitation programme alone or with tDCS have higher parameter scores suggesting that the telerehabilitation and the telerehabilitation programme plus tDCS is an effective and user-friendly method for rehabilitation with good potential for long-term benefits

Conclusion

This study outlines the development and consensus of an exercise programme with or without tDCS aimed at alleviating the symptoms of stroke survivors. This exercise intervention was rigorously designed, drawing on theory, literature, and clinical experience. During three rounds of critical opinion, several experts and the population of interest reached an agreement on the content and structure of the exercise intervention. The next step would be to see if this exercise intervention is clinically useful in managing the symptoms of stroke survivors in a randomized controlled trial, which could help determine which combinations of interventions are most effective in managing post-stroke symptoms among older adults with mild cognitive impairment.

List of Abbreviations

tDCS: Transcranial Direct Current Stimulation
BMT: Brunnstrom Movement Therapy
BRS: Brunnstrom Movement Therapy

Declarations

Ethics approval and consent to participate

The Research Ethics Committee of UniOsun Teaching Hospital, Osun State, Nigeria (Ethical approval number: UTH/REC/2022/08/602) and the Biomedical Research Ethical Committee, BREC, of the University of KwaZulu-Natal, Durban, South Africa (Ethical approval number: BREC/00004363/2022) approved this study. The UTH ethical approval was for the site data collection, while the BREC ethical approval was for the university of study ethical approval. Written informed consent was provided to the participants in English and Yoruba.

Consent for Publication

Availability of Data

Data for this work are available with the authors and may be presented on request

Conflicts of Interest

There is no conflict of interest in this project.

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Authors Contributions

The data collection and preliminary writing of the manuscript were done by the Author, AT. The other authors participated in revising the manuscript until it reached the quality required for publication.

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Trial status

This study has been registered with the Pan African Clinical Trial Registry (the identification number for the registry is PACTR202208571972367). The data collection is ongoing.

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