Video-based Instructions for Prescription of Home Exercise Programs in Rehabilitation

Kellie Bree Emmerson

BOT

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College of Science, Health and Engineering

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Victoria

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List of Abbreviations

Apps……..………………………………………………………………….Applications

AUD……………………………………………………………Australian Dollars

BOT…………………………………………………Bachelor of Occupational Therapy

CI………………………………………………………………..Confidence Interval

Con…………………………………………………………………..Control group

C……………………………………………………………………… Comparison

CONSORT………………………………..Consolidated Standards of Reporting of Trials

CPM……………………………………………………….……Continuous Passive Motion

CRP………………………………………….….Community Rehabilitation Program

EORTC QLC-C30….European Organisation for Research and Treatment of Cancer Quality of Life Questionnaire Core 30

Exp………………………………………………………………Experimental group

F…………………………………………………………………………Female

FIT……………………………………………………....Frequency, Intensity and Time

FITT……………………………………….……..Frequency, Intensity, Time and Type

GRADE……...Grading of Recommendations, Assessment, Development and Evaluation

HEP…………………………….…………………...Home Exercise Program/Programme

I……………………………………………………………………...Experimental

IQR…………………………………………………….………Interquartile range

k………………………………………………………………….…………..Kappa

n…………………………………..…………………………...Number of participants

NR……………………………………………………….……………………Not reported

M…………………………………………………………….………………………..Male

MD…………………………………………………………….………Mean Difference

METS…………………………………………….…...Metabolic Equivalent Task units

Mins……………………………………………………………….……………………Minutes

MOT……………………………………………….………Master of Occupational Therapy

MD…………………………………………………………….…………Mean Difference

OT………………………………………………………………....Occupational Therapist

P……………………………………………………………….…………………p value

PASE……………………………………….…..Physical Activity Scale for the Elderly

PRISMA…….……Preferred Reporting Items of Systematic Reviews and Meta-Analyses

PROSPERO….………………..International Prospective Register of Systematic Reviews

PT…………………….………………………………………………………Physiotherapist

QOL……………………………….…………………………………..Quality of Life

RE-AIM…………….…...Reach, Effectiveness, Adoption, Implementation, Maintenance

RevMan…………………..………………………………………………Review Manager

SD…………………..…………………………………………………..Standard Deviation

SMD……………………..……………………………Standardised Mean Difference

SP…………………………………..…………………………………...Speech Pathologist

SPSS…………….……….………….………...Statistical Package for the Social Sciences

STROBE…….…STrengthening the Reporting of OBservational studies in Epidemiology

TIDieR…………………...……..Template for Intervention Description and Replication

VHI………………………..…………………………………Visual Health Information

UK……………………….…………………………………………………United Kingdom

USA…………………………..……………………………United States of America

WMFT………………………………..………………………Wolf Motor Function Test

yrs………………………………..……………………………………………………Years

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Firstly, thank you to my amazing supervisors *Katherine Harding* and *Nicholas Taylor,* who provided such fantastic support and guidance, as well as lots of encouragement and belief that I was capable of completing this thesis. Thank you for your understanding of my complex and crazy lifestyle, setting realistic timeframes and enabling me to balance different commitments whilst supporting me to constantly progress.

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Finally, thanks to my dad Ian for a final read through, as well as my husband Tegyn for his support with this thesis throughout most of our relationship. His handy technical skills and assistance with editing were very much appreciated.

Summary / Abstract

This thesis addressed the problem of finding the most effective way of providing home exercise programs within a community rehabilitation program by comparing traditional paper-based prescription methods with the use of technology.

A randomised controlled trial (RCT) investigated home exercise programs supported by video (n=30) compared with paper-based home exercise programs (n=32) in patients with stroke. Video exercise instructions were not superior to paper-based home exercise programs for adherence (MD 2%, 95% CI -12 to 17) or upper limb function (MD 0.02 seconds Wolf Motor Function Test, 95% CI -0.1 to 0.1).

Qualitative analysis (n=10) explored the experience of video exercise instructions to support upper limb home exercise programs post stroke. Participants viewed smart technology as an accessible, novel, and convenient way to provide home exercise programs. Video exercise instructions were not appropriate for everyone but may suit those who already use these devices.

A systematic review and meta-analysis exploring exercise-based interventions for health conditions indicated that multimedia approaches to exercise instruction may result in increased adherence compared with instructions provided in written or verbal format (SMD 0.60, 95% CI -0.06 to 1.25). There was insufficient evidence to determine whether this resulted in improved patient-related outcomes such as pain intensity, uptake of physical activity, or health-related quality of life.

A final project explored cost efficiency with a cost-minimisation approach. Each initial home exercise program provided on a patient’s own electronic device saved 5.5 minutes (95% CI 0.5 to 10.5) with a cost saving of AUD $4.70 (95%CI -8.89 to -0.52) compared with paper-based instructions.

While not superior to paper-based instructions in achieving improved clinical outcomes, video-based instructions using the patient’s own device are a feasible and low-cost method of prescribing exercise programs, and may be provided as an option by allied health professionals working in rehabilitation.

Statement of Authorship

This thesis includes work by the author that has been published as described in the text. Except where reference is made in the text of the thesis, this thesis contains no other material published elsewhere or extracted in whole or in part from a thesis accepted for the award of any other degree or diploma. No other person's work has been used without due acknowledgement in the main text of this thesis. This thesis has not been submitted for the award of any degree or diploma in any other tertiary institution.

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Signed:

Kellie Emmerson

Date: 22 May, 2020

Preface

This thesis comprises a series of published chapters that may be read independently or in the order they appear as part of the overall thesis. Chapters 2 and 4 are presented in published format with permission from *Clinical Rehabilitation*. Chapters 3 and 5 have been published in the *Australian Occupational Therapy Journal* and *Disability and Rehabilitation* respectively, and are presented in pre-publication format as the author-accepted version in accordance with copyright agreements with these journals. All chapters use the referencing and citation style of the particular journal in which they were published.

Each paper presented within this thesis was designed, executed and written by the authors listed. The contribution of the PhD candidate, Kellie Emmerson, towards each paper is described in the publication statements (Appendix 2). Co-authors who contributed to published articles have signed publication statements confirming that the PhD candidate made a significant and leading contribution to the research design, conception, data collection, analysis and interpretation of findings, writing of the manuscript and the reviewing process.

Research procedures reported in this thesis that involved the recruitment of participants were approved by the La Trobe University (FHEC14/269, LR42-2017) and Eastern Health Human Research Ethics Committees (LR98/1213, LR42/2017; Appendix 1).

The remaining chapters, Chapter 1 (Introduction) and Chapter 6 (General discussion) conform to an author-date style of referencing and citation and are written in Australian English. A combined reference list for both chapters appears at the end of this thesis.

In health care literature, different words are used to describe people receiving health services including patients, clients and consumers. The word “patients” has been used for this purpose throughout this thesis. Occasional exceptions may appear in published chapters in keeping with the style of the respective journals.

List of Publications

Chapter 2 **Emmerson KB,** Harding KE, Taylor NF. Home exercise programmes supported by video and automated reminders compared with standard paper-based home exercise programmes in patients with stroke: a randomized controlled trial. *Clinical Rehabilitation*. 2017;31(8):1068-1077. DOI:10.1177/0269215516680856

Chapter 3 **Emmerson KB,** Harding KE, Lockwood KJ, Taylor, NF. Home exercise programs supported by video and automated reminders for patients with stroke: A qualitative analysis. *Australian Occupational Therapy Journal*. 2018;65(3):187-197. DOI: 10.1111/1440-1630.12461

Chapter 4 **Emmerson KB,** Harding KE, Taylor NF. Providing exercise instructions using multimedia may improve adherence but not patient outcomes: a systematic review and meta-analysis. *Clinical Rehabilitation*. 2018; 33(4): 607-618. DOI:0269215518819706

Chapter 5 **Emmerson KB,** Harding KE, Fong C, Taylor NF. A resource analysis of the use of the video function of electronic devices for home exercise instruction in rehabilitation. *Disability and Rehabilitation*. 2019:1-5. DOI:10.1080/09638288.2019.1663281 (early online)

List of Conference Presentations

Emmerson KE, Harding K, Taylor NF. Home exercise programs supported by video and automated reminders for stroke patients: A randomised controlled trial. Occupational Therapy Australia National Conference & Exhibition. Melbourne, Australia, July 3, 2015 (Oral presentation)

Emmerson KE, Harding K, Taylor NF. Home exercise programs supported by video and automated reminders for stroke patients: A qualitative analysis**.** Smart Strokes Conference, Canberra, Australia, August 25, 2016 (Oral Presentation)

Emmerson KE, Harding K, Taylor NF. Home exercise programs supported by electronic tablets compared with standard paper-based home exercise programs in patients with stroke. Occupational Therapy Australia National Conference & Exhibition, Perth, Australia July 20, 2017 (Oral presentation)

Chapter 1: Introduction

Problem Statement

During rehabilitation programs, allied health clinicians commonly prescribe exercises for patients to complete at home. Traditionally, written notes and/or pictures are provided as instructions for patients. These home exercise programs enable increased dosage within the limited scope of allied health clinician time and resources, and promote self-management, with the aim of optimising recovery. However, adherence to home exercise programs is often low. There has been much research on strategies to improve adherence, but there has been less attention on the best way to deliver home exercise programs, particularly in consideration of recent advances in technology. Smart technology presents an opportunity to trial alternative methods of providing home exercise instructions. This thesis addresses the problem of finding the most effective way of providing home exercise programs within a community rehabilitation program by exploring traditional paper-based prescription methods compared with the use of technology.

1.1 Mary's story

When Mary arrived at the emergency department by ambulance with weakness down the right side of her body and slurred speech, she was scared and confused. She was diagnosed with a stroke and transferred to the acute ward. The next day Mary was visited by a physiotherapist who assessed Mary's strength and mobility and instructed her to begin doing some exercises. By the time the physiotherapist had left the ward Mary had already forgotten the instructions. The next day the occupational therapist came in and assessed her arm function and ability to do a few things for herself, like eat her lunch and get dressed. Mary's daughter was on hand to hear the therapist explain what she should be practicing but unfortunately, she had to go and pick up her children from school at 3pm and those precious exercise instructions went with her. The speech pathologist arrived a short time later, conversing with Mary and leaving three pages of instructions, which Mary carefully stowed away in her drawer for later.

A week passed and Mary was transferred to a rehabilitation ward. She was confused and had started feeling a bit down about her loss of independence. As much as she wanted to rest, she was visited by a new physiotherapist, occupational therapist, and speech pathologist, who commenced new exercises and task-specific training to help Mary achieve her goals. To aid recovery and promote self-management, the clinicians each took time between treatment sessions to prepare a set of written instructions describing exercises for Mary to do in between therapy sessions. She gratefully accepted these pieces of paper, and dutifully stored them away for later. Mary was so overwhelmed that she just didn't know where to start, so she didn't do any exercises. Despite this she achieved enough independence in activities of daily living to return home, and Mary was admitted to a community rehabilitation program. She saw a whole new set of clinicians, and was given more exercises to complete, to give herself the best chance of recovery. Pieces of paper with exercise instructions continued to accumulate. They did not really make much sense to Mary, but she reassured herself that it would be ok to wait until she sees one of the clinicians again. She looked forward to the clinicians visiting her at home each week.

This story describes a typical journey of a patient through the Australian health care system, and highlights an issue faced by many people receiving home exercise programs from multiple clinicians over extended periods of time. It is patients like Mary who sparked an initial interest and desire for best practice within the setting of the Community Rehabilitation Program in which this research took place.

1.2 Setting

Community rehabilitation programs are short-term programs designed to enhance recovery after a recent illness or health set-back. Allied health clinicians, including occupational therapists, physiotherapists, and speech pathologists, work with patients to facilitate goal setting, guide recovery and assist them back to participating in their normal and enjoyed daily activities. Treatment can occur either in a group, individually with a therapist, or as a combination of both. Consultations may take place at home or at the rehabilitation centre dependent on individual rehabilitation needs, and patients are often expected to complete exercises and practice tasks independently between therapy sessions. Each week, patients would typically receive between one and three supervised clinical sessions from each relevant allied health profession, for a period of about six weeks.

The studies included in this thesis were completed within a community rehabilitation program that sits within a large publicly funded health network, Eastern Health. Eastern Health provides health services for almost 800,000 people in the eastern metropolitan and outer metropolitan area of Melbourne, Victoria, Australia. Patients receiving community rehabilitation services at Eastern Health are attending for a wide variety of health conditions. Most commonly these are neurological or musculoskeletal in nature.

Patients are asked to pay a modest fee for service contribution that can be waived in the event of hardship.

1.3 Therapeutic Exercise

Therapeutic exercise is defined as the prescription of a structured physical activity program that involves the patient completing voluntary muscle contraction and/or body movement with the aim of relieving symptoms, improving function or improving, retaining or slowing deterioration of health (Licht, 1984; Taylor, Dodd et al., 2007). Therapeutic exercise is commonly prescribed for patients attending a community rehabilitation program, and could include exercise with a focus on aerobic conditioning, muscle strength and endurance exercises, stretching techniques, postural control, balance exercises and task-specific functional training or skill-training exercises (Kilsner, Colby et al., 2018). Therapeutic exercise is prescribed for many different health conditions, with evidence for benefits to those with both acute and chronic conditions (Smidt, de Vet et al., 2005; Kujala, 2009; Hoffmann, Maher et al., 2016). There is strong evidence indicating benefits for patients with multiple sclerosis (Taylor, Dodd et al., 2007; Canavan, 2016), osteoarthritis of the knee (Taylor, Dodd et al., 2007; Tanaka, Ozawa et al., 2013; Uthman, van der Windt et al., 2013; Hoffmann, Maher et al., 2016), chronic low back pain (Taylor, Dodd et al., 2007; Searle, Spink et al., 2015; Gordon and Bloxham, 2016; Hoffmann, Maher et al., 2016), coronary heart disease (Taylor, Dodd et al., 2007; Anderson, Thompson et al., 2016; Hoffmann, Maher et al., 2016), chronic heart failure (Taylor, Dodd et al., 2007; Sagar, Davies et al., 2015; Hoffmann, Maher et al., 2016; Palmer, Bowles et al., 2018), chronic obstructive pulmonary disease (Taylor, Dodd et al., 2007; Kujala, 2009; McCarthy B, Casey D et al., 2015), and for those with cancer (Segal, Zwaal et al., 2017; Stout, Baima et al., 2017).

Exercise prescription, like any prescription, has a type and dose, a dosing frequency, a duration of treatment, a therapeutic goal, and anticipated adverse effects (Moore, 2004). Effective exercise programs have common characteristics; they involve patient-related instruction in which a therapist helps a patient to reduce impairments and activity limitations, and how to participate fully in the plan of care to achieve goals (Kilsner, Colby et al., 2018); and they may be more effective when exercise is individualised or targeted and tailored to the condition (Taylor, Dodd et al., 2007; Frontera, DeLisa et al., 2010; Hoffmann, Maher et al., 2016; Kilsner, Colby et al., 2018). They also appear to be more effective when engagement is intensive, with patients participating in therapeutic exercise four to five times per week at relatively high intensity (Taylor, Dodd et al., 2007).

Dosage

Exercise dose or volume can be described as the product of three discrete variables: frequency, intensity and time (duration) or FIT of exercise (Wasfy and Baggish, 2016; American College of Sports Medicine, 2018; Kilsner, Colby et al., 2018). Frequency describes the number of exercise sessions over a time period (i.e. per week). Exercise intensity is typically quantified in absolute terms as the metabolic cost of an exercise session or, in relative terms, as the performance of a given activity as a function of some percentage of measurable maximal capacity (heart rate, oxygen uptake or metabolic equivalents). Duration reflects the amount of time accrued in a single exercise session and is most often characterised using minutes or hours (Wasfy and Baggish, 2016; American College of Sports Medicine, 2018).

Dosage is specific to the purpose or aim of an exercise and can have a direct impact on outcomes. The FITT (Frequency, Intensity, Time and Type) principles incorporate the components of exercise dosage, with the addition of 'type,' referring to modality (Billinger, Boyne et al., 2015; American College of Sports Medicine, 2018). Physiologic adaptations to exercise are specific to the type of exercise performed, hence specificity of exercise selection is important when aiming to achieve individual patient goals. The prescription of an effective therapeutic exercise program requires the right dosage of the right exercise, at the right time for that patient (Brody, 2012).

If the purpose of an exercise is to improve any elements of muscle performance, dosage will vary depending on the specific muscle performance aim. Muscular fitness refers collectively to strength, power and endurance (American College of Sports Medicine, 2018). To improve muscle strength, exercises are best performed by muscle groups lifting, lowering, or controlling heavy loads for a relatively low number of repetitions over a short period of time until the point of muscle fatigue is reached. If the focus is more on power, this can be enhanced by either increasing the work a muscle must perform within a specified time period or reducing the amount of time required to produce a given force (fast-velocity muscular contractions). If the overall aim is improving muscular endurance, exercise prescription would involve lower intensity muscle contractions with a large number of repetitions over a longer time period (Garber, Blissmer et al., 2011; Kisner and Colby, 2012; American College of Sports Medicine, 2018). Resistance training guidelines for general muscular fitness suggest each major muscle group is trained two to three days per week. The resistance training stimulus must be progressively increased as strength increases if additional gains for any component are to be accrued (Garber, Blissmer et al., 2011; American College of Sports Medicine, 2018).

If the purpose of an exercise is to improve aerobic or cardiorespiratory fitness, rhythmic aerobic exercise of moderate (64-76% max heart rate) to vigorous (77-95% max heart rate) intensity exercise that involves large muscle groups and requires little skill to perform is recommended for 30 to 60 minutes on at least five days of the week. (Garber, Blissmer et al., 2011; American College of Sports Medicine, 2018). This is consistent with the guidelines outlined clearly by the Heart Foundation, "activity on most, preferably all, days every week; aiming for 150 minutes of moderate intensity or vigorous intensity physical activity each week" (Heart Foundation, 2019).

Although there are well developed guidelines for improving muscle and aerobic fitness, in rehabilitation the goal is often to improve goal-related participation in everyday activities. For this reason, exercises in community rehabilitation prescribed by occupational therapists and physiotherapists often involve task-specific training or neuromotor exercise training (Garber, Blissmer et al., 2011). Task-specific training refers to therapy involving intentional practice of a specific movement, action or task, such as reaching for a cup (Bayona, Bitensky et al., 2005; McCluskey, Lannin et al., 2017). Task-specific training regimens performed two to three days per week (Garber, Blissmer et al., 2011) can produce cortical reorganization and associated, meaningful functional improvements (Bayona, Bitensky et al., 2005). There is low to moderate quality evidence that repetitive task-specific training improves both upper and lower limb function for patients following stroke (French, Thomas et al., 2016).

Of particular importance for task-specific training is repetition. More time spent practicing leads to improved performance across many skill areas (McCluskey, Lannin et al., 2017). If the purpose of an exercise is for motor skill learning or neuromuscular activity, dosage requires a high number of repetitions sufficient to make a neurological change (Veerbeek, van Wegen et al., 2014; McCluskey, Lannin et al., 2017). However, there is limited evidence on optimal dose or training regimens (McCluskey, Lannin et al., 2017; American College of Sports Medicine, 2018). Constraint induced movement therapy, for example, requires participants to practice for three to six hours a day, aiming for at least 250 repetitions per hour (Taub, Uswatte et al., 2013). Even early after stroke, high exercise dose may be important, a cohort study finding that completion of more than 703 leg exercise repetitions in the first week of admission was associated with a quicker recovery of unassisted walking (Scrivener, Sherrington et al., 2012). Stroke guidelines reflect this with their recommendations for "as much practice as possible" for both upper limb activity and walking (Stroke Foundation, 2017). It is important to note that specificity and accuracy of performance are important in neuromotor skill performance, and this may be enhanced with feedback mechanisms that are intrinsic (provided by the task itself) or extrinsic in nature (provided by an outside source such as the therapist, biofeedback device or timer) (McCluskey, Lannin et al., 2017).

Supervised versus unsupervised practice

Therapeutic exercise can be supervised or unsupervised. Supervision by an experienced exercise professional can enhance accuracy and adherence to exercise, may improve safety for individuals with chronic diseases and health conditions (American College of Sports Medicine, 2018), and may also improve functional outcomes. A Cochrane review of 14 randomised controlled trials, updated in 2018 for a total of 21 trials, found statistically significant improvements in maximal treadmill walking distance for participants with intermittent claudication who engaged in supervised practice when compared with unsupervised practice (Fokkenrood, Bendermacher et al., 2013; Hageman, Fokkenrood et al., 2018). Another systematic review of 11 randomised controlled trials found improved measures of balance and muscle strength/power in older adults when balance and resistance training was supervised compared to unsupervised (Lacroix, Hortobágyi et al., 2017).

Despite these findings from systematic reviews a number of randomised controlled trials have reported no differences in functional outcomes between supervised or unsupervised groups following a period of strength/resistance training (Olney, Nymark et al., 2006; Hartvigsen, Morsø et al., 2010; Orange, Marshall et al., 2019). However, it must be considered whether these individual trials had sufficient power to detect meaningful differences. Despite some uncertainty, if clinicians are not available to supervise, unsupervised practice such as a home exercise program may be a practical way to achieve recommended intensity and dosage. The community rehabilitation model aligns with suggestions to include some supervised training in a weekly program (Lacroix, Hortobágyi et al., 2017) but with a strong emphasis on home exercise programs as an important part of a patient’s rehabilitation.

1.4 Home exercise programs

Home exercise programs are defined as exercises completed at home under the indirect supervision of a trained therapist (Heart and Stroke Foundation of Canada, 2018). Also known as home exercise instructions, or as home programs, these are an important part of many rehabilitation programs, with high quality evidence supporting their effectiveness (Novak, 2011). They are not designed to replace time spent within therapy sessions, but to add intensity and dosage by adding more practice time at home. National guidelines for stroke (Stroke Foundation, 2017), arthritis (Arthritis Australia, 2014), and cardiac rehabilitation (National Heart Foundation of Australia, 2004) all recommend home exercise programs as an adjunct to face-to-face therapy. While often unsupervised, home exercise programs can also enable family to be involved in rehabilitation and therefore provide some level of supervision and engagement in self-management.

1.5 Self-management

The term self-management was used to suggest that patients are active participants in their own treatments (Lorig and Holman, 2003). This definition has evolved over time, and commonly refers to chronic illness management (Grady and Gough, 2014), but it is also important in the rehabilitation of more acute injuries. To optimise motor learning and improve long-term outcomes, self-management should be an explicit component of rehabilitation care (Dobkin, 2016). With guidance, home exercise programs can provide an avenue to promote self-management, facilitating motivation, sense of responsibility and confidence to practice (Dobkin, 2016; Poureslami, Kwan et al., 2016). This, in turn, can result in greater adherence and increased dosage to optimise functional outcomes, as well as improving long-term exercise behaviour (Mansfield, Knorr et al., 2016).

Adherence

Adherence is defined as, “the extent to which a person’s behaviour – taking medication, following a diet, and/or executing lifestyle changes, corresponds with agreed recommendations from a health care provider” (World Health Organisation, 2003). This definition has been adapted to encompass exercise and indicate the inclusion of participation, quantity and technique; “the extent to which an individual corresponds with the quantity and quality of exercise, as prescribed by their health care professional," (Argent, Daly et al., 2018). Adherence and non-adherence can be described in numerous ways. A patient is typically described as non-adherent if they fail to complete a certain proportion of recommended exercise repetitions, recommended exercise duration, or recommended exercise frequency (Essery, Geraghty et al., 2017). Given the importance of exercise dosage identified for improvement, adherence is an important factor in fulfilling home exercise completion. Patients who fail to adhere to the prescribed exercise program may extend the duration of their treatment, negatively impact on the therapeutic relationship, and make treatment less effective (Pisters, Veenhof et al., 2010; Argent, Daly et al., 2018). A survey of 73 occupational therapists indicated that patient's goals and interests were commonly incorporated to create meaning in a home program, suggesting that personal motivation was a key moderator of adherence (Donoso Brown EV and Fichter R, 2017); however, perhaps this is not enough. Adherence continues to be problematic due to a range of factors (Essery, Geraghty et al., 2017), including lack of self-efficacy, pain, previous physical activity levels, psychological symptoms and lack of social support (Argent, Daly et al., 2018). It is therefore important to explore ways of addressing these factors to improve adherence.

Within this thesis, adherence is referred to as per the definitions above, encompassing prescribed exercise dosage, duration and frequency. However, it is important to note that the terms adherence and compliance are often used interchangeably and in the literature. The main difference is that adherence requires the patient's agreement to the recommendations, whereas compliance implies a lack of patient involvement (World Health Organisation, 2003; Horne, Weinman et al., 2005).

A recent systematic review of 12 fair to high quality randomised controlled trials (Peek, Sanson-Fisher et al., 2016) explored a range of studies that used internal and external interventions to improve exercise adherence. Interventions found to be associated with improvements in adherence included behavioural exercise programming (Pisters, Veenhof et al., 2010), weekly phone calls and home visits (Steele, Belza et al., 2008), verbal instruction supplemented with written instruction relative to verbal instruction alone (Schneiders, Zusman et al., 1998), and use of an objective activity monitor to provide self-monitoring and visual feedback regarding level of physical activity and exercise frequency (Goto, Takedani et al., 2014). There were conflicting results for goal setting as an intervention, perhaps influenced by the method of goal setting. One moderate quality study reported significant improvements when patients were allocated to a goal setting group facilitated by a sports psychologist as opposed to a social support group or usual care (Evans and Hardy, 2002). However, a fair quality study reported no improvements in adherence with either collaborative or physiotherapist mandated goal setting compared with usual care (Bassett and Petrie, 1999). Adherence rates were not improved with provision of an education program with behavioural advice (Alewijnse, Metsemakers et al., 2003) or protection motivation theory (Bassett and Prapavessis, 2011). Moderate quality studies involving counselling, motivational support, action and coping plans, treatment contracts and exercise reporting (Friedrich, Gittler et al., 1998; O'Brien and Bassett, 2013) also reported no improvement to adherence. It was concluded that there was insufficient evidence to support use of these interventions in clinical practice. However, preliminary evidence of improved adherence with provision of written exercise instructions (Schneiders, Zusman et al., 1998) and the use of visual feedback (Goto, Takedani et al., 2014) suggested the mode of exercise instruction may be important.

1.6 Mode of prescription

Only 40% of all Australian adults can understand and follow health messages in the way in which they are usually presented (Australian Commission on Safety and Quality in Health Care, 2014). This is a problem, and actions are being taken as a key priority on all levels (government, civil society, media, community leaders and research and academic institutions) to improve the approach to the provision of health information (World Health Organisation, 2020). Health literacy is defined as the way in which people understand information about health and health care, and how they apply that information to their lives, use it to make decisions and act on it (Australian Commission on Safety and Quality in Health Care, 2014).

At a local level, there are simple ways to improve health literacy. Communicating health messages in different ways or via different modes can appeal to different learning styles (Giuse, Koonce et al., 2012) and promote increased motivation (Inott and Kennedy, 2011). Use of multimedia has been shown to increase health knowledge for those with low health literacy (Kandula, Nsiah-Kumi et al., 2009). Alternative modes of exercise instruction may assist patients in personalising, comprehending and following through on advice.

Written/paper-based instructions

Written notes or pictures are commonly provided as instructions for patients when they are prescribed home exercises. Paper-based instructions can be easily and cheaply integrated into exercise practice (Peek, Sanson-Fisher et al., 2016), and have been reported to improve adherence when added to verbal instruction alone (Schneiders, Zusman et al., 1998). Sometimes these are hand-written and other times they are generated using computer programs such as Visual Health Information (VHI) (Beaulieu, 2016) or HEP2go (HEP2go Inc, 2010), and then printed. While occasionally these instructions are written alongside the patient, preparation prior to patient appointments is also common to ensure accuracy and legibility without reducing time for quality face-to-face patient interactions. This can be time consuming for clinicians (Australian Commission on Safety and Quality in Health Care, 2012) who need to find time to produce and regularly update, multiple home programs alongside busy clinical workloads, administration and quality projects. Written instructions also tend to be generic and can vary in the level of detail provided by a clinician. There is risk of misunderstanding. They can be difficult to read. Unless a patient is well-organised, growing collections of paper can get confusing and lost around the home. It was these anecdotal observations that led to the idea that there might now be a better way to provide home exercise instructions.

Technology

A systematic review exploring interventions to aid patient adherence (Peek, Sanson-Fisher et al., 2016) included two trials of fair quality that found no additional benefits in providing a video tape of customised exercises (Lysack, Dama et al., 2005; Schoo, Morris et al., 2005). These trials were completed 15 years ago, in which time significant advances to technology have been made. It has become more common for patients presenting for community rehabilitation to be using various forms of smart technology in their day-to-day lives. A *smart* device is an electronic gadget that is able to connect, share and interact with its user and other smart devices (Techopedia, 2020). Observed common uses included calling and sending text messages, managing appointments, interacting on social media, taking photos, and for sourcing information on the World

Wide Web. Australian Bureau of Statistics data from the Multipurpose Household Survey for 2016-17 indicated that 91% of internet connected households were using smart phones, and 66% using tablets (Australian Bureau of Statistics, 2018). Likewise the 2016 American Community Survey Report indicated that 76% of households had a smart phone, and 58% had a tablet (Ryan, 2017). Cisco anticipates that by 2022, nearly three-quarters of all devices connected to the mobile network globally will be ‘smart’ devices (Cisco, 2018). The idea for this thesis was born out of the observation that use and accessibility of technology was becoming increasingly common among patients attending community rehabilitation programs. This led to the development of a hypothesis that smart devices might provide a simple and effective way of enhancing adherence to rehabilitation programs.

There are now thousands of ‘apps’ or applications on smart devices available for all sorts of activities from playing games, to checking the weather forecast and online banking. Given the huge uptake in everyday life, it is not surprising that smart technology is being adopted in rehabilitation settings for a wide range of purposes. A 2019 systematic review of six high quality randomised controlled trials concluded that there is insufficient evidence to support the clinical benefit of personal smart technologies to improve outcomes in acquired brain injury (Kettlewell J, das Nair R et al., 2019). However, smart technology is commonly used and has shown to be effective for such things as: cognitive rehabilitation (Cogollor JM, Rojo-Lacal J et al., 2018); cognitive compensatory strategies such as memory aids (Mokhtari, Aloulou et al., 2012; Charters, Gillett et al., 2015); reducing progression of cognitive decline (Liapis and Harding, 2017); assisting with communication (Zheng, Lynch et al., 2016; Faltynek, Salter et al., 2018; Pugliese M, Ramsay T et al., 2018) and; improving fine motor skills (Pugliese M, Ramsay T et al., 2018).

A recent systematic review of 102 studies explored medical mobile applications used in environments relevant to physical medicine and rehabilitation (Nussbaum, Kelly et al., 2019). This review identified applications within four main categories: lifestyle-oriented apps (eg. Tracking progress for things like diet or menstruation); patient-oriented apps (eg. Monitoring symptoms for chronic health conditions); clinician-oriented apps (eg. medical decision making); and mHealth systems to support service delivery (eg. telehealth). There were eight different study designs found in this review, and only nine of the included studies were randomised controlled trials. Approximately a third of the studies used apps as an intervention (including exercise prescription) with reported positive effects on functional outcomes including gait, mobility and self-management skills, and health outcomes such as disease symptoms, pain, health care use and quality of life. However, due to the low number of randomised controlled trials contributing to these conclusions, and the increased risk of bias with other designs, these conclusions must be treated with caution.

There are now many applications specifically focused on exercise that are designed to promote performance, consistency and adherence. They are marketed in a way that appeals to those aiming for self-improvement; however, these must be used with caution. While apps that fall under the definition of ‘Medical device’ (such as apps with software algorithms to support diagnosis) are regulated in Australia by the Therapeutic Goods Administration (TGA) (Therapeutic Goods Administration, 2018) there is no regulation of health and lifestyle apps that do not meet the definition of a medical device. Hence there is little regulation of exercise-based apps. Anyone can design and promote an exercise-based app, without any consideration of the evidence. A recent systematic review of 74 studies concluded that apps pose can clinical risks to consumers. This review considered apps falling into five distinct categories (wellness management, disease management, self-diagnosis, medication reminder, physical medicine and rehabilitation), and identified a total of 80 safety concerns. Most related to the quality of information, including incorrect or incomplete information, variation in content, and incorrect or inappropriate response to consumer needs (Akbar, Coiera et al., 2019).

Aside from the lack of governance overseeing exercise-based apps, other barriers include cost, maintenance, security and technological skill (Kao and Liebovitz, 2017; Zhou, Bao et al., 2019). Applications can be expensive and often require regular updating in order to remain functional. Not all apps work on all devices. It can be difficult to individualise apps, and all require some level of skill in order update and use. An alternative to specialised applications is to make better use of simple tools commonly available on all smart devices, such as the camera, GPS map, alarm and calendar. Given the barriers identified in using non-standard 'applications,' and the fact that community rehabilitation programs typically provide services for an older population less familiar with technology, studies reported in this thesis focused on making use of the video and reminder functions common to all smart technology.

This thesis describes studies that used the basic tools available on all smart devices to prescribe home exercise instructions. This program of research investigates whether filming patients completing their own exercises has advantages over traditional paper-based exercise prescription methods in terms of clinical effectiveness, adherence, user experience and service efficiency.

1.7 Research aim

The aim of this thesis is to investigate the use of multimedia exercise instructions provided using smart technology compared with traditional verbal and paper-based exercise instructions. Patient-related outcomes are considered, including upper limb function, satisfaction and perception, as well as service-related outcomes including adherence, time efficiency for allied health professionals and cost-minimisation.

1.8 Outline of thesis and research program

This thesis explores adherence, functional outcomes, patient satisfaction and overall costs of home exercise programs when exercise instructions are presented in various formats. It specifically considers multimedia or electronic programs in comparison to paper-based or written programs. It comes from both patient and health service perspectives, to provide a broad view and assist health professionals to make the most appropriate decisions for their patients when providing home exercise programs in their rehabilitation.

This thesis comprises four studies presented as a series of published papers (Chapter 2 to 5). Each chapter is presented in the format that it was published, intended to stand alone but can be read in order as part of the entire thesis.

Chapter 2 is a randomised controlled trial designed to investigate whether patients with stroke, receiving rehabilitation for upper limb deficits, demonstrate greater adherence and better functional outcomes when home exercise instructions are provided using smart technology (video and reminder functions) when compared with traditional paper-based instructions.

Chapter 3 is a qualitative analysis completed as part of a convergent mixed methods study alongside the randomised controlled trial to explore the lived experience of patients using touch screen tablets to support an upper limb home exercise program post stroke.

Chapter 4 is systematic review of the literature to synthesise evidence about whether patients receiving exercise-based interventions for health conditions have better outcomes when exercise instructions are provided using multimedia approaches compared with verbal or written instructions. This chapter followed the quantitative and qualitative chapters reporting the results of an intervention on patients after stroke, to synthesise the evidence more broadly. It includes a number of meta-analyses of the data, including the trial that comprises Chapter 2 of this thesis.

Chapter 5 is an observational cohort study taking a cost minimisation approach to compare resources required to provide paper-based versus videoed instructions for home exercise in rehabilitation.

Chapter 6 uses the RE-AIM framework (Gaglio, Shoup et al., 2013) to discuss the key findings, clinical implications of the research, strengths and limitations and provides direction for future research.

Table 1. Summary table

Chapter	Method	Population	Objective
1	Introduction	n/a	Introduction
2	Randomised controlled trial	Patients with stroke attending a community rehabilitation program.	Investigates whether patients, receiving rehabilitation for upper limb deficits, demonstrate greater adherence and better functional outcomes when home exercise instructions are provided using smart technology (video and reminder functions) when compared with traditional paper-based instructions.
3	Qualitative analysis	Patients with stroke attending a community rehabilitation program.	Explores the lived experience of patients using touch screen tablets to support an upper limb home exercise program post stroke.
4	Systematic review and meta-analysis	Patients receiving exercise-based interventions for health conditions.	Synthesis of evidence about whether patients receiving exercise-based interventions for health conditions have better outcomes when exercise instructions are provided using multimedia approaches compared with verbal or written instructions.
5	Observational cohort study	Allied health professionals (physiotherapists, occupational therapists and speech pathologists) providing exercise instructions for patients attending a community rehabilitation program.	Takes a cost minimisation approach to compare resources required to provide paper-based versus videoed instructions for home exercise instruction.
6	Summary	n/a	Key findings, clinical implications, strengths and limitations, and direction for future research.

Chapter 2: Randomised Controlled Trial

2.1 Introduction

Allied health professionals working in rehabilitation frequently prescribe home exercise programs for patients to practice independently between therapy sessions. Traditionally, written notes and/or pictures are provided as instructions for patients. However, smart technology presents an opportunity to trial alternative methods of providing home exercise instructions.

Chapter 2 presents the randomised controlled trial completed to determine whether patients with stroke receiving rehabilitation for upper limb deficits receiving exercise instructions using smart technology (video and reminder functions) demonstrate greater adherence to prescribed home exercise programmes and better functional outcomes when compared with traditional paper-based exercise instruction.

2.2 Study one

This paper is presented in published format (Emmerson et al, 2017):

> Emmerson K, Harding KE, Taylor NF. Home exercise programmes supported by video and automated reminders compared with standard paper-based home exercise programmes in patients with stroke: a randomized controlled trial. *Clinical Rehabilitation.* 2017;31(8):1068-1077. DOI: 10.1177/0269215516680856

Original Article

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Home exercise programmes supported by video and automated reminders compared with standard paper-based home exercise programmes in patients with stroke: A randomized controlled trial

Kellie B Emmerson[1,2], Katherine E Harding[1,2] and Nicholas F Taylor[1,2]

Abstract

Objective: To determine whether patients with stroke receiving rehabilitation for upper limb deficits using smart technology (video and reminder functions) demonstrate greater adherence to prescribed home exercise programmes and better functional outcomes when compared with traditional paper-based exercise prescription.
Design: Randomized controlled trial comparing upper limb home exercise programmes supported by video and automated reminders on smart technology, with standard paper-based home exercise programmes.
Setting: A community rehabilitation programme within a large metropolitan health service.
Subjects: Patients with stroke with upper limb deficits, referred for outpatient rehabilitation.
Interventions: Participants were randomly assigned to the control (paper-based home exercise programme) or intervention group (home exercise programme filmed on an electronic tablet, with an automated reminder). Both groups completed their prescribed home exercise programme for four weeks.
Main measures: The primary outcome was adherence using a self-reported log book. Secondary outcomes were change in upper limb function and patient satisfaction.
Results: A total of 62 participants were allocated to the intervention ($n=30$) and control groups ($n=32$). There were no differences between the groups for measures of adherence (mean difference 2%, 95% CI −12 to 17) or change in the Wolf Motor Function Test log transformed time (mean difference 0.02 seconds, 95% CI −0.1 to 0.1). There were no between-group differences in how participants found instructions ($p=0.452$), whether they remembered to do their exercises ($p=0.485$), or whether they enjoyed doing their exercises ($p=0.864$).
Conclusions: The use of smart technology was not superior to standard paper-based home exercise programmes for patients recovering from stroke.

[1]School of Allied Health, La Trobe University, Australia
[2]Eastern Health, Australia

Corresponding author:
Kellie Emmerson, Community Rehabilitation Program, Peter James Centre- Eastern Health, PO Box 3030, Burwood East, VIC 3131, Australia.
Email: kellie.emmerson@easternhealth.org.au

This trial design was registered prospectively with the Australian and New Zealand Clinical Trials Register, ID: ACTRN 12613000786796. http://www.anzctr.org.au/trialSearch.aspx

Keywords
Stroke, rehabilitation, home exercise programme, upper extremity, occupational therapy, technology

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Introduction

Clinical practice guidelines indicate that for the best outcome, rehabilitation should be structured to provide as much practice as possible within the first six months after stroke,[1,2] and that patients should be encouraged to continue to practice skills they learn in therapy sessions throughout the remainder of the day.[1,2] Consistent with these guidelines, allied health professionals working in rehabilitation frequently prescribe home exercise programmes for patients to practice independently between therapy sessions.[3,4]

Patients who most closely follow their treatment recommendations experience better treatment outcomes.[5] However, patients who are older, in poor health, or experiencing anxiety, depression, or mental health problems, typically have low adherence to home exercise programmes.[6] Poor adherence to home exercise programmes has been identified as a factor that may contribute to disability in patients after stroke.[7]

Traditionally, written notes and/or pictures have been provided as reminders to clients when prescribing home exercises. However, these paper-based programmes are sometimes difficult to follow for patients.[8] The mode of delivery of information can make a difference to recall and compliance, with visual information appearing to be more beneficial than verbal information alone.[9–12] The format of home exercise programme may be a significant factor in determining adherence and therefore functional outcomes.

Smart technology, including smart phones and touch-screen tablets, are becoming increasingly accessible and offer an opportunity to enhance the presentation of home exercise programmes. As of January 2015, 80% of Internet users globally owned a smart phone and 47% owned a tablet.[13] These devices provide easy access to tools, such as reminder functions and video recording, that could be used to complement existing rehabilitation programmes.[1,11,14–16] Little is known however, about the impact of smart technology and video-assisted home programmes on adherence to exercise programmes and clinical outcomes.

The primary aim of this randomized controlled trial was to compare adherence to prescribed upper limb home exercise programs provided using video and reminder functions on touch-screen tablets for patients recovering from stroke, compared with home exercises provided using a paper-based format. Secondary aims were to explore effectiveness of these programmes on upper limb functional outcomes, and to explore patient satisfaction with mode of prescription.

Method

A randomized, controlled, assessor-blinded clinical trial was conducted between February 2014 and January 2016. Participants were recruited from two community rehabilitation programme sites within one large metropolitan health service in Melbourne. Health service and university ethics committee approvals were obtained prior to the study commencing. The trial was registered prospectively with the Australia New Zealand Clinical Trials Registry (ACTRN 12613000786796). Written informed consent was obtained from all participants, or from carers of participants with cognitive deficits.

Participants were eligible for inclusion if they had a diagnosis of stroke resulting in any degree of impairment to upper limb function, and had been

Table 1. Home exercises – most common examples under categories.

Stretching/range of movement (Typically more gross motor)	Strengthening (Both gross and fine motor)	Fine motor/coordination (Typically more functional)
Shoulder elevation/depression	Shoulder flexion against gravity	Picking up toothpicks
Shoulder protraction/retraction	Shoulder abduction against gravity	Picking up beans/marbles/coins
Shoulder rolls	Shoulder external rotation	Flipping buttons/coins/cars
Shoulder flexion- hands clasped	Elbow extension against gravity	Writing
Horizontal shoulder abduction	Wrist extension against gravity	Thumb abduction/opposition
Wrist extension stretch	Supination/pronation	Pegs
Polishing table	Supine, large circles from shoulder	Typing
Supination stretch	Electrical stimulation	Throw/catch ball
Prayer stretch	Theraputty pinch	Grasp/release cup
Active assisted elbow flexion	Theraputty squeeze	Paper scrunch

referred for occupational therapy. They were excluded if they had visual or cognitive deficits that would prevent use of the technology; or no carer or family member was available to provide daily assistance (where necessary).

Participants were randomly assigned to the control and experimental groups using a block randomization sequence with allocation concealed using sealed opaque envelopes. An independent researcher, who had no other role in patient recruitment or management, prepared and managed the randomization process from an independent off-site office. After completion of baseline assessments, participants were allocated to their treatment group by opening the next envelope in the allocation sequence.

Participants allocated to the intervention group were provided with an iPad tablet for use during the trial and were instructed in the use of the tablet (Appendix 1, available online). During the first therapy session, a home exercise programme was developed by the occupational therapist with the participant, according to usual practice. The tablet was used to video the participant performing their home exercise programme with commentary from the therapist. A reminder/alarm was also set up to provide both a visual and audio daily exercise cue. Videos were updated throughout the programme upon review with the treating occupational therapist.

Participants in the control group were given instructions for their home exercise programme in a written format, often including diagrams, during their first therapy session. The therapist supervised the participant as they practised their programme, and exercises were updated throughout the programme upon review with the treating clinician. Participants in the control group who owned or had easy access to a touch-screen tablet were asked not to use video or reminder functions on their device as part of therapy programmes. However, these participants were offered a video home exercise programme at the end of the trial.

Participants were asked to complete their home exercise programmes for a period of four weeks. After this time, follow-up outcome measures were collected by an assessor blinded to group allocation.

The content of both the video and paper-based home exercise programmes was based on the recommendations from the National Stroke Foundation Clinical Guidelines,[1] including techniques such as constraint-induced movement therapy, repetitive task-specific training, mirror therapy, and bilateral training. Content varied depending on individual deficits. The number of exercises within a programme varied, as did the number of recommended sessions per day. Home programmes were typically recommended to be completed once to twice per day. Three general categories of exercise were prescribed: stretching/range of movement; strengthening; and fine motor/coordination exercises (Table 1). All participants completed their usual individual therapy and group programmes throughout the trial period.

The primary outcome of *adherence* was measured by a self-report logbook. This recorded how many sessions were conducted per day, how much time was spent engaging in home exercises per day, and the proportion of prescribed exercises that were completed during any given session. Participants were asked to tick whether they completed 'less than half', 'about half', 'more than half', or 'all' of their home exercise programme within each session. For analysis this was converted to percentages. For example, 'less than half' = 25%, 'about half' = 50%, 'more than half' = 75%, and 'all' = 100%.

The secondary outcome of *upper limb function* was assessed with the Wolf Motor Function Test, an index of upper limb motor ability, measured through a series of 15 timed functional tasks, and two strength based tasks.[17–20] The average Wolf Motor Function Test functional scores were used to describe the severity of upper limb impairment at baseline.

The secondary outcome of participant satisfaction, surveyed participant's *perceptions* of their home exercise programmes (paper or video). A customised questionnaire, comprised four questions requiring responses on a Likert scale, collected data on ease of use, ability to remember to complete exercises, level of enjoyment, and level of difficulty.

The primary outcome of exercise adherence, expressed as a percentage of prescribed home exercise programme completed daily and average daily time spent completing home exercise, was compared using independent samples *t*-tests.

The secondary outcome measures for upper limb function were compared at four weeks using analysis of covariance using baseline scores as a covariate. A sample size of 36 participants for each group was identified as necessary to enable detection of a moderate to large effect size on the clinical outcome, the Wolf Motor Function Test (above the minimum clinically significant difference of a 20% change in score[17]) with alpha set at 0.05, and power of 0.8.

The secondary outcome of participant satisfaction was evaluated through distribution of the responses to each of the four questions between the groups using Pearson's chi square.

Results

A total of 81 potentially eligible patients were referred to the community rehabilitation programme from February 2014 to January 2016. Of these, 62 participants were recruited, with 32 randomly allocated to the control group, and 30 allocated to the intervention group (Figure 1). Within the intervention group, seven people used their own smart technology; everyone else was loaned a device for the duration of the intervention period. Three participants in each group were supported by a carer.

There were no adverse events recorded as a result of participation in this trial.

Of 62 participants, there were four withdrawals. One participant died from unrelated medical issues. The other three participants decided to withdraw owing to good progress and self-discharged from the community rehabilitation programme prior to four week assessment. A total of 58 participants completed the study.

The groups appeared well matched for age, gender, time since stroke, type and location of stroke, and severity of upper limb impairment (Table 2).

Mean age of participants was 66 years (SD 16). At baseline, the median number of days since stroke was 120 (interquartile range (IQR) 58–226).

Of the 58 participants who completed the study, 53 returned their logbook at follow-up. There were no differences between the groups for measures of adherence, either in percentage of prescribed home exercises completed (mean difference 2%, 95% CI −12 to 17) or in time spent exercising (mean difference −9 minutes/day, 95% CI −26 to 8) (Table 3).

There were no between-group difference in change in the Wolf Motor Function Test from Week 0 to Week 4 in either time taken (mean difference −5 seconds, 95% CI −11 to 1) or log transformed time taking account of the skewed nature of these data (mean difference 0.02 seconds, 95% CI −0.1 to 0.1) (Table 4). There were no between-group differences in the grip strength item or functional score item of the Wolf Motor Function Test.

There were no between-group differences in how participants found instructions ($p=0.452$), whether they remembered to do their exercises ($p=0.485$), and whether they enjoyed doing their exercises ($p=0.864$) (Table 5). A total of 70% of

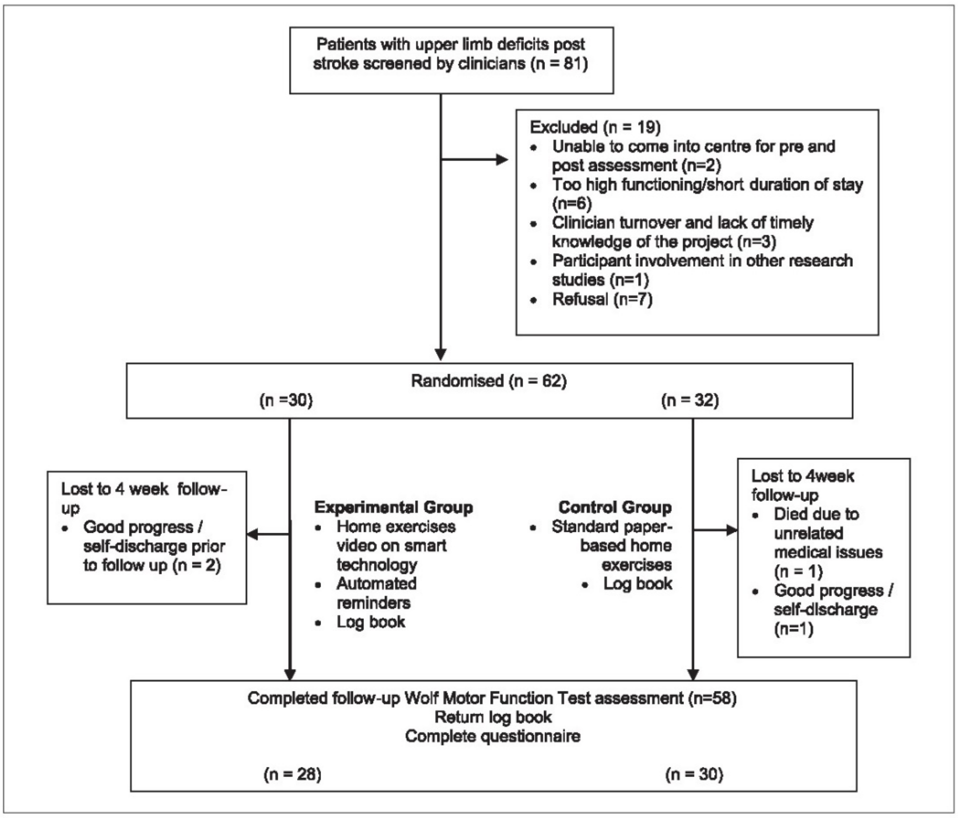

Figure 1. Design and flow of participants through the trial.

participants from the intervention group found instructions easy or very easy to follow, compared with 84% in the control group. A total of 63% of participants in the smart technology group reported that they always remembered to do their exercise compared with 57% in the control group.

A total of 71% of the intervention group reported 'usually' or 'always' enjoying their home exercises, compared with 67% in the control group.

Discussion

Among participants with upper limb impairment post-stroke, there were no group differences in exercise adherence, upper limb function, or satisfaction with use of an electronic tablet to support completion of home exercise when compared with standard, paper-based home exercise provision. The use of this smart technology device, including the alarm function, was not superior to paper-based methods of prescribing home exercise programmes.

There may be no additional functional benefit in prescribing home exercise programmes on electronic tablets when compared with standard practice for patients receiving rehabilitation for upper limb deficit following stroke. However, there also appeared to be no detriment. Both

Table 2. Baseline characteristics of participants.

Characteristic	Total (n=62)	Randomized (n=62)	
		Exp	Con
		(n=30)	(n=32)
Participants			
Age (years), mean (SD)	66 (16)	68 (15)	63 (18)
Gender, *n* males (%)	39 (63)	17 (61)	19 (63)
Time since stroke (days), median (IQR)	120 (58–226)	122 (77–193)	133 (58–228)
Type of stroke (%)			
Infarct	53 (86)	22 (79)	27 (90)
Haemorrhage	9 (15)	6 (21)	3 (10)
Location of stroke (%)			
Right hemisphere	25 (40)	10 (36)	11 (37)
Left hemisphere	35 (57)	18 (64)	17 (57)
Brain stem	2 (3)	0 (0)	2 (7)
Side of hemiplegia (%)			
Left	28 (45)	11 (39)	13 (43)
Right	34 (55)	17 (61)	17 (57)
Severity of upper limb[a] impairment (%)			
Mild	22 (36)	11 (39)	9 (30)
Moderate	20 (32)	9 (32)	10 (33)
Severe	20 (32)	8 (29)	11 (37)

Exp: experimental group; Con: control group; IQR: interquartile range.
[a]Derived from the Wolf Motor Function Test functional scores.

Table 3. Adherence: mean (SD) of groups, mean (SD) difference within groups, and mean (95% CI) difference between groups.

Outcome			Difference between groups
	Exp (n=26/28)	Con (n=27/30)	Exp minus Con (95% confidence interval)
Percentage of HEP completed daily *Mean %*, (SD)	62 (25)	60 (28)	2 (–12 to 17) *p* = 0.785
Time spent completing HEP *Mean minutes/day* (SD)	34 (20)	43 (38)	–9 (–26 to 8) *p* = 0.293
Time spent with OT during intervention period *Hours* (SD)	8.3 (6.2)	8.0 (5.8)	0.3 (–2.8 to 3.3) *p* = 0.871

Exp: experimental group; Con: control group; HEP: home exercise programme; OT: occupational therapist.

groups achieved modest improvements in upper limb function in four weeks, as measured by the Wolf Motor Function Test. The outcome of this trial encourages clinicians and patients to have a choice in the method of home exercise prescription.

Despite the trial results indicating that that there was no significant difference in adherence, functional outcomes, or satisfaction, there may have been other benefits of using a tablet for home exercise prescription; for the patient, for carers, and even for clinicians.

Table 4. Wolf Motor Function Test: Mean (SD) of groups, mean (SD) difference within groups, and mean (95% CI) difference between groups.

Outcome	Groups				Difference within groups		Difference between groups[a]
	Baseline		Week 4		Week 4 minus Week 0		Week 4 minus Week 0
	Exp (*n* = 30)	Con (*n* = 32)	Exp (*n* = 28)	Con (*n* = 30)	Exp	Con	Exp minus Con
WMFT Mean time	39	49	33	45	–8	–4	–5
Seconds (SD)	(44)	(47)	(37)	(44)	(13)	(13)	(–11 to 1) $p = 0.101$
Log WMFT time	1.2	1.3	1.2	1.2	–0.1	–0.1	0.02
Seconds (SD)	(0.6)	(0.7)	(0.6)	(0.7)	(0.2)	(0.1)	(–0.1 to 0.1) $p = 0.688$
Grip strength	10.5	10.8	10.6	11.5	1.4	0.9	0.4
kg (SD)	(11.0)	(10.4)	(8.1)	(10.3)	(2.5)	(4.5)	(–1.5 to 2.3) $p = 0.682$
Functional score	3.1	2.8	3.2	3.0	0.2	0.2	0.1
Mean (SD)	(1.4)	(1.6)	(1.4)	(1.6)	(0.2)	(0.5)	(–0.1 to 0.3) $p = 0.454$

Exp: experimental group; Con: control group; WMFT: Wolf Motor Function Test.
[a]Difference between groups adjusted for baseline with analysis of covariance.

There may be time benefits for the clinician. Although not measured in the current trial, it appears that when prescribing written home exercise programmes, clinicians need to go away with the client's upper limb assessment, and utilise a computer program (such as Visual Health Information software) to develop a home exercise program. By using a tablet, the clinician can commence videoing a home exercise programme within the session, and alter it as needed within subsequent therapy sessions. This means that the patient receives their home exercise programme earlier, and less non-clinical time is required of the clinician. Future studies could evaluate this factor as part of a broader health economic analysis of this intervention.

Other potential benefits of using smart technology to prescribe exercises include accuracy of movement and feedback. Accuracy of movement was not examined. However given the visual feedback provided to patients via the video, this may be evaluated in future studies. Though this was not recorded, the videos have the potential to assist carers in knowing how to help, and enable them to review exercises as needed. A more in-depth qualitative analysis could explore these ideas further, both from the client/carer perspective and from the clinician's perspective.

There were a number of limitations to the study. Functional outcomes may be considered more important than adherence. However, given the hypothesised benefit and the importance of adherence to effective interventions we chose adherence as the primary outcome.

This study had minimal exclusion criteria, resulting in a sample of patients with chronic and acute stroke; both groups are seen within community rehabilitation. It was anticipated that while patients with chronic stroke may not demonstrate a significant gain in function, and may therefore impact the overall secondary outcome measure, adherence, and satisfaction measures would still be relevant. It may be useful to restrict criteria in future studies to those with mild to moderate upper limb impairment following recent stroke, particularly when considering functional outcome measures.

While used widely for neurological upper limb assessment, the Wolf Motor Function Test is

Table 5. Participant satisfaction: Mean (SD) of groups, mean (SD) difference within groups, and mean (95% CI) difference between groups.

Outcome	Week 4		Pearson Chi Square
	Exp (*n*=27)	Con (*n*=30)	
How easy was it to follow instructions? n (%)			3.7 (4), $p=0.452$
Very difficult	2 (7)	1 (3)	
Difficult	1 (4)	0 (0)	
Neither easy or difficult	5 (19)	4 (13)	
Easy	7 (26)	14 (47)	
Very easy	12 (44)	11 (37)	
How often did you remember to do your exercises?			2.5 (3), $p=0.485$
I forgot all the time	1 (4)	0 (0)	
I sometimes forgot	6 (22)	6 (20)	
I usually remembered	3 (11)	7 (23)	
I remembered all the time	17 (63)	17 (57)	
Did you enjoy doing your home exercises?			0.7 (3), $p=0.864$
Never	1 (4)	1 (3)	
Sometimes	7 (26)	9 (30)	
Usually	11 (41)	14 (47)	
Always	8 (30)	6 (20)	
How did you find the level of difficulty of the exercises you were asked to do at home?			0.5 (2), $p=0.769$
Too difficult	2 (7)	1 (3)	
About right	21 (78)	25 (83)	
Too easy	4 (15)	4 (13)	

Exp: experimental group; Con: control group.
Note one survey from experimental group not completed.

targeted at those with mild to moderate upper extremity weakness, and has not been routinely used for evaluation of more severe hemiparetic stroke.[17,21] A floor effect was observed in our trial,[21] preventing accurate representation of performance of severely impaired participants who could not complete many of the tasks required of the assessment. More detailed or accurate information may have been gained by the addition of other upper limb assessments such as the Action Research Arm Test or the Motor Activity Log.[22]

Our planned sample of 72 participants was approached, but not reached, as funding for the trial had stopped. However, the small effect sizes observed suggest that even with an enlarged sample, it would have been unlikely to detect any between-group differences. The four-week timeframe was chosen to reflect community rehabilitation practice. Given the primary outcome measure of adherence, four weeks was deemed an appropriate timeframe to maintain a logbook. This timeframe has also been used to measure adherence outcomes in other studies.[12]

Dosage and content of home exercise programmes were not controlled within this study. However, this reflected clinical practice and random allocation between the groups was expected to account for this factor. The self-report logbook could also be considered a limitation, as patients have been known to over-report. However, self-report logbooks are often used to record adherence within clinical trials.[5,10,12]

Finally, it must be acknowledged that technology is constantly evolving, and since the commencement of the trial, there are many new applications and functions available that may benefit home exercise programmes, including means of remote monitoring. The aim of this trial however, was to avoid the need for special applications and utilise only standard features on smart technology, accessible to anyone in possession of a modern smart phone or touchscreen tablet.

In conclusion, while tablets can be perceived as novel, basic functions are no better than the traditional paper-based method of prescribing home exercises for improving adherence and functional outcomes for patients receiving rehabilitation after stroke. Patients with stroke require trained health professionals to prescribe evidence-based exercises within their home exercise programmes in order to achieve the best functional outcomes. While tablets may present a range of other benefits, individual characteristics and preferences should be taken into account, with both standard and electronic methods being an option for home-based rehabilitation. It is reasonable to tailor a home exercise programme to a patient's preference.

Clinical messages

Among participants with upper limb impairment post-stroke, there were no differences in adherence, upper limb function, or satisfaction when using an electronic tablet to support completion of home exercise compared with paper-based home exercise provision.

Declaration of Conflicting Interests

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Chapter 3: Qualitative Analysis

3.1 Introduction

The randomised controlled trial in Chapter 2 explored the outcome measures of adherence and functional outcomes when patients with stroke received upper limb home exercise instructions electronically using smart technology, compared with traditional paper-based exercise prescription. However, what was the patient experience of utilising smart technology for this purpose? Were there other benefits?

Chapter 3 presents the qualitative analysis completed as part of a convergent mixed methods design alongside the randomised controlled trial. It used in depth, semi-structured interviews to explore the lived experience of patients using touch screen tablets to support their upper limb home exercise programs post stroke.

3.2 Study two

This paper is presented in preprint format, published by *Wyley Online Library* in the *Australian Occupational Therapy Journal* on 11th March 2018, available from: https://onlinelibrary.wiley.com/doi/abs/10.1111/1440-1630.12461

> Emmerson KB, Harding KE, Lockwood KJ, et al. Home exercise programs supported by video and automated reminders for patients with stroke: A qualitative analysis. *Australian Occupational Therapy Journal*. 2018;65(3):187-197. DOI: 10.1111/1440-1630.12461

ABSTRACT

Background: Allied health professionals working in rehabilitation often prescribe home exercise programs. Smart technology offers an alternative format for presentation of home exercise programs with potential advantages over traditional paper-based programs, but how do patients feel about this?

Design: This qualitative analysis was part of a convergent mixed methods design, using in depth, semi-structured interviews to explore the lived experience of patients utilising touch screen tablets to support an upper limb home exercise program post stroke.

Methods: Ten participants with stroke and upper limb impairment who received home exercise programs using video and reminders on tablet computers participated. Interviews were transcribed and analysed thematically.

Results: There were three main themes: 1) exercises on the tablet helped patients' recovery in a variety of ways; 2) everyone could use the tablet for their home exercise program; but 3) not everyone liked using the tablet.

Conclusions and significance of the study: Smart technology is increasingly accessible and provides a novel, convenient way to provide home exercise programs post stroke with a number of benefits. This technology is not for everyone, but may be well suited to patients who already own and use these devices in daily life.

Keywords

Stroke, rehabilitation, home exercise program, upper extremity, occupational therapy, technology

INTRODUCTION

Technology is becoming more widely accepted and used in daily activities. As of January 2015, 80% of internet users globally owned a smart phone and 47% owned a tablet (Mander, 2015). Over 20 years mobile phones have evolved from portable devices used simply for talking, to pocket computers. Standard functions on these devices enable users to communicate in a variety of ways, take photographs and videos, navigate, store and play music and organise their lives with clocks, calendars and reminders.

Technology has been identified as a novel tool for use within stroke rehabilitation. Games and targeted applications available for devices such as the Nintendo Wii, Apple iPads and iPhones, provide potentially useful strategies that can apply learning principles of repetition, intensity, and task-oriented training (Saposnik et al., 2014). Strategies provided by these applications are consistent with recommendations of the Guidelines for Stroke Management (National Stroke Foundation, 2010) and are widely used. In Australia, up to 76% of stroke rehabilitation facilities use these types of commercial gaming systems in their programs (Lam et al., 2015). However, the potential for utilising basic functions on the devices carried in the pockets and handbags of so many patients to augment stroke rehabilitation has received much less attention (Saposnik et al., 2014).

The prescription of home exercise programs is one area in which readily available technology has the potential to enhance patient care. Occupational therapists commonly prescribe home exercise programs for patients with upper limb deficits after stroke to enable the recommended dose of exercise required for ongoing improvement. Despite extensive evidence on the benefits of home exercise programs, adherence is often suboptimal (Lam et al., 2015). Barriers to adherence include motivation and time constraints, fatigue, and lack of equipment (Lam et al., 2015). In addition, home exercise programs have traditionally been provided in a paper-based format. Paper-based instructions can become confusing and disorganised, and use of a single mode of delivery (visual/written instructions) provides additional challenges for patients with visual impairments, language barriers or communication deficits following their stroke. More tailored, multi-modal approaches to communication are recommended to improve health literacy (Australian Commission on Safety and Quality in Healthcare, 2014), and it is reasonable to expect that the same principles could be applied to improve delivery of home exercise programs. The increasing availability of tablet technology and smart phones provides an opportunity to introduce a personalised, multi-media approach to delivering this information using the standard video and reminder features on these devices.

The proportion of people using computers decreases with age (Almeida et al., 2012). Therefore, given that 69% of people who have a stroke are aged 65 years or older (Australian Bureau of Statistics, 2016), one consideration is whether age is a barrier to the incorporation of smart technology into the rehabilitation setting. Findings from focus groups of older adults regarding the use of technology in rehabilitation support these concerns (Lam et al., 2015), with participants suggesting that their age stopped them from reaping the full benefits of such technology due to concerns about their unfamiliarity with managing such tools.

A recent randomised controlled trial comparing the use of tablet technology for home exercise programs post stroke with traditional paper-based home exercise programs (Emmerson, Harding, & Taylor, 2016) provided an opportunity to explore the use and acceptability of technology among older people recovering from stroke. Patients in the intervention group of this trial were provided with an iPad for a four week period, used to film and store video of their individual home exercise program. The trial used only the basic functions of the video and the alarm. There was no difference in adherence, upper limb function, or satisfaction identified between the two different methods of prescription when measured using quantitative scales. Qualitative methods, however, offer potential for a deeper understanding of participants' responses to the use of technology. The current study aimed to explore the patient experience of utilising smart technology to support an upper limb home exercise program post stroke, with focus on acceptance, feasibility, benefits, and barriers.

METHODS

Design

This study involved qualitative research methods using in depth, semi-structured interviews. These provided a means of exploring the patient's experience of using technology for upper limb home exercise programs in greater depth. Prior to commencement of the research, ethics approval was obtained from the relevant hospital and university ethics committees, and all participants provided written informed consent. The design framework was based on phenomenology to understand the lived experience of each individual (Liampputong, 2013) utilising this technology for their rehabilitation. Using convergent mixed methods, the results of the qualitative analysis were triangulated with quantitative results that have been reported elsewhere (Emmerson et al., 2016).

Participants

Participants were included if they had been admitted to a community rehabilitation program in a large metropolitan health service, and had participated in the intervention group of a randomised controlled trial comparing the impact of touch screen tablets to support upper limb home exercise programs with usual care post stroke. Over a four week period, intervention group participants completed an exercise program that was filmed by their therapist on an iPad, and supported by an electronic reminder. They were provided with a basic instruction sheet and demonstration of how to use the iPad. Participants watched themselves on screen while they exercised. Control group participants were provided with a standard, paper-based home exercise program.

Seventy-two participants were recruited into the randomised controlled trial. A consecutive sample of the intervention group from this trial was invited to participate in the current study to explore their experiences of the use of technology in greater depth.

Participants were not excluded if they had receptive or expressive aphasia or a cognitive impairment, as these conditions are common to many of the stroke population requiring an upper limb home exercise program. However, these participants were accompanied by a carer during the interview. Carers had been required to support the home exercise program and were therefore able to provide additional insights. With participants with aphasia or a cognitive impairment, the interviewer used validation techniques and specific closed questions to first elicit a yes or no from the participant. Where further information was required, the carer was encouraged to answer. Participants were recruited until data saturation was achieved.

Data Collection

The interviews were conducted by the principal researcher in a quiet room at the health service. The interviews were recorded using the "Voice Memo" app on an iPhone. Experience of technology for home exercise programs was investigated by asking questions under four broad themes: previous use of technology, experiences of using the technology for home exercises, the impact of this technology on the patient's rehabilitation, and their intentions for future use. An interview schedule was used as a flexible guide to ensure that all topics of interest were covered, while allowing patients to add any further comments (Table 1).

Data analysis

All recorded data from the interviews were transcribed verbatim. The transcribed interviews and the researchers' initial interpretation of the emerging themes were provided to the patient to check for accuracy. Member checking is a quality control process by which a researcher seeks to improve the accuracy, credibility and validity of what has been recorded during a research interview (Harper & Cole, 2012). It helps to ensure that both the transcript and the researcher's interpretations are an accurate representation of the patient's experience (Liampputong, 2013). If participants did not agree with the transcripts or interpretation, they were provided with the opportunity to amend. Transcripts were then de-identified by assigning an identification number to ensure anonymity.

After member-checking of transcripts and initial themes was completed, the transcripts were then read in full by two researchers who examined the data line-by-line and independently assigned codes to sections of text, in order to analyse and interpret data in a meaningful way (Liampputong, 2013). This aspect of analysis was managed with the assistance of qualitative software (NVivo, QSR International). Common themes emerged, and were discussed by the research team until consensus was reached. Wherever possible, direct quotes were used to reflect participant views.

The research process was documented in detail and preserved so that an audit trail was possible.

Reflexivity is used to enhance credibility, recognising the influential experiences and personal history of the researchers (Liampputong, 2013). The principal researcher (KE) is an occupational therapist working clinically across the two community rehabilitation programs used for recruitment. The other researchers (NT and KH) have a background in physiotherapy and occupational therapy respectively, working across a health service and a university, and have experience in qualitative research methods.

RESULTS

Ten male participants with a mean age of 72 years (range 51 to 85 years) were recruited; all had had a stroke resulting in some level of upper limb impairment (two severe, three moderate, five mild). Two participants had an expressive aphasia, and hence their partners assisted with the interview. Participants previous exposure to technology varied. Eight had used a computer in the past (some proficient, others for only basic functions), but only two had ever used a touch screen tablet. Of the nine participants who returned their logbooks, all were classified as adherent, reporting spending at least 15 minutes daily completing their prescribed home expercise program. The average time spent completing the daily upper limb home exercise program was 34 minutes per day.

No participants made changes to the content of their interview transcript or expressed disagreement with the researchers' interpretation of emerging themes during the process of member checking. Table 2 summarises the characteristics of participants.

Three main themes emerged (Table 3): (1) Exercises on the tablet helped rehabilitation; (2) Participants could use the tablet for their home exercise program; (3) but not everyone liked using the tablet.

1. Exercises on the tablet helped rehabilitation

The majority of participants found the tablet useful in their rehabilitation. Many reported improved recovery and recognised that their overall function had improved. Many reported feeling stronger and/or having increased range of movement in their upper limbs.

"I think it was useful. Everything makes progress. They did a sort of evaluation of what I could do with the arm and the hand before and after and everything seemed to be improved on the second evaluation, and what I was doing in the trial was basically the only thing I was doing at the time, so it must have had an effect." (P1)

"I reckon I improved, just in the month." (P2)

"Yes I was definitely getting better range of movement, so that was good." (P6)

Aside from functional recovery, a wide range of other benefits were identified, including increased motivation to complete home exercises, ease of following instructions, improved organisation, and as a way of reviewing progress.

The tablet was a novel way to complete a home exercise program

Participants were intrigued by the tablet, and this provided more interest and motivation to engage in their exercises at home.

"Oh I guess it's more interesting watching a screen rather than reading a boring sheet of paper." (P1)

"Oh, I wasn't nervous. Yeah good value. Something different, you know." (P2)

It was much easier to follow instructions

Participants enjoyed watching themselves complete exercises, and used the visual and auditory feedback to identify where they needed to work harder or in a different way.

"Yeah, so really it helped with the accuracy, in getting them right, so you're working the right muscles." (P6)

"I can see what I'm doing, if I'm doing it wrong you know, and if there were problems in doing it you know, so I could put more effort into it and adjust myself." (P4)

The tablets provided a variety of stimuli to aid replication of exercises, including visual and auditory.

"I could see myself, and there was obviously some comments from the OT when we're doing them, just stressing what was important." (P6)

"Well it gave you a visual run down on what you had to do, which is probably better for understanding exactly what you've gotta do rather than trying to read it and interpret the written word. " (P1)

The tablet encouraged better organisation and adherence

Participants often compared the tablet to a standard, paper-based home exercise program, and recognised that the tablet enabled a convenient way to manage their exercises.

"Ah, beneficial, rather than lots of paper that gets lost." (P2)

"I can just do it at any location. I think it's very convenient." (P5)

It also appeared to be a good memory aid.

"Well number one I used it to make sure I covered all the exercises, so if I'd

forgotten to do one of them, I'd go back and review whether I'd missed one." (P6)

"No you didn't have to remember them, they were there." (P7)

There were benefits for carers too

Carers also found benefits in this method of home exercise program provision. Rather than have to provide one-on-one attention, one carer found that she could just set it up, and go and tend to other chores.

"It freed me up, like I could set it up for him, and he would just copy then, and press the button. That was good." (P10)

Another participant realised that although his family couldn't accompany him to therapy sessions, he could show them everything he had been doing by presenting the videos on the tablet. They could then also assist if required, avoiding the need for face-to-face carer training.

"Oh, the other advantage was that the family, all of my family, could actually see how the exercise was supposed to be done, which was really good." (P6)

Videos enabled a record of progress

It can be difficult for patients to see gains over time. In this study, videos acted as a baseline measure of performance, giving an opportunity to reflect on progress.

"You can see the difference and how you've improved." (P6)

"Yeah so it's very good to have that visual, and you go, 'oh look what I can do now,' and 'oh look what it was.'" (P10)

"So it helps looking at the video to see where he was before." (P5)

2. Participants could use the tablet

Despite some initial anxiety, all participants were able to use the tablet for their home exercise program, with or without support.

Brief training and instructions were important

The instruction sheet prepared by the researchers and provided to participants appeared to be enough to enable basic use of the video function, with some participants requesting further troubleshooting assistance from family. If they so desired, a more detailed user manual for the tablet was also available.

"There were a couple of instructions that I found pretty useful that came with the program." (P6)

"Only the…getting a bit of a run down on how to drive it from the first person who gave it to me. Other than that I didn't need any ongoing assistance." (P1)

Aphasia and/or impaired cognition was not a barrier to use

One participant had a severe expressive aphasia, one had a moderate expressive and receptive aphasia, and some others had cognitive impairments as a result of their stroke. While these conditions presented a greater challenge, they did not stop participants from utilising this technology for their home exercise program, as long as there was a carer to assist.

"But no, it was really helpful, I think especially with someone with memory issues, I thought it was great." (P10)

Physical limitations were not a barrier to use of the tablet

Upper limb home exercise programs were provided on the tablet to address upper limb impairment as a result of the stroke. This in itself presented some difficulties in handling and operating the tablet at times, but participants were all able to problem solve ways to manage.

"There were no specific problems, just ah, undoing the case one handed." (P2)

Assistance from younger family members was helpful for troubleshooting

Most participants had a preconceived view that smart technology was for the younger generation, however used this to their benefit.

"Yeah well particularly when I was trying to save something, or umm, change something on the tablet, I'd get the boys to help me." (P6)

"Oh, my son came and taught me how to use it." (P3)

Using tablets for exercise was a good way to introduce some older people to technology

Despite some initial apprehension and preconceived ideas, following exposure and an opportunity to try the tablet, most participants were more open to the use of this technology, and much less anxious.

"I found it very user friendly, especially for a laddard like me!" (P1)

"The tablet's really simple. It's like a telephone, a bigger telephone really." (P2)

"Once you know what to hit and move, it's not very hard. It's like, when we first

got a new television, a colour television! And you don't know what you're looking at, and it's not on, but eventually someone goes and presses the button, and you get a picture! And then you push it on the bottom and move the pieces this way and that way and get in central on the screen, and it's the same sort of thing, you just don't freak out about it." (P10)

The two participants who owned tablets reported that they were now using them more often. Others advised that they planned on making new purchases or borrowing family member's tablets.

"Well I was thinking of getting one, for my birthday. If the kids put in." (P9)

But some could not justify the cost over their existing computer.

"And the cost and everything else. Like if you're in business or at [son's] age, you can use them all the time. At our age, we've been good for 80 years without them, I can live a bit longer without them." (P8)

3. But not everyone liked using the tablet

While most participants were able to use the tablet for the purpose prescribed, and many became more accepting of the concept, not everyone found it useful, and one in particular did not like it.

Technology makes some people anxious

When allocated to the tablet group, there were mixed responses and some particpants were anxious about using it.

"I thought it might be a bit much." (P10)

"A bit of trepidation, when you press something and goes…woops!" (P7)

Some participants felt that technology is too complex for older people.

Most participants were open to the idea, some a little excited, but others were apprehensive, and a common theme was that people felt they may be too old for technology.

"Well, I mean I'm in my mid 70s. I should be afraid, and have a bit of anxiety over it." (P10)

"I'm not the generation that reacts easily to technology, so I have to be dragged kicking and screaming to embrace it usually, but generally once I get my mind around it I am happy to use it." (P1)

"And because, a lot of new technology don't stick well with older people." (P10)

Tablets were difficult to learn when new to technology

For the participants who already owned a tablet, participation in this project helped to reinforce their positive opinions.

"Well I thought it was a good innovation and it was suggested, and I thought it as ideally suited for that sort of application. And having experienced it, I'm still of that opinion, that it's ideally suited." (P6)

For other participants, this technology was quite a new concept. Some had difficulty following instructions or navigating functions.

"Oh, one day it took me about half an hour. I kept pressing buttons and nothing worked," (P8)

And others forgot that they needed to charge the tablet or weren't sure how to go about it.

"I said to [wife], don't plug it in, 'cos the kids have got leads all over the place, might plug it in the wrong one." (P8)

Two participants continued to have some difficulty and question the benefits. These were the older, less experienced participants.

"I don't think personally I got much benefit out of it." (P8)

"I remembered the exercises but not on the computer. I don't know anything about tablets or anything." (P9)

Other features were rarely used

A purpose of the study was not only to explore the video function, but to look at the whether an electronic reminder system (standard alarm feature) would improve adherence to the completion of a regular home exercise function. Most participants did not find this feature useful, and stopped using it after the first week.

"No, I didn't need reminding, I wanted to get these exercises done so that I could get my hand back to normal.." (P7)

"I remember the exercises, but I couldn't use the alarm." (P3)

"Pretty inaudible. The alarm part of it wasn't all that helpful." (P1)

The tablet offered a range of other features. Those participants who owned tablets or iPhones already tended to use features such as the calendar, stopwatch, email, electronic books, camera, and skype. However, none of the other participants used other features or applications.

Convergence of qualititative and quantitative data

Qualitative findings in this study did not converge with the quantitative data previously reported. Quantitative data demonstrated that there was no difference in function, adherence or satisfaction when prescribed a videoed home exercise program when compared to standard practice. This qualitative study however suggested that despite minimal change in these outcome measures, there was a range of benefits for using technology for this purpose (Table 4).

DISCUSSION

The overall response from participants and family members utilising smart technology for their upper limb home exercise programs was positive. Although some would not *choose* to use smart technology, all participants were *able* to use it for the purpose described, and the majority felt that it helped their recovery.

Learning styles have been shown to influence understanding, performance and retrieval of information in adult education (Dirette & Anderson, 2016); some people benefit from information presented visually, others respond to auditory approaches, and others learn best through kinaesthesia (practice and touch and feel of the movement) (Anbarasi et al., 2015; Education Victoria, 2007). There is also evidence that tailoring the presentation of health information to individual learning styles can improve health literacy (Koonce, Giuse, Kusnoor, Hurley, & Ye, 2015). The findings of this study suggest that a major benefit of touch screen tablets compared to paper-based delivery of information is that they enable multi-modal presentation, through vision, hearing, and touch, promoting well rounded learning (Education Victoria, 2007; Kozica et al., 2015). Participants acknowledged *seeing* themselves and the correct actions, *hearing* the therapist's instructions, and they often commented on physical aspects of utilising the machine.

While technology uptake within the community is at a high level and increasing, uptake within rehabilitation settings has been a slow process, despite the acknowledged benefits of multi-modal therapy provision. It has long been recognised that "major changes needed to take place in clinical practice to take account of the patient's needs as an active learner and the need to increase practice opportunity and time spent in exercising to optimise muscle strength" (Shepherd, 2001). Client motivation specifically has an influence on rehabilitation outcomes (Lam et al., 2015), hence novel interventions and approaches to rehabilitation have been introduced in attempts to achieve adherence and sufficient dosage to induce neuroplastic changes (Tatla et al., 2015). In Australia in 2012, up to 76% of stroke rehabilitation facilities were using commercial gaming systems such as the Nintendo Wii (National Stroke Foundation, 2012). But when it comes to home exercise programs, therapists revert to basic instructions on paper, possibly due to habit, accessibility, or other barriers to change.

Despite many reported benefits of using the tablets, some people felt they were 'too old for technology.' This was consistent with recent findings in which older people were concerned regarding their unfamiliarity with technology, and wanted to ensure it was cost-effective (Lam et al., 2015). This is also a common opinion of clincians, who have reported using technology in a limited capacity due to barriers that include a 'lack of age appropriateness' (Tatla et al., 2015). Despite all users in this study being able to use the technology for the purpose described, there were some who were somewhat apprehensive and anxious about utilising it. In fact, the two oldest participants were also those who had never used a computer, and also the ones who were least accepting of the technology. Technology may not be for everyone; however, recent studies suggest that technology use may have benefits for older people, and there may be additional benefits in promoting its uptake. For example, engagement in moderate physical exercise and computer use late in life has been associated with decreased odds of having mild cognitive impairment (Geda et al., 2012). Computer use has also been associated with a reduced risk of dementia (Almeida et al., 2012), and preliminary epidemiological data suggest that more stimulating environments, may be leading to a reduction in the prevalence of dementia in the community (Almeida et al., 2012; Sachev, 2014). Nevertheless, electronic home exercise prescription must consider the appropriateness and acceptibility to users (Lam et al., 2015). It appears that previous exposure to technology is a key factor here. Similar to Lam's research (Lam et al., 2015), we found most people were open to the integration of technology into rehabilitation as long as it was simple to use and effective.

Smart technology such as touch screen tablets and smartphones are not only accessible but so ingrained in the lifestyles of health service consumers, that they have huge potential for wider use. In Australia in February 2016, the average household had six devices (computer, smart phone or tablet) on which to access the internet (Australian Bureau of Statistics, 2016). Most households who accessed the internet did so through a desktop or laptop computer (94%), followed by households who accessed via mobile or smart phones (86%) and households who accessed via tablets (62%) (Australian Bureau of Statistics, 2016). Potential use of this technology was recognised by a number of participants who suggested that the technology could also be used to support the services provided by other disciplines within the rehabilitation service.

Physiotherapists could easily replicate similar processes utilised in this study for home exercise programs, not only for neurological conditions but for a wide variety of other conditions including joint replacements and sports injuries. On a wider scale, the video function on this technology could be used for training purposes. For example, nursing staff could use the video function for training wound care; occupational therapists could use the video for training the use of different assistive aids.

The current study found that electronic reminder functions in this context may not be as beneficial as initially anticipated; most participants choosing to turn the alarm off after the first week. Home exercises may have been a focal point for patients undergoing a rehabilitation program and less likely to be simply forgotten. Reminder functions are perhaps better suited to activities or tasks that must be completed at a particular time, such as taking medication. Electronic medication reminder systems have shown positive effects on adherence (Paterson, Kinnear, Bond, & McKinstry, 2016). Reasons for non-compliance with home exercise programs are likely to be much more complex, including factors relating to motivation, confidence, time use, availability of carer assistance or understanding of the program, and less likely to be influenced by a simple reminder.

Despite the positive findings from the current qualitative study, results diverged with quantitative findings from the same trial which found that there was no difference between paper-based and tablet-based exercises in adherence, functional outcomes or satisfaction. Particpants reported a range of potential advantages over paper-based programs that were not captured in the outcome measures used in the quantitative outcomes of the trial, such as making the home program more interesting, being able to show family members, and observing progress over time. Also, it must be considered that what participants valued most may have been receving rehabiltiation with the assitance of an expert clinician, so that the mode of exercise delivery might be a lesser consideration. It is possible that semi-structured interviews conducted with participants from the control group receiving a paper-based home exercise program would have been similarly positive about their experiences.

A strength of this study was that it addressed the four criteria of trustworthiness for qualitative analysis; credibility, transferability, dependability and confirmability (Shenton, 2004). A limitation of the study, was that it contained a relatively small sample size and all participants were men. A convenience sample was taken from the final recruits of the randomised controlled trial for the qualitative analysis. Though findings of this study are specific to the patients who were interviewed, data saturation was reached, and consistent themes emerged. It is important to remember that this study looked at basic functions available as standard on smart technology, including the video and alarm. Purpose-designed health care applications for use on touchscreen devices were beyond the scope of this study. Some female partners assisted their husbands with their home exercise programs and within the interview process. However, it would be beneficial to also consider a direct female perspective on the first-hand use of this technology. Future studies should also consider the clinician's perspectives on prescribing smart technology for use, exploring things such as time taken for prescription and updating, and ease of doing so.

CONCLUSION

Prescription of home exercise programs in the form of videos on touch screen devices should be considered within stroke rehabiltation programs on an individual basis. This technology is not for everyone, but may be particularly well suited to patients who already own and use these devices in daily life. The range of benefits described by participants in this study warrants it to be an option for stroke clients in their recovery.

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Ethics:

Eastern Health and La Trobe University ethics committees approved this study. All participants gave written informed consent before the commencement of data collection.

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Competing Interests:

The authors declare no conflict of interest related to this work.

Correspondence:

Ms Kellie Emmerson, Allied Health Clinical Research Office, Eastern Health, VIC Australia. Email: kellie.emmerson@easternhealth.org.au

Table 1. Interview guide.

Theme	Sample questions
Previous use of technology	Tell me about your previous experiences of using a computer. Tell me about your previous experiences of using a smart phone. Tell me about your previous experiences of using an iPad or tablet. Do you own an iPad or tablet? What were your opinions of technology/tablets/iPhones prior to the project?
Experiences of using technology	How did you feel about being given an iPad to use? Describe your overall experience using the iPad? Tell me about some of the positive things you found in using the iPad? Tell me about any problems you had? Tell me about a specific problem you had and how you solved it? Describe what sort of assistance if any that you needed to use the iPad? Describe the training you received in order to use the iPad and how you felt about that? Tell me about your experiences of charging the iPad?
Impact of technology on rehabilitation	How did you find the alarm? What effect did it have on helping you to remember to complete your home exercises? Did you continue to use the alarm? How did the video and therapist feedback impact on your ability to follow the exercises? How did you feel you were able to copy the exercises from the videos? Tell me about any other features of the iPad that you used? Did you look back on the previous videos at all? Describe how looking at the videos over the four weeks made you feel about your own recovery. How do you think the iPad helped your recovery?
Intentions regarding use of technology into the future	Describe how your feelings about use of this technology changed after using it (if at all)? Would you consider purchasing /have you purchased an iPad or tablet since the completion of the project? Explain why. If you had an iPad or tablet prior to the project, how has being involved in this project affected its use; are you now using it more or less? Do you have anything else you would like to add?

Table 2: Participants.

Participant number	Gender	Age	Previous exposure to technology	Previous use of tablet	Time since stroke (months)	Stroke severity	Average time spent on HEP per day (minutes)
1	M	67	Y	N	7.0	Mod	17
2	M	63	Y	N	4.0	Severe	39
3	M	85	N	N	6.0	Mod	75
4	M	72	Y	N	3.5	Mild	15
5	M	51	Y	Y	8.5	Severe	15
6	M	57	Y	Y	4.0	Mod	unknown
7	M	84	Y	N	2.0	Mild	30
8	M	85	N	N	3.5	Mild	17
9	M	79	Y	N	4.0	Mild	33
10	M	73	Y	N	2.0	Mild	65

*Stroke severity as determined by average functional score on all pre-test WMFT items, where 0-1.9=severe, 2-3.9=moderate, 4-5=mild impairment; HEP = home exercise program; M= male.

Table 3: Main Themes.

Exercises on the tablet helped rehabilitation	
	The tablet was a novel way to complete a home exercise program
	It was much easier to follow instructions
	The tablet encouraged better organisation and adherence
	There were benefits for carers too
	Videos enabled a record of progress
Everyone could use the tablet for their home exercise program	
	Brief training and instructions were important
	Aphasia and/or impaired cognition was not a barrier to use
	Physical limitations were not a barrier to use of the tablet
	Assistance from younger family members was helpful for troubleshooting
	Using tablets for exercise was a good way to introduce some older people to technology
But not everyone liked using the tablet	
	Technology made some anxious
	Some participants felt that technology is too complex for ‘older people’
	Tablets were difficult to learn when new to technology
	Other features were rarely used

Table 4: Triangulation of quantitative and qualitative findings

Outcome measures / topic areas	Key quantitative findings	Related themes in qualitative data	Triangulation of data
Adherence	No differences between the groups for measures of adherence. Smart technology group completed 62% (SD 25) of HEP in an average of 34 mins/day. Control group completed 61% (SD 28) of HEP in average of 43 mins/day.	The tablet encouraged better organisation and adherence.	Divergent
Upper limb function	No between-group differences in change in WMFT from week 0 to week 4 (mean difference -5 seconds, 95% CI -11 to 1) or log transformed time (mean difference 0.02 seconds, 95% CI -0.1 to 0.1).	Participants reported improved upper limb function and that using the tablet helped their recovery.	Divergent
Patient satisfaction	No between-group differences in how participants found instructions (p=0.452), whether they remembered to do their exercises (p=0.485), or whether they enjoyed doing their exercises (p=0.864).	The tablet was a novel way to complete HEPs. It was easy to follow instructions. There were benefits for carers too. Aphasia, impaired cognition, and physical limitations were not a barrier to use. Using tablets for exercise was a good way to introduce some older people to technology. Technology makes some people anxious. Tablets can be difficult to learn when new to technology.	Convergent and Divergent

*WMFT: Wolf Motor Function Test; HEP: Home Exercise Program.

Chapter 4: Systematic Review

4.1 Introduction

Chapters 2 and 3 specifically explored home exercise instructions for people with stroke. A systematic review followed, to interpret the findings within the context of existing literature, and to determine whether patients with a wider range of health conditions have better outcomes when exercise instructions are provided using multimedia approaches compared with verbal or written instructions. A wider range of health conditions was included in this review due to the potential learnings and the potential application of this technology to populations other than stroke.

Chapter 4 presents the systematic review and meta-analyses.

4.2 Study three

This paper is presented in published format (Emmerson et al, 2018):

> Emmerson KB, Harding KE, Taylor NF. Providing exercise instructions using multimedia may improve adherence but not patient outcomes: a systematic review and meta-analysis. *Clinical Rehabilitation*. 2018; 33(4): 607-618. DOI:0269215518819706.

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Providing exercise instructions using multimedia may improve adherence but not patient outcomes: a systematic review and meta-analysis

Kellie B Emmerson[1,2], Katherine E Harding[1,3] and Nicholas F Taylor[1,3]

Abstract

Objective: To determine whether patients have better outcomes when exercise instructions are provided using multimedia approaches compared with verbal or written instructions.

Data sources: Electronic databases (MEDLINE, EMBASE, CINAHL, and PsychInfo) searched up to October 2018.

Study selection: Randomized controlled trials exploring exercise-based interventions for health conditions, and comparing instructions provided using multimedia approaches with conventional verbal or written instructions.

Results: Fourteen trials from seven countries were included, with a total of 2156 participants. Diagnoses included orthopaedic, neurological, pulmonary, cardiac, and women's health conditions. A meta-analysis of three trials (140 participants) provided very low-quality evidence that multimedia exercise instructions may be more effective than written instructions in improving exercise adherence (standardized mean difference (SMD) 0.60, 95% confidence interval (CI) –0.06 to 1.25). Two of nine trials that could not be included in the meta-analysis for adherence due to heterogeneity reported that multimedia exercise instructions were more effective than written instructions in improving exercise adherence. Four other meta-analyses (three trials each) found low- to high-quality evidence that provision of exercise instructions using multimedia is no more beneficial than paper-based instructions for patient-related outcomes of pain intensity (SMD 0.09, 95% CI –0.47 to 0.28); uptake of physical activity (SMD 0.07, 95% CI −0.08 to 0.23); or physical (SMD 0.21, –0.21 to 0.64) or emotional (SMD 0.16, 95% CI −0.04 to 0.36) domains of health-related quality of life.

Conclusion: Multimedia approaches to exercise instruction may result in increased adherence compared with instructions provided in written or verbal format, but there is insufficient evidence to determine whether this results in improved patient outcomes.

[1]School of Allied Health, La Trobe University, Melbourne, VIC, Australia
[2]Healesville Hospital and Yarra Valley Health, Eastern Health, Healesville, VIC, Australia
[3]Allied Health Clinical Research Office, Eastern Health, Box Hill, VIC, Australia

Corresponding author:
Kellie B Emmerson, School of Allied Health, La Trobe University, Kingsbury Drive, Melbourne, VIC 3086, Australia.
Emails: 14749109@students.latrobe.edu.au; kellie.emmerson@easternhealth.org.au

Keywords
Exercise therapy, multimedia, randomized controlled trial, treatment adherence and compliance

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Introduction

Prescription of exercise is a common component of rehabilitation for a wide range of health conditions, including multiple sclerosis, osteoarthritis, back pain, heart conditions, and chronic obstructive pulmonary disease.[1] Home exercise programmes are both a positive adjunct to therapy and cost-effective and are often as effective as expert-provided therapy.[2]

Patients who most closely follow their treatment recommendations experience better treatment outcomes.[3] However, patients who are older, in poor health, or experiencing anxiety, depression, or mental health problems, typically have low adherence to home exercise programmes.[4] Exercise instructions provided verbally or using words or diagrams on paper are common forms of delivery of this information. Increased awareness and understanding of different learning styles[5,6] and the emergence of new technology have created opportunities for exercise instructions to be provided in a wider variety of formats, to promote better adherence and ultimately better functional outcomes.

Increasing availability of technology makes the possibility of providing exercise instructions using multimedia efficient and convenient. Mobile phones and tablet devices have the ability to record still images, video, and audio and are readily available to the majority of health consumers. Almost every developed country has at least 90% mobile phone penetration.[7] Australia is one of the leading global adopters of the smart phone at 88% ownership in 2017, with market growth being driven by older generations.[7]

The aim of this systematic review was to determine whether patients have improved adherence and better health outcomes when exercise instructions are provided using multimedia, including video, audio, and/or reminder functions, compared with written or verbal instructions.

Methods

This systematic review is reported according to the Preferred Reporting Items of Systematic Reviews and Meta-Analyses (PRISMA) guidelines.[8] It was registered prospectively with the International Prospective Register of Systematic Reviews (PROSPERO, reference CRD42017055183).

The following electronic bibliographic databases were searched to October 2018: MEDLINE, EMBASE, CINAHL, and PsychInfo. The search combined key concepts of 'instruction' (including 'patient education', 'information', and 'home exercise programme'), 'multimedia' (including 'video', 'audiovisual', and 'mobile device'), and 'traditional format' (including 'written', 'handout', and 'information sheet'). 'Randomized controlled trial' was the final concept in the search. Key words and MeSH terms for each concept were combined with OR and then combined using the AND operator (see Supplemental Appendix 1 for the full search strategy).

To be included, studies had to be randomized controlled trials involving patients receiving exercise-based interventions for health conditions, which compared instructions for these interventions provided using multimedia with verbal or written instructions. Exercise was defined as 'the prescription of a physical activity programme that involves the client undertaking voluntary muscle contraction and/or body movement with the aim of relieving symptoms or improving function, or improving, retraining or slowing deterioration of health'.[1] For the purpose of this review, exercise prescription could include structured (planned, specific exercise) or unstructured exercise (generalized physical activity).[9]

Titles and abstracts were screened independently by two reviewers. Full texts of abstracts were retrieved for those that appeared to meet inclusion criteria, or contained insufficient information to make a decision on inclusion. Full texts were also reviewed independently by two reviewers. Disagreement was managed through discussion until consensus was reached, or by consulting a third reviewer. Agreement between reviewers was estimated using Kappa(κ). A κ value of 0.41–0.60 indicated moderate agreement, 0.61–0.80 good agreement, and 0.81–1.0 excellent agreement.[10]

Data collection process and data items

Extracted information included: full reference details; population (diagnosis, location); sample characteristics (age, gender); duration of study; description of interventions for both control and experimental groups (purpose, recommended dose, format of delivery); and outcome measures. Outcome measures considered both processes (adherence, satisfaction) and patient outcomes (impairment, activity, participation). Data extraction was completed by one reviewer and checked for accuracy by a second reviewer.

Risk of bias was assessed using the Cochrane Risk of Bias Tool.[11] Two reviewers assessed all domains independently, including selection bias (randomized sequence generation and allocation concealment); reporting bias (selective outcome reporting); performance bias (blinding of participants and personnel); detection bias (blinding of outcome assessors); attrition bias (incomplete outcome data); and other sources of bias. Disagreements between the reviewers were resolved through discussion until consensus was reached. The Cochrane handbook discourages the use of scales for summarizing bias,[11] but does suggest weighting domains.[12] Trials were deemed of lower quality if all domains were marked as 'high risk of bias' or 'unclear', or specifically if the domains of random sequence generation, allocation concealment, and blinding for outcome assessment were deemed high risk. Lower quality articles were not excluded from meta-analyses.

The completeness of intervention description for both experimental (multimedia instructions) and comparison (written or verbal instructions) groups of all trials was assessed using the Template for Intervention Description and Replication (TIDieR) checklist.[13] Two reviewers independently applied this checklist to each trial and resolved disagreements through discussion. The percentage of TIDieR items achieved by each trial was reported for experimental and comparison groups.

Summary measures and synthesis of results

Meta-analyses were performed using Review Manager (RevMan) version 5.3.[14] Continuous data were combined using standardized mean differences (SMDs) where a minimum of three trials was homogeneous for interventions and outcomes. Data were combined using the inverse variance method and a random effects model. Where standard deviations were not reported, these were estimated using recommended methods.[11] Positive SMD values were used to indicate that the outcome favoured the experimental group. SMD values of 0.2 indicated a small effect, around 0.5 a moderate effect and 0.8 a large effect.[15]

The Grading of Recommendations, Assessment, Development and Evaluation (GRADE) approach[15] was applied to each meta-analysis to determine risk of bias across trials. This approach involved downgrading the evidence from high to moderate to low and to very low quality based on criteria. Downgrading evidence occurred if (1) a majority of trials in the meta-analysis were deemed lower quality, (2) there was greater than low levels of statistical heterogeneity between trials ($I^2 > 25\%$),[16] or (3) there were large confidence intervals (>0.80) about the SMD. A footnote was used to explain the reasons for the grade applied to each meta-analysis.

Results

The initial search strategy yielded 3326 articles (inclusive of duplicates) (Figure 1). Once duplicates were removed and inclusion and exclusion criteria (Table 1) were applied to titles and abstracts, 21 articles were retrieved for full-text review, with moderate agreement between reviewers κ = 0.51, 95% confidence interval (CI) (0.40–0.62).

Following full-text review, seven articles were excluded.[17–23] Fourteen articles describing the results of 14 trials were included for final review (Table 2).

Included trials investigated a range of clinical populations, including participants being treated

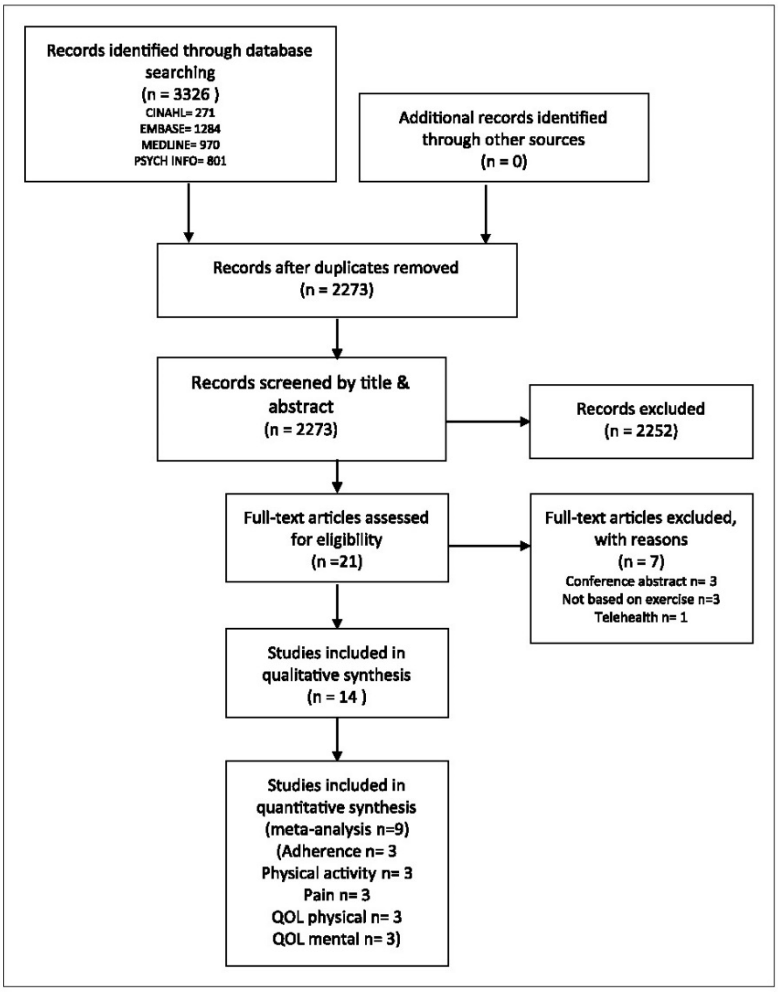

Figure 1. PRISMA flow diagram.

for incontinence (n = 1)[24]; orthopaedic conditions (n = 5)[25,26,34,36,37]; pulmonary conditions (n = 1)[27]; cardiac conditions (n = 1)[28]; voice disorders (n = 1)[29]; traumatic hand injuries (n = 1)[30]; women's health conditions (n = 2), including obesity in pregnancy[32] and breast cancer[33]; and neurological conditions (n = 2).[31,35] Seven countries were represented, all could be considered 'developed'; two were Asian.[33,34,36] Sample sizes varied from 12[29] to 1105.[32] Ten of the trials had exercise durations of four to twelve weeks, with three studies following patients over one to two weeks[29,34,37] and one up to six months.[28] Most participants were outpatients.

Table 1. Inclusion and exclusion criteria.

	Inclusion	Exclusion
Study design	Randomized controlled trials	Systematic reviews Case studies
Participants	Patients/clients (carers if information is targeted at the care of the client and outcomes and outcomes are client related) receiving exercise interventions for health conditions	People not actively seeking/accessing health services Target recipients of health promotion measures, screening, and so on
Intervention	Exercise instructions provided using multimedia approaches, with an intention for patient action/ behaviour change	General information not tailored or selected specifically for individual patients Telemedicine using real-time audio/visual interaction with a clinician
Comparison	Exercise instructions provided in a traditional format – written or verbal	
Outcomes	Improved quality of care Effectiveness – improved health outcomes, adherence, retention of information Safety – avoiding adverse events Patient experience – satisfaction	Clinician outcomes Service level outcomes
Publication	Peer reviewed journal articles	Thesis Abstracts Non-English Book chapters

Multimedia interventions included audiotapes ($n=2$)[24,26]; videotapes or DVDs ($n=10$)[25–32,35]; smart phone applications ($n=2$)[33,36]; and text messages ($n=2$)[34,36]; either alone or in combination. Comparison interventions were typically written instructions, in the form of brochures, instruction sheets, booklets, and pamphlets (Table 2). Most trials recommended at least daily practice of prescribed exercises ($n=9$), while some did not specify the recommended dose ($n=3$).[25,28,32] Overall, dosage was low, ranging from 5 minutes[34] to 1 hour daily.[31] Trial duration ranged from one week to six months. Most trials provided standard instructions for all participants ($n=9$) with others personalizing instructions (e.g. video/audio of the participant or selecting specific exercises based on individual assessment) ($n=5$).[25,29,31,33,35]

The most common outcome was exercise adherence ($n=12$).[24–30,32–36] Other outcomes included physical changes such as exercise tolerance and range of movement ($n=7$),[27,28,33–37] health knowledge ($n=2$),[28,32] health behaviours ($n=3$),[28,32,33] patient satisfaction ($n=6$),[25,29,30,33–35] pain intensity ($n=3$),[34,36,37] health-related quality of life ($n=4$),[31,33,36,37] and activity limitation ($n=2$).[35,36]

Risk of bias items of included trials ranged from poor to high (Supplemental Figure 1). All trials demonstrated a high risk of bias in relation to blinding of participants and personnel. Six of the 14 trials were considered poor quality based on criteria.

On average, reporting of comparison groups achieved 78% of TIDieR criteria. Reporting of the experimental groups achieved 81% of criteria. The most satisfactorily reported criteria (100%) included name of trial, rationale, materials, procedures, and who provided the intervention. Modifications to interventions were reported poorly (0%). Trials reported details of the experimental group intervention (85%) better than comparison group intervention (69%) (Supplemental Table 1).

Synthesis of results

Adherence. A meta-analysis of three trials[24,29,35] (140 participants) provided very low-quality evidence that multimedia exercise instructions may be more effective than written instructions for

Table 2. Characteristics of included trials.

Study	Population	Group	Sample		Duration	Programme details			Outcomes measured	
			n	Characteristics		Purpose	Recommended action/ dose	Format of delivery	*Process measures* – compliance, satisfaction	*Patient outcomes (ICF)* – impairment, activity, participation
Gallo and Staskin[24]	Adults with stress urinary incontinence, *USA*	I	41	Age 20–80 All females	4–6 weeks	Adherence to exercise programme	10 minutes practice, 2× daily	Audiotape + instruction sheet	Exercise compliance Teaching effectiveness	
		C	34	Age 20–80 All females	4–6 weeks			Instruction sheet		
Lysack et al.[25]	Orthopaedic rehab for total hip or total knee surgery, *USA*	I	18	Age NR 10 F, 8 M	4 weeks	Adherence to exercise programme	NR	Videotape + instruction sheet	Exercise compliance Satisfaction Quality of performance	
		C	22	Age NR 14 F, 8 M	4 weeks			Demonstration, feedback + instruction sheet		
Schoo et al.[26]	Adults with osteoarthritis of knee or hip, *Australia*	I	30	Age 70.9 (7.23) 20 F, 10 M	8 weeks	Compliance with home exercise programme	5 mobility exercises (2× reps) and 4 strengthening exercises (5–10 reps) daily	HEP Brochure + audiotape	Exercise compliance Quality of performance	
		I	30	Age 69.2 (6.36) 21 F, 9 M	8 weeks			HEP Brochure + videotape		
		C	30	Age 71.1 (6.83) 19 F, 11 M	8 weeks			HEP Brochure		
Moore et al.[27]	Adults with moderate to severe COPD, *UK*	I	10	Age 70 (13) 4 F, 6 M	6 weeks	Exercise tolerance	Exercise 4 times per week	Video, exercise diary, booklet	Exercise compliance	Exercise tolerance
		C	10	70.5 (57.5–78.5) 6 F, 4 M	6 weeks		Non-specific lifestyle changes	Educational booklet		
Eckman et al.[28]	Adults with coronary artery disease, *USA*	I	83	Age 58.49 48 F, 35 M	6 months	Health literacy on knowledge and health behaviours	Non-specific lifestyle changes	Educational VHS/ DVD + printed booklet	Exercise compliance	Lifestyle changes (medication adherence, diet, smoking, health literacy, weight, BP) Disease knowledge
		C	87	Age 61.37 56 F, 31 M	6 months			Printed booklet		
Van Leer and Connor[29]	Adult voice therapy patients, *USA*	I	6	Age 28–64 3 F, 3 M	1 week	Adherence to exercise programme	3–5 times per day for one week	Portable media videos + written instructions	Exercise compliance Satisfaction	Motivation Confidence
		C	6	Age NR 5 F, 1 M	1 week			Written instruction		
Kingston et al.[30]	Adults with traumatic hand injury requiring surgery and treatment, *Australia*	I	26	Age 34.5 (IQR 23–48.5) 7 F, 19 M	6 weeks	Exercise compliance	Daily home exercise	DVD + brochure	Exercise compliance Satisfaction Quality of performance	
		C	27	Age 37 (IQR 23–48) 6 F, 21 M	6 weeks			Brochure		

Table 1. (Continued)

Study	Population	Group	Sample *n*	Sample Characteristics	Duration	Programme details: Purpose	Programme details: Recommended action/ dose	Programme details: Format of delivery	Outcomes measured: *Process measures* – compliance, satisfaction	Outcomes measured: *Patient outcomes (ICF)* – impairment, activity, participation
Dettmers et al.[31]	Adults with hand paresis following stroke, *Germany*	I	19	Age 62.8 (11.48) 8 F, 11 M	6 weeks	Improve functional outcomes and QOL	One hour per day for 6 weeks	DVD		QOL Functional Performance
		C	19	Age 53.9 (14.74) 5 F, 14 M	6 weeks			Written instructions		
		C	18	Age 58.8 (11.25) 5 F, 13 M	6 weeks			No intervention		
Szmeja et al.[32]	Overweight/ obese women in pregnancy, *Australia*	I	541	Age 29.2 (5.6) All females	8 weeks	Health behaviours	Non-specific lifestyle changes	Educational DVD + written materials	Exercise compliance	Lifestyle changes (physical activity, weight gain, nutritional intake) Disease knowledge
		C	564	Age 29.4 (5.3) All females	8 weeks			Written dietary and exercise materials		
Uhm et al.[33]	Women with breast cancer, *Korea*	I	179	Age 49.3 (8.0) All females	12 weeks	Improve QOL and physical outcomes	Aerobic exercise: 90–150 min/week Resistance exercise: 2x10 twice/week	Smart phone app and pedometer	Exercise compliance Satisfaction	QOL Health changes (BMI, BP, pulse rate, arm circumference, hand oedema, strength & cardio-respiratory endurance)
		C	177	Age 51.3 (10.7) All females	12 weeks			Brochure		
Chen et al.[34]	Adults with frozen shoulder, *Taiwan*	I	33	Age 56.1 (7.5) 20 F, 12 M	2 weeks	Exercise compliance	2 exercises daily for 5 minutes	Daily text messages + pamphlet	Exercise compliance Satisfaction	Functional Performance (ROM, strength, ADLs) Pain
		C	33	Age 59.0 (9.4) 17 F, 11 M	2 weeks			Pamphlet		
Emmerson et al.[35]	Adults with upper limb deficits following stroke, *Australia*	I	30	Age 68 (15) 13 F, 17 M	4 weeks	Adherence to home exercise programme	Individually prescribed exercises, 1–2 sessions per day	Video on ipad + reminder alarm	Exercise compliance Satisfaction	Functional Performance
		C	32	Age 63 (18) 13 F, 19 M	4 weeks			Written exercise instructions		
Lee et al.[36]	Office workers with chronic neck pain, *Korea*	I	11	Age 27.1 (4.83) 6 F, 5 M	8 weeks	Pain management	15 min/day, 2× days per week	Mobile app- + weekly text message	Exercise compliance	Fear avoidance Strength Pain Neck disability QOL
		C	9	Age 27.6 (4.67) 3 F, 6 M	8 weeks		NR	Brochure + weekly text message		
Villafañe et al.[37]	Adults following total knee replacement, *Italy*	I	14	Age 70.4 (7.5) 7 F, 7 M	2 weeks	Improve recovery and functional outcomes	30 min twice/day, 5 days/week. CPM twice daily/20 minutes	Exercise video + written instructions		Functional Performance (ROM, balance, ADLs) Pain QOL
		C	17	Age 70.1 (7.7) 14 F, 3 M	2 weeks			Nature video + written instructions		

NR: not reported; I: intervention; C: comparison; F: female; M: male; CPM: continuous passive motion; QOL: quality of life; HEP: home exercise programme; BP: blood pressure; ROM: range of movement; ADL: activities of daily living.

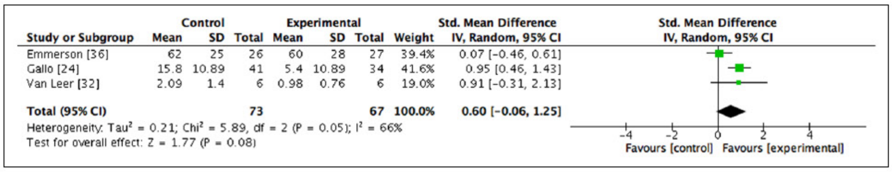

Figure 2. Meta-analysis for adherence [Ref].

Table 3. Meta-analyses for multimedia versus written or verbal format for provision of exercise instructions.

Experimental	Comparison	Number of trials	Number of participants	Outcome	Timeframe	SMD (95% CI), I^2	Quality of evidence (GRADE)
Audiotapes Videos	Written instructions	3[24,29,35]	140	Adherence	1 to 6 weeks	0.60 (–0.06, 1.25), 66%	Very low[a]
Videos Smart phone applications DVDs	Written instructions Exercise brochure	3[28,32,33]	1,614	Physical activity	8 weeks to 6 months	0.07 (–0.08, 0.23), 46%	Low[b]
Smart phone applications Text messages Videos	Exercise brochure	3[33,36,37]	390	Quality of Life – physical	2 to 12 weeks	0.21 (–0.21, 0.64), 41%	Moderate[c]
Smart phone applications Text messages Videos	Exercise brochure	3[33,36,37]	390	Quality of Life – emotional/ mental	2 to 12 weeks	0.16 (–0.04, 0.36), 0%	High[d]
Smart phone applications Text messages Videos	Exercise brochure Pamphlet	3[34,36,37]	111	Pain intensity	2 to 8 weeks	0.09 (–0.28, 0.47), 0%	High[e]

SMD: standardized mean difference; CI: confidence interval.
[a]Reason for downgrade: low participant numbers, wide confidence interval, statistical heterogeneity, and two[24,29] of three trials rated lesser quality with unclear details or without randomization, allocation concealment, or blinding for outcome assessment.
[b]Reason for downgrade: statistical heterogeneity, and one[28] of three trials deemed lower quality without allocation concealment or blinding for outcome assessment.
[c]Reason for downgrade: statistical heterogeneity.
[d]Reason for downgrade: no downgrade.
[e]Reason for downgrade: no downgrade.

exercise adherence (Figure 2). A moderate effect size favouring the experimental group approached but did not reach statistical significance (SMD 0.60, 95% CI −0.06 to 1.25) (Table 3).

Adherence was recorded as time spent exercising,[24,26,35,36] frequency of exercise,[24,27,29,30,34–36] and accuracy of exercise performance.[25,26,30] Individual trials that could not be included in the adherence meta-analysis due to heterogeneity or insufficient reporting varied in their results. Two trials, with sample sizes of 66 and 170, respectively, suggested the provision of instructions provided in multimedia format enhanced exercise adherence.[28,34] Others with sample sizes ranging from 56 to 1105 did not find significant between-group differences in adherence.[25,26,30,32,33]

Physical activity. A meta-analysis of three trials (1614 participants) provided low-quality evidence that multimedia exercise instructions are no more effective than written instructions for increasing the amount of physical activity (SMD 0.07, 95% CI −0.08 to 0.23)[28,32,33] (Table 3). Amount of physical activity was measured using Metabolic Equivalent Task units (METS)[32,33] and the Physical Activity Scale for the Elderly (PASE).[28]

Health-related quality of life. Two meta-analysis of three trials (390 participants) provided moderate- to high-quality evidence to indicate that multimedia exercise instructions are no more effective than written instructions for physical (Table 3) (SMD 0.21, 95% CI–0.21 to 0.64) or emotional (SMD 0.16, 95% CI −0.04 to 0.36) health-related quality of life.[33,36,37] Quality of life was measured using the Short Form-36 (SF-36)[36,37] and a cancer-specific measure, the European organization for Research and Treatment of Cancer Quality of Life Questionnaire Core 30 (EORTC QLQ-C30).[33,38,39] One trial could not be included in meta-analyses due to insufficient reporting.[31] This trial, which used the Stroke Impact Scale, reported significant differences in favour of the multimedia (video) intervention.

Pain intensity. A meta-analysis of three trials (111 participants) provided high-quality evidence that multimedia exercise instructions are no more effective than written instructions for reducing pain (SMD 0.09, 95% CI −0.47 to 0.28) (Table 3).[34,36,37] All three trials used a visual analogue scale to measure pain.

Other outcomes. A range of other physical outcomes were measured in the included studies, such as range of movement,[34,37] strength,[33,36] exercise tolerance,[27] weight loss,[28] and upper limb speed/quality.[31] Four of seven trials demonstrated statistical significance between groups in favour of the group receiving multimedia exercise instructions.[27,31,33,34] Exercise instructions provided in either format were observed to improve health knowledge, but there were no statistically significant differences between groups.[28,32] Activity limitations were reduced via either format of exercise instruction,[31,35,36] but only one trial demonstrated a statistically significant difference between groups in favour of the group receiving multimedia instructions.[36] Participants were generally satisfied with exercise instructions being provided using multimedia methods,[25,29,33,34] but there were no statistically significant differences between groups.[25,33,35]

Discussion

This systematic review identified 14 randomized controlled trials comparing provision of exercise instructions using multimedia approaches with more traditional methods using paper-based or verbal instructions. Five meta-analyses showed no differences in patient outcomes between participants who received the different methods of instruction. Process measures were favourable for multimedia, with a moderate effect size observed for exercise adherence; however, the quality of evidence was very low and differences in this outcome approached but did not reach statistical significance.

If the use of multimedia to provide exercise instructions had a positive effect on adherence, this may have been due to a number of reasons. The use of multimedia to provide instructions for patients is more novel and therefore may be more motivating to patients than using traditional formats such as written instructions.[40] Multimedia also has a greater potential to be more realistic and personalized. For example, two trials included in this review filmed the participant completing their own exercises.[29,35] The use of multimedia also caters for different learning styles.[41] While none of the trials in this review considered individual preferences or learning styles, most did combine different forms of instruction in mutually reinforcing ways,[24–30,32,34,37] as recommended in the literature.[5,6]

Despite a possible positive effect on adherence, the use of multimedia to prescribe exercise did not appear to translate to improved patient outcomes. Perhaps, this was a result of reduced intensity, inadequate dosage, or lack of individualization. For the majority of trials ($n=9$), all participants were given the same generalized intervention, and many of these were not consistent with recommended clinical guidelines.[42–44] Adherence to an exercise of insufficient dose would not be expected to result in improved patient outcomes. Also, trials included in the meta-analysis for adherence were of relatively short duration (one week to six weeks); the relatively short duration may have positively influenced adherence in these trials. The majority of trials included in the meta-analyses for patient outcomes were held over a longer period of time (up to six months); it is possible that the lack of significant between-group differences in some of these trials[32,33,37] may have been associated with difficulty maintaining adherence over a longer time.

Despite the increased use of technology in healthcare settings, this review demonstrated no clear benefits to patient outcomes when providing instructions in multimedia format over written and/or verbal formats. Neither format was superior to the other in relation to patient outcomes. However, there is literature to suggest a range of other benefits of multimedia. A qualitative analysis[40] found other benefits to the use of smart technology for home exercise prescription, including ease of following instructions, and benefits to carers. Therefore, choice to use multimedia for exercise prescription may be dependent on factors such as patient preference and access to resources. If the patient owns and is familiar with technology, it may be an option. However, investment by health services in technology to enable multimedia exercise prescription is unlikley to be justified given the current evidence.

A limitation of this review is that trials exploring a wide variety of clinical populations were combined. Also, study duration ranged from one week to six months, although 10 of the 14 studies had a study duration of four to twelve weeks. It is possible that different clinical populations instructed to exercise over different durations may have a different response to the mode of exercise instruction and subsequent adherence. However, the results from meta-analyses and individual trials not included in the meta-analyses were consistent, suggesting no pattern of a differential effect due to mode of exercise instruction. Furthermore, all trials met specified inclusion criteria, including the use of exercise as an intervention with comparison of different methods of exercise instruction. Because we only included randomized controlled trials in our review, factors such as clinical population and exercise duration were controlled within each study.

The meta-analysis for adherence may have been underpowered. From 14 studies, only three were suitable for statistical synthesis. There were low participant numbers, a wide confidence interval, statistical heterogeneity, and two of the three trials rated lesser quality with unclear details or without randomization, allocation concealment, or blinding for outcome assessment. A strength of this review is that it was reported according to PRISMA[8] guidelines. It used robust methods of reporting bias both within and across trials[11] and used the TIDieR checklist[13] to explore completeness of reporting.

This systematic review specifically looked at *exercise instructions*, but there are many other reasons to provide health information. There is extensive literature available that reports positive results from the use of information provided in multimedia formats for surgical preparation and consent,[45,46] patient education,[47,48] and decision-making.[49,50] Given the positive trends of multimedia for these purposes, further research could explore differences that may not have been captured by this review, such as patient preferences based on experience and available resources.

In conclusion, exercise instructions provided using multimedia may have resulted in increased adherence to exercise over instructions provided in written or verbal format, but there is insufficient high-quality evidence to conclude whether the mode of exercise instructions affects patient outcomes.

Clinical messages

- Exercise instructions provided using multimedia may have positive effects on adherence.
- There is insufficient high-quality research to conclude whether exercise instructions provided using multimedia lead to better clinical outcomes than those provided in standard formats.

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ORCID iD

Kellie B Emmerson https://orcid.org/0000-0003-0485-134X

Supplemental material

Supplemental material for this article is available online.

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Supplementary Table 1. PRISMA checklist

PRISMA 2009 Checklist

Section/topic	#	Checklist item	Reported on page #
TITLE			
Title	1	Identify the report as a systematic review, meta-analysis, or both.	1
ABSTRACT			
Structured summary	2	Provide a structured summary including, as applicable: background; objectives; data sources; study eligibility criteria, participants, and interventions; study appraisal and synthesis methods; results; limitations; conclusions and implications of key findings; systematic review registration number.	Abstract (separate)
INTRODUCTION			
Rationale	3	Describe the rationale for the review in the context of what is already known.	2
Objectives	4	Provide an explicit statement of questions being addressed with reference to participants, interventions, comparisons, outcomes, and study design (PICOS).	3
METHODS			
Protocol and registration	5	Indicate if a review protocol exists, if and where it can be accessed (e.g., Web address), and, if available, provide registration information including registration number.	3
Eligibility criteria	6	Specify study characteristics (e.g., PICOS, length of follow-up) and report characteristics (e.g., years considered, language, publication status) used as criteria for eligibility, giving rationale.	4
Information sources	7	Describe all information sources (e.g., databases with dates of coverage, contact with study authors to identify additional studies) in the search and date last searched.	3
Search	8	Present full electronic search strategy for at least one database, including any limits used, such that it could be repeated.	23 (appendix)
Study selection	9	State the process for selecting studies (i.e., screening, eligibility, included in systematic review, and, if applicable, included in the meta-analysis).	4
Data collection process	10	Describe method of data extraction from reports (e.g., piloted forms, independently, in duplicate) and any processes for obtaining and confirming data from investigators.	4
Data items	11	List and define all variables for which data were sought (e.g., PICOS, funding sources) and any assumptions and simplifications made.	4
Risk of bias in individual studies	12	Describe methods used for assessing risk of bias of individual studies (including specification of whether this was done at the study or outcome level), and how this information is to be used in any data synthesis.	5
Summary measures	13	State the principal summary measures (e.g., risk ratio, difference in means).	6
Synthesis of results	14	Describe the methods of handling data and combining results of studies, if done, including measures of consistency (e.g., I^2) for each meta-analysis.	6

PRISMA 2009 Checklist

Section/topic	#	Checklist item	Reported on page #
Risk of bias across studies	15	Specify any assessment of risk of bias that may affect the cumulative evidence (e.g., publication bias, selective reporting within studies).	6
Additional analyses	16	Describe methods of additional analyses (e.g., sensitivity or subgroup analyses, meta-regression), if done, indicating which were pre-specified.	6
RESULTS			
Study selection	17	Give numbers of studies screened, assessed for eligibility, and included in the review, with reasons for exclusions at each stage, ideally with a flow diagram.	6
Study characteristics	18	For each study, present characteristics for which data were extracted (e.g., study size, PICOS, follow-up period) and provide the citations.	7 & Table 2
Risk of bias within studies	19	Present data on risk of bias of each study and, if available, any outcome level assessment (see item 12).	8 & Table 3
Results of individual studies	20	For all outcomes considered (benefits or harms), present, for each study: (a) simple summary data for each intervention group (b) effect estimates and confidence intervals, ideally with a forest plot.	8
Synthesis of results	21	Present results of each meta-analysis done, including confidence intervals and measures of consistency.	8 & Table 4
Risk of bias across studies	22	Present results of any assessment of risk of bias across studies (see Item 15).	8, Table 4 & Figure 2
Additional analysis	23	Give results of additional analyses, if done (e.g., sensitivity or subgroup analyses, meta-regression [see Item 16]).	Not applicable
DISCUSSION			
Summary of evidence	24	Summarize the main findings including the strength of evidence for each main outcome; consider their relevance to key groups (e.g., healthcare providers, users, and policy makers).	11
Limitations	25	Discuss limitations at study and outcome level (e.g., risk of bias), and at review-level (e.g., incomplete retrieval of identified research, reporting bias).	12
Conclusions	26	Provide a general interpretation of the results in the context of other evidence, and implications for future research.	13
FUNDING			
Funding	27	Describe sources of funding for the systematic review and other support (e.g., supply of data); role of funders for the systematic review.	14

From: Moher D, Liberati A, Tetzlaff J, Altman DG, The PRISMA Group (2009). Preferred Reporting Items for Systematic Reviews and Meta-Analyses: The PRISMA Statement. PLoS Med 6(6): e1000097. doi:10.1371/journal.pmed1000097

For more information, visit: **www.prisma-statement.org**.

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Chapter 5: Resource Analysis

5.1 Introduction

Chapters 2, 3 and 4 focused on the impacts of videoed instructions compared with paper-based instructions for home exercises in rehabilitation on patient and process outcomes. Another consideration in deciding best practice, are the resources required from the health service perspective.

Chapter 5 presents an observational cohort study comparing resources required to provide videoed home exercise instructions compared with paper-based instructions when patients use their own smart technology. It considers overall cost based on health professional time, paper used, and printing.

5.2 Study four

This paper is presented in preprint format, published by Taylor & Francis in *Disability and Rehabilitation* on 17th September 2019, available from: http://www.tandfonline.com/10.1080/09638288.2019.1663281

> Emmerson KB, Harding KE, Fong C, Taylor NF. A resource analysis of the use of the video function of electronic devices for home exercise instruction in rehabilitation. *Disability and Rehabilitation*. 2019:1-5. DOI:10.1080/09638288.2019.1663281

A resource analysis of the use of the video function of electronic devices for home exercise instruction in rehabilitation

Purpose: To compare resources required to provide paper-based versus videoed instructions for home exercises in rehabilitation.

Materials and methods: An observational cohort study included twenty-two allied health professionals (physiotherapists [n= 13], occupational therapists [n= 6] and speech pathologists [n= 3]), providing exercise instructions for n=110 patients within a community rehabilitation program of a large metropolitan health service.

Home exercise instructions were provided to patients with various health conditions. Patients chose between receiving paper-based home exercise instructions, or using their own smart technology to video their home exercises.

The primary outcome measure was cost from a health service perspective, based on health professional time, paper used, and printing.

Results: A total of 128 initial home exercise instructions were provided to 110 patients, with 36 patients reviewed at least once. Each initial exercise instruction provided using electronic devices saved 5.5 minutes (95% CI 0.5 to 10.5) with a cost saving of Australian dollar $4.70 (95% CI -8.89 to -0.52) compared with paper-based instructions. There were no significant cost differences (MD $1.16 95% CI -3.87 to 6.18) between modes for exercise review.

Conclusions: Home exercise instructions provided on electronic devices cost less than paper-based instructions when patients are using their own smart devices.

KEYWORDS: exercise therapy; multimedia; video recording; rehabilitation; cost-minimisation analysis; instructional films and videos

Introduction

Allied health professionals provide exercise instructions for home programs in the rehabilitation of a wide range of conditions such as stroke[1], pulmonary disease[2], cardiac disease[3], osteoarthritis[4], and orthopaedic conditions[5, 6]. There is high-quality evidence from a summary of 38 systematic reviews demonstrating the benefits of therapeutic exercise for improved outcomes in a range of conditions[7]. Given rising health care costs and time pressures for staff, home exercise has been identified as complementary and important to clinic-based therapy[1, 8, 9]. Home exercise programs enable increased practice in order for patients to achieve optimal dosage for improvement. Instructions for these programs are commonly provided in written or printed format. However, multimodal information provision may be beneficial[10, 11]. Therefore, it may be of value for allied health professionals to use the video function of electronic devices such as smart phones or tablets to provide exercise instructions. Electronic devices and smart technology are now widely available[12] and can be used in a range of activities, from simple tasks such as taking photos or setting reminders, to more complex actions such as information sourcing or operating home appliance controls[13, 14]. While there appears to be little difference in satisfaction between methods [16], patients and families who feel comfortable with technology have identified a range of benefits of using personalised video for home exercise instructions[15] such as finding it novel, easier to follow instructions, and enabling a record of progress over time, with increased exercise adherence[17]. Despite these advantages, a recent systematic review[17] did not find any clear evidence that exercises instructions provided electronically result in better patient outcomes than written or verbal instructions. The value of investing resources in promoting the use of technology for exercise instruction is therefore unclear.

Since previous research demonstrated no difference in effectiveness [16, 17], one issue that could influence the decision to provide exercise instructions using the video function of electronic devices is a difference in cost. The four approaches to economic evaluation include cost-benefit, cost-effectiveness, cost-utility and cost-minimisation[18]. Cost minimisation[18-20] assumes that the clinical outcomes are equal in both groups, and therefore the option with the lowest costs is preferred. The use of technology has the potential to save material resources (paper and printing) and time for clinicians if it can improve efficiency. However, it is also possible that time required for training or to address technical issues may outweigh any benefits. The aim of this study was to compare the health service costs when home exercise instructions were provided in paper-based mode versus when they were provided using the video function of electronic devices for patients receiving community rehabilitation.

Materials and methods

An observational cohort study was completed between July and December 2017. Participants were allied health professionals recruited from two community rehabilitation program sites within one large metropolitan health service in Melbourne. The community rehabilitation program provides home-based and centre-based allied health services for approximately six to eight weeks for patients living in the community with a wide range of neurological and musculoskeletal conditions. The frequency, intensity and content of therapy sessions includes some discretion on the part of the health professional but typically promotes goal orientated, individualised patient-centred care.

All physiotherapists, occupational therapists and speech pathologists who were employed with the participating services were invited to participate. Ethics approval was obtained from the health service and university ethics committees and all participating health professionals provided written informed consent.

All patients received standard clinical care as per usual community rehabilitation program protocol, but they were given the choice between the two modes of exercise instruction. Patients who owned a smart phone or tablet with video function were offered the opportunity to receive their home exercise instructions in video format. Video instructions were generated using the video function on a patient's smart phone or device. Videos recorded the patient completing each single exercise, with equipment and clinician instruction (or corrections) as appropriate. They may have included a number of repetitions for better demonstration. Exercises were saved individually in an album in the patient's normal 'photo' app so that they could be accessed easily and followed as directed. Those who did not have a device or preferred not to use it were given a written or printed home exercise instructions as per usual care. These instructions may have been hand-written, or printed from various computer programs such as Visual Health Information (VHI)[21] or HEP2go[22].

Participant allied health professionals were requested to document home exercise program choice for all patients for whom they would normally prescribe a home exercise program. They recorded the time used for the initial set-up of home exercise instructions for both written and electronic formats. They noted whether this time was spent within treatment sessions with the patient, or external to this. Data were also recorded from one review appointment (if this was completed), used to update or modify the home exercise instructions. Allied health professionals recorded material resources used, including the type of electronic device (smart phone or tablet), the number of sheets of paper used, and the number of printed pages (supplementary table S1).

Content of both the electronic and paper-based home exercise instructions were based on allied health professional's clinical reasoning and standard practice, and dependent on individual patient goals. All electronic home exercise instructions were individually created each time, by videoing the patient completing their own exercises. Written instructions were either individually selected from a data base of common exercises for common conditions, or individually customised. The number of exercises varied, as did the number of recommended sessions per day. This detail was not recorded, as the purpose of the study was to measure resource use rather than patient outcomes.

A total of 128 exercise instructions were required for a power of 80% at alpha level 5% using two-tailed tests, assuming a difference of 10 minutes and a standard deviation of therapist time of 20 minutes. A cost minimisation approach was taken to explore which method would cost less from the perspective of the health service. Data analysis included comparison of time spent developing and modifying home exercise instructions with independent samples

t tests; and comparison of costs (including direct resource costs and assigning dollar values to therapist time). Costs were estimated in AUD and based on time, paper and printing. Cost for allied health professionals was calculated based on a Grade 2, Year 3 (mid-career level) award rates plus 20% on-costs for November 2017. This resulted in an estimate of $50.05 per hour according to the Allied Health Professionals Single Interest Enterprise Agreement 2016-2020.[23] Paper costs were based on the supply system of the health service, at $3.33 for 500 pages of A4 plain white paper. A percentage of 2.1 based on the consumer price index was subtracted from this to ensure costs reflected 2017 pricing, resulting in paper cost of 0.66 cents per page. Printing was also based on the health service costs minus 2.1% consumer price index, at 4.85 cents per page. SPSS version 24.0 (IBM, Armonk, NY) was used for statistical analyses.

Results

Twenty-two mid-career allied health professionals were recruited, representing 100% of the eligible health professionals employed within the service at the time. These were occupational therapists (n= 6), physiotherapists (n=13) and speech pathologists (n=3) working in a community rehabilitation program across two sites. All participating health professionals had at least three years of professional experience. A total of 128 initial home exercise instructions were provided to 110 patients, with 36 of these patients reviewed at least once. Fifteen patients received initial instructions from more than one allied health profession, and the majority came from physiotherapy (69 of 110, 63%). Patients had a variety of primary conditions, including stroke (40 of 110, 36%), other neurological conditions (13 of 110, 12%), and orthopaedic conditions (35 of 110, 32%) (table 1). There were no differences between groups based on age (Mean difference (MD) 6.0 years, 95% CI -12.4 to 0.4, p=0.065), gender (Fisher's exact test p=0.344), or condition (stroke or not stroke; Fisher's exact test p= 0.055). Of the 30 patients who elected to receive their exercise instructions electronically, 22 (73%) used a smart phone and 8 (27%) used an electronic tablet.

For paper-based home exercises provided during the initial appointment, allied health professionals used an average of one to two pieces of paper and printed on two to three sides. The length of paper-based home exercise instructions and therefore the amount of material resources used varied depending on discipline. Physiotherapists used the least, using on average one piece of paper and printing on one to two sides. Occupational therapists provided on average two pieces of paper, printing on three sides. Both of these disciplines reviewed home exercises with further paper and printing. Speech pathologists provided initial instructions on an average of 14 pieces of paper. They did not record any paper-based updates.

The total time required to provide each initial home exercise instruction was 5.5 minutes less (95% CI 0.5 to 10.5) with electronic mode compared to a paper mode (table 2). Preparation time of each home exercise instruction away from the patient was 4.3 minutes less (95% CI 2.0 to 6.6) with electronic mode compared to paper mode. When reviewing the home exercises, there were no time differences between modes. With individual disciplines, speech pathologists (n=3) saved nearly 43 minutes when providing their initial exercise programs electronically (95% CI 16.5 to 68.5). Physiotherapists (n=13) were the only discipline to show a significant difference with exercise review, saving nearly 7 minutes (95% CI 3.7 to 9.7) if doing so electronically.

The cost to provide each initial home exercise instruction was $4.70 less (95% CI 0.52 to 8.89) with electronic mode compared to paper mode (table 3). There were no significant cost differences (MD $1.16 95% CI -3.87 to 6.18) between modes for the review of exercises.

Discussion

Home exercise instructions using the video function of electronic devices were less costly and less time consuming than the provision of paper-based instructions within a community rehabilitation setting. This is consistent with reports that health services could benefit from the use of smart technology by saving both time and money[24-26], adds to previous literature demonstrating a range of other benefits of electronic devices for exercise instruction[15, 16, 26], and is consistent with the national digital health strategy[27]. Since patient outcomes appear to be similar[17] with either method, cost and time benefits may assist allied health professionals in their decision making when choosing how to provide home exercise instructions.

The lower costs of providing exercise instruction in electronic mode can mostly be attributed to health professional time. It appears that the time savings using smart technology were a result of less preparation time required of allied health professionals away from patients. Paper-based exercise instructions were often developed on the allied health professional's computer during non-clinical time, and then provided to patients during their therapy sessions. Video-based exercise instructions using electronic devices were developed with the patient during their session. Both could also be practiced under supervision, as therapy, within treatment time. There was no significant difference in average time taken by health professionals to review home exercises.

Time savings varied between professions. On average, physiotherapists and occupational therapists saved approximately four minutes for preparation of an initial exercise instruction and four minutes for a review. Speech pathologists spent much longer that the other professional groups in preparing paper-based instructions (60 minutes), and therefore had much higher potential for time savings. With instructions provided using electronic devices, time reduced by over 40 minutes to be much more in line with their occupational therapy and physiotherapy colleagues.

The cost savings of just under $5.00 for the provision of each initial home exercise instruction when using an electronic mode may appear modest. However, the community rehabilitation program in which this research took place accepted on average 1,680 referrals in each of the 2016/2017 and 2017/2018 financial years [28]. Assuming many of these patients will be provided with written exercise instructions this could mean a significant dollar saving for the health service, by freeing up time and resources. The time savings, an average of 5.5 minutes for the initial exercise instruction of each patient, could be considered even more important than actual cost savings, as it can contribute to greater productivity for the allied health professional. They effectively have more time to spend directly with other patients, or more non-clinical time for tasks such as administration duties.

A limitation of this study was that participants were not randomised to modality of home exercise instruction. Patients were allowed to choose the mode of delivery of their exercise instruction, influenced by their access to a device and personal preference, and it is likely that this led to some differences between the characteristics of the patients in the two groups. However, the aim of the study was to measure resource use from a service perspective, so differences between the patients in the groups would have been unlikely to have a substantial influence on the outcomes measured. Furthermore, the majority of time savings were achieved away from the patient, further supporting the hypothesis that the difference in clinician time was not explained by patient factors. Despite the lack of randomisation, there were no significant differences between groups based on patient age, gender or condition. Within this study, choice of modality may also have been influenced by the allied health professional's preference. Cultural resistance by health professionals to technological uptake has been a common issue[26] and therefore therapists who were more comfortable with technology may have been more likely to encourage their patients to try this option. Furthermore, recruitment was dependent on the compliance of participant clinicians completing recording forms for patients' prescribed home exercise programs. Compliance was not measured. We estimate that we sampled approximately 16% of total referrals to our sites during the study period [28]. However, it is not known how many of these patients would have received home exercise instruction. In addition, the number of home exercise programs provided compared to total number of patients was not recorded. However, the conditions of patients receiving home exercise instructions was broadly consistent with referrals to the community rehabilitation program at the health service, with a relatively larger of proportion of patients with a neurological condition relative to referrals [28]. It is possible patients with a neurological condition may be more likely to receive home exercise instructions compared with other conditions.

While there are many alternatives to how electronic home exercise instruction can be provided, including various ‘apps’ and computer programs, this study was designed to suit community rehabilitation. The key advantages of the videoing method used in the current study, were that it was simple, visual, individualised and could be easily translated into practice. It avoided issues related to privacy and intellectual property, it did not require updating of technology, and required very little training. The findings of this study could be generalised to community rehabilitation type programs focusing on individual patient goals for occupational therapists and physiotherapists. Caution should be made about generalising the results to speech pathologists (due to the small numbers involved in the study) and for other programs where standardised exercise instructions might be provided to patients based on diagnosis rather than individual patient goals.

It has previously been determined that smart technology is well suited to patients who already own and use these devices in their daily life[15], therefore electronic devices were not provided on loan to patients for the purpose of this study. Whether the cost benefits demonstrated within this study are enough to justify health services purchasing smart devices for the use of patients would need to be the subject of further study. However, aside from the cost of supplying technology in the first instance, additional resources would be required to update and maintain devices in working order; train patients in their use; and problem solve technical issues. In Australia, almost 80% of people own a smart phone[27], and smart phones are now used by over 91% of households who have internet connection[12]. Given the high uptake of this technology within the community[26, 27], they should be readily available for use for this purpose, without extra resources being required of health services.

With this in consideration, video-based home exercise instruction should be encouraged by allied health professionals when patients have their own electronic devices.

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Table 1. Baseline characteristics of participants, therapists and resources

Characteristic	Patients (total)	Exercise instructions (n=128)[#]	
	n=110	Video-based (n = 41)	Paper-based (n = 87)
Participants			
Age *(yr)*, mean (SD)	68.0 (16.8)	63.8 (17.6)	69.8 (16.7)
Gender, n males (%)	62 (56)	26 (63)	47 (54)
Condition, n (%)			
Stroke	40 (36)	23 (56)	32 (37)
Other neurological	13 (12)	9 (22)	6 (7)
Orthopaedic	35 (32)	7 (17)	29 (33)
Other medical	22 (20)	2 (5)	20 (23)
Exercise instruction by, n (%)			
Occupational Therapy (OT)	23 (21)	14 (34)	23 (26)
Physiotherapy (PT)	69 (63)	23 (56)	59 (68)
Speech Pathology (SP)	7 (6)	4 (10)	5 (6)
More than one discipline	11 (10)	-	-
Electronic type			
Smart phone, n (%)	22 (73)	26 (63)	-
Tablet, n (%)	8 (27)	15 (37)	-

[#]95 patients received home exercise instructions from one discipline, 12 from two disciplines and three from three disciplines, resulting in a total of 128 episodes of provision of exercise instructions for 110 individual patients.

Table 2 Time for instruction of home exercises

	Modality of Home Exercise instruction		
	Video-based Mean (SD)	*Paper-based Mean (SD)*	MD (95% CI)
Initial instruction: total (min)	*n=41*	*n=87*	
Total time	16.6 (10.5)	22.1 (14.4)	5.5 (0.5 to 10.5)
Time with patient	16.1 (10.1)	17.3 (9.1)	1.2 (-2.3 to 4.8)
Time away from patient	0.5 (2.5)	4.8 (10.3)	4.3 (2.0 to 6.6)
Initial instruction: discipline (min)			
Occupational Therapy	22.4 (10.8)	26.5 (12.2)	4.1 (-4.0 to 12.1)
Physiotherapy	12.9 (8.6)	17.2 (8.4)	4.3 (0.2 to 8.4)
Speech Pathology	17.5 (12.6)	60.0 (18.7)	42.5 (16.5 to 68.5)
Initial instruction: condition (min)			
Stroke	19.2 (10.8)	27.6 (18.6)	8.4 (0.4 to 16.4)
Other neurological	17.3 (11.0)	28.8 (15.8)	11.5 (-3.4 to 26.4)
Ortho	7.6 (4.2)	16.0 (9.1)	8.5 (1.3 to 15.7)
Other medical	15.0 (0.0)	20.2 (8.0)	5.2 (-6.9 to 17.2)
Review instruction: total (min)	*n=8*	*n=28*	
Total time	14.1 (8.8)	12.7 (7)	-1.5 (-7.5 to 4.6)
Time with patient	14.1 (8.8)	11.7 (7.2)	-2.4 (-8.6 to 3.8)
Time away from patient	0.0 (0.0)	1.0 (3.1)	1.0 (-1.3 to 3.2)
Review instruction: discipline (min)			
Occupational Therapy	13.3 (5.4)	16.3 (6.8)	3.1 (-6.3 to 12.5)
Physiotherapy	5.0 (0.0)	11.7 (6.8)	6.7 (3.7 to 9.7)
Speech Pathology	25.0 (7.07)	-	-
Review instruction: condition (min)			
Stroke	17.6 (8.9)	15.0 (6.1)	2.6 (-13.7 to 8.5)
Other neurological	10.0 (7.07)	20.0 (0.0)	10.0 (-1.9 to 21.9)
Orthopaedic	5.0 (-)	11.3 (7.3)	-
Other medical	- (-)	10.6 (6.9)	-

Table 3. Costs (AUD) based on mode of exercise instruction

	Mode of exercise instruction				Cost Difference
	Video-based		Paper-based		
Outcome	Resources Mean (SD)	***Cost ($) Mean (SD)***	Resources Mean (SD)	***Cost ($) Mean (SD)***	Electronic minus paper *MD (95%CI)*
Initial prescription	**n=41**		**n=87**		
Total time (mins)	16.61 (10.49)	13.86 (8.75)	22.13 (14.40)	18.46 (12.02)	-4.60 (-8.76, -0.45)
Time with patient (mins)	16.07 (10.10)	13.41 (8.43)	17.31 (9.11)	14.44 (7.60)	-1.03 (-3.98, 1.92)
Time without patient (mins)	0.54 (2.46)	0.45 (2.05)	4.82 (10.34)	4.02 (8.62)	-3.57 (-5.51, -1.63)
Paper (n)	0 (0.00)	0 (0.00)	2.71 (4.72)	0.02 (0.0311)	-0.02 (-0.03, -0.01)
Printing (n, sides)	0 (0.00)	0 (0.00)	1.75(2.30)	0.08 (0.1115)	-0.08 (-0.12, -0.06)
Total cost ($)		**13.86 (8.75)**		**18.56 (12.12)**	**-4.70 (-8.89, -0.52)**
Review appointment	**n=8**		**n=28**		
Total time (mins)	14.13 (8.81)	11.78 (7.35)	12.68 (6.96)	10.57 (5.80)	1.21 (-3.81, 6.22)
Time with patient (mins)	14.13 (8.81)	11.78 (7.35)	11.71 (7.24)	9.77 (6.04)	2.01 (-3.15, 7.17)
Time without patient (mins)	0.00 (0.00)	0.00 (0.00)	0.96 (3.06)	0.80 (2.55)	-0.80 (-2.66, 1.05)
Paper (n)	0 (0.00)	0 (0.00)	1.29 (1.05)	0.01 (0.01)	-0.01 (-0.01, -0.01)
Printing (n, sides)	0 (0.00)	0 (0.00)	0.86 (0.59)	0.04 (0.03)	-0.04 (-0.06, -0.02)
Total cost ($)		**11.78 (7.35)**		**10.63 (5.83)**	**1.16 (-3.87, 6.18)**

Supplementary Table S1. Home exercise prescription- Resource use data collection

HOME EXERCISE PRESCRIPTION- RESOURCE USE DATA COLLECTION

CLIENT ID

THERAPIST NAME: ______________________________

DISCIPLINE (please circle): OT PT SP

CLIENT DIAGNOSIS: ______________________ AGE______ SEX F M

METHOD OF HOME EXERCISE PRESCRIPTION: (please tick) ☐ **PAPER** | ☐ **ELECTRONIC**: ☐ SMART PHONE ☐ IPAD/TABLET

Comments regarding choice:

INITIAL SETUP:

DATE	WHAT (please tick most approriate boxes, can be >1)	TOTAL TIME SPENT (minutes)	ADDITIONAL FEATURES/ COMMENTS
Time with patient	☐ Ipad setup/training ☐ Video recording ☐ Preparing written instructions ☐ Training patient in program ☐ Other		☐ Interpreter ☐ Cognitive issues ☐ Complex exercises ☐ Client unfamiliar with technology ☐ Pre-prepared program ☐ Other
Time away from patient	☐ Preparing written instructions ☐ IT management (IPad loans, tech issues etc) ☐ Other		
Paper	No. of pieces_________	No. of sides________	

REVIEW:

DATE	WHAT (please tick most approriate boxes, can be >1)	TOTAL TIME SPENT (minutes)	ADDITIONAL FEATURES/ COMMENTS
Time with patient	☐ Ipad setup/training ☐ Video recording ☐ Preparing written instructions ☐ Training patient in program ☐ Other		☐ Interpreter ☐ Cognitive issues ☐ Complex exercises ☐ Client unfamiliar with technology ☐ Pre-prepared program ☐ Other
Time away from patient	☐ Preparing written instructions ☐ IT management (IPad loans, tech issues etc) ☐ Other		
Paper	No. of pieces ________	No. of sides________	

Chapter 6: Discussion and Conclusions

The aim of this thesis was to investigate the use of multimedia exercise instructions provided using smart technology compared with traditional verbal and paper-based exercise instructions. It commenced with a randomised controlled trial and associated qualitative analysis investigating the use of multimedia exercise instructions provided using smart technology compared with traditional verbal and paper-based exercise instructions for patients post stroke. These findings were considered within the context of published literature with a systematic review and meta-analysis. The final study took a service-based approach exploring resources required for various methods of home exercise instruction. This thesis considered patient-related outcomes including upper limb function and satisfaction, as well as service-related outcomes including adherence, time efficiency for allied health professionals, and cost-minimisation. In this chapter, key findings of the research are discussed within the context of the RE-AIM framework (Gaglio, Shoup et al., 2013), summarising and discussing possible explanations, and clinical implications. Finally, strengths and limitations, and directions for future research are discussed, with consideration of issues for dissemination and generalisability.

6.1 Summary of findings

This research commenced in a community rehabilitation program within a large metropolitan health service with a randomised controlled trial, comparing upper limb home exercise instructions supported by video and automated reminders on smart technology, with standard paper-based home exercise instructions for patients with upper limb deficits post stroke (Chapter 2). A total of 62 participants were randomly allocated to the intervention (n = 30) and control groups (n = 32). There were no differences between the groups for measures of adherence (mean difference 2%, 95% CI −12 to 17) or upper limb function measured by change in the Wolf Motor Function Test log transformed time (mean difference 0.02 seconds, 95% CI −0.1 to 0.1). There were no between-group differences in how useful participants found exercise instructions ($p = .452$), whether they remembered to do their exercises ($p = .485$), or whether they enjoyed doing their exercises ($p = .864$). The study concluded that the use of smart technology was not superior to standard paper-based home exercise instructions for prescribing home exercise for patients recovering from stroke.

Clinical effectiveness, as evaluated in the randomised controlled trial (Chapter 2), is only one aspect of quality of care. Quality of care also includes patient safety and the patient experience (National Health Service, 2008). Therefore, it was important to gain an understanding of the lived patient experience of using smart technology for home exercise instructions to determine whether there were any other factors that should be considered when making decisions about the use of smart technology over paper-based exercise instructions. A qualitative analysis was performed alongside the randomised controlled trial as part of a convergent mixed-methods design, using in-depth, semi-structured interviews (Chapter 3). Ten male participants with stroke and upper limb impairment who received home exercise instructions using video and reminders on tablet computers participated in the interviews, which were transcribed and analysed thematically. Three main themes emerged: (1) exercises on the tablet helped patients' recovery in a variety of ways; (2) everyone could use the tablet for their home exercise program; but (3) not everyone liked using the tablet. Patients found smart technology to be novel, with easy to follow instructions, which enabled better organisation and benefits to carers, as well as providing a record of progress over time. Despite some anxiety reported by older people in relation to the complexity and ability to learn something new, all were able to use the smart devices for the purpose of home exercise programs following some brief training. Aphasia, cognition and physical limitations were not a barrier to use, and many felt that using tablets for exercise were a good way to introduce some older people to technology. Automated reminders were often switched off and not viewed as a useful reminder tool. The study concluded that smart technology may provide a novel, convenient way to provide home exercise instructions post stroke with a number of unintended benefits not identified in the outcomes reported in the randomised controlled trial (Chapter 2). For example, participants were positive about multimodal feedback, being able to review progress over time, and share the rehabilitation experience with family and carers. This technology was not for everyone but may be well suited to patients who already own and use these devices in daily life.

A systematic review (Chapter 4) followed to interpret the findings described in Chapter 2 within the context of existing literature, including a wider range of health conditions to acknowledge the potential learnings and the potential application of this technology to populations other than stroke. The aim of this synthesis was to determine whether there was evidence that patients have better outcomes when exercise instructions are provided using multimedia approaches compared with verbal or written instructions. The 14 selected randomised controlled trials, including the randomised controlled trial described in Chapter 2, comprised of 2,156 participants with orthopaedic, neurological, pulmonary, cardiac and women's health conditions. A meta-analysis of three trials (140 participants) provided very low-quality evidence that multimedia exercise instructions may be more effective than written instructions in improving exercise adherence with a moderate-sized, standardised mean difference (SMD) 0.60, (95% confidence interval (CI) –0.06 to

1.25) that approached but did not reach statistical significance. Two of nine trials that could not be included in the meta-analysis for adherence due to heterogeneity reported that multimedia exercise instructions were more effective than written instructions in improving exercise adherence. Four other meta-analyses (three trials each) found low- to high-quality evidence that provision of exercise instructions using multimedia is no more beneficial than paper-based instructions for patient-related outcomes of: pain intensity (SMD 0.09, 95% CI –0.47 to 0.28); uptake of physical activity (SMD 0.07, 95% CI −0.08 to 0.23); or physical (SMD 0.21, –0.21 to 0.64) and emotional (SMD 0.16, 95% CI −0.04 to 0.36) domains of health-related quality of life. This review concluded that multimedia approaches to exercise instruction may result in increased adherence compared with instructions provided in written or verbal format, but there was insufficient evidence to determine whether this results in improved patient outcomes.

Findings from Chapter 4 were consistent with the findings from the randomised controlled trial reported in Chapter 2. While there was some very low-quality evidence in the systematic review that adherence could be enhanced using video instructions, neither study demonstrated statistically significant effects of traditional paper-based home exercise instructions or videoed home exercise instructions being superior for adherence or functional outcomes. This may have been due to inadequate sample sizes, lack of sensitivity of outcome measures, or exercise factors, including inadequate intensity, inadequate dosage or ineffective exercises. A further explanation could be that there was simply no effect. The outcomes considered in this review were limited to adherence and functional outcomes and only randomised controlled trials were included. The qualitative study described in Chapter 3 did not meet these criteria but suggested that participants recognise a variety of other benefits of using video-based instructions over paper, such as sharing their rehabilitation experience with their family.

A final consideration is the health service perspective. The final study was an observational cohort study comparing resources required to provide paper-based versus videoed instructions for home exercises in rehabilitation (Chapter 5). Participants included 22 allied health professionals (physiotherapists n=13, occupational therapists n=6 and speech pathologists n=3) providing home exercise instructions for n=110 patients within a community rehabilitation program. Home exercise instructions were provided to patients with various health conditions. For this study patients were able to choose between receiving paper-based home exercise instructions or using their own smart technology to video their home exercises. The primary outcome measure was cost from a health service perspective, based on health professional time, and resources including paper and printing. A total of 128 initial home exercise instructions were provided to 110 patients, with 36 patients reviewed at least once. Each initial exercise instruction provided using electronic devices saved 5.5 min (95% CI 0.5 to 10.5) with a cost saving of AUD $4.70 (95% CI 8.89 to 0.52) compared with paper-based instructions. There were no significant cost differences (MD AUD $1.16 95% CI −3.87 to 6.18) between modes of exercise instruction for exercise review. This study concluded that home exercise instructions provided on electronic devices cost less than paper-based instructions when patients are using their own smart devices.

6.2 Key issues and Implications

In the following section, the key issues and implications of this body of research are presented in a format aligned with the RE-AIM framework (Figure 1). RE-AIM provides a framework for determining what programs are worth sustained investment and for identifying those that work in real-world environments (Glasgow, Vogt et al., 1999). It is designed to enhance the quality, speed, and public health impact of efforts to translate research into practice (Glasgow, 2020), and assesses five main dimensions occurring at multiple levels: reach, efficacy, adoption, implementation and maintenance (Glasgow, Vogt et al., 1999; Gaglio, Shoup et al., 2013).

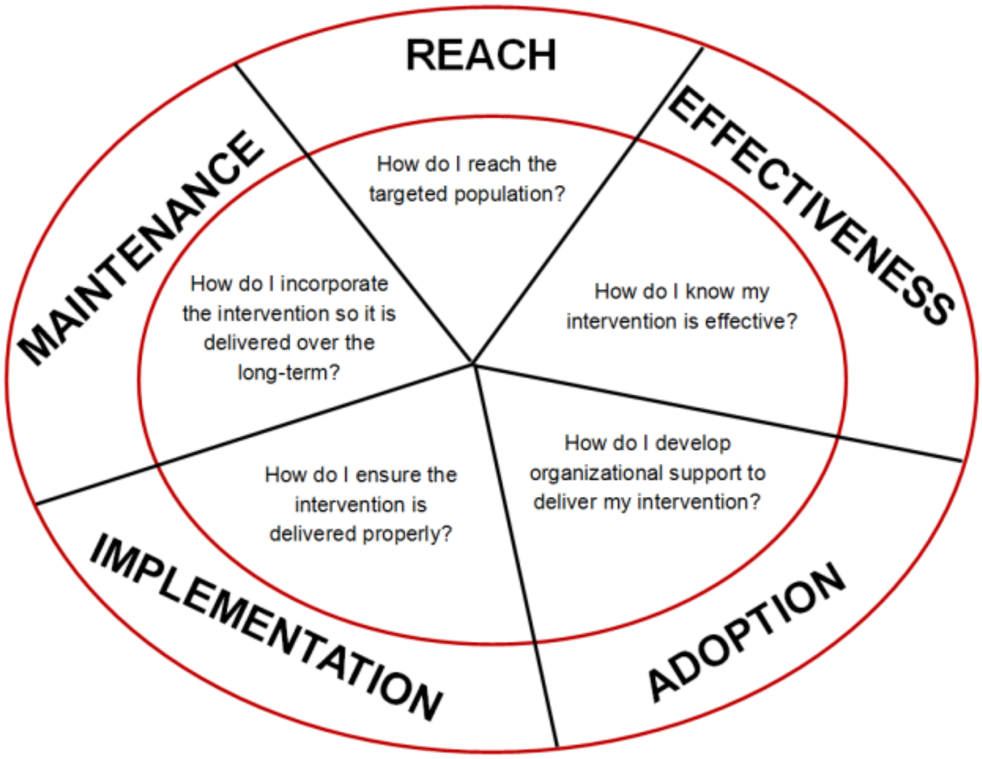

Figure 1: RE-AIM framework (RE-AIM.org., 2020).

The studies included in this thesis are focused on a single service community rehabilitation program, presenting a larger question about the potential value and practicality of translating the findings to other settings. When considering whether to adopt new innovations, clinicians, service managers and policy makers need to consider not only questions like “does it work” and “how much will it cost” but also “will it work in my setting?” and “will my staff and patients be prepared to try it?” RE-AIM provides a useful perspective to consider the feasibility and challenges for broad dissemination, generalisation and translation of evidence into practice (Gaglio, Shoup et al., 2013) and thereby provides a framework to discuss key issues arising from the studies comprising this thesis.

Reach

Reach is an individual-level measure of participation from the perspective of those that the program is intended to serve. It refers to the percentage and risk characteristics of persons who receive or are affected by a policy or program (Glasgow, Vogt et al., 1999). There are three main factors affecting the reach of the use of technology for home exercise instruction: the availability of technology, clinicians as 'gate-keepers' and patient willingness.

In 2018, 97% of Australian households with children under the age of 15 years had access to the internet, with an average of seven internet-connected devices in each household (Australian Bureau of Statistics, 2018). The Australian Government has a commitment to ensuring that the population "enjoy an enhanced quality of life and share in the opportunities of a growing, globally competitive modern economy, enabled by technology" (Australian Government, 2018). They have acknowledged that 90% of Australian jobs will require digital skills and the use of technology within the next few years (The Foundation for Young Australians, 2017) and continue to take action to prepare young Australians for this.

While reach of technology for younger people is nearing 100%, there remains a notable digital divide disadvantaging those who are older, less affluent or have lower levels of education (Anderson and Perrin, 2017). However, American data shows that overall smartphone ownership more than doubled from 2013 to 2017, with 4 in 10 American seniors owning a smart phone in 2017, and approximately 70 per cent connected to the internet (Anderson and Perrin, 2017). In Australia, a 2018 survey showed that while over 95% of people 12 to 54 years old owned a smart phone, 77 per cent of those 55 years and older also owned a smart phone (Hughes, 2019). The Australian Government is actively committed to supporting older Australians to develop skills in the area of technology, introducing initiatives such as Be Connected, an Australia wide enterprise dedicated to increasing the confidence, skills and online safety of older Australians (Commonwealth of Australia, 2018). Given these actions, availability and accessibility of technology is expected to continue to grow at a rapid rate and, therefore, should facilitate the reach for the use of video-based exercise instructions in rehabilitation.

For many patients, clinicians will be the gatekeepers to the use of technology for home exercise instruction. It is common for patients to develop a trust and belief that their health professionals know best, and therefore are more likely to agree or adhere to their clinician's suggestions and encouragement (Kornhaber, Walsh et al., 2016; Birkhäuer, Gaab et al., 2017). Without prior experience, it is unlikely that patients will initiate a new method of home exercise instruction themselves, particularly older people less familiar with technology. Implementation of strategies to address adoption of technology for home exercise instruction by clinicians is therefore likely to be a key component for maximising reach. Clinicians can be reluctant to engage with technology, partly due to the scale and pace of development, and also due to the lack of education and training in deploying them in a clinical setting (Taylor, 2015). Although recent and emerging clinicians are digital natives, many experienced health professionals may have insufficient comfort and skill with a range of computing devices and emerging technologies (Slovensky, Malvey et al., 2017). Relatively few health professionals have been formally trained to deliver their professional services using smart devices and so a determined commitment to education and training of health professionals may help to empower them and, consequently, their patients (Slovensky, Malvey et al., 2017).

The final consideration for accessibility or reach is patient willingness to try. Within this thesis it has been demonstrated that older people are willing to adopt a technological method of home exercise instruction. In the study exploring resource use, 30 of 110 patients chose to use their own smart technology when given a choice between methods; 22 used a smart phone and 8 used a tablet. The average age of those opting to use technology was 64 years. The qualitative analysis sought in-depth information regarding the patient experience of using technology for home exercise instructions. The average age of participants in this study was 72 years, and only 2 of 10 participants had ever used a touch screen device prior to their rehabilitation at this time. While not everyone liked this method of home exercise instruction, the study indicated that age was not a barrier to use, with all participants able to use smart technology for the purpose of home exercise instruction. It is anticipated that reach will grow as people become more familiar with technology in their daily lives, and as clinicians adopt the technology and promote it to their patients.

Efficacy

Efficacy is the impact of an intervention on important outcomes, including potential negative effects, quality of life, and economic outcomes (Glasgow, 2020). These different aspects of efficacy are not dissimilar to the components of quality of care, described by the National Health Service in the United Kingdom, which describe the patient experience of care, including patient safety, patient experience and effectiveness of care (National Health Service, 2008). The studies within this thesis demonstrated that while there was little difference between methods of home exercise instruction for patient functional outcomes, there were other process and qualitative benefits that make the use of videoed home exercise instructions a worthwhile option.

Patient safety assumes no harm to patients (National Health Service, 2008). Throughout the studies included in this thesis there were minimal negative effects experienced by patients when using videoed home exercise instructions, aside from some mild anxiety reported in those unfamiliar with technology.

Patient experience refers to patient satisfaction with an intervention or through a lived experience (National Health Service, 2008). The patient experience of the use of videoed home exercise instructions was evaluated in this thesis, with a study dedicated to understanding this component (Chapter 3). While not everyone liked using a tablet and some found it uncomfortably complex, the majority found that it helped their rehabilitation, being a novel intervention that enabled better organisation with easy to follow instructions. Although the randomised controlled trial (Chapter 2) demonstrated no difference between groups for enjoyment of exercises, participants in the qualitative study found that videos enabled a record of progress over time, and that there were benefits to carers too. Families could be involved in rehabilitation and carers could set up the devices for the patient to follow autonomously. While brief training and instructions were important, physical limitations, cognition and communication impairment were not a barrier to use. Several participants suggested that using tablets for exercise was a good way to introduce older people to the use of technology.

Effectiveness of care refers to clinical measures of improvement combined with the patient perspective of effectiveness (National Health Service, 2008). Within the individual studies included in this thesis, there was no evidence for effectiveness of video-based exercise instructions being superior to paper-based instruction for functional outcomes, and only very low-quality evidence that video-based instructions may have conferred a benefit of increased exercise adherence.

It was initially hypothesised that an improvement in adherence would result in improved functional outcomes. There are a few possible explanations for why this was not found. FITT-VP principles refer to recommended targets for frequency, intensity, time, type, volume and progression of exercise as derived from available scientific evidence (American College of Sports Medicine, 2018). Exercises should be evidence based to ensure they are appropriate and effective (Scurlock-Evans, Upton et al., 2014), and while the randomised controlled trial stated that exercises were prescribed according to clinical guidelines for the management of stroke, there was no record of type, intensity, or volume of exercises within each individual program to ensure they were evidence-based. A study exploring home exercise compliance and performance in adults over the age of 65 years found that performance decreased as the number of exercises increased, despite no change in adherence (Henry, Rosemond et al., 1999). In Henry et al (1999), an assessment tool was also used to monitor accuracy of performance. Accuracy of performance was not explored within this thesis. A study exploring a range of musculoskeletal disorders found that patients performed most of their home exercises inaccurately with compensatory movements, and exercises were not effective in reducing pain (Erdem, Unver et al., 2018). If participants are not performing exercises accurately, that is, if the fidelity of exercise performance is poor, they cannot be expected to achieve anticipated functional gains.

Another possible reason that the studies described in Chapters 2 and 4 found no benefits in outcomes associated with the use of smart technology for home exercise programs may have been the choice of outcome measures. Perhaps the outcome measures used, such as the Wolf Motor Function Test, were not sensitive enough for the range of stroke impairment included within the studies. Or, perhaps the wrong outcomes were chosen. Some alternative outcomes could have been accuracy of performance, ability to recall exercises, or even a more holistic measure of function and independence rather than specifically upper limb function. The fact that the qualitative research identified other benefits that were not measured in the quantitative research provides some support for this hypothesis. Finally, perhaps there simply is no difference in effectiveness between video or paper-based home exercise instructions. Given that no significant benefits in patient outcomes were found across 12 randomised controls (Chapters 2 and 4), this is an important consideration. Nevertheless, given minimal safety concerns for the patient, likely equivalence in functional outcomes, and positive patient experiences, use of the patient's own electronic smart devices for their home exercise instructions may be a worthwhile option.

Adoption

Adoption refers to the proportion and representativeness of settings (such as health departments) that adopt a given policy or program (Glasgow, Vogt et al., 1999). It can be considered at the setting and clinician levels, which will ultimately impact patient uptake.

At the setting where the studies described in this thesis were conducted, there is only anecdotal evidence of ongoing adoption of technology for home exercise instruction within the Community Rehabilitation Program. This setting introduced technology as an intervention as part of a trial. Agreement to participate was in a controlled way as part of the trial, rather than a choice to adopt a new intervention. However, the evidence collected provides information about the likelihood and benefit of adoption in other settings.

Given similar functional outcomes to traditional paper-based home exercise instruction, and cost and time savings for clinicians, the foreseeable barriers at an organisational level could be addressed to facilitate adoption of this intervention. It may not be worth a health service purchasing smart tablets for loan, but if patients already use this technology, promoting the use of smart devices for delivery of exercises programs may be appealing to service managers. Other settings in which this could be adopted include inpatient rehabilitation, community health, and private allied health services in which a younger clientele may enable greater uptake due to greater familiarity with technology.

Given the role of clinicians as the gatekeepers to the use of technology for home exercise instruction, their choice to adopt the intervention directly impacts on patient uptake, particularly with older people less familiar with technology. In our study exploring resource use, 22 clinicians agreed to participate in the project, representing 100% of eligible health professionals within the setting (occupational therapists= 6, physiotherapists=13, speech pathologists=3). However, of the 20 participants who provided home exercise programs to their patients, there were six who did not use technology at all and only provided written home instructions. Six others provided less than 50% of their instructions via technology. While these figures may reflect patient preference, it is an important consideration given that cultural resistance by health professional to technological uptake has been a common issue (Taylor, 2015) that may affect adoption.

It is also relevant to consider features of exercise instruction using technology that make it more likely to be adopted by a health service. There are many gaps between evidence-based recommendations and current healthcare. As suggested by the diffusion innovation theory, the adoption of a new clinical behaviour by a clinician and health care system is a consequence of multiple factors, not just research evidence (Sanson-Fisher, 2004). Rogers' theoretical approach suggests five elements of a new clinical behaviour that contribute to adoption or diffusion of a new activity: relative advantage, compatibility, complexity, trialability and observability (Rogers, 1983).

There are some areas in which it appears that smart technology use for home exercise programs has a 'relative advantage' over traditional paper-based exercise prescription. Technology is commonly perceived as better even though evidence within this thesis suggests that technology for this purpose was not superior for patient outcomes. This could still be seen as a relative advantage at an organisational level with equivalent outcomes at a decreased cost. However, at an individual level perception of relative advantage may depend on comfort with technology and the perceived balance between benefits and the inconvenience of trying something new. Age may be a contributing factor here. In the qualitative analysis, older patients unfamiliar with technology were anxious about using it. It has also been reported that clinicians share this concern, limiting technology use in their practice due to perceived lack of age appropriateness (Tatla, Shirzad et al., 2015).

Technology use for home exercise instruction is likely to be compatible with clinicians' values and experiences. Clinicians are likely to use smart technology for other purposes in their daily lives. If they observe that their patients are doing the same, they are more likely to encourage use, particularly when acknowledging that the innovation is far from complex, and that it is compatible with current practices. Patients will often already have the technology with them, and programs can be set up within existing sessions. It is an easy innovation to trial and modify. If the use of technology is not perceived by users to have any benefits, there is no serious consequence; they simply revert to traditional paper-based exercise. Finally, observability is the degree to which the results of the innovation are visible to others (Rogers, 1983). If patients like this method of home exercise instruction, they will tell their family, and tell their other clinicians about it. In the resource use study, 15 of 41 participants receiving video home exercises used their smart devices to receive home exercises from more than one discipline. Diffusion rates are more likely to spread with positive patient and clinician experiences as familiarity increases.

Implementation

Implementation refers to the extent to which a program is delivered as intended. It can be thought of as interacting with efficacy to determine effectiveness, on both individual-level and program-levels (Glasgow, Vogt et al., 1999). Within this thesis, video home exercise instructions were a very simple and practical approach to home exercise prescription that was easy to implement. While there were minimal process or outcome benefits, these were not required to make it worthwhile. It minimised cost and no significant additional resources were required. Only simple features of smart technology were used, and everyone demonstrated that they could use the technology for the purpose intended. While ‘apps’ are constantly changing with updates, discontinuations and new products coming online, the video function remains the same with little variation other than aesthetic improvements. Only basic instructions were required to train participants in its use (Appendix 1). The simplicity and low cost of this approach to home exercise instruction means that it could easily be implemented in a wide variety of health service settings.

In contrast, in the randomised controlled trial the alarm function was rarely implemented as intended. Its aim was to act as a reminder system to increase adherence as an added bonus of the technology being used. The electronic alarm sits as a standard feature on smart devices alongside the camera. However, participants commonly disabled the alarm. Some found it unnecessary, already motivated to complete their daily exercises in order to give themselves the best chance of recovery, without the need for external cues. Others found it inaudible and unhelpful, and some found it disruptive to the rest of their daily routine. A 2018 systematic review exploring reminder systems in physical therapy found positive effects on adherence in 35% of studies included, but the key difference with these studies was the use of therapist-controlled reminder methods including SMS, phone calls, letters, emails and notices on the wall rather than giving patients control or choice over electronic systems within technology used (Jangi, Ferandez-de-Las-Penas et al., 2018).

Health programs and interventions are more likely to be implemented when patients are provided with choice (Zolkefli, 2017). Giving patients choice and participation in decision-making has been linked to greater trust in the health professional-patient relationship, better adherence to treatment, better outcomes, and greater satisfaction (Elwyn, Edwards et al., 2016; Zolkefli, 2017). Method of home exercise instruction is therefore not just about functional outcomes or adherence, but about patient choice. A recent qualitative systematic review (Davenport, Dickinson et al., 2019) found patients want exercise programs that are individualised and adapted to their personal interests and choices. A recent cross-sectional study at an upper extremity rehabilitation facility in the United States found similar outcomes (Ouegnin and Valdes, 2019). Patients were given both written instructions and a video recording of themselves performing their exercises. The majority of participants preferred the mobile-based video home exercise instructions, finding it more visually appealing and more effective than written handouts. Aside from any other identified benefits, video-based delivery of home exercise programs could be introduced on a wider scale based primarily on a better patient experience.

Maintenance

Maintenance refers to the extent to which a program or policy becomes institutionalised or part of the routine organisational practices and policies. At the individual level, maintenance has been defined as the long-term effects of a program on outcomes after six or more months after the most recent intervention contact (Glasgow, 2020). We have not explored whether the Community Rehabilitation Programs involved in this thesis have continued to offer their patients this method of home exercise instruction or made it part of their policies, however there are a number of ways to assist the program to maintain use.

The evidence gathered in this thesis suggests that common barriers to maintenance of health programs are unlikely to apply in the application of smart technology for delivery of home exercise programs. Firstly, there are no ongoing costs (assuming patients use their own electronic devices), and, in fact, the resource use study described in Chapter 4 suggests that this approach has modest time and cost savings to the health service. Secondly, personal technology ownership continues to rise, making this approach more, rather than less, accessible as time passes. Thirdly, it is very simple to implement and required virtually no ongoing maintenance or refresher training. Third, it is not dependent on changes in policies, regulations or infrastructure to implement. Clinicians can implement this approach simply by asking their patients if they have a mobile phone.

Once this intervention is operating it should be easy to embed into practice. Some strategies to encourage ongoing use could include ceasing pre-printing of generic exercise instructions and replacing these with printed ‘cheat sheets’ for using video on smart devices readily available to hand out to patients if needed. Policy level changes could also be implemented to help influence clinician behaviour. For example, intake forms could be altered to prompt service coordination to ask patients on admission whether they own and/or use any form of smart technology. Discipline-specific initial assessment forms could be amended to include a question regarding current use of smart technology and preference for home exercise programs. The topic of smart technology use could be added as an agenda item to team meetings so that clinicians are regularly prompted to consider the intervention, share experiences and address any new issues that arise.

In summary, the RE-AIM framework suggests an overall positive indication for the use of video home exercise programs from reach to maintenance. While efficacy was neutral, the positive sway for the other components of reach, adoption, implementation and

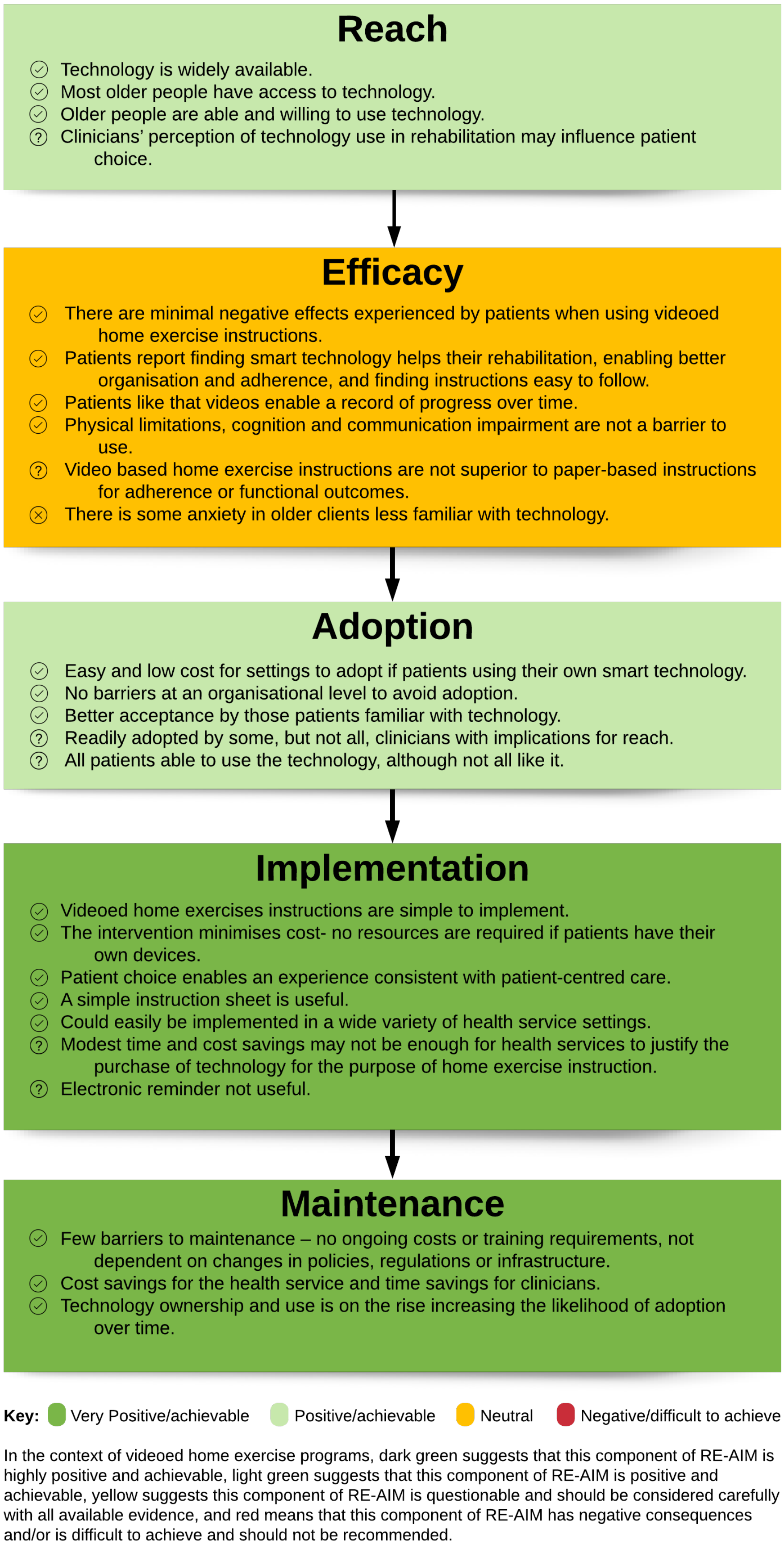

Figure 2. Using the RE-AIM framework to describe video home exercise instructions.

maintenance suggest that it would be beneficial and could be translated well into practice. Figure 2 presents a summary of the RE-AIM framework to explain this translation of research into practice. It summarises the use of home exercise instructions via personalised video using a modified version of the evidence alert traffic light system. This system provides a simple, common language between clinicians, families, managers, and funders, based upon three-level colour coding that recommends a course of action for implementation of the evidence within clinical practice (Novak, 2012; Novak, McIntyre et al., 2013; Novak, Morgan et al., 2020).

6.3 Areas for further research

The individual studies in this thesis, confined to a Community Rehabilitation Program in a large health service in Melbourne, Australia, could lead to further research in other populations. The basic tools used in video exercise instruction, namely the camera on personal smart devices, have the potential for use in many different skills areas and target groups in addition to exercise. Some of these include teaching skills to patients and carers, and for medical interventions.

There are many studies detailing educational videos for a range of health areas, including palliative care (Cruz-Oliver, Pacheco Rueda et al., 2020), falls prevention (Lee, Pritchard et al., 2013) and cardiovascular recovery (Commodore-Mensah and Dennison Himmelfarb, 2012). However, in all of these studies, general education is provided within generic videos that are aimed at educating all viewers as one. While generic one-size-fits-all videos may be less time consuming for the service, and on many occasions can be generalised to a population, they are not well suited to situations requiring a more tailored approach. Personalised video instruction has significant advantages over generic approaches that could be used for providing specific skill training to individual patients and their carers, consistent with the principles of person-centred care (Australian Commission on Safety and Quality in Health Care, 2011). Anecdotally, there are health facilities providing this service but there appears to be a gap in the literature exploring the effectiveness of this approach.

Personalised video is an ideal medium for training people to complete complex tasks in specific contexts. For example, carers could be trained in complex transfers using various pieces of equipment, such as slide sheets, hoists or even for procedures such as wound care while their family member is still in hospital. They could be filmed on their smart devices and then take these home in order to follow instructions later, step-by-step as they had practiced. Again, the key in this method is that each individual is different and likely to transfer in a particular way, requiring their own cues. Further research into smart technology for this purpose may be beneficial for the confidence of carers and the safety of patients.

Finally, further research could be conducted into the use of the video function on smart technology for skill acquisition of medical interventions. For example, use of an asthma preventer or insulin injection in diabetes management. There have been studies exploring generic videos for this purpose (von Schantz, Katajavuori et al., 2018), but a key oversight identified was lack of patient feedback. By using personalised video, patients could perform these skills under the supervision of a medical professional while being videoed. They could then take their smart device home and re-watch the videos to ensure they are performing the correct actions, while hearing the instructions and corrections from the medical professional.

In the post COVID-19 era, the recommended next steps would be to review some of this research given the rapid uptake of technology and telehealth by health services and the community. The world as a whole has had no choice but to rapidly become familiar with the use of smart technology in order to receive contactless healthcare. Therefore, some of the barriers identified within this thesis may have been overcome within the past six months. This thesis reinforces the role of recorded video for feedback and recall. Further research could look at the benefits of recording telehealth specialist consultations for patients and health professionals.

6.4 Strengths and limitations

A strength of this thesis is that it includes a range of study designs, including a randomised controlled trial, a qualitative analysis, a systematic review with meta-analyses, and a resource analysis (observational cohort study) to gain a comprehensive understanding of various perspectives on the use of smart technology for home exercise instruction. This thesis includes the patient perspective in relation to process and outcome measures, as well as the clinician and health service perspective in relation to time and cost savings. Four peer reviewed articles were published in three different journals: *Clinical Rehabilitation* (United Kingdom), the *Australian Occupational Therapy Journal* (Australia), and *Disability and Rehabilitation* (United Kingdom).

There are some limitations to the research conducted in this thesis. First, research was conducted in a single setting, a Community Rehabilitation Program in a large health service in Melbourne, Australia. This program may have features that are not replicated elsewhere, with a specific funding model enabling both home and centre-based allied health services for a short period following discharge from an acute or inpatient rehabilitation setting. It is unknown how this service, and the use of technology for home exercise instructions in this way, could be generalised to other service models and in other countries.

The focus on smart technology could be interpreted as a limitation of this thesis, in that the intervention may not be available to a large proportion of the world's population in less wealthy nations. However, the gap in smart phone penetration across the world has closed considerably over the last few years, with an average difference between regular mobile phone and smart phone uptake within most countries sitting at around 10 per cent or less (Deloitte Touche Tohmatsu Limited, 2017). In developing countries there is now 82% ownership of smart phones (Deloitte Touche Tohmatsu Limited, 2017). In some places it may soon be the case that a smart phone is more accessible than supplies of paper or printers.

The completion of a randomised controlled trial prior to the completion of a systematic review is a less common approach to a body of research for a thesis and could be viewed as a limitation. The idea for the research and early planning for the randomised controlled trial arose from the clinical problem of stroke patients failing to complete their written home exercise programs. It was identified that patients were collecting large amounts of exercises on paper collected from various levels of their hospital journeys, and from various allied health disciplines. Patients were observed to be overwhelmed and not engaging in any home program, with perceived detrimental effects on their recovery.

A limited, narrative scoping review of the literature was conducted with technology determined to be a potential solution. Completion of the systematic review later in the timeline of the body of work provided an opportunity to directly consider the findings of the randomised controlled trial within the context of similar studies.

There were a range of limitations discussed within each publication. Within the randomised controlled trial, adherence was chosen as the primary outcome measure due to the hypothesised pathway for improved outcomes mediated through increased adherence. There were no differences in adherence or function in this study. Perhaps future research could trial specific exercises that are known to be effective; only including those recommended to be consistent with clinical practice guidelines. However, a difficulty is that clinical practice guidelines often do not provide recommendations about specific exercises. The population included within the studies could also be of importance. Patients with chronic stroke were included in the randomised controlled trial, but perhaps this meant that outcome measures such as the Wolf Motor Function Test were not sensitive enough resulting in a floor effect for functional measures. The qualitative analysis contained a relatively small sample size of only men. While data approached saturation, it is possible a larger sample may have revealed further themes, especially any related to gender. In the resource analysis patients were not randomised to modality of instruction. The aim was to measure resource use from a service perspective with patient choice and access to technology considered in the real context of exercise provision for the future. There were no significant demographic differences between the groups, and the majority of time savings were achieved away from the patient, indicating that the difference in clinician time was not explained by patient factors.

Finally, it is important to consider the information within this thesis in the context of rapid changes in technology uptake and function over time. There has been a considerable increase in technology uptake by the population. A 2018 report demonstrated a 0% to 50% adoption of the tablet computer within only 5 years (Desjardins, 2018). As a result, older patients will be more likely to be familiar with technology in the future. This should only make it easier to implement such things as videoed home exercise instruction. In addition, one of the main reasons for using the video function of smart technology was its ease of use and stability over time. This method of home exercise instruction was not dependent on specific apps, most of which require regular updating and upgrading due to advances in technology and creative ideas. The video function on smart technology has essentially remained the same, other than enhancements to such things as speed and resolution. Therefore, findings of this thesis are likely to remain applicable into the future.

A final strength of this thesis is its timeliness within the context of the 2019/20 Coronavirus pandemic in which the use of smart technology has grown rapidly for a variety of purposes, from simple everyday social contact to more complex health interventions. The pandemic has accelerated technology uptake generally, and specifically in the rapid implementation of telehealth (Australian Academy of Technology & Engineering, 2020). It is anticipated that this global health crisis may be a catalyst to bring about change in the way technology is used to facilitate home exercise instruction and a range of other uses.

Lessons can be taken from this thesis with implications for therapists, rehabilitation service providers and users of rehabilitation services. The introduction of telehealth for services to patients may still come down to individual therapist opinions and uptake. However, it is important that specific and regular training is provided to therapists to improve their comfort, confidence and enthusiasm to give telehealth a go. Many assumptions continue to be made regarding older patients being unfamiliar with technology with the result that they are often still not given a choice about method of therapy delivery. It is important to give people choice to enable access to ongoing healthcare. As restrictions ease, the other benefits of technology as identified in this research, such as time and cost savings, are likely to be realised and influence models of care into the future."

6.5 Conclusion

Given the combination of evidence provided in this thesis, video-based instructions using the patient's own device are a feasible and low-cost method of prescribing exercise programs, and should be provided as an option by allied health professionals working in rehabilitation. While not superior to paper-based instructions in achieving improved clinical outcomes, video-based instructions can enhance the patient experience of health care and minimise costs for the health service.

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Appendix 1: iPAD for Upper limb home exercise program-Quick guide

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-iPAD for Upper Limb Home Exercise Program-
QUICK GUIDE

1) Press HOME button to turn on 

2) Unlock by sliding bar 

3) Tap " VIDEO BOOTH" app 

4) Tap "EXERCISE 1"

5) Tap play 

6) Repeat as necessary

7) Tap "BACK" (top left of screen)

8) Tap "EXERCISE 2"

9) Repeat until all exercises complete

10) Press 'SLEEP' button for power save off 

Video booth is a commercially available app that was used purely for organising videos on iPads for ease of accessibility for trial participants.

Appendix 2: Ethics Approval Statements

Study 1: Home exercise programmes supported by video and automated reminders compared with standard paper-based home exercise programmes in patients with stroke: A randomized controlled trial.

La Trobe University	FHEC14/269
Eastern Health	LR98/1213

Study 2: Home exercise programs supported by video and automated reminders for patients with stroke: A qualitative analysis.

La Trobe University	FHEC14/269
Eastern Health	LR98/1213

Study 3: Providing exercise instructions using multimedia may improve adherence but not patient outcomes: a systematic review and meta-analysis.

La Trobe University	N/A
Eastern Health	N/A

Study 4: A resource analysis of the use of the video function of electronic devices for home exercise instruction in rehabilitation.

La Trobe University	LR42-2017- TAYLOR/Emmerson
Eastern Health	LR42/2017

LA TROBE UNIVERSITY

FACULTY OF HEALTH SCIENCES

MEMORANDUM

To: **Nicholas Taylor – Department of Physiotherapy**

Student: **Kellie Emmerson**

From: **Chair, La Trobe University Faculty Human Ethics Committee**

Subject: **FHEC acceptance of Eastern Health HREC approved project – LR98/1213 FHEC14/269**

Title: **A comparison of Home Exercise Programs supported by video and automated reminders with standard paper-based Home Exercise Programs on adherence and functional outcomes in stroke patients.**

Date: **8 December, 2014**

Thank you for submitting the above protocol to the Faculty Human Ethics Committee (FHEC). Your material was forwarded to the FHEC Chair for consideration. Following evidence of a full review and subsequent final approval by the **The Eastern Health HREC**, the FHEC Chair agrees that the protocol complies with the National Health and Medical Research Council's *National Statement on Ethical Conduct in Human Research* and is in accordance with La Trobe University's *Human Research Ethics Guidelines*.

Endorsement is given for you to take part in this study in line with the conditions of final approval outlined by The Eastern Health HREC.

Limit of Approval. La Trobe FHEC endorsement is limited strictly to the research protocol as approved by The Eastern Health HREC.

Variation to Project. As a consequence of the previous condition, any subsequent modifications approved by The Eastern Health HREC for the project should be notified formally to the FHEC.

Annual Progress Reports. Copies of all progress reports submitted to The Eastern Health HREC are to be forwarded to the FHEC. Failure to submit a progress report will mean that endorsement for your involvement in this project will be rescinded. An audit related of your involvement in the study may be conducted by the FHEC at any time.

Final Report. A copy of the final report is to be forwarded to the FHEC within one month of it being submitted by The Eastern Health HREC.

If you have any queries related to the information above or require further clarifications, please fhechealth@latrobe.edu.au. Please quote FHEC application reference number FHEC14/269.

On behalf of the Faculty Human Ethics Committee, best wishes with your research!

Owen M Evans, PhD
Chair
Faculty Human Ethics Committee
Faculty of Health Sciences

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GREAT HEALTH AND WELLBEING

5 Arnold Street, Box Hill
Victoria 3128 Australia
PO Box 94, Box Hill 3128
Tel (03) 9895 3281
Fax (03) 9895 4896
info@easternhealth.org.au
ABN 68 223 819 017

www.easternhealth.org.au

Human Research Ethics Committee - Scientific and Ethical Review

Ethical Approval – Granted

Commencement of Research at Eastern Health has been authorised

25 June 2013

Kellie Emmerson
Community Rehabilitation Program
Eastern Health
Locked Bag 1
Forest Hill
VIC 3131

Eastern Health Research and Ethics Committee
Ph: 03 9895 3398
Fax: 03 9094 9610
Email: ethics@easternhealth.org.au
Website: www.easternhealth.org.au/ethics

Dear Miss Emmerson

LR98/1213 – A comparison of Home Exercise Programs supported by video and automated reminders with standard paper-based Home Exercise Programs on adherence and functional outcomes in stroke patients.

Principal Investigator: Miss Kellie Emmerson

Associate Investigators: Miss Anna Joy; Mrs Katherine Harding

Other Approved Personnel: Nil

Eastern Health Sites: Wantirna Health & Peter James Centre

Approval Period: On-going - subject to a satisfactory progress report being submitted annually.

Thank you for the submission of the above project for review. The project has been reviewed by the Eastern Health Research and Ethics Committee. The project is considered of low risk in accordance with definitions given in the National Statement (2007). All queries have now been addressed and the project is accordingly **APPROVED**.

Documents submitted for review:
- Application Form – version 2 dated June 2013
- Participant Information and Consent Form (Participant) – version 2 dated June 2013
- Participant Information and Consent Form (Person Responsible) –version 4 dated June 2013
- Discharge survey – version 2 dated 17 June 2013

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5 Arnold Street, Box Hill
Victoria 3128 Australia
PO Box 94, Box Hill 3128
Tel (03) 9895 3281
Fax (03) 9895 4896
info@easternhealth.org.au
ABN 68 223 819 017
www.easternhealth.org.au

IMPORTANT: A final progress report should be submitted on project completion. If the project continues beyond 12 months an annual progress report should be submitted in **June 2014**. Continuing approval is subject to the submission of satisfactory progress reports. Progress report template can be downloaded from our web-page:
http://www.easternhealth.org.au/research/ethics/progressreports.aspx

Please quote our reference number ***LR98/1213*** in all future correspondence.

Yours sincerely,

Astrid Nordmann
Research Governance Officer
Eastern Health Office of Research and Ethics
(Signed on behalf of the Eastern Health Research and Ethics Committee)

Copy to:
- Miss Anna Joy; Mrs Katherine Harding

Confidentiality, Privacy & Research

Research data stored on personal computers, USBs and other portable electronic devices must not be identifiable. No patients' names or UR numbers must be stored on these devices.

Electronic storage devices must be password protected or encrypted.

The conduct of research must be compliant with the conditions of ethics approval and Eastern Health policies.

Publications

Whilst the Eastern Health Research and Ethics Committee is an independent committee, the committee and Eastern Health management encourage the publication of the results of research in a discipline appropriate manner. Publications provide evidence of the contribution that participants, researchers and funding sources make.

It is very important that the role of Eastern Health is acknowledged in publications.

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Members of Eastern Health

Angliss Hospital Tel (03) 9764 6111 | Box Hill Hospital Tel (03) 9895 3333 | Healesville & District Hospital Tel (03) 5962 4300 | Maroondah Hospital Tel (03) 9871 3333 | Peter James Centre Tel (03) 9881 1888 | Wantirna Health Tel (03) 9955 1200 | Yarra Ranges Health Tel (03) 9091 8888 | Yarra Valley Community Health Service Tel 1300 130 381

LA TROBE UNIVERSITY

COLLEGE OF SCIENCE, HEALTH & ENGINEERING

MEMORANDUM

To: **Professor Nicholas Taylor – School of Allied Health**

Student: **Kellie Emmerson**

From: **Secretariat, La Trobe University Human Ethics Sub-committee**

Subject: **HESC acceptance of Eastern Health modification to approved project – LR98/1213.**

FHEC14/269.

Title: **A comparison of Home Exercise Programs supported by video and automated reminders with standard paper-based Home Exercise Programs on adherence and functional outcomes in stroke patients.**

Date: **24 March, 2015**

Thank you for submitting your modification to Human Ethics Sub-committee (HESC). Your material was forwarded to the HESC Chair for consideration. Following evidence of review and subsequent approval of the modification by the **The Eastern Health HREC**, the HESC Chair agrees that the modified protocol complies with the National Health and Medical Research Council's *National Statement on Ethical Conduct in Human Research* and is in accordance with La Trobe University's *Human Research Ethics Guidelines*.

Endorsement is given for you to take part in this study in line with the conditions of modification approval outlined by The Eastern Health HREC.

Limit of Approval. La Trobe HESC endorsement is limited strictly to the research protocol as approved by The Eastern Health HREC.

Variation to Project. As a consequence of the previous condition, any subsequent modifications approved by The Eastern Health HREC for the project should be notified formally to the HESC.

Annual Progress Reports. Copies of all progress reports submitted to The Eastern Health HREC are to be forwarded to the HESC. Failure to submit a progress report will mean that endorsement for your involvement in this project will be rescinded. An audit related of your involvement in the study may be conducted by the HESC at any time.

Final Report. A copy of the final report is to be forwarded to the HESC within one month of it being submitted by The Eastern Health HREC.

If you have any queries related to the information above or require further clarifications, please hesc.she@latrobe.edu.au. Please quote FHEC application reference number FHEC14/269.

On behalf of the Human Ethics Sub-committee, best wishes with your research!

Ms Kate Ferris
Human Ethics Officer
Secretariat – SHE College Human Ethics Sub-Committee
Ethics and Integrity / Research Office
La Trobe University Bundoora, Victoria 3086
E: hesc.she@latrobe.edu.au
P: (03) 9479 – 3370
http://www.latrobe.edu.au/researchers/ethics/human-ethics

COLLEGE OF SCIENCE, HEALTH & ENGINEERING

MEMORANDUM

To:	Nicholas Taylor – Department of Rehabilitation, Nutrition & Sport
Student:	Kellie Emmerson
From:	Secretariat, SHE College Human Ethics Sub-Committee (SHE CHESC)
Reference:	SHE CHESC acceptance of Eastern Health HREC approved project - LR42-2017.
Title:	A resource analysis of the use of electronic tablets for home exercise prescription in rehabilitation
Date:	1 June, 2017

Thank you for submitting the above protocol to the SHE College Human Ethics Sub-Committee (SHE CHESC). Your material was forwarded to the SHE CHESC Chair for consideration. Following evidence of a full review and subsequent final approval by the Eastern Health HREC, the SHE CHESC Chair agrees that the protocol complies with the National Health and Medical Research Council's *National Statement on Ethical Conduct in Human Research* and is in accordance with La Trobe University's *Human Research Ethics Guidelines*.

Endorsement is given for you to take part in this study in line with the conditions of final approval outlined by The Eastern Health HREC.

Limit of Approval. La Trobe SHE CHESC endorsement is limited strictly to the research protocol as approved by The Eastern Health HREC.

Variation to Project. As a consequence of the previous condition, any subsequent modifications approved by The Eastern Health HREC for the project should be notified formally to the SHE CHESC

Annual Progress Reports. Copies of all progress reports submitted to The Eastern Health HREC are to be forwarded to the SHE CHESC. Failure to submit a progress report will mean that endorsement for your involvement in this project will be rescinded. An audit related of your involvement in the study may be conducted by the SHE CHESC at any time.

Final Report. A copy of the final report is to be forwarded to the CHESC within one month of it being submitted by The Eastern Health HREC.

If you have any queries related to the information above or require further clarifications, please contact chesc.she@latrobe.edu.au. Please quote reference number LR42-2017– TAYLOR/Emmerson.

On behalf of the College Human Ethics Sub-Committee, best wishes with your research!

Ms Kate Ferris
Human Ethics Officer
Secretariat – SHE College Human Ethics Sub-Committee
Ethics and Integrity / Research Office
La Trobe University Bundoora, Victoria 3086
E: chesc.she@latrobe.edu.au
P: (03) 9479 – 3370
http://www.latrobe.edu.au/researchers/ethics/human-ethics

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Office of Research and Ethics
T 03 9895 3398
F 03 9094 9610
E ethics@easternhealth.org.au
W easternhealth.org.au/research-ethics
ABN 68 223 819 017
www.easternhealth.org.au

Human Research Ethics Committee - Scientific and Ethical Review
Ethical Approval – Granted

30 May 2017

Dear Ms Kellie Emmerson

LR42/2017 – A resource analysis of the use of electronic tablets for home exercise prescription in rehabilitation

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Principal Investigator: Ms Kellie Emmerson
Associate Investigators: Alexandra Robinson, Professor Nicholas Taylor, Dr Katherine Harding, Cynthia Fong
Eastern Health Sites: Peter James Centre, Wantirna Health

Approval Period: On-going - subject to a satisfactory progress report being submitted annually

Thank you for the submission of the above project for review. The project has been reviewed by the Eastern Health Human Research Ethics Committee. The project considered negligible risk in accordance with definitions given in the National Statement (2007). All queries have now been addressed and the project is accordingly **APPROVED**.

Documents submitted for review:

- Low Risk & Negligible Risk Research Application Form v1 dated 05 May 2017
- Patient Information Sheet/Consent Form v2 dated 27 May 2017

Reporting Requirements:

Please note, an **annual progress report is required every February for the preceding calendar year until project completion.** Continuing approval is subject to the timely submission of a satisfactory progress report. Progress report template can be downloaded from our web-page:
http://www.easternhealth.org.au/research-ethics/research-ethics/quick-links-to-forms-and-templates

Please ensure you notify the Ethics Committee of all personnel changes and any serious adverse events that may affect study conduct. Any changes to the approved Protocol or other approved documents must be submitted for ethical review and approval prior to use.

Please quote our reference number **LR42/2017** in all future correspondence.

Yours sincerely

Robert Reid
Administrative Assistant (Intern)
Eastern Health Office of Research and Ethics

On behalf of:

1. Eastern Health Human Research Ethics Committee (Ethics Approval)
2. Executive Director Medical Services and Research (Site Authorisation)

Confidentiality, Privacy & Research

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Electronic storage devices must be password protected or encrypted.

The conduct of research must be compliant with the conditions of ethics approval and Eastern Health policies.

Publications

Whilst the Eastern Health Research and Ethics Committee is an independent committee, the committee and Eastern Health management encourage the publication of the results of research in a discipline appropriate manner. Publications provide evidence of the contribution that participants, researchers and funding sources make.

It is very important that the role of Eastern Health is acknowledged in publications.

Appendix 3: Publication Statements

Study 1

Statement from the co-authors confirming contribution of the PhD candidate:

As co-authors of the paper, “Home exercise programmes supported by video and automated reminders compared with standard paper-based home exercise programmes in patients with stroke: a randomised controlled trial,” we confirm that Kellie Emmerson has made the following contributions:

- Conception and design of the research
- Collection of data
- Analysis and interpretation of the findings
- Writing the paper
- Critical appraisal of the content, and
- Response to reviewers

Professor Nicholas Taylor Date: 22 May, 2020

Dr Katherine Harding Date: 22 May, 2020

Study 2

Statement from the co-authors confirming contribution of the PhD candidate:

As co-authors of the paper, "Home exercise programs supported by video and automated reminders for patients with stroke: A qualitative analysis," we confirm that Kellie Emmerson has made the following contributions:

- Conception and design of the research
- Participant interviews
- Collection of data
- Analysis and interpretation of the findings
- Writing the paper
- Critical appraisal of the content, and
- Response to reviewers

Professor Nicholas Taylor Date: 22 May, 2020

Dr Katherine Harding Date: 22 May, 2020

Dr Kylee Lockwood Date: 25 May, 2020

Study 3

Statement from the co-authors confirming contribution of the PhD candidate:

As co-authors of the paper, “Providing exercise instructions using multimedia may improve adherence but not patient outcomes: a systematic review and meta-analysis,” we confirm that Kellie Emmerson has made the following contributions:

- Conception and design of the research
- Collection of data
- Analysis and interpretation of the findings
- Writing the paper
- Critical appraisal of the content, and
- Response to reviewers

Professor Nicholas Taylor Date: 22 May, 2020

Dr Katherine Harding Date: 22 May, 2020

Study 4

Statement from the co-authors confirming contribution of the PhD candidate:

As co-authors of the paper, “Providing exercise instructions using multimedia may improve adherence but not patient outcomes: a systematic review and meta-analysis,” we confirm that Kellie Emmerson has made the following contributions:

- Conception and design of the research
- Collection of data
- Analysis and interpretation of the findings
- Writing the paper
- Critical appraisal of the content, and
- Response to reviewers

Professor Nicholas Taylor Date: 22 May, 2020

Dr Katherine Harding Date: 22 May, 2020

Cynthia Fong Date: 22 May, 2020

Appendix 4: Permissions

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