Project Title

Value-based Introduction of Exoskeletons for Gait Rehabilitation in Physiotherapy

Project Lead and Members

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Organisation(s) Involved

Singapore General Hospital

Healthcare Family Group(s) Involved in this Project

Allied Health, Healthcare Administration, Medicine

Applicable Specialty or Discipline

Physiotherapy, Medical & Clinical Services Office, Rehabilitation Medicine, Innovation & Technology

Project Period

Start date: April 2022

Completed date: October 2023

Aims

To investigate whether 1) we could successfully adopt and sustain the use of RAGR in our hospital setting and 2) whether adding RAGR to usual care would result in higher functional mobility gains in stroke survivors.

Project Attachment

See poster appended/ below

Background

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Methods

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Results

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Additional Information

National Healthcare Innovation & Productivity (NHIP) 2024 – Best Adopter

Conclusion

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Project Category

Care & Process Redesign

Value Based Care, Functional Outcome

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Exoskeleton, Gait, Rehabilitation

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Value-based Introduction of Exoskeletons for Gait Rehabilitation in Physiotherapy

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Background of the Problem

At Singapore General Hospital (SGH), **stroke survivors make up 70% of the ward occupancy in the inpatient rehabilitation unit.** Despite this high volume of stroke survivors being seen, only usual care has been provided. The **most common presentation post stroke is the loss of muscle strength, causing gait disability (Wall et al, 2020) and loss of independence**. **Traditional rehabilitation methods may fall short in providing adequate assistance for restoring walking ability. The resource-intensive nature of conventional therapy approaches can strain healthcare systems and limit access to rehabilitation services for those in need.**

With the findings of the Improving Mobility Via Exoskeletons (IMOVE) study by Chew et al 2022 that showcased the successful utilisation of Robotic Assisted Gait Rehabilitation (RAGR) in various inpatient rehabilitation settings in Singapore and the Australian and New Zealand living clinical guidelines advocating for increased opportunities for stroke survivors to engage in repetitive walking practice, we embarked on a transformative journey and sought to address this need by **integrating RAGR within our inpatient rehabilitation unit, specifically utilizing the Hybrid Assistive Limb (HAL) exoskeleton**. The HAL is a wearable exoskeleton that can detect voluntary contraction to assist the wearer to move (Wall et al, 2020).

Mission Statement

To investigate whether 1) we could successfully adopt and sustain the use of RAGR in our hospital setting and 2) whether adding RAGR to usual care would result in higher functional mobility gains in stroke survivors.

Implementation / Initiatives

To ensure **successful and efficient integration of exoskeletons into our rehabilitation framework, we customized our rehabilitation protocols, staff training and reviewed our billing framework to ensure compatibility with our patient population, workflows and existing infrastructure.**

In the exploration phase, we trialled all available exoskeletons that met the needs of our patient population. The HAL was chosen as it utilises an **EMG based control system** (Picture 1). With the EMG feedback, it allows the device to **assist the wearer to move as per how they intended to, promoting active participation during the task specific practice which facilitates neuro-recovery**.

Next, our team **sought buy-in from key stakeholders** through comprehensive presentations and discussions highlighting the benefits and potential impact of introducing RAGR. Together, senior management, key stakeholders and end users collaboratively determined the projected workload and costing to be comparable to a non-robotic session to ensure accessibility and sustainable implementation of RAGR.

Staff training and capability building were prioritized to ensure proficiency in operating and integrating RAGR into our rehabilitation protocols. This involved identifying a **service champion and train the trainer programme.**

The team started at 50% of the target workload and took 6 months to ramp up to reach full workload of 6-7 patients per day or 128 attendances per month (Figure 1). We focused on recruiting patients from the inpatient rehabilitation unit. The criteria to recruit patients to receive HAL training are listed in Table 1. Overground walking practice was implemented with the HAL and a mobile suspension system as this was logistically more feasible (Picture 2). To ensure efficiency, we had 1 Physiotherapist (PT), 1 Therapy Assistant together with 1 Healthcare Attendant to run the service.

We conducted **a retrospective non-randomized treatment** comparison on patients recovering from stroke in the inpatient rehabilitation unit **between April 2022 and October 2023**. The patients either received HAL training on top of usual care or just usual care alone. Depending on the therapy goals to be achieved, the total number of HAL sessions varied between the patients. The Mobility Scale for Acute Stroke (MSAS) was the primary outcome measure. It is a valid and reliable tool that provides specific information on functional mobility (Tinl et al, 2014). It assesses 6 different functional activities and the scores range from 6-36, with 36 points being the highest score. Every 1 point difference for the better indicates that the patient requires less assistance during mobilization and this is clinically meaningful. It was assessed upon admission to and at discharge from the inpatient rehabilitation unit. Multivariable linear regression was used to analyse the association between RAGR and MSAS.

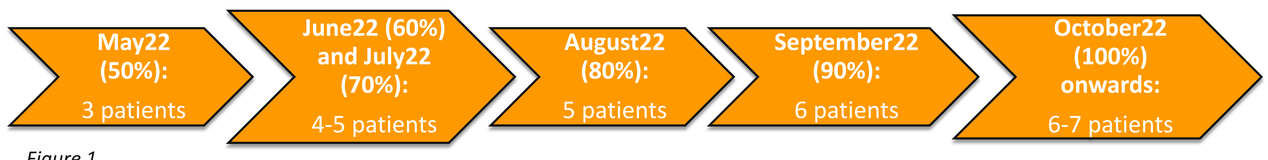


Figure 1

Inclusion Criteria
Medically stable
Follow 1 step instruction
Sit with at least minimum assist for 3 minutes
Within the device's height and weight restrictions

Table 1

Picture 1

Picture 2

Implementation Risk & Complexity

We mitigated the associated risks of implementing RAGR by commencing **proactive discussions with clinicians, IT, Biomechanical engineering (BME), safety network and Infection Control departments** prior to renting the HAL unit. Cybersecurity measures to safeguard patient data included ensuring patient data was not stored on a cloud and was not accessible by the manufacturers in Japan. We worked collaboratively with the vendors to ensure the straps and surfaces could be wiped down with alcohol wipes to meet infection control standards.

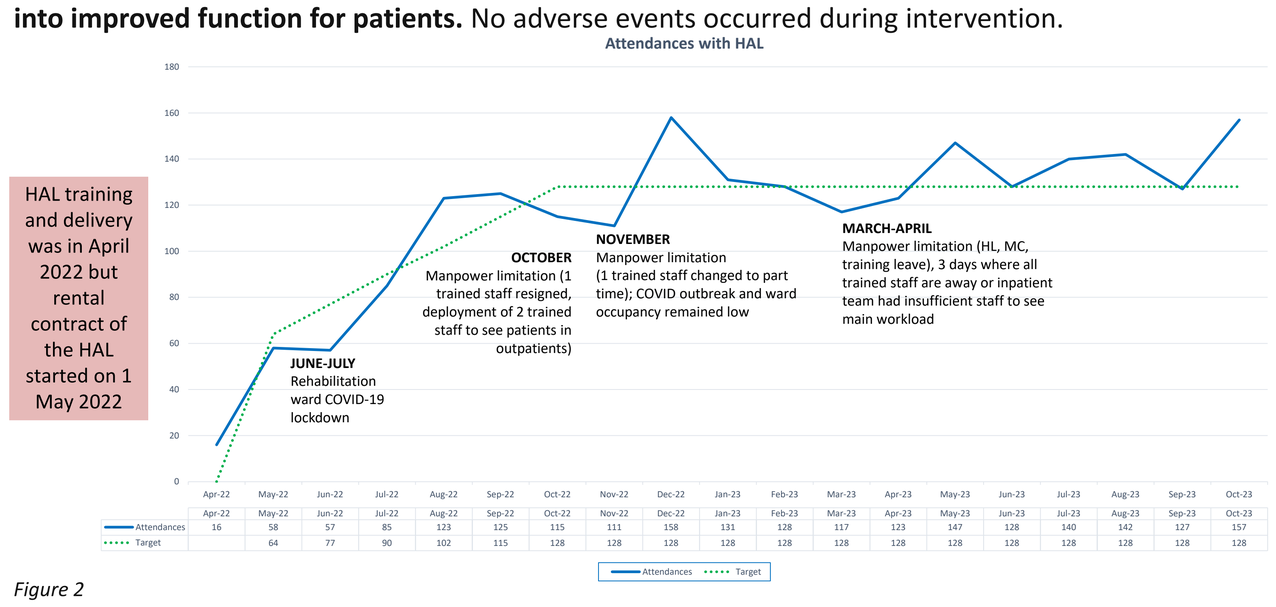
The manpower and resource challenges which included staff training and space utilisation were mitigated through close collaboration and support from senior management and key stakeholders. Capital budget projections and securing funding from relevant stakeholders or sources were essential to mitigate the financial constraints.

To **ensure patient's voice while implementing RAGR**, we asked them for their experience and **patients reported the use of robotics beneficial in improving their functional recovery, reporting a score of 7.2 (+/- 2.3) on an 11-point Likert scale.**

Results

For the paced workload in the first year, the RAGR service has **exceeded the targeted workload** of 1344 attendances with 1350 attendances. On average, we **continue to hit the monthly target attendances even after the first year** (Figure 2).

Data from 170 patients with stroke were included in the analyses (Table 2). Of these patients, 118 patients received HAL training and on average, each patient received 10.8 (+/- 6.6) sessions. After adjusting for age, gender and baseline MSAS measured upon admission to rehabilitation, patients who received HAL training showed greater improvement in MSAS scores compared with patients who received only usual care (adjusted differences, 3.89 points; $p < 0.001$; 95% CI 1.77 to 6.00) (Figure 3). It was also found that in the HAL group, **58% of the patients who were unable to walk at admission could only start walking practice with the help of HAL**. This meant that **patients could start receiving repetitive practice of walking early on in their rehabilitation journey and overall, this has translated into improved function for patients.** No adverse events occurred during intervention.



	Apr-22	May-22	Jun-22	Jul-22	Aug-22	Sep-22	Oct-22	Nov-22	Dec-22	Jan-23	Feb-23	Mar-23	Apr-23	May-23	Jun-23	Jul-23	Aug-23	Sep-23	Oct-23
Attendances	16	58	57	85	123	125	115	111	158	131	128	117	123	147	128	140	142	127	157
Target		64	77	90	102	115	128	128	128	128	128	128	128	128	128	128	128	128	128

Figure 2

Patient Characteristics

Variables	HAL (*N*= 118)	Control (*N* = 52)
Age, years	60.92 (13.01)	67.62 (11.50)
Male, N (%)	79 (67)	24 (46)
MSAS (Admission), points	19.58 (6.98)	23.46 (9.07)
MSAS (Discharge), points	28.73 (6.39)	27.27 (9.79)

Table 2: Values are mean (SD) or N (%). MSAS: Mobility Scale for Acute Stroke

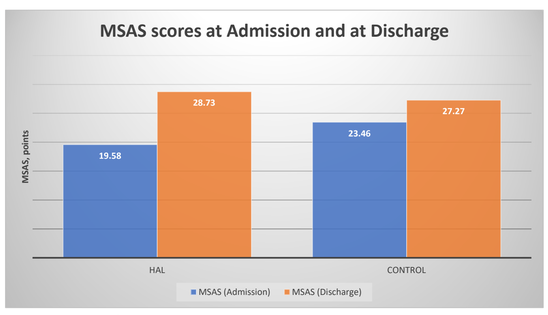


Figure 3: Values are mean

Conclusion and Sustainability Plans

The successful integration of RAGR into existing rehabilitation practices demonstrates the **organization's commitment to staying at the forefront of healthcare innovation to meet the evolving needs of patients and stakeholders.** We have learnt that **engaging key stakeholders early and often** is critical for successful adoption. It was also important to ensure there was **continuous product support to ensure smooth and safe adoption of technology**. We have learnt the importance of including all associated maintenance costs and accessories during initial discussions with vendors to keep the overall cost of robotic sessions low to ensure high uptake.

In patients with sub-acute stroke, the **use of HAL as an adjunctive therapy is associated with greater functional recovery**. As a 1-point improvement in MSAS already represents a meaningful reduction in mobility assistance, we believe **the estimated effect size was sizeable and clinically meaningful**.

The team has also tapped into other initiatives to ensure sustainability of the service. This includes:
1) **receiving accreditation for the HAL Robotics Rehabilitation Therapy Support Associate (TSA) Training Programme** to upskill our support staff to aid in running the service which would free up the PT to manage patients with more complex rehabilitation needs and 2) **being involved on policy making platforms such as MOH MTAC to promote funding for RAGR services in stroke survivors.**

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