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Video guided exercise after stroke: A feasibility randomised controlled trial

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Abstract

Background: Facilitating self-directed upper-limb exercise in people after a stroke whilst not in therapy sessions may increase therapy intensity and improve outcomes.

Objectives: To investigate the feasibility and acceptability of video guided exercise for facilitating upper-limb exercise after stroke.

Methods: A single-blind feasibility randomised controlled trial with embedded qualitative study in stroke wards at a large teaching hospital in the United Kingdom.

Fourteen participants with stroke were randomized to either video guided exercise intervention or a "treatment-as-usual" control group. Intervention participants received a computer tablet containing filmed individualised exercises to guide out of therapy practice. The primary outcome measure was the Motor status scale (MSS) for upper limb, which was used to guide possible sample sizes for a future main trial. Qualitative focus group and interview data on feasibility/acceptability were collected and analysed.

Results: The intervention was acceptable, but the need for motivation/support to exercise was highlighted. Based on similar assumptions to the feasibility study, circa ninety two patients in each group would be needed to detect a difference of 5 in upper limb motor status for a main trial.

Conclusion: A trial of video guided exercise is feasible, although an optimal main trial would require some relatively minor changes to design, outcome measures, eligibility and the intervention.

Keywords: pilot clinical trial, stroke, physiotherapy, mobile tablet, self-directed exercise.

Introduction

Rehabilitation of the upper limb after a stroke aims to promote motor recovery and function (Dimyan and Cohen, 2011). Evidence suggests that the more rehabilitation received, the better the outcome (Lohse, Lang and Boyd 2014). However, delivering intensive rehabilitation is challenging within resource limited health systems such as the UK NHS (Pollock et al, 2014). Effective self-directed exercise, may be a way of increasing rehabilitation intensity with less professional input/time and commensurate costs; an approach supported by the Royal College of Physicians, whose stroke guidelines state 'patients who have some arm movement should be given every opportunity to practice these activities within their capacity' (Royal College of Physicians, 2016)

Two possible advantages to self-directed exercises early in rehabilitation exist. First, they may be a way of delivering greater intensity (Eng et al, 2014) during a period of enhanced brain plasticity and greater recovery potential (Murphy and Corbett, 2009). Secondly, mastering appropriately tailored exercises may promote and reinforce self-efficacy (Bandura, 1997),

making future self-management more likely.

Currently, some 81% of therapists use exercise sheets or booklets to encourage upper limb exercises outside formal therapy sessions (Connell, McMahon, Eng, and Watkins 2014). This is time consuming and providing sufficient detail for fidelity in enactment can be challenging for the third of people with aphasia after their stroke (Stroke Association, 2018).

This feasibility trial examines using the medium of computerised tablets as an alternative means of delivering detailed visual guidance for self-directed exercise. Watching videoed exercises being performed is not reliant upon written or spoken language skills and may be more accessible to those with language impairment. Tablets are relatively inexpensive, accessible to many patients in western health systems, and generally acceptable to people after stroke (Pugilese, Ramsey, Johnson and Dowlatshahi, 2018).

Video guides can be tailored to individual needs, abilities, and personal goals. Auditory prompts can be tailored to guide the movements required according to an individual's impairment. The opportunity to review progress when performing exercises may promote self-efficacy and assist motivation.

In a systematic review of self-directed therapy for arm rehabilitation after stroke, Da Silva, Moore and Price (2018) demonstrated self-directed therapy can improve upper limb outcomes in patients receiving constraint-induced movement therapy, electrical stimulation and therapy programmes to promote increased practice without additional technology-use. Whilst this feasibility study explores technology as a medium to deliver guidance for self-directed exercise the resultant practice is without technology assistance.

Potential barriers to tablet-delivered video-guided exercises include the need to follow, possibly complex, action sequences to use devices and access exercises. Finger dexterity for touch screen use is also required (Pugilese, Ramsay, Johnson and Dowlatshahi, 2018).

As a complex intervention (Medical Research Council 2008), development should include assessment of feasibility prior to a costly definitive trial of effectiveness. Accordingly, our two study aims were to:

i) evaluate the feasibility and acceptability of a mobile tablet and user interface, for delivering and individually tailored, filmed exercise programme.

ii) provide information to inform the design of a future randomised controlled trial of effectiveness.

Four objectives helped address these aims:

Objectives

i) Ascertain participant recruitment/retention rates

ii) Determine sample size and magnification factors for estimating statistical significance of the primary outcome in a full trial

iii) Assess feasibility of testing procedures, including ease of use of video guides and the utility of secondary outcome measures.

iv) Determine acceptability and experience of trial processes for patients and staff.

Materials and Methods

The trial Registration was registered with ClinicalTrials.gov (NCT03260686) and had ethical approval from the xxxxxxx Research Ethics Committee Ref: xxxxx

Design and Participants

This was a randomised controlled feasibility study with an embedded qualitative study. Participants were randomised to either the intervention group (provided with a video guide on a tablet to support exercise) or a control group (treatment as usual)

The trial period was four weeks from first therapy session after recruitment, or until discharge if less than 4 weeks. Aside from the mobile tablet intervention, intervention and control groups continued treatment as usual for upper limb rehabilitation.

Participants were newly diagnosed stroke inpatients at a large teaching hospital in the UK. To be eligible participants had to be 18 or over, diagnosed with first time stroke, mild or moderate upper limb paresis (mild MSS 15-19, Moderate ≥MSS 30, parameters judged by local clinicians familiar with the tool) with minimal inattention, no previous/existing upper limb pathology, not enrolled in another trial, and a predicted four week hospital stay with active rehabilitation goals, mild/moderate or no aphasia and understood consent. Participants with aphasia were deemed eligible if a speech and language therapist judged they were able to follow the consent procedure with support.

Recruitment and Randomisation

Patients and professionals were recruited from three acute or rehabilitation pathway wards, consisting of two stroke units and a general neuro-rehabilitation ward, with support for those with mild/moderate aphasia from a Speech and Language therapist.

Using Viecchtbauer et.al's (2015) formula for feasibility study sample sizes, our aim was a sample of 16 patients (four participants with mild and four with moderate upper limb impairment in each group e.g. n=2x8). The approach accounts for potential (but unforeseen) problems in feasibility studies. We arrived at this sample size by inputting into the calculation an 80% certainty of detecting problems that will arise once for every five participants. Patients were randomised by an independent clinician to intervention or control using rudimentary block stratification for initial level of limb weakness (mild or moderate).

Intervention: video-guided exercise out of therapy

In addition to usual care in terms of physiotherapy input (repetitive upper limb task training and functional task training), participants had out-of-therapy-time exercises provided as video on a mobile tablet. Exercises were filmed during the participants normal therapy sessions from 2-3 feet away at a therapist-determined angle to include as much of the patient's body as they felt was required. Therapists were filmed three times performing exercises, followed by the patient participant performing the exercises three times. Therapist-provided verbal prompts helped correct movements.

Verbal and written instructions on accessing videos on the mobile tablet were provided to patients. They were encouraged to watch chosen exercise videos three times before practising themselves. No prescribed amount of exercise was provided and participants were free to undertake exercises as often as they wished. The number of different exercises, and when they were updated or re-recorded was judged by the physiotherapist. Because filming was part of normal therapy for the intervention group, it was not possible to blind therapists to patient allocation.

Screen shots of the tablet interface are presented in Appendix 1. After selecting a sole 'photo'

icon on the opening screen, an exercise was chosen from a page of available exercises. Patients received a pack containing a tablet, a user guide, a diary (for recording time spent exercising), a charger, and tablet stand. Tablets were accessible at all times and ward staff ensured tablets were charged.

Control: treatment as usual

The control group received usual care in terms of physiotherapy input (repetitive upper limb task training and functional task training), with out-of-therapy-time exercise instructions presented verbally or in writing, as determined by the therapist.

Outcomes and measurement

Quantitative data

Outcome measurements were recorded by pairs of assessors, who were experienced therapists, blinded to patient allocation and independent from the immediate clinical setting. Pairs of assessors were used to avoid assessment bias, with scores agreed with discussion should any between scorer differences occur. Patients were instructed not to reveal their allocation.

Outcomes were assessed before randomisation (baseline) and at the end of the trial (outcome).

Primary outcome was impairment and disability measured by the Motor Status Scale (MSS) (Ferraro et al, 2002). This measures shoulder, elbow, wrist, hand, and finger movements, as well as soda can grasp, key pinch grip, pincer grasp and use of a pen. It has good levels of internal consistency, inter-rater reliability, and criterion validity – it correlates well with the standard Fugl-Meyer scale (Fugl-Meyr 1975).

Secondary outcomes included:

- Quality of Movement as measured by the Leeds Movement Performance Index (Ross, McCluskey, Fletcher-Cook, and Stephenson, 2014): i) controlled grasping a soda can; ii) pincer grasping a pen: pick up pen, sign date, name or three vertical lines; iii) lateral key pinching; iv) touching the opposite knee whilst sitting and v) touching the opposite shoulder whilst sitting.
- Self-efficacy – as measured by the General self-efficacy scale (GSE) (Schwarzer and Jerusalem, 1995).
- Time (T), minutes spent engaged in practicing prescribed exercises outside of therapy, recorded by patient participants in a diary (by both intervention and control groups).
- Time (TPT/OT), minutes spent engaged in physical rehabilitation in face to face therapy sessions involving the upper limb. (Selected to enable statistical control of participant time spent in one to one therapy in a future trial). Time spent using the upper limb whilst walking for balance or as part of daily living was not logged. Recorded by therapist at the end of each participant's therapy session.
- Recruitment and attrition rates.
- Perceived and expressed acceptability and experience of the process for patients and staff, feasibility of testing procedures, ease of use of video guides and ease of completion of secondary outcome measures; explored using interview and focus groups.

Qualitative Data

To explore intervention acceptability and accommodate communication difficulties, patient participants were interviewed. Participant interviews were carried out by the researcher (MK), at four-week trial end or before discharge - whichever came first. The researcher was

not involved with the patient's clinical care, and was only known to the participant by the consenting process. Interviews allowed for tailoring to accommodate those with communication difficulties. A question guide was prepared by the researcher and modified for study groups. Additional probe questions were used depending on responses, and modifications including recapping of information in answers given by those who had mild communication difficulties employed. Interviews were recorded and transcribed verbatim.

The focus group for the therapists was moderated by the researcher (XX) and a co-moderating experienced researcher – to aid reflection on the process - and undertaken after the last participant had finished the intervention. Focus group methodology was chosen to promote idea generation (Stewart, 2007). A bespoke topic guide ensured study objectives were addressed. The co-moderator made notes throughout the session, then verified the group was satisfied these expressed the views of the therapists. The focus group was recorded and transcribed verbatim.

Data Analysis

Quantitative Data

As a feasibility trial, inferential analysis of between group differences was inappropriate; however indicative effect sizes and confidence intervals are presented - with appropriate caveats – (c.f. Sims, 2019) to indicate *possible* effects rather than suggesting *probable* effects (Rosner, 2000).

A sample size calculation for a future main trial was carried out using Brant's (2017) formula assuming normal distribution, two-sided Significance (α) of 0.05 and a power (1-β) of 0.90. We used the SD of the MSS in the control group. Thus,

$n = \frac{(\sigma_1^2+\sigma_2^2)(z_{1-\alpha/2}+z_{1-\beta})^2}{\Delta^2}$ = sample size for each group

Where$\Delta = |\mu_2 - \mu_1|$. The means and variances of the two respective groups are (μ_1, σ_1^2) and(μ_2, σ_2^2).

Qualitative Data

After verbatim transcription and familiarisation with the data (by closely reading the text and listening to recordings), the template strategy of King (2017) guided interview and focus group data analysis. *A priori* themes were first identified, guided by the study objectives. Data was coded along with emergent themes developed inductively (for example, 'needing support') and organised using templates to bring together insights, summary and raw quotes/informing evidence.

Trustworthiness was enhanced by member checking (Birt et al, 2016) with focus group participants at the end of the session, and three participating physiotherapists reviewed the results write up for fairness and accuracy, with their comments incorporated. An independent physiotherapist reviewed anonymised transcripts from both focus group and interviews, and judged whether themes resonated with their interpretation of the results/text/sentiments expressed. Differing interpretations were discussed with the researcher until consensus was reached.

In line with recommended dynamic approaches to qualitative research in complex intervention development (O'Cathain, 2015), patient interviews were analysed before conducting the focus group. This meant patient-led themes could be explored with physiotherapists.

Results

Five intervention and six control group participants finished the trial and were included in the final analysis. See Figure 1 for trial participant flow.

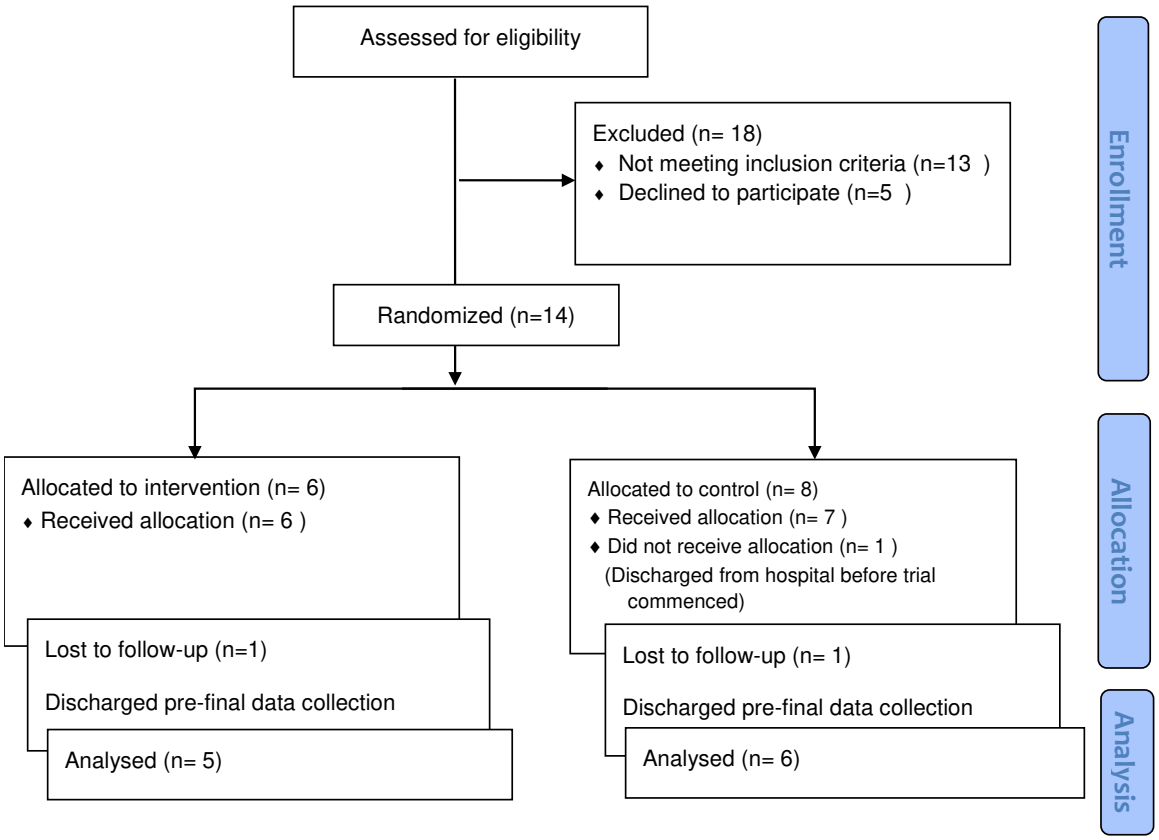

Figure 1. Study participant flow.

Particip't Number	Gender	Age	Type of stroke	Mild or moderate arm weakness	Previous tablet use	Communication difficulties	One ne inte iews
Control							
1	m	61	Left fronto-parietal infarct	mild	yes	Mod Dysphasia	
2	f	82	L MCA infarct	mild	no	Mod dysphasia (Supported consent)	
3	f	82	Left MCA infarct	mod	no	no	X
4	m	69	Left MCA infarct	mild	no	Mod dysphasia	X
5	f	85	Left MCA	mod	no	Mild dysphasia and dysarthria	X
Intervention							
1	m	41	Right lacunar infarct (thrombolysed)	mod	Minimal	no	X
2	m	71	Lacunar infarct	mild	no	Expressive dysphasia	X
3	f	84	Right thalamic bleed	mild	minimal	no	X
4	f	81	Left MCA infarct	mod	no	Mod dysphasia (supported consent)	
5	m	67	Clinical diagnosis ischaemia R corona radiata	mod	no	no	
1*	m	82	R PACI	mild	no	no	
2*	f	88	Right LACI	mild	no	no	
3*	f	62	Left MCA	-	no	no	

Table One: Patient participant demographic details

Physio/Physio Assistant Participant number	Role in trial
71	Senior Physiotherapist carrying out intervention
68	Senior Physiotherapist carrying out intervention
20	Senior Physiotherapist carrying out intervention
35	Senior Physiotherapist carrying out intervention
87	Physiotherapist carrying out intervention
61	Physiotherapist carrying out intervention
33	Physiotherapy assistant
25	Physiotherapist measuring outcomes

Table Two: Relevant Demographic of Physiotherapist participants Focus Group

Objective i) Estimate recruitment and retention rates

Eighteen potential patients were screened but excluded; two with shoulder pain, one with significant mental health issues, three with previous diagnosis of stroke, six were already enrolled in other trials, and one was unable to provide informed consent. Of those declining to participate, four were apprehensive towards the tablet and one gave no reason. Two patients recruited and then lost to follow up were unexpectedly discharged from hospital. Thus, our recruitment rate was 1 patient per week

Objective ii) estimate a sample size and magnification factors for a full RCT

The number of participants needed for a definitive trial of the intervention using 3 clinically significant, but feasible, differences between the groups is presented in Table Three**.** There is no published consensus on a clinically significant difference in the MSS and so differences in scale scores of 3-10 are presented. Whilst effect sizes and confidence intervals (as estimates of uncertainty) can be estimated from pilot trials, caution should be used in using them as the sole basis for estimating main trial sample sizes (Sims, 2019). However, as indicative estimates of possible rather than probable effects we present these in Table Four

Increase in MSS if MCID considered at three values	Sample Size per Treatment Group
3	256
5	92
12	23

Table Three: Sample size calculation table

Control	Pre-trial MSS	Post-trial MSS	Change in MSS
1	32.6	55.0	22.4
2	37.4	55.0	17.6
3	43.2	62.8	19.6
4	6.9	20.2	13.3
5	52.0	56.2	4.2
6	28.0	68.3	35.8
Mean			18.8
Population Standard deviation			12.4
Intervention			
1	37.2	47.4	10.2
2	52.6	60.4	7.8
3	44.5	49.8	5.3
4	26.4	71.8	45.4
5	25.2	51.0	25.8
Mean			18.9

Table Four: Pre and Post trial period MSS, and change in MSS

The mean change in Motor Status Score for the control group was 18.8 CI 95% 8.9-28.7, and the

mean change in Motor Status Score for the intervention group was a similar 18.9 CI 95% 8.1-29.8

Objective iii) Assess feasibility of testing procedures

There were no reported difficulties administering the MSS and assessors found the LMPI easy to administer. In contrast, GSE scoring was considered difficult. Therapists perceived questions as vague (e.g. 'I can usually handle whatever comes my way') and hard for patients to respond to, particularly those with communication difficulties.

Diaries measuring time spent exercising out of therapy were poorly completed by patients (3 of 11 completed). Therapists had no difficulties recording time spent in upper limb exercise during therapy sessions at the end of sessions. Notably, therapists adapted their own treatment record systems to encourage completion.

Qualitatively, patients and physiotherapists all found the video guide "easy". The patients had minimal or no previous use of tablets, in contrast, all physiotherapists were familiar with tablets.

Objective iv) Determine acceptability and experience

Nine themes described the acceptability and experience of using tablet-guided exercises out of therapy. Perhaps unsurprisingly given the study aims, they offered a broadly functionalist (Sovacool and Hess, 2017)) insight into the potentially enabling technology.

As a visual guide

The intervention was valued as a visual guide for exercise prescription, particularly for error correction.

> "….you can see what you're doing, you can go back and correct it"
>
> Patient Participant

And

> 'I watched the video. I thought, 'I could do them at first'… when I watched the video again I thought, 'well I haven't been doing that right'. When I watched you do it, I know I have to do it properly'
>
> Intervention Participant

The prompt effect was strong enough in one participant, that after initially watching the video, it was not referred to again because they could remember what to do.

Therapists were concerned that unsupervised exercise encouraged compensatory movement patterns; for example, when reaching for an object, moving the trunk and elevating the shoulder to move the hand to the object rather than attempting to extend the affected arm. (Levin, Klein and Wolf, 2009) These concerns were ameliorated by having a video to watch.

> ‘I felt more reassured that they were having a visual representation of how the movement should be being produced, which reassured me a little bit more than just giving the verbal, ‘’this is what you need to be doing and remember that and do that’’ ‘.
>
> Physiotherapist

Therapist concerns were not completely assuaged however,

> ‘Unless they're doing it watching… and watching themselves at the same time, then actually you still may still be doing the wrong pattern of movement because like a lot of the time they've got sensory issues so they don't feel like they're doing it’
>
> Physiotherapist

An environmental prompt

Treatment as usual often discounts the environment in which prescribed exercise takes place. Filming exercises served to prompt to counter this:

> ‘I did do them [exercises] in the therapy room but I brought their table in so I did it in like in a chair with arms, so that's if they could sit in one like that and then, so I tried to replicate it as best that we could……in a quiet environment because that made more sense for me to do it like that.’
>
> Physiotherapist

Less experienced staff needed support from experienced colleagues to devise exercises appropriate for bedside implementation.

‘Me and xxxxx had to link in with the (band) fives when they were videoing when they were devising exercises. We had to link in quite a bit with them to say ‘we need to make this transferable to a bedside setting.’

Physiotherapist

An exercise prompt

Tablets seemed to stimulate therapists to provide independent upper limb exercise.

‘We were more aware of giving upper limb exercises out to people’

Physiotherapist

One therapist reported using patients’ own phones to record their exercises.

‘so I think before I used phones to record people, and show the family how their walking is getting on and things, but I actually never thought to use it for exercises, so it's been useful for that.’

Physiotherapist

The implementation environment

Environmental challenges to exercise provision were unresolved by using the tablet. Cluttered ward tables impacted on intervention use.

‘Not having the right space, you know like some of my exercises I didn’t have enough….the right room on my table.’

Intervention Participant

Cognition as barrier to use

Cognitively impaired patients were less likely to engage with the tablet.

> '…other than when (the physiotherapy assistant) went in or we incorporated it as part of a session, for a good handful of patients there was a correlation between the cognitively impaired patients. They just tended to sit on the side and didn't initiate using it...'

Physiotherapist

Therapists reported being less likely to provide exercises to cognitively impaired patients.

Security

Fears tablets would be lost in busy ward environments were expressed – but unfounded.

> 'We were always like on edge all the time making sure we knew where the iPads were, making sure it's locked up. I think especially on ward x where, um, as well the patients can come and go all the time, they do leave the ward and go all over the place'

Physiotherapist

Burden and motivation

Technical and pragmatic aspects of intervention acceptability were accompanied by psychological factors that helped or hindered intervention use; specifically, motivation:

'I think its good (having the tablet), but like I said before, you've got to have people who *want* to do it'

Intervention Participant

A control group participant was overwhelmed by the perceived enormity of prescribed exercises:

'And then they come back and ask you if you've done them (The exercises) and you think "Oh God, not another one, not another one".'

Control Participant

Needing support

Participants preferred someone else to be present – usually family or an assistant:

'…if I had someone there all the time, my family helped a lot'

Intervention Participant

'It's quite hard to do your exercises when you're on your own… I just don't seem to get it right'

Control Participant

Suggestions for optimisation

A number of modifications to the intervention were suggested by participants. Therapists suggested targeting relatives to better meet perceived support needs.

‘So yes having the alarm for them to do it independently, but for the ones who perhaps need a bit more coaxing along, getting the family a lot on board because families want to be able to do something. They often ask us. "What can we do to help, is there anything we can be doing?"’

Physiotherapist

Group sessions for practicing individually prescribed exercises:

> ‘They can sit together and do the exercises with, with example someone like (names assistant). Have someone that goes around, tweaks things, changing things. So, actually people get upper limb therapy as a group but actually it’s their exercises. Emotionally, that would help them. Many ways, that would help them.’

Physiotherapist

To reinforce motivation, recording and feeding back exercise completion alongside goals and reviews of previous filmed exercises to see improvement over time was suggested:

> ‘…when I started on the wrist exercise I couldn’t hardly use my wrist and then I did it more…do certain exercises, aim for that goal’

Intervention Participant

Therapists proposed a number of changes to the user interface to develop motivation: an alarm to remind people to do their exercises; ‘rewards’ when targets are reached; using older videos to demonstrate progress, and goal attainment. Physiotherapists also suggested using the tablet to monitor the amount of independent exercise undertaken.

To counter environmental constraints, therapists suggested tablet 'work stations' on the ward that patients could access.

Discussion

Summary of Findings

A tablet based delivery system for tailored exercise was feasible and acceptable. In line with our aim of assessing feasibility, the study highlights important factors to inform a future trial of video guided exercise after stroke. Changes to the study design and processes were accompanied by qualitatively-informed perceptual barriers and potential levers for optimisation and implementation related effectiveness modifiers.

Recruitment was feasible, but limited by our exclusion criteria. With hindsight, including patients in trials that permitted co-enrolment, and those with previous strokes would enhance recruitment and better represent the post-stroke population (Oude et al, 2017).

Including patients with more severe aphasia may be suitable, but strategies for inclusion require more study. Using aphasia-friendly consent and patient information sheets and optimising the role of Speech and language therapists could be a possibility. If video enables those who struggle with written instruction, then knowing more about possible intervention effects in this sub- group is vital. A future study might also measure baseline cognitive functioning to isolate its role as a potential effect moderator - as suggested in the qualitative findings.

Four weeks is a relatively short time to demonstrate change after a stroke. A future trial may require a longer time period and extending the intervention into community settings (e.g. care

homes). Attrition may be lower, as participants could continue the intervention upon discharge.

Whilst able to isolate the causes of non-recruitment flagged to the researcher, we were unable to identify ward staff failing to put forward participants for researcher screening. This could be addressed by recording the preliminary screening process in a future study.

While effect sizes have been reported for the primary outcome measure (MSS) these need to be seen in the light of the limitations of a feasibility study, with no clinical relevance.

Since this study was completed, Kwakkel et al. (2017) have proposed recommended outcome measures for practice and research. A future trial should consider including ARAT (Action Research Arm Test) and Fugl-Meyer as part of a battery of theoretically defensible outcome measures for function and motor impairment.

Adjusting the secondary outcome measures used in a further trial is warranted. Measuring the amount of upper limb rehabilitation actually delivered is needed if estimates of effect are to be valid. Therapists debate the accuracy of the amount of time stroke survivors spend in physiotherapy sessions and the active nature of task practice (Bagley et al, 2009; Kaur, English, and Hillier 2009). With better recording and randomisation, such systematic inaccuracies would be equally distributed between intervention and control groups.

Practice diaries were poorly completed and more effective methods for collecting quality data are needed. Alternatively, better behavioural strategies for encouraging completion are needed. A Hawthorne effect (Payne and Payne, 2004) or confounding is an obvious risk (i.e. diary completion rather than exercises prompt improvement). But the risk would be similar in both groups and potentially help motivate participants in the intervention arm.

The generalised self-efficacy scale (Schwarzer, 1995) was considered too vague and an alternative is warranted for a future trial. Scales exist that are specific to upper limb function

after stroke such as the reaching self-efficacy scale, and these may be more appropriate given the contextualised nature of self-efficacy (Chen, Lewthwaite, Schweighofer and Winstein, 2013).

None of the patients described difficulty handling the tablet, despite fears that finger dexterity would limit capacity (Pugilese, Ramsey, Johnson and Dowlatshahi, 2018). However, other physical and environmental factors hindered exercising out-of-therapy-time; something highlighted by Eng et al. (2014) who suggest lack of "another [dedicated, private and accessible] place to go" as a barrier to independent exercise. In reality, ward tables can often be cluttered, unstable, and not always close enough to patients, particularly in specialist seating for stroke patients.

Devising exercises for the patient's bedside environment was challenging; but only in relation to populating the tablet video guide. It may be that novel means of prescribing exercises generated focus on the practicalities of enactment and a prioritisation of upper limb exercises. This is important as Hayward and Brauer (2015) found the amount of arm training during acute and subacute rehabilitation (a period of enhanced brain plasticity) limited, postulating that it could result from prioritizing mobility to achieve faster discharge from hospital.

The importance of motivation is a common thread in qualitative studies of stroke survivors' rehabilitation and exercise experience (Luker et al 2015; MacLean, Pound, Wolfe and Rudd 2000; Maclean, Pound, Wolfe and Rudd 2002). Support with rehabilitation is valued by stroke survivors during all stages of rehabilitation, from professionals *and* families (Nicholson et al., 2013, Poltawski L, 2015) and is associated with better outcomes (Harris, Eng, Miller and Dawson 2010).

Group interventions - with individually prescribed and video-guided exercises - has appeal in

terms of scalability and motivation may be increased by group support (Carin-Levy, Kendall, Young and Mead, 2009). Nicholson et al's (2013) systematic review of perceived barriers and motivators to physical activity after stroke, revealed meeting other stroke survivors was a key motivator; with group exercise classes specifically highlighted (Nicholson et al, 2013). Group therapy is not for everyone; in their qualitative study of in-patients MacLean , Pound , Wolfe and Rudd. (2000) found some felt disheartened if their recovery was not as fast as others. The suggestion of incorporating goal setting (achievement targets) in the intervention to enhance motivation is supported by stroke care guidelines (National Institute for Clinical Excellence 2013, Royal College of physicians 2016).

Outcomes blinding generally worked well, with the patient participants not revealing the group they had been randomised to. Unfortunately blinding was compromised on one occasion by the home team asking the outcome assessor to return a charger to the researcher. This was post-recording of outcome, but more emphasis on importance of blinding in pre-trial training, and timely collection of equipment could conceivably have helped.

Limitations

Whilst we were aware of the comprehensive theoretical frameworks to help overcome barriers to implementation of technology (see Greenhalgh et al, 2017) the study could have made greater use of an explicitly theory-based approach to intervention development, focusing on systematically identifying the active components of technology, behavioural and contextual factors driving possible effects.

This was a single site feasibility study and whilst recruitment, intervention fidelity and monitoring a usual care control was easier (Weinberger et al, 2001), further multi-site testing is needed for greater generalisability (Griffiths 2009).

Performance and social desirability biases may have influenced the efforts of the clinicians participating in this trial using the intervention – something that a multi-site study, and more distant relationship between "researcher and researched" would have mitigated.

A future study would be strengthened by prescribing the amount of self-directed therapy. No consensus on an effective amount of therapy exists; but Bernhardt et al (2019), suggest 1-2 hours/day on task should be an aim for facilitating upper limb recovery after stroke, with lower doses being sub-therapeutic.

There was no formal measure of agreement, given the studies feasibility status and associated sample sizes. A future trial may include such measures (for example, Kappa) as a potential modifier of any effects.

The constraints on therapy provision in the UK healthcare system mean a commitment by the stroke survivor to self-directed exercise for the upper limb is needed. A future trial might be more attractive if the amount of therapy time released and whether it is used productively is established as part of the rationale for the trial.

Conclusion

Tablet guided exercises for out of therapy practice are broadly feasible and acceptable. However, before a future definitive trial can be undertaken, more work is required to optimise outcome measures; recruitment and attrition strategies; the role of appropriate behavioural and technology-adoption theory in development and systematic testing of both intervention and theory; and required components of any accompanying process evaluation to understand the

evident adaptation, perceptual barriers and levers to implementation.

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Declarations of Interest

The authors report no conflicts of interest

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Appendix One

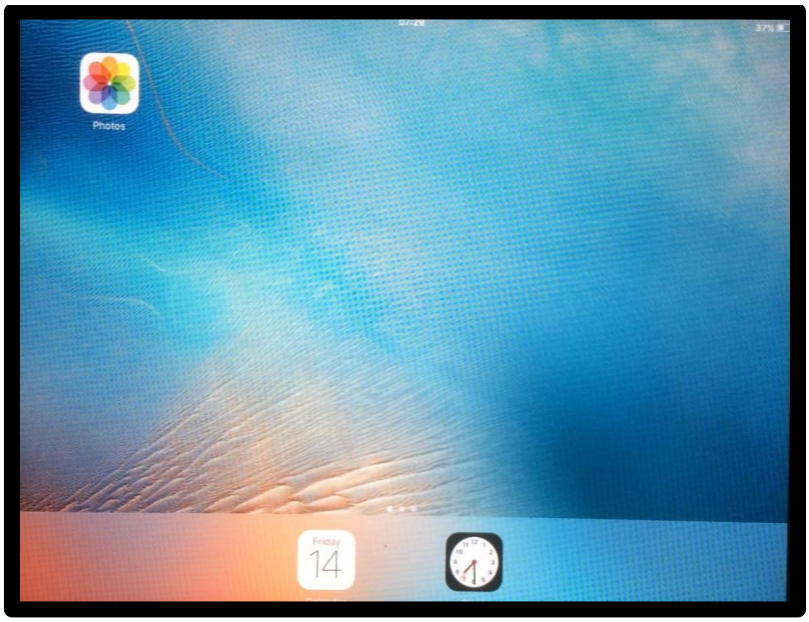

Image One: Tablet interface, initial screen, appears as soon as tablet opened

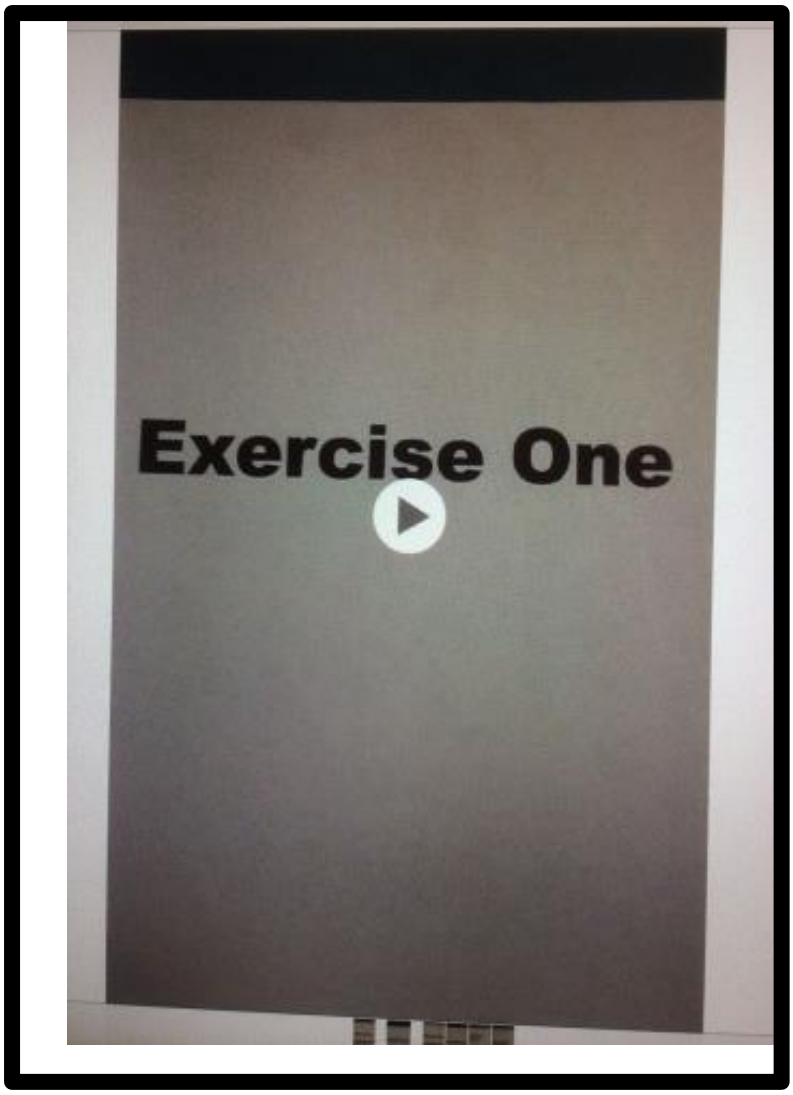

Image Two: Icon for video of Patient doing exercise video with verbal prompts from physiotherapist.

Image Three: Still of video of physiotherapist demonstrating exercise