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Abstract

Introduction: The routine use of evidence-based upper limb rehabilitation interventions after stroke has the potential to improve function and increase independence. Two such interventions are Constraint Induced Movement Therapy (CIMT) and Robot Assisted therapy (RAT). Despite evidence to support both interventions their use within the NHS appears, anecdotally, to be low. We sought to understand user perceptions in order to explain low uptake in clinical practice.

Methods: A combination of a cross-sectional online survey with therapists and semi-structured interviews with stroke patients were used to explore uptake and user opinions on the benefits, enablers and barriers to each intervention.

Findings: The therapists surveyed reported low use of CIMT and RAT in clinical practice within NHS Scotland. Barriers identified by therapists were inadequate staffing, and a lack of training and resources. Interviews with stroke patients identified themes which may help us to understand the acceptability of each intervention, such as the impact of motivation.

Conclusion: Barriers to uptake of CIMT and RAT within the clinical setting were found to be similar. Further qualitative research should be completed in order to help us understand the role patient motivation plays in uptake.

Keywords: stroke, upper limb rehabilitation, novel techniques, barriers, benefits, enablers

Introduction

The World Health Organisation reports 15 million people worldwide suffer a stroke annually. Of these, 5 million are left permanently disabled (Mackay and Mensah, 2004) leading to an estimated socio-economic cost of 9 billion pounds a year in the United Kingdom (UK) alone (Saka et al., 2009).

Upper limb (UL) impairments are the most common disabling deficits after stroke, with a reported 69% of stroke survivors experiencing initial functional motor impairments (Urton et al., 2007) and as many as 50% reporting long-term severe UL impairments and functional limitations (Huang et al., 2012).

The development and refinement of upper limb rehabilitation strategies after a stroke has the potential to improve an individual's function as well as decrease the burden on caregivers and the health care system (Lee et al., 2016).

Two interventions which are currently used for the rehabilitation of the UL after stroke are Constraint Induced Movement Therapy (CIMT) and Robot Assisted Therapy (RAT).

CIMT emerged as a neurorehabilitation technique in the 1990's and is based on the premise that overcoming learned non-use promotes cortical reorganisation. The original protocol for CIMT involves a two-week programme of intensive graded practice with the affected upper limb, for up to six hours per day, while constraining the non-affected upper limb in a mitten for 90% of waking hours to promote functional use (Taub, 1993). Difficulties adhering to the original CIMT protocol led to development of protocols featuring varying practice schedules (Fleet et al., 2014a), known as modified CIMT (mCIMT). However, little is known as yet about the optimal dose of CIMT (Etoom et al., 2016).

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Intensity is considered to be a key element in rehabilitation (French et al., 2010) and, in recent years, robotic devices capable of delivering high intensity training have been used to improve functional movement of stroke patients (Kwakkel et al., 2008). Rehabilitation robots can be divided into therapeutic and assistive robots. The purpose of assistive robots is compensation, such as robotic feeders and smart powered wheelchairs, whereas therapeutic rehabilitation robots provide task-specific training. The latter will be explored during this study and, within the context of upper limb rehabilitation after stroke, predominately consist of hardware in which the arm is placed, often involving a weight compensation function, linked to software in the form of interactive games on a screen which encourage repetitive movement of the affected arm.

A systematic review and meta-analysis completed by Veerbeek et al (2017) suggested translational research in rehabilitation robotics poststroke is still in its infancy, requiring interdisciplinary collaboration from the outset. This should involve consultation with bioengineers, designers, neuroscientists, clinicians, clinical trialists as well as the end-users themselves (i.e. stroke patients), in order to take the findings from clinical research and produce innovation in healthcare settings. With the slow spread of innovations in health care, the dissemination of new ideas and effective practices from one organisation to another to improve care is one of the central challenges of the NHS (Horton et al., 2018). It is, therefore, of upmost importance that when examining the uptake of rehabilitation techniques that these are considered within the environmental and social context of the service in order to better understand barriers and facilitators to successful widespread implementation.

Users have identified the importance of addressing such priorities as access to equipment, ease of use, feedback and training in order to enhance adoption of rehabilitation technologies (Kerr et al., 2018). In addition, other factors such as patient motivation to adhere to specific treatment techniques should also be acknowledged when we consider that, in acquired brain injury (ABI) populations, low motivation to engage in rehabilitation is associated with poor rehabilitation outcomes (Kusec et al., 2018).

Modified (m)CIMT has been embedded into practice within some, but not all, NHS Lanarkshire (NHSL) services for some time, and a small trial of RAT has recently been undertaken at one site within NHSL. The authors sought to understand how best to support widespread implementation of these interventions in stroke services.

Review of the literature

Despite Cochrane systematic reviews showing good quality evidence of efficacy for both CIMT (Pollock et al., 2014; Corbetta et al., 2015) and RAT (Mehrholz et al., 2018) the uptake of new techniques is known to be low within the NHS. A review of the literature was conducted to assess the reported clinical use of the two interventions and to explore both clinician and patient perceptions of CIMT and RAT as a means of understanding potential barriers and facilitators to uptake.

CIMT

Throughout the literature there is evidence of attempts to quantify the application and use of CIMT and mCIMT, primarily through surveys with users to explore the incidence of its use in practice, alongside perceived challenges and benefits. Despite international differences in prevalence of use, there are common perceived challenges in relation to implementation.

In 2014 a large, (n=489), online survey of UK based therapists treating patients with ABI, was conducted. This revealed low proportions (37%) of therapists using CIMT (Pedlow et al., 2014).

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Therapists identified two main barriers to implementation; 1) a lack of resources (primarily staffing) and 2) training. Additionally, therapists felt the main factors interfering with patients attending CIMT sessions were difficulty adhering to the length of contact time and number of therapy days.

Similar numbers were reported by Fleet et al. (2014b) in a survey of 338 therapists working within adult neurological rehabilitation. Here 43% reported using CIMT in the preceding two years. Interestingly the authors also reported that a higher self-reported level of CIMT knowledge predicted greater use of CIMT ($P \leq 0.001$).

In order to further explore clinician knowledge and experience in the delivery of CIMT protocols within neurorehabilitation, Christie et al. (2019) completed a further survey of 169 therapists from eleven countries. Only those who had used CIMT within the past two years were included in the study. The findings suggested that occupational therapists (OT's) were more likely to use CIMT than physiotherapists (PT's), with almost 75% of PT and OT's using mCIMT, rather than original CIMT. The results further highlighted the importance of formal training, with respondents who had attended an external CIMT training workshop being more likely to report higher levels of knowledge of CIMT (83.3%, $P = 0.032$) and confidence using it in practice (92.3%, $P = 0.002$). The vast majority of respondents (95.9%) felt CIMT was a useful intervention, with functional improvement and increased use of the affected hand cited as the most notable benefits. Whilst support from management (n=31) and a collaborative interdisciplinary approach (n=24) were frequently considered to be important factors in the sustainability of CIMT delivery.

The literature, so far, has largely focused on therapist's opinions and perspectives. Very little attention has been paid to patient views and opinions on the acceptability of CIMT/mCIMT. This is an important omission given the effort and time commitment required from patients.

Through use of a comprehensive self-reported questionnaire, Page et al. (2002) examined both patient and therapist opinions of CIMT. The study obtained a large sample of 208 patients with stroke, and 85 therapists. Sixty eight percent of patients who responded stated they were not interested in CIMT, with the most salient concerns reported to be practice schedule (six hours self-practice per day) and the actual constraint device schedule (mitt to be worn on affected arm 90% of waking hours). It should be noted that the reading material provided alongside the questionnaire outlined the original CIMT protocol and did not explore the option of a modified CIMT programme, which may have had an impact on acceptability of the programme.

The surveys reported in the literature which have examined clinical use of CIMT do not specify whether the sampled therapists worked within the NHS alone, as opposed to those employed within private practice. Furthermore, the literature provides little insight to patient perceptions of this intervention. Given the importance of patient compliance, this is a notable omission.

In order to understand, and perhaps attempt to maximise the acceptability of the intervention, further qualitative research would be of benefit to explore patient opinions following completion of CIMT programmes.

RAT

Despite an acknowledgement in the literature that robot technology for stroke rehabilitation is developing rapidly (Veerbeek et al., 2017), a Cochrane review in 2018 (Mehrholz et al.) recognised that the general applicability of robot therapy might be limited simply by the lack of access to the devices. Furthermore, the authors of this review suggested differences in outcomes between electromechanical or robot-assisted arm training and other interventions could be due to an improvement in motivation due to feedback from the device, or the novelty of a robotic device. They

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suggested a lack of quality research in this area, however, means that these possible recovery mechanisms are simply speculation.

There is emerging recognition that human–robot interaction can play an essential role in assistive and rehabilitation robotics (Beckerle et al., 2017). As such, it is important that robot-assisted environments should be modified to better engage the stroke survivor, to improve relevance to the person and the activities they do in real life (Johnson, 2006). Although attempts have been made to explore patient acceptability of robot assisted therapy in other clinical areas, an extensive search of the literature reveals very few studies have been conducted to explore perceptions of RAT upper limb interventions with patients after stroke. The vast majority of studies conducted on the intervention have focussed on motor control and function and little consideration has been given to user perspectives (i.e. patient/therapist), or indeed to attrition and acceptability.

A review of the literature found no published studies to date have investigated how commonly these devices are being used and few have addressed the barriers to implementation into clinical practice.

Two surveys (Lu et al., 2010, n=233; Lee et al., 2005, n=17) explored clinician perspectives on the need and requirements of a robotic device for therapy, with therapists highlighting the need for software/games to reflect activities of daily living, devices being useful in-home, and affordability. Furthermore, a recent qualitative study explored therapist perceptions (n=12) following clinical use of RAT within an Australian rehabilitation facility (Flynn et al., 2019). Within this study, therapists reported that uptake of RAT in routine practice was linked to three main elements: leadership, adequate training and availability of suitable patients.

Overall, there is very little in the literature which helps us to understand user perceptions of RAT. In addition, to the authors knowledge, there have been no studies published to date which quantify the current access to, and clinical use of, rehabilitation robots within the UK. Further research into the area of patient and therapist perceptions may help inform future robot designs and address the highlighted issues of user acceptability and adherence.

Study Aims

This study will address the following research questions:

1. What do NHS Scotland therapists perceive to be the main benefits and barriers for *patients* in regard to the use of CIMT and RAT?
2. What do NHS Scotland therapists perceive to be the main barriers and enablers for *services* in regard to the implementation and sustainability of each intervention?
3. What are the barriers and enablers of each intervention?
4. To what extent are CIMT and RAT used within clinical practice in NHS Scotland rehabilitation services?

The insights gained by addressing these questions can help inform strategies designed to integrate these promising rehabilitation interventions into routine practice.

Methods

Background

This qualitative study was embedded within a larger feasibility randomised controlled trial (RCT), the full results of which are yet to be published. Within the feasibility RCT, participants were randomly

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assigned into one of three groups; normal treatment (NT) only, NT + mCIMT, NT + RAT, in order to examine the effects of the two interventions with patients in the sub-acute phase after stroke.

Participants in the two intervention groups took part in 12 sessions of either mCIMT or RAT within a hospital outpatient setting, delivered by an OT. The four-week mCIMT protocol involved wearing a constraint mitt for at least 50% of waking hours with 3 hours of task practice at home five days a week, in addition to three 45 min sessions with the OT per week. The RAT protocol was over a four to six-week period with participants receiving a 45 min session of RAT at least twice per week and given general advice about using their affected arm at home during daily activities. The timetable for sessions was made following discussion between the OT and participant, taking their capabilities and existing rehabilitation programme into account.

The robotic device used was a passive 5 degrees of freedom weight compensation system (Armeo®Spring, Hocoma AG, Switzerland) with on screen interactive games and activities.

Participants were recruited from three acute stroke units in NHS Lanarkshire over a three-year period, with the following criteria for selection, (devised using CIMT criteria (Taub et al., 1993) and guidance provided by the robotic device manufacturer);

Inclusion criteria:

- Diagnosis of new stroke event within 3 months
- Medically stable as determined by a medical consultant
- Degree of upper limb impairment directly linked to stroke event
- At least 10° of active extension of each metacarpophalangeal joints, interphalangeal joints of all the digits and 10° wrist extension of the affected limb.
- No excessive spasticity in any of the joints of the affected UL (shoulder, elbow, wrist, fingers)
- Ability to follow single word instructions and perform study tasks
- Willing to provide written informed consent

Exclusion criteria:

- Involvement in any other rehabilitation research study
- Significant cognitive impairment (Score of less than 73/100 in Addenbrookes Cognitive Examination ACE-III)
- Subjects with excessive pain in any joint that might limit participation
- Recent fracture in affected upper limb (within 12 months)
- Communication difficulties which would severely impact on ability to participate in self report measures and semi structured interviews

Design

This separate qualitative study used a mixed methods approach, consisting of a cross-sectional online survey of therapists and semi-structured interviews of patients.

Participants

<u>Therapist survey:</u> An online survey of occupational therapists (OT's, n=62) and physiotherapists (PT's, n=34) working in stroke services within NHS Scotland (NHSS) was conducted in January 2019. The only inclusion criterion was participants were currently employed as an OT/PT within NHSS stroke services.

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Patient interviews: Semi-structured interviews were completed with patients after stroke who had completed either a programme of mCIMT (n=2) or RAT (n=6), which were delivered as part of aforementioned clinical trial. The inclusion criteria for these participants was therefore the same as the clinical trial and assignment into one of the intervention groups.

Ethical considerations

Advice was sought from the local NHS research and development department, and in line with current guidance produced by the UK NHS Health Research Authority (https://www.hra.nhs.uk) the staff survey was deemed as service evaluation, therefore ethical approval was not required.

Ethical approval for the semi-structured interviews was granted by the West of Scotland Research Ethics committee in October 2014. Written informed consent was obtained from each participant prior to commencing the study.

Development of therapist survey

A questionnaire was developed with guidance from therapists with extensive knowledge of NHS stroke services in order to address the aims 1 and 2 of the study. To maximise response rate the questionnaire was kept short (10 questions) and consisted of a mixture of multiple choice, closed and open questions. Open questions were used to explore therapist's perceptions of the benefits and challenges of the intervention for the patient and service, with respondents free to report as many 'ideas' as they wished. A small pilot with four therapists was conducted initially to detect any previously unconsidered difficulties, and appropriate revisions made.

Survey distribution

Once this process had been satisfactorily completed the survey was made available through a freely available software package, Survey Monkey (SurveyMonkey Inc., California USA www.surveymonkey.com) to maximise distribution, this also had the advantage of preserving the anonymity of respondents.

A snowball sampling strategy (Braun and Clarke, 2013) was used to recruit participants. The survey was disseminated by email to stroke clinical specialist/senior therapists in every health board within NHSS and to members of the Scottish Stroke Allied Health Professionals Forum. These therapists were invited to share the survey link with colleagues and all qualified OT's and PT's working within their stroke services (no limitations were set on banding/experience level). Therapists were informed that their participation in the survey was entirely voluntary and anonymous.

Semi-structured interviews of stroke participants

Semi-structured interviews were carried out, audio recorded, and transcribed verbatim by an independent interviewer (experienced psychology student). Interviews were carried out either in the participant's home or in a hospital outpatient setting, depending on the participant's preference.

An interview guide was produced using 'a framework for the development of a qualitative semi-structured interview guide' as described by Kallio et al. (2016). Questions were based around their experience of the intervention and their views on benefits and challenges of such. Care was taken to avoid leading questions.

Analysis

Analysis of the survey and interview data were completed separately. Responses to all closed questions within the survey were collated and presented as percentages. A thematic analysis approach was used to analyse responses to open questions from both the survey and interviews (Braun and Clarke, 2006).

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Findings

Survey Results

A total of ninety-six responses were received, sixty-two respondents were occupational therapists (65%) and thirty-four were physiotherapists (35%). Responses were received from all fourteen health boards within NHSS.

Respondent demographics

Table 1. Banding of respondents

Banding	**Number of respondents (Total n=96)**
Band 5 (basic grade)	9% (n=9)
Band 6 (specialist)	50% (n=48)
Band 7 (highly specialist/team lead)	34% (n=33)
Band 8 (consultant/manager)	6% (n=6)

Table 2. Respondents setting of employment

Setting	**Number of respondents (Total n=96)**
Inpatient secondary care (i.e. acute/rehabilitation unit)	53% (n=51)
Community services (i.e. community team)	28% (n=27)
Outpatient services	9% (n=9)
Combination of above services	9% (n=9)

Use of CIMT/RAT interventions

Only 30% (28/96) of therapists had used CIMT with their stroke patients while only 5% (5/96) had used RAT.

Perceived challenges and benefits of interventions

Perceived benefits and challenges of mCIMT

The majority (57%, 16/28) of therapists using mCIMT, considered a benefit to the patient was promotion of functional use of the affected arm. Therapists felt a further benefit was a reduction in learned non-use of the affected arm (18%, 5/28).

When asked to consider the benefits of mCIMT in respect to the health service, a large proportion of therapists (43%, 12/28) felt that by completing a short programme of high intensity therapy, this reduced the overall length of time the patient required to attend the service. A further 21% (6/28) felt the programme promoted self-management. Inadequate resources to deliver such a programme of high intensity was cited by 46% (13/28) of respondents as the most important challenge to implementing the intervention within a service.

When asked to consider the challenges, the majority (57%, 16/28) felt frustration and maintaining motivation were the main factors. Therapists also felt the criteria for inclusion 29%, (8/28) and time commitment (18%, 5/28) were challenges also faced by patients.

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Perceived benefits and challenges of RAT

Of the small number of respondents (n=5) who used RAT with stroke patients, two felt a benefit was greater intensity of treatment, with a further two reporting the ability to self-practice as a benefit.

Providing the opportunity to complete more self-practice was also cited as a benefit to the service, consequently 'freeing up' therapy time (n=2). With respondents also reporting RAT led to better outcomes and patient satisfaction (n=2). The cost of purchasing the equipment (n=4) and the time taken to set the equipment up (n=2) were reportedly the greatest barrier to using RAT within practice.

Frustration (40%, 2/5), cognitive issues (40%, 2/5) and inability to use at home (20%, 1/5) were all perceived as challenges.

Barriers to adoption

Of the respondents who stated they had not used CIMT with patients after stroke (70%, 68/96), 62% (42/68) reported they would consider using this intervention and felt the main barriers to adoption were poor staffing/time constraints and training needs (Table 3).

Table 3. Therapists' perceived barriers to introducing CIMT into practice within service

	Number of respondents (Total n=68)
Time constraints/staffing	35% (n=24)
Training	34% (n=23)
Lack of protocol/resources	14% (n=10)
Patients fitting criteria	13% (n=9)
Difficulty to apply in community setting/environment	7% (n=5)
Safety/compliance concerns in regard to patients	6% (n=4)
Maintaining a multi-disciplinary approach/all staff being 'on board'	6% (n=4)
Lack of support from management to develop services	1% (n=1)

Respondents who had not used RAT (95%, 91/96) were less likely to consider using this intervention within their service, with only 38% (35/91) stating they would consider introducing this to practice. Therapists felt, to a great degree that cost implications, a lack of resources and training needs were the main barriers to introducing the use RAT within their service (Table 4).

Table 4. Therapists' perceived barriers to introducing RAT into practice within service

	Number of respondents (Total n=91)
Cost implications	38% (n=35)
Lack of resources	32% (n=29)
Training needs	23% (n=21)
Therapist time/staffing	13% (n=12)
Portability of equipment/difficulty using in community setting	7% (n=6)
Space to house equipment/carry out sessions	4% (n=4)
Unclear evidence base	3% (n=3)

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Low staff confidence in using technology	1% (n=1)

Patient interviews

Semi-structured interviews were completed with eight stroke patients from the CIMT (n=2) and RAT (n=6) groups. The anonymised transcripts from each participant was analysed by the researcher in order to identify common themes in the sample, these are outlined and discussed below.

CIMT user experience (n=2)

Theme 1. Functional Improvement: Participants cited functional improvement as the main benefit from the intervention naming activities of daily living they were now able to perform following the programme.

> "Loads of things like pick up a cup of tea, brush my teeth, tie my…I couldn't tie my shoelaces, do the buttons up on my jeans. I couldn't do all of that. And now I can do them no problem" Participant 9

> "Putting my shoes on, putting my underwear on, my trousers….well I can do most things now" Participant 12

Theme 2. Adherence to protocol: Despite therapists' concerns in previous studies that patients may have difficulties adhering to CIMT practice and constraint device schedules, this was not reported by the two interviewed participants. Instead participants reported positive experiences with the protocol.

> "I had to wear a glove, like a mitt on my good hand which allowed me to use my affected hand more and I found that really quite good…It gave you more confidence to use the affected hand more, because obviously you had this (other hand) in a mitt. Like to go and grab things, like a cup of tea. It just pushed you more to use the affected hand" Participant 9

> "It, it was constant, so it was, I know that's important for the brain to, to keep re-programming so, but I thought the, the therapy they gave me was excellent" Participant 12

Also, contrary to the therapist's concerns cited in the survey discussed in this study that frustration may impact on adherence, neither participant highlighted this as an issue, with only mild frustration with particular activities discussed during both interviews. Instead both participants perceived the programme as mildly frustrating hard work, mitigated by positive outcomes.

> "It was a lot of hard work doing the things and a lot of time doing the exercises but for me personally, it was well worth it…it's as good as it's going to get after what I had" Participant 9

> "The tasks get more difficult week by week, but I was able to perform them, you know" Participant 12.

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Theme 3. Feedback: The feedback received through the use of timing specific tasks/activities to gauge potential improvement was identified as a motivating factor within the programme in both interviews.

> "they started timing them (activities) to show you the difference in time from when you start to when you finish…to see before and after was just amazing to be honest. It was like day and night" "It was just a confidence booster to see you were getting quicker" Participant 9

> "I think coming down and doing the timing thing… let you see how much you had progressed" Participant 12

Theme 4. Competitive nature: It should be noted that both participants could be described as being intrinsically motivated (Ryan and Deci, 2000), defined as the doing of an activity for its inherent satisfaction rather than for some separable consequence. This may be a contributory factor in their adherence and acceptability of the programme.

> " I'm very competitive" Participant 9

> "I was just trying to beat myself all of the time" Participant 12

<u>**RAT user experience (n=6)**</u>

Theme 1. Motivation: The majority (67%, 4/6) of participants reported high levels of motivation.

> "It kind of pushed you as far as you wanted to go, or it was up to you how far you wanted to go with it" Participant 1

> "you were competing against yourself, eh.. and driving yourself on to get the benefits out of it" Participant 13

With one participant acknowledging improved motivation through attending sessions.

> "I couldn't motivate myself the same (at home) as I could up here. You need that wee bit of push" Participant 7

This may be due to the need for extrinsic motivation, which is present when an individual performs a behaviour for an extrinsic reason (Dacey et al., 2008), such as a reward or praise from a clinician.

Theme 2. Improvement

All participants felt the main benefit of RAT was an increase in strength of the affected arm, with some also reporting an improvement in active movement.

> "You could feel it, my grip getting stronger every week, and movement" Participant 7

Compared with the mCIMT group, however, participants were less likely to mention a change in functional performance, with only 50% (3/6) recognising this as a benefit of the intervention.

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"Washing myself-I can get up to my shoulder" Participant 3

"Bringing in hot tea, I had more trust in the arm to do that" Participant 6

Theme 3. Non-use of the affected arm: Participants reported continued 'non-use' of the affected arm. This may account for the lack of perceived impact on functional performance.

"I tend to use my right (non-affected) arm now" Participant 7

"I'm still not using my left (affected arm) as much as I used to" Participant 10

Theme 4. Technical Issues: 83% (5/6) reported issues with the software/games, indicating this was at times a source of frustration.

"There was some of the games, you could say were a bit tedious. That was maybe because they didn't tax you enough" Participant 1

"Some of the games are frustrating" Participant 3

Theme 5. Weight compensation: Half the participants (3/6) reported benefits attributed to the weight compensation properties of the robotic arm. It is worth noting that these participants had less range of movement and strength in their affected arm compared to the other participants.

"The robotic arm pushed you to a different level than what the physio…eh the OT would do, because of the fact that it would lift your arm, hold it up, and you could balance it, and weight it to what strength you wanted to put into do an exercise" Participant 1

"I couldn't lift it, the robotic arm showed me. It's on there and they take gravity out of it, I could lift it up. I was going up to the top and getting things, and away back down, that's when I said, this can be done" Participant 3

Theme 6. Novelty: As hypothesised in a Cochrane review (Mehrholz et al., 2018), half the participants (3/6) indicated a novelty aspect to the treatment which may have led to increased enjoyment and consequently acceptability of RAT.

"It was different from what your normal occupational therapy was and, because of that I think it was probably a bit more enjoyable" Participant 1

Discussion

With only 30% of therapists reporting use of CIMT in practice, the survey completed during this study would suggest the use of CIMT within NHS Scotland is not statistically different, (χ^2=1.6, df=1, P=0.2), to that of UK wide services (37%, Pedlow et al. 2014). The survey would also suggest the use of RAT within NHS Scotland is currently extremely low with only 5% of therapists surveyed reporting ever having used the intervention in practice. This would appear to be the first published study exploring the levels of uptake of RAT, with no previous similar UK or international studies to compare this data to.

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Rodgers (2003) diffusion of innovations theory seeks to explain how, and at what rate, new ideas and technology spread. When this theory is applied to the therapist views expressed in the survey, we can perhaps identify barriers which may have impacted on uptake of both CIMT and RAT into clinical practice within the NHS;

a. The innovation: Therapists have highlighted that the resources required in order to deliver an intensive programme of CIMT are not *compatible* with the staffing levels of their service. Whilst the lack of access to robotic devices, due to cost, affect the *trialability* of this intervention in order for therapists to 'try out' this intervention and consider potential benefits. With the low use of both interventions in practice, newly qualified therapists are less likely to have the experience of observing visible results (*observability*).

b. Communication channels: Therapists report lack of training and knowledge in both interventions and are therefore unlikely to gain experience and pass on to other therapists working in their service.

c. Time: Given the issues outlined above, adoption through the innovation-decision making process and rate of adoption within services is likely to be low, especially as there appears to be a lack of access to training programmes in order to upskill therapists and encourage clinical use.

d. Social system: Lack of strong multidisciplinary team working was listed as a barrier to implementing both interventions as this is likely to impede problem solving to accomplish common goals.

Enablers which may positively influence therapist adoption of both these interventions, and the likelihood of sustaining good levels of implementation in practice are therefore; adequate staffing/resources and robust training. In addition, designers should be mindful of affordability of robotic devices as this is a significant barrier to use within clinical practice.

This study has provided an insight into patient perceptions following completion of programmes of mCIMT and RAT, which thus far the literature has failed explore. In contrast to the challenges that therapists, both within this study and that conducted by Pedlow et al. (2014), perceived patients to experience with the programme schedule of mCIMT, participants who engaged in semi-structured interviews following this four-week programme reported no such difficulties. Both participants described benefits to the programme and constraint device schedule and felt the feedback given through the timing of tasks/activities was a motivating factor. In coherence with therapist views, participants also felt the predominant benefit of mCIMT was functional improvement in the affected arm and attributed this to better performance in specific activities of daily living.

Participants who were interviewed following a programme of RAT did indeed report levels of frustration, as predicted by clinicians, which were invariably due to issues with software/games. As hypothesized by Mehrholz et al. (2018) the novelty of using a technology which was different to normal therapy appeared to motivate participants, and those with a lower baseline strength in their arm found the gravity reducing aspect of the device particularly helpful.

The vast majority of participants believed the main benefit they experienced as a result of RAT was improved strength in the affected arm. It was notable however, that participants had a lesser tendency than that of the mCIMT group to report functional improvements, with some reporting continued non-use of the affected arm in daily life.

Participants in both groups described motivation as having effect on their compliance with their programmes. This can be interpreted as in the form of external motivation, for example when

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feedback is given to provide encouragement, or intrinsic motivation, whereby participants describe feeling motivated to achieve self-set goals and compete with their own previous performance. The latter was the predominant type of motivation discussed by both groups.

A model of health motivation has emerged from many studies guided by self-determination theory (Deci and Ryan, 2000), which suggests that a general trait towards intrinsic motivation, and encouragement from practitioners to maximise this, predict patient autonomous motivation for participating in medical treatments (Sheldon et al., 2003).

The data gleaned from the interviews in this study would indicate that those who agreed to participate tended to have high levels of intrinsic motivation, which might suggest that others who had less intrinsic motivation may have declined to participate, or indeed drop out of such a programme of therapy.

Limitations of the study

Due to small sample sizes, care should be taken when generalising these findings as the data obtained is unlikely to have reached saturation (Weller et al., 2018).

As there is no national database of all therapists working within stroke services a snowball sampling method was employed to contact the target population and disseminate the survey effectively. It is recognised that due to this non-random sampling method, there may be an element of sample bias (Faugier and Sargeant, 1997). Researcher bias may also have had an impact as, due to the researchers own connections, a higher proportion of the initial emails containing the survey link were sent to OT's, which may account for the lower response rate of PT's. It is also noted the sampling method results in self-selection for inclusion, whereby therapists who have no experience of using either intervention may have opted not to respond. This is a possible explanation for the relatively small number of band 5 (basic grade) respondents, and may have exaggerated the use of CIMT, and even RAT, in Scotland.

With only five NHS Scotland therapists who completed the survey reporting having used RAT in practice, there is limited generalisability of the opinions gathered. Future studies may look to further explore a larger sample of therapists who have used this intervention in practice.

A convenience sample of stroke patients was used for the semi-structured interviews, consequently it is likely to be biased (Etikan et al., 2016). The selection criteria and use of a group who are already motivated to take part in an RCT, contribute to this bias. It is also acknowledged that the number of participants interviewed following completion of a mCIMT programme was less than that of those following RAT. This was due to recruitment and retention of participants into the main pilot RCT. It should be noted that during the trial two participants dropped out of the mCIMT programme, one due to full spontaneous recovery before the programme commenced and another cited finding the programme "too difficult". An attempt was made to further understand the reasons behind this; however, the participant withdrew their consent for a semi-structured interview to be completed.

A limitation of the study is the lack of interviews completed with patients who may have declined to participate in the novel interventions or dropped out of the programmes. Further qualitative research with this patient group may help us to further understand rates of uptake and attrition for these upper limb programmes.

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Conclusion

Findings suggest the use of CIMT in clinical practice remains low within NHS Scotland. Despite therapist concerns around patient's ability to adhere to protocols, some patients clearly respond well to this type of programme, leading to reported functional gains. In order to allow patients after stroke better access to this evidence-based therapy, it is of the upmost importance that service providers and managers consider the staffing, resources and training opportunities within their stroke service in order to address the barriers consistently highlighted by therapists.

Despite evidence to support its use in stroke UL rehabilitation, the implementation of RAT would appear to be extremely low within NHS Scotland, with cost implications cited as the overriding barrier for introduction into practice. Although stroke patients interviewed after programmes of RAT reported perceived improvement to arm strength, it is unclear if this translated into increased functional use in daily activities. The novelty of using the robotic device, and the weight compensation feature of the device were appreciated by the users, however frustration with software/games were perceived as a challenge. If this intervention is to be further accepted into clinical practice, it is crucial that designers work with users, both clinicians and patients, to address these issues.

The role that both intrinsic and extrinsic motivation play in patient uptake and adherence to these two types of intervention, at different times in the rehabilitation process, should be further explored in order to maximise acceptability.

Key findings

- Use of CIMT and RAT remains low in NHS Scotland.
- Despite good acceptability of both interventions for some patients, similarities in barriers for uptake in clinical practice exist, such as limited resources.

What this study has added

This study helps us to further understand why the uptake of novel, evidence-based UL rehabilitation techniques remain low in NHS stroke services and provides some insight into patient opinion of CIMT and RAT interventions.

References

Beckerle P, Salvietti G, Unal R et al. (2017) A Human-Robot Interaction Perspective on Assistive and Rehabilitation Robotics. Frontiers in Neurorobotics, 11: 24.

Braun V and Clarke V (2006) Using thematic analysis in psychology. Qualitative Research in Psychology, 3: 77–101.

Braun V and Clarke V (2013) Successful Qualitative Research: a practical guide for beginners. London: SAGE Publications Ltd.

Christie L, McCluskey A and Lovarini M (2019) Constraint-induced movement therapy for upper limb recovery in adult neurorehabilitation: An international survey of current knowledge and experience. Australian Occupational Therapy Journal, Feb: doi:10.1111/1440-1630.12567.

Corbetta D, Sirtori V, Castellini G et al. (2015) Constraint-induced movement therapy for upper extremities in people with stroke. The Cochrane Database of Systematic Reviews, 2017(10).

This is a peer-reviewed, accepted author manuscript of the following research article: Sweeney, G., Barber, M., & Kerr, A. (2020). Exploration of barriers and enablers for evidence-based interventions for upper limb rehabilitation following a stroke: use of Constraint Induced Movement Therapy and Robot Assisted Therapy in NHS Scotland. *British Journal of Occupational Therapy*, 1–11. https://doi.org/10.1177/0308022620909023
Dacey M, Baltzell A and Zaichkowsky L (2008) Older adults' intrinsic and extrinsic motivation toward physical activity. American Journal of Health Behavior, 32(6): 570-82.

Etikan I, Musa SA and Alkassim RS (2016) Comparison of convenience sampling and purposive sampling. American Journal of Theoretical and Applied Statistics, 5(1): 1-4.

Etoom M, Hawamdeh M, Hawamdeh Z et al. (2016) Constraint-induced movement therapy as a rehabilitation intervention for upper extremity in stroke patients: Systematic review and meta-analysis. International Journal of Rehabilitation Research, 39(3): 197-210.

Faugier J and Sargeant M (1997) Sampling hard to reach populations. Journal of Advanced Nursing, 26(4): 790-797.

Fleet A, Che M, Mackay-Lyons M et al. (2014b) Examining the use of constraint-induced movement therapy in Canadian neurological occupational and physical therapy. Physiotherapy Canada, 66(1): 60-71.

Fleet A, Page SJ, Mackay-Lyons M et al. (2014a) Modified Constraint-Induced Movement Therapy for Upper Extremity Post-Stroke: What is the evidence? Topics in Stroke Rehabilitation, (21)4: 319-331.

Flynn N, Kuys S, Froude E et al. (2019) Introducing Robotic Upper Limb Training into Routine Clinical Practice for Stroke Survivors: Perceptions of Occupational Therapists and Physiotherapists. Australian Occupational Therapy Journal 66(4): 530-38. Web.

French B, Thomas L, Leathley M et al. (2010) Does repetitive task training improve functional activity after stroke? A Cochrane systematic review and meta-analysis. Journal of Rehabilitation Medicine, 42(1): 9-15.

Horton T, Illingworth J and Warburton W (2018) How to support successful uptake of innovations and improvements in health care. London: The Health Foundation.

Huang S, Luo C, Ye S et al. (2012) Motor Impairment Evaluation for Upper Limb in Stroke Patients on the Basis of a Microsensor. International Journal of Rehabilitation Research, 35(2): 161-169.

Johnson, MJ (2006) Recent trends in robot-assisted therapy environments to improve real-life functional performance after stroke. Journal of NeuroEngineering and Rehabilitation, Dec: Vol.3.

Kallio H, Pietilä A, Johnson M et al. (2016) Systematic Methodological Review: Developing a Framework for a Qualitative Semi-structured Interview Guide. Journal of Advanced Nursing, 72(12): 2954-965.

Kerr A, Smith M, Reid L et al. (2018) Adoption of Stroke Rehabilitation Technologies by the User Community: Qualitative Study. JMIR Rehabilitation and Assistive Technology, 5(2).

Kusec A, Velikonja D, Dematteo C et al. (2018) Motivation in rehabilitation and acquired brain injury: Can theory help us understand it? Disability and Rehabilitation, 1-7.

Kwakkel G, Kollen B, and Krebs H (2008) Effects of robot-assisted therapy on upper limb recovery after stroke: A systematic review. Neurorehabilitation and Neural Repair, 22(2):111-121.

Lee J, Kim C and Kim H (2016) Short-Term Effects of Whole-Body Vibration Combined with Task-Related Training on Upper Extremity Function, Spasticity, and Grip Strength in Subjects with Post

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stroke Hemiplegia: A Pilot Randomized Controlled Trial. American Journal of Physical Medicine & Rehabilitation, 95(8): 608–617.

Lee M, Rittenhouse M and Abdullah HA (2005) Design Issues for Therapeutic Robot Systems: Results from a Survey of Physiotherapists. Journal of Intelligent Robotic Systems, 42: 239.

Lu EC, Wang RH, Herbert D et al. (2010) The development of an upper limb stroke rehabilitation robot: identification of clinical practices and design requirements through a survey of therapists. Journal of Disability and Rehabilitation: Assistive Technology, 6(5).

Mackay J and Mensah G (2004) The Atlas of Heart Disease and Stroke WHO, Marketing & Dissemination: Geneva, Switzerland.

Mehrholz J, Pohl M, Platz T et al. (2018) Electromechanical and robot-assisted arm training for improving activities of daily living, arm function, and arm muscle strength after stroke. Cochrane Database of Systematic Reviews, Issue 9.

Page SJ, Levine P and Sisto S (2002) Stroke patients' and therapists' opinions of constraint-induced movement therapy. Clinical Rehabilitation, 16(1):55–60.

Pedlow K, Lennon S and Wilson C (2014) Application of Constraint-Induced Movement Therapy in Clinical Practice: An Online Survey. Archives of Physical Medicine and Rehabilitation, 95(2): 276-282.

Pollock A, Farmer S, Brady M et al. (2014) Interventions for improving upper limb function after stroke. The Cochrane Database of Systematic Reviews, 2014(11).

Rogers EM (2003) Diffusion of Innovations (Fifth Edition). Free Press, New York.

Ryan RM and Deci EL (2000) Self-Determination Theory and the facilitation of Intrinsic Motivation, Social Development, and Well-Being. American Psychologist, (55)1: 68-78.

Saka O, McGuire A and Wolfe C (2009) Cost of stroke in the United Kingdom. Age and Ageing, 38(1): 27-32.

Sheldon KM, Williams G and Joiner T (2003) Self-determination theory in the clinic motivating physical and mental health. New Haven: Yale University Press.

Taub E, Miller N, Novack T et al. (1993) Technique to improve chronic motor deficit after stroke. Archives of Physical Medicine and Rehabilitation, 74(4): 347-54.

Urton ML, Kohia M, Davis J et al. (2007) Systematic review of treatment interventions for upper extremity hemiparesis following stroke. Occupational Therapy International, 14 (1):11-27.

Veerbeek J, Langbroek-Amersfoort A, Van Wegen E et al. (2017) Effects of Robot-Assisted Therapy for the Upper Limb After Stroke: A Systematic Review and Meta-analysis. Neurorehabilitation and Neural Repair, 31(2): 107-121.

Weller SC, Vickers B, Bernard HR et al. (2018) Open-ended interview questions and saturation. PLos one, 13(6).

This is a peer-reviewed, accepted author manuscript of the following research article: Sweeney, G., Barber, M., & Kerr, A. (2020). Exploration of barriers and enablers for evidence-based interventions for upper limb rehabilitation following a stroke: use of Constraint Induced Movement Therapy and Robot Assisted Therapy in NHS Scotland. *British Journal of Occupational Therapy*, 1–11. https://doi.org/10.1177/0308022620909023