



University of  
**Strathclyde**  
**Glasgow**



**Sir Jules Thorn Co-Creation Centre in Rehabilitation Technology**

**Annual report 2023**

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## Introduction

The Sir Jules Thorn Centre for Co-Creation of Rehabilitation Technology (CCRT) was set up in early 2021 following a philanthropic award from the Sir Jules Thorn Charitable Trust of £449,000. This allowed two rooms in the Wolfson centre (Biomedical Engineering, University of Strathclyde, Glasgow) to be equipped with state-of-the-art rehabilitation technology (de-weighting systems, neurostimulation, virtual reality, treadmills, bespoke rehab games, communication apps, powered exercise equipment and gamified resistance equipment) and measurement equipment, to add to existing facilities. Following installation of key equipment and ethical approval from the University, the centre commenced recruitment of participants in September 2021.

The centre was established as a response to the overwhelming, global, need for rehabilitation (across many conditions) and our universal inability to meet this need. The stated aim of the centre is to lead a multi-faceted rehabilitation revolution by developing a range of cutting-edge technology based on a co-creation approach with users, clinicians and the wider rehabilitation community. The resulting technology and programmes can then be made available in community settings in a cost effective, user friendly way for society-wide benefit.

To achieve the aim the team designed an 8-week supervised rehabilitation program located in a gym-like space equipped using a range of integrated technology designed to holistically address the full range of motor and communication impairments caused by stroke. Through this close engagement between technology and users our team of engineers and therapists could create, design and evaluate truly useful rehabilitation technology and develop the necessary protocols around delivering a technology enriched rehabilitation intervention.

## CHSS award

The award of £168,675.00 from CHSS in May 2022 has increased research activity substantially and accelerated plans for the centre. The funding has paid for two research assistants (RA) for two years. This was divided into one band 7 F/T RA (HCPC registered physiotherapist to organise and supervise the rehabilitation sessions) and a second post which was further divided into a P/T RA to manage the centre (data collection storage and quality checking, equipment maintenance, safety, promotion of centre) and provide assistance during sessions and a P/T secondment of NHS staff to supervise the sessions (especially the upper limb and cognitive training elements) and provide strong links to the NHS. These posts also freed up academic time for grant applications and paper writing.

## The team

The CCRT is supported by a multi-disciplinary team that is part of the broader Rehabilitation Engineering Research group in the Biomedical Engineering Dept., University of Strathclyde.

### Directors

The centre is led by two co-directors;

1. Dr Andy Kerr is the clinical director, overseeing the everyday operation of the centre (**physiotherapist**)
2. Professor Phil Rowe is the technical director and oversees the technical aspects of the centre (**engineer**)

*While there is a distinction in these roles, there is also considerable overlap.*

We have two other members of the centre management group, Professor Madeleine Grealy (**Psychology**) and Dr Anja Kuschmann (**Speech Therapy**) who provide academic guidance and support in grant application and shaping the direction and management of the centre.

#### Therapy team

1. Milena Slachetka (FTE 1.0) is our CHSS physiotherapist who designs and supervises the rehabilitation programme as well as managing the day-to-day operation of the centre. **Physiotherapist**
2. Dr Gillian Sweeney (part time secondment from NHS Lanarkshire) is our CHSS occupational therapist who supervises the rehabilitation programme as well as co-ordinating the pilot project at Wilshaw University Hospital and liaising with NHS colleagues. **Occupational Therapist**
3. Maisie Keogh (FTE 0.5) is our part time research assistant who oversees data collection, collation, storage, maintains the equipment, provides administrative support and assists during rehab sessions. **Engineer**

#### PGR (Post Graduate Researchers)

We have six current PhD students conducting their research in the centre, collaborating with the participants.

1. Fiona Boyd: Development of a rehabilitation intensity tracker and collaborative game to support home-based stroke recovery. **Engineer**
2. Rhona Campbell: Clinical tool for measuring gait propulsion mechanisms in post stroke population. **Orthotist**
3. Chioma Wodu: low-cost orthosis for hand rehabilitation in people with moderate to severe spasticity after a stroke. **Engineer**
4. Maisie Keogh: Fusion of Vicon Pulsar Active Marker Clusters and Blue Trident Inertial Measurement Units (IMUs). **Engineer**
5. Milena Slachetka: Development of an educational intervention to improve adherence to rehab programme. **Physiotherapist**
6. Lesley –Anne Rollins: The effects of brain stimulation combined with mirror therapy on movement, daily living and quality of life in stroke survivors. **Psychologist**

We have two new students commencing their PhDs in the centre from September 2023.

We also have between five and ten new MSc students every year engaged in research related to the centre and three to eight undergraduate engineering students.

## Impact

### Participant feedback

“Thank you for giving me the opportunity to take part in your research study. Your commitment, understanding and encouragement throughout the block have increased my confidence, particularly in balance and walking”

#### Participant 16

“I have loved the classes and meet you all. Will try swimming next week”

#### Participant 53

“I liked the exercises combined with games and puzzles, as it allowed me to enjoy them games while exercising. There was a lovely atmosphere of friendliness which was very nice.”

#### Participant 50

“A massive thank you for all your amazing help and support and for also giving me the chance to improve and progress within my stroke journey. It has helped me immensely and I shall miss coming here every day.”

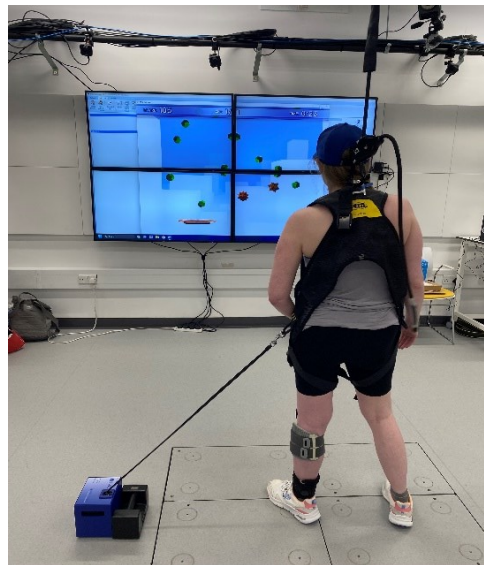
#### Participant 28

“The trial has helped to improve my strength, stamina, and confidence”

#### Participant 21

“There is only one word that I can use to describe my recent experience at a stroke research programme in Strathclyde University and that is WOW. As a stroke survivor of over 7 years I found myself demotivated and a bit lost. However, after attending for 8 weeks using the amazing upper and lower limb equipment my recovery has taken another huge leap and brought my mojo!! So, thank you to the team.”

#### Participant 56



## Participant Story

“I had seen this on the BBC Click programme and was really impressed with what it was trying to deliver.

On my first day I was taken through a series of assessments and tests, before being taught how to use the machines and equipment.

Over the next few weeks I personally recorded my own progress and I realised that I was making remarkable progress

My stability when standing and walking was more controlled, I was able to push weights on the leg press of 60kg ... when I started it was hard to push 15kg.

My arm function had also improved, grip became more active, my fine finger movement increased with the introduction of both the vibrating ball and EMS stimulating my arm and hand. I have bought one of these now and use it every day and even introduced it to Stroke Survivors in Paisley and Dundee.

After the 8 weeks of the course I investigated the possibility of being able to carry this on out with the trial, this has motivated me to set up [www.rsbec.org](http://www.rsbec.org) a dedicated Stroke Exercise club which will run every Monday from Monday 21st Aug 23 weekly to try to get Stroke survivors much needed dedicated exercises working on the examples used in the trial. Personally, I have benefited so much from this trial and I consider myself to be a success case in being involved in this trial.”

## Participant 47

## Media impact

Our activity in the centre was reported by the STV news (December 2021) and featured in an episode of the BBC technology programme (BBC Click, August 2022). We were also short listed for the Herald HE awards in the Outstanding Business Engagement category. Our work has also featured in the UK physiotherapy magazine “Frontline” and the Daily Record.



## Academic Impact

A critical output of any academic department is peer reviewed scientific publications and conference presentations. We have published three full papers on methods, feasibility and device development and have two more in process related to the co-creation model and development of another rehabilitation technology.

### Papers and conference presentations

Authors	title	Year	Journal/conference
Kerr, Keogh, Slachetka, Grealy, and Rowe	An Intensive Exercise Program Using a Technology-Enriched Rehabilitation Gym for the Recovery of Function in People With Chronic Stroke: Usability Study	2023	JMIR Rehabilitation and Assistive Technologies
Kerr, Grealy, Kuschmann, Rutherford and Rowe	A Co-creation Centre for Accessible Rehabilitation Technology	2022	Frontiers in Rehabilitation Sciences
Nown, Kerr, Andonovic, Tachtatzis, Grealy	A mapping review of real-time movement sonification systems for movement rehabilitation	2022	IEEE Reviews in Biomedical Engineering
Campbell, Buis and Kerr	Development of tools for post-Stroke data collection - Validation of novel fabric EMG sensor, with Arduino-driven data collection, on non-affected participants.	2023	International conference of Society of Prosthetics and Orthotics
Kerr, Keogh, Wodu, Slachetka, Grealy, and Rowe	Feasibility of a technology based, intensive and integrated rehabilitation programme for stroke recovery	2022	UK Stroke Forum
Nown, Kerr, Andonovic, Tachtatzis, Grealy	Development of tools for post-Stroke data collection - Validation of novel fabric EMG sensor, with Arduino-driven data collection, on non-affected participants.	2022	International Conference of the IEEE Engineering in Medicine and Biology Society
Sweeney, Kerr and Rowe	Technology to Boost Intensity: The Missing Link in Clinical Practice? Dr. Gillian Sweeney	2022	SRR and SSAHPF
Keogh, Kerr and Rowe	Fusion of Vicon Pulsar Active Marker Clusters and Blue Trident Inertial Measurement Units (IMUs)	2022	SRR and SSAHPF
Wodu and Kerr	Design of an orthosis for hand rehabilitation in people with hemiplegia resulting from a stroke	2022	SRR and SSAHPF
Nown, Kerr, Andonovic, Tachtatzis, Grealy	Verifying a Sense of Agency with a Real-Time Movement Sonification System for Stroke Survivors with Hemiparesis	2022	SRR and SSAHPF

*We have six abstracts accepted for UKSF (2023) and an invited talk (Kerr). We are also presenting two papers (Slachetka and Kerr) at this year's UK physiotherapy conference. All our papers and conference presentations include an acknowledgement of support from CHSS.*

In addition to publications the centre is (or has) supported seven PhD projects (two more commencing in September 2023), 10 MSc projects and hosts teaching sessions in two undergraduate

(Biomedical Engineering and Prosthetics and Orthotics) and one postgraduate taught programme (Biomedical Engineering)

In November 2022 we hosted the annual conference for the Society of Research in Rehabilitation, which was combined with the annual Scottish Stroke AHP forum (<https://srr.org.uk/>). This was a great opportunity to show case our current work and plans to academics and clinicians across Scotland and the UK. Talks from individuals with lived experience of stroke, including participants from our programme were features of this conference. We also had talks from our staff; Sweeney (Technology to Boost Intensity: The Missing Link in Clinical Practice? Dr. Gillian Sweeney), Kerr (Control of the stand to sit movement in acute stroke survivors) and posters from our PhD students; Campbell (Validation study of novel AFO-compatible fabric EMG device in non-affected volunteer), Keogh (Fusion of Vicon Pulsar Active Marker Clusters and Blue Trident Inertial Measurement Units (IMUs) for a Full Biomechanical Model of Human Motion Capture), Wodu (Design of an orthosis for hand rehabilitation in people with hemiplegia resulting from a stroke) and Nown (Verifying a Sense of Agency with a Real-Time Movement Sonification System for Stroke Survivors with Hemiparesis)

#### Additional Funding related to centre

Innovate UK awarded Professor Rowe £168k, as part of a Knowledge Transfer Partnership with Visibility Scotland to develop assessment and rehabilitation technology for people with visual impairment as a result of stroke.

EPSRC (Impact Accelerator Award) awarded £15k to Dr Kerr to run a feasibility study with Innerva Ltd on the use of power assisted equipment in acute stroke survivors.

#### Fundamental research awards

While our primary concern is developing the model of technology-enriched rehabilitation for widespread adoption we are also involved in fundamental scientific work. In collaboration with Dr Melanie Jimenez (Biomedical Engineering, Strathclyde) we are investigating (Innovation in rehabilitation technologies through multimodal blood analysis, EPSRC, £50K) on changes in blood biomarkers before and after a programme of rehabilitation. This is the first research of its kind in stroke rehabilitation and, we hope, will uncover new knowledge in how the body and brain responds to intensive rehabilitation. Initially this is funded as a pilot project (small sample and one 8-week block) but will put us in a good position to apply for future grants.

We have also been awarded a grant, as co-investigators, to develop smart textiles that support rehabilitation. This is funded by the EPSRC's rehabilitation technology network (led by Nottingham Trent University) and is initially focused on musculoskeletal conditions but has clear implications for stroke.

#### Grant applications pending

Our success so far has motivated applications to other funding bodies and raised our profile to the point where we are being invited to join funding applications.

- EPSRC: Health Research and Partnership hub for the Co-creation of Rehabilitation Technology (£9.7m)
- EPSRC: Future Surgery and Perioperative Care underpinning Wellbeing and Care within and beyond the hospital walls (£9.8m)
- Parkinson's UK: Pilot study to test the feasibility and acceptability of an intensive, technology delivered, exercise programme and assess impact on, and relationships across, function and biomarkers in people living with Parkinson's. £73, 178



## Technology development

Our dept. (Biomedical Engineering) has a 50-year history of developing assistive and rehabilitative technology for health conditions. Continuing this work, and ensuring the resulting devices are fit for purpose through engagement with stakeholders, is the primary objective of our research group (Rehabilitation Engineering). We are guided by the principle of designing our devices and protocols through a co-creation process to ensure they are accessible in terms of usability and access as well providing the evidence for their effectiveness.

Since the start of the centre we have started the development of six rehabilitation technologies through this co-creation process, see table below, two are now registered as inventions with commercialisation funding being sought, and gained with one technology.

### Devices under development

Principle developer	Title	Funding	Population
Kerr	Low cost de-weighting system for arm and hand rehabilitation	Medical Devices Doctoral training programme + commercialisation funding (£30k)	Stroke
Wodu	Low-cost orthosis for hand rehabilitation in people with moderate to severe spasticity after a stroke	PhD studentship from Nigerian Government	Stroke
Campbell	Low cost clinical tool for measuring ankle propulsion strategy in gait	Prosthetics and Orthotics Doctoral training	Stroke
Industrial partners & Kerr	A novel method for remote assessment of exercise capacity using a telehealth platform and a wearable medical device	Innovate UK	COPD
Boyd	Rehabilitation intensity tracker and collaborative game	EPSRC studentship	Stroke
Nown	Real-time movement sonification system for stroke survivors with hemiparesis	Medical Devices Doctoral training programme	Stroke

We have also co-created rehabilitation games for our upper limb robot (H-Man) through masters and undergraduate projects.

## Health Service Impact

Translating our work into a sustainable model that can, realistically, be adopted by healthcare providers (primarily NHS) and local council services (leisure services) is an objective of our group. This can only be done through close engagement, we have approached this in three ways; 1)

secondment of NHS staff, 2) establishing a pilot project within the NHS and 3) being involved in the education of rehabilitation professionals.

#### Secondment of NHS staff

The secondment of Dr Gillian Sweeney from the NHS Lanarkshire community rehabilitation team has been very rewarding for us in terms of ensuring our practice aligns (where appropriate) with the NHS. This will make translation simpler. She has also brought specific experience in cognitive rehabilitation which is something we are keen to embed into all the rehabilitation activities. She has also provided an advisory role to the student projects, especially those related to cognitive and upper limb recovery and provided a strong link to the NHS including the visit of several rehabilitation teams to observe our sessions.

#### Pilot project at Wishaw University Hospital acute stroke unit

Alongside supporting with the participant groups at UoS, Gillian Sweeney's part-time secondment from NHS Lanarkshire (funded by CHSS) has allowed the research group to begin to progress plans to pilot with the model of stroke rehabilitation with those in an earlier stage of stroke recovery. A pilot study is due to start in November this year, whereby a large room has been allocated on the stroke unit at University Hospital Wishaw to house stroke rehabilitation technology on loan from UoS. Inpatients on the stroke ward, who are medically fit and in need of rehabilitation, will have the opportunity to be involved in the study which will involve being prescribed appropriate activities using the equipment and being supported to use this by NHS staff. A part-time research assistant will be in place for six months to gather data around the amount of extra activity time carried out, and to interview patients, carers, and staff about their experiences. This has been funded through an award from the Impact Accelerator account (EPSRC) with equipment being donated by a UK company (Innerva Ltd). There has been interest in this research nationally, with an invitation to speak at this year's joint Scottish Stroke AHP Forum and Scottish Stroke Nurse Forum conference. A press release and possible national news segment is also being planned to coincide with the launch.

#### Training Physiotherapy/OT students

We have hosted three physiotherapy students from GCU and QMU over the past 12 months. Introducing our model of rehabilitation to future rehabilitation professionals is an important aspect of changing the model, including our centre on the list of student placements is part of this process. This was only feasible due to the funding received from CHSS for a full-time physiotherapist.

#### Delivering talks to NHS rehab teams

We have hosted nine visits from NHS rehabilitation teams in the past year; GG&C, NHS Lanarkshire and NHS Lothian as well as private therapy providers (Neurophysio Scotland). We have also had a visit from the Glasgow Royal Intensive care rehab team who are keen to augment their therapy with technology.

We have also given talks to a range of teams for their in-service training and invited colleagues to our stakeholder event.

#### Spend from CHSS award

Our funding from CHSS was costed to pay for two temporary (24 months) members of staff, a band 7 and a band 6 research assistant to support and expand the centre's activity. For ethical and insurance reasons we were required to recruit HCPC registered individuals and our preference was

to recruit experienced therapists. Recruitment of therapists from the NHS is challenging given the better pay conditions. To attract the band 7 post, we included the chance to register for a PhD (the university waived the academic fees) and successfully recruited Milena Slachetka. Unfortunately, we could not attract a suitable person for the band 6 post and decided to split this post into a part time admin/management/data analysis post to release funds and release funds to second a member of staff from the NHS. This strategy was successful as we recruited Maisie Keogh and seconded Gillian Sweeney from NHS Lanarkshire. Our current spending from this award is £78,658.17, as of 24<sup>th</sup> July 2023, which leaves £90,257.83 to pay for the remaining 14 months of salaries. There are no other costs associated with this grant.

## Branding and fundraising

The partnership with CHSS has been a critical part of our success. We are, therefore, enthusiastic about supporting fund raising efforts and highlighting the role of CHSS in our centre. We are currently doing this in four ways (see below) and keen to be involved in any other way.

### 1) Social media

We have a dedicated Twitter account (@CoCreationRehab) which we mainly use for sharing news/publications from the centre. We also use it during conferences and when we host events for example, the SRR Conference. We ensure that we tag CHSS in all relevant tweets and where possible, we share content from CHSS.

### 2) Visibility of CHSS within the centre

We have a wealth of CHSS resources available within our centre in the patient waiting area. These are available to take away/ be read by visitors. We also have a dedicated display area highlighting our fundraising efforts for CHSS along with a pop-up poster and a wall mounted notice at the entrance with the CHSS logo.

### 3) Fund raising activities

Members of the team have been directly involved in fundraising activities for CHSS, this has included Ride the North (Kerr), Kilt walk (Slachetka, Boyd and Kerr) and the upcoming abseiling the Forth Bridge in October (Sweeney, Campbell and Keogh). We also promote CHSS through word of mouth during all relevant conversations regarding the centre and encourage all our participants to become members if they have been recruited through a different route (e.g. word of mouth or media).

### 4) Hosting visits to potential funders.

## Engagement with stakeholders

The outputs from the centre (devices, protocols and papers) are co-created with participants and the broader rehabilitation community. Part of this process is an annual stakeholder event which we host every August (starting in 2022). Last year the feedback from this event (67 individuals from CHSS, NHS, Strathclyde, local council and Scottish government) was categorised into five themes which we have tried to respond to.

### Stakeholder event 2022

Feedback from the first stakeholder event were grouped into five categories/themes.

- 1) **Collaboration:** Linking with existing services such as Active health programmes and apply for funding with other organisations

- 2) **Scottish government involvement**; engage with MSPs to progress agenda
- 3) **Education** for individuals and families and include peer support
- 4) **Innovative ideas**: YouTube channel, informing standards of rehab, establish direct access process
- 5) **Future research**; long terms benefits and introducing to mainstream rehab

*In addition, there were miscellaneous questions related to people being able to attend multiple times and how the model fits with the BSRM*

We have tried to address some of these themes over the past year. We have engaged with South Lanarkshire leisure services about how to integrate our model into the Active health programmes. We have a PhD student (Milena Slachetka) currently engaged in developing an educational package through a co-creation process. The YouTube idea is excellent, we have two promotional videos already on YouTube but we would like to add some instructional/educational videos and finally we are in the process of setting up a pilot to integrate our model into mainstream rehab at Wishaw University hospital.

#### Stakeholder event 2023

A stakeholder event, attended by 45 people, was held at the University of Strathclyde on the 3<sup>rd</sup> of August. Representatives from CHSS, the NHS, the University of Strathclyde attended, as did 14 people with lived experience of stroke and their carers.

This event allowed the opportunity for presentations to be delivered on the research being carried out by the research team and future plans. A tour of the Sir Jules Thorn Centre was also offered.

Importantly, a focus was placed on user and stakeholder feedback during this event. A meeting of the established user-group (made up of previous study participants) was held at the beginning of the afternoon, and then facilitated focus groups were carried out with the larger group at the end of the event.

The focus groups were asked what the priorities of the centre should be over the next year, and what methods/strategies could be adopted to achieve these. A summary of feedback from the groups is outlined below;

#### **Priority 1 – Aphasia/communication support**

A significant proportion of those who are attending the sessions have speech and language difficulties. How is it we can address this? Where can we get funding from that we contribute towards building in S&L therapy that would provide a more holistic approach to stroke rehabilitation. How can the games/devices used encourage a holistic approach which encourages communication by engagement?

#### **Priority 2 – Peer support**

Stroke survivors who had attended the groups felt that they benefited from the support of others in the group. They would like to see the opportunities for this increased. Discussion around a peer support programme which would see past participants come back to the centre and contribute to the orientation of new participants. Dedicated peer support volunteers would also contribute to the building of a community and help to bridge the gap between the rehab centres and the wider stroke community.

#### **Priority 3 - Increasing awareness of the rehab centre/research at a local and National level**

Stroke survivors felt this would give hope to people after stroke and puts pressure on the NHS and Scottish Government to take more action. There should be increased publicity about the programme which would also help drive participant numbers. The user-group also felt the use of different social media platforms, such as Tik Tok, Facebook, Instagram would help to 'spread the word' in regards recruitment and awareness of the research/model as a whole.

### Advisory group

We organise three meetings per year with our advisory group who advise on a range of points including, but not limited to; 1) recruitment, 2) funding applications, 3) understanding results, 4) ideas, 5) fund raising and 6) commenting in accessibility of materials like grant applications, talks, papers and instructions for tests etc. Members of the advisory group have also contributed to talks, providing a user perspective.

### Industrial engagement

Technology enriched rehabilitation requires the involvement of industry if a sustainable model is to be achieved. While we are busy designing prototypes through our co-creation model the bulk of the equipment in our centre comes from industry. We have very good relationships with the companies involved and have a good will relationship with most of them. We have been awarded two industrial relationship wards (£25K) to conduct specific studies with companies and one of the companies has kindly provided equipment and training for our Wishaw pilot scheme, free of charge.

### Evidence of feasibility and early data on efficacy

We collect a range of data from our participants to gather evidence on feasibility, device usability and effectiveness of the model. The first year of the project (September 2021 until September 2022) focussed on feasibility and recruited 31 participants, including a small pilot of five individuals. This phase of the project was not funded by CHSS and relied on existing staff. Consequently, the numbers were relatively small with less sessions offered. The second phase focussed on collecting data on effectiveness of the intervention, funding of the therapy staff was critical to this phase as it allowed more sessions to be offered (from four to six per week) larger group sizes and a broader range of outcome measures to reflect the complex nature of stroke recovery.

The following tables represent these two phases of the study.

### Phase 1: Feasibility

Participant details during feasibility stage, separated into the three cohorts

	Age (years), mean (SD)	Gender (female/male)	Time since stroke (months), mean (SD)	Aphasia, n	MoCA score	Attendance, mean number of sessions (SD)
Cohort 1 (n=9)	57.4 (17.7)	3/6	51.1 (34.8)	2	26.7 (2.1)	15.4 (3.3)
Cohort 2 (n=7)	61.9 (12.9)	4/3	20.9 (17.3)	4	21.17 (8.6)	20.1 (0.8)
Cohort 3 (n=10)	62 (9.1)	3/7	42.6 (26.6)	4	21.2 (9.8)	21.3 (6.9)
Total (N=26)	60.4 (13.3)	9/17	39.0 (2.2)	10	23.1 (8.3)	18.7 (4.9)

Mean (and 95% confidence interval) of change in outcome measures before and after the program

	RMI	SIS-16	FAC	FTSTST	10mWT	ARAT
Before	11.0 (9.9 to 12.2)	61.2 (57.9 to 65.6)	3.8 (3.4 to 4.3)	26.8 (17.0 to 36.6)	30.4 (16.6 to 44.2)	29.8 (20.1 to 39.6)
After	12.7 (11.9 to 13.6)	66.5 (63.1 to 69.9)	4.5 (4.2 to 4.8)	21.7 (15.5 to 27.8)	21.7 (15.5 to 27.8)	30.8 (20.4 to 41.2)
Difference	1.9 (1.3 to 2.6)	5.5 (3.5 to 7.5)	0.7 (0.4 to 1.0)	-8.0 (-15.4 to -0.6)	-10.6 (-19.4 to 1.7)	3.1 (0.9 to 5.3)

*RMI: Rivermead Mobility Index. SIS-16: Stroke Impact Scale-16. FAC: functional ambulatory category. FTSTST: five times sit to stand test. 10mWT: 10-meter walk test. ARAT: action research arm test.*

A total of 493 total sessions were attended representing 986 hours of therapy. Five individuals achieved, or exceeded, their target number of sessions, and there was, overall, an average adherence rate of 82% (number of attended sessions or number of sessions planned). In total, 21 participants missed a total of 91 (18% of total) planned sessions for the following reasons: illness (n=13), hospital appointment (n=4), weather (n=15), work (n=5), vaccination (n=5), holidays (n=8), personal (n=24), child care (n=7), and transport (n=12). Safety No serious adverse events were reported during this study. There were, however, a number (n=19) of non-serious adverse events considered to be related to the study: joint or muscle soreness (n=6), viral illness (including COVID-19; n=5), cardiovascular (dizziness; n=3), fatigue (n=3), and skin irritation (n=2). These all resolved within 1 week without intervention.

More details on the first phase of this study are available from our publication (Kerr et al, 2023, details below).

Kerr, A., Keogh, M., Slachetka, M., Grealy, M. and Rowe, P., 2023. An Intensive Exercise Program Using a Technology-Enriched Rehabilitation Gym for the Recovery of Function in People With Chronic Stroke: Usability Study. *JMIR Rehabilitation and Assistive Technologies*, 10, p.e46619.

Phase 2: Evidence of efficacy. We are 50% of the way through this study with 35 participants recruited across three groups. Analysis is therefore simple and should be free of inference.

Participant (n=35) details during efficacy stage,

Age (years), mean (SD)	Gender (female/male)	Time since stroke (months), mean (SD)	Aphasia, n	MoCA score	Attendance, mean number of sessions (SD)
57.6 (13.7)	12/23	45.6 (33.0)	12/35	24.6 (6.2)	17.5 (7.5)

Phase 2: change in outcome measures, mean and SD

	RMI	SIS-16	Grip (Kg)	Balance Berg scale	FAC	FTSTST	10mWT	ARAT
Before	11.1 (3.1)	59.1 (11.9)	4.8 (5.3)	44.1 (10.6)	4.3 (1.0)	27.5 (24.1)	30.5 (37.3)	21.5 (25.4)
After	12.1 (2.6)	64.0 (12.3)	9.1 (9.7)	47.9 (8.7)	4.7 (0.5)	17.3 (9.9)	17.4 (15.4)	26.6 (26.4)

Two participants withdrew between consenting and starting (transport issues), a further three participants withdrew after completing 10, 2 and 3 sessions respectively, two were for transport reasons and one unknown. In this group two individuals managed to attend 33 times, accruing 66 hours of rehab. Again, there were no serious adverse events, we had 8 adverse events potentially linked to the intervention including sore joints (n=2), high tone (n=1), feeling unwell (n=2), feeling tired (n=2) and one non-injurious trip. No lasting effects were observed.

## Other long-term health conditions

Our primary focus has been supporting recovery from stroke due to the size and complexity of this rehabilitation challenge. We are, however, aware of the impact our work might have on other long-term conditions. Recently we were awarded a grant from Innovate UK (£657,639.00) with two industrial partners; Spirit Digital (leaders in telehealth and remote sensing) and Waire Health (sensor company) to develop a telehealth platform for home base pulmonary rehabilitation in people with **COPD**.

We are also part of an application to establish a doctoral training centre on **Multiple Sclerosis** (led by GCU) and an application to Parkinson's UK to run a pilot study for people with **Parkinson's**.

## Future plans in collaboration with CHSS

The funding from CHSS has been critical to the success of our rehabilitation technology innovation centre, allowing us to develop realistic plans to expand our activities and deliver technology-enriched rehabilitation in the community.

With this in mind our plans for the next 12 months are:

- 1) Recruit another 40 individuals to our programme at Strathclyde, this will mean achieving an overall target of 100 people living with stroke
- 2) Write a user's manual for technology enriched that can be accessed by all
- 3) Introduce a counselling service to the centre to support full access to the programme
- 4) Deliver a pilot project at Wishaw University Hospital acute stroke unit
- 5) Use knowledge gained from the pilot to develop plans for multiple hubs (including Maryhill centre) capable of delivering an intensive rehabilitation programme
- 6) Apply, in partnership with CHSS, to the Chief Scientists Office and NIHR to fund this community roll out
- 7) Work with CHSS to involve other populations in the programme including long COVID and COPD
- 8) Apply, in partnership with CHSS, to the Chief Scientists Office and NIHR to fund a rigorous controlled trial of our model of rehabilitation
- 9) Achieve greater integration of speech and cognitive activities. While this has been introduced we would like to develop specific technologies to embed communication and cognitive tasks into all our "physical" therapy. We plan to apply for a grant with the Speech Therapy Dept. to conduct a small study with this aim.

We would like to conclude this report by restating the importance of the investment from CHSS, which has allowed us to expand tremendously in both the service we offer and also the quality and volume of the research we are doing. It has also been instrumental in raising our profile, we are now viewed as a demonstration site for rehabilitation of the future. We would value the opportunity to discuss this report further and scope out future funding arrangements.