Project Title

Telerehabilitation Using a Home Based 2D Planar Arm Rehabilitation Robot For Hemiparetic Stroke: A Pilot Feasibility Trial Reporting Cost Effectiveness

Project Lead and Members

Project Lead: Karen SG, Chua

Project Members: Poo Lee Ong, Christopher WK Kuah, Tegan K Plunkett, Chwee Yin Ng, Wei Binh Chong, Lay Wai Khin, Kim Huat Goh, Gabriel A Ollinger, Asif Hussain

Organisation(s) Involved

Institute of Rehabilitation Excellence (IREx), Tan Tock Seng Hospital Rehabilitation Centre Singapore, Lee Kong Chian School of Medicine, Nanyang Technological University, Singapore, Clinical Research and Innovation Office, Nanyang Business School, Nanyang Technological University, Singapore, Articares Pte Ltd, Singapore

Healthcare Family Group(s) Involved in this Project

Allied Health

Applicable Specialty or Discipline

Rehabilitation Therapy, Occupational Therapy, Physiotherapy, Neurology

Project Period

Start date: 3 March 2022

Completed date: 1 June 2023

Aim

Post stroke upper extremity (UE) impairments often persist into the chronic phase. The majority of UE recovery occurs beyond hospital discharge when intensity of rehabilitation interventions needed to drive neuroplasticity wanes. Minimally assisted Robotics assisted therapy (RAT) may provide effective solutions. We

evaluated the feasibility, safety, efficacy and cost effectiveness analysis (CEA) of clinic to home telerehabilitation using a 2D portable planar arm robot.

Background

Post-stroke upper extremity impairments persist into the chronic phase, and robot-assisted therapy (RAT) may help improve outcomes through telerehabilitation.

Methods

A prospective pilot study was conducted with stroke patients, using a home-based 2D planar robot (HMAN) for 30 days with telemonitoring and assessment at different time points (baseline, 5 weeks, 12 weeks, 24 weeks)

Results

Statistically significant improvements in Fugl-Meyer Motor Assessment (FMA) and Action Research Arm Test (ARAT) scores were observed at 5 weeks and 24 weeks. Cost savings were found in the home-based program compared to clinic-based therapy

Lessons Learnt

Telerehabilitation with robotics can be both cost-effective and efficacious in improving upper limb rehabilitation post-stroke

Conclusion

The study demonstrated the feasibility and potential cost-saving benefits of home-based robotic therapy for stroke patients, reducing direct costs of rehabilitation.

Project Category

Care Continuum

Intermediate and Long Term & Community Care, Home Care

Technology

Assistive Technology, Robotic

Care & Process Redesign

Productivity, Cost Saving, Value Based Care,

Keywords

Telerehabilitation, Stroke, Robotics, Upper Limb, Feasibility Study, Robotics, Hemiparetic Stroke, Upper Limb Rehabilitation, Cost-Effectiveness

Name and Email of Project Contact Person(s)

Name: Karen Chua Sui Geok

Email: karen_chua@ttsh.com.sg

ISPRM International Society of Physical and Rehabilitation Medicine

TRAUMA TECHNOLOGY & TIMING 1-6 June 2024 Sydney Australia

RMSANZ Rehabilitation Medicine Society of Australia and New Zealand

Telerehabilitation using a home-based 2D planar arm rehabilitation robot for hemiparetic stroke: A pilot feasibility trial reporting cost effectiveness

Tan Tock Seng Hospital

ARTICARES

Authors: Karen SG, Chua*[1,2], Lay Wai, Khin[3], Kim Huat, Goh[4] Poo Lee, Ong[1,2], Christopher WK, Kuah[1], Tegan K, Plunkett[1], Chwee Yin, Ng[1], Wei Binh, Chong[1], Jaclyn AM Low[1,] Gabriel A, Ollinger[5], Asif Hussain[5]

Affiliations: 1. Institute of Rehabilitation Excellence (IREx), Tan Tock Seng Hospital Rehabilitation Centre, Singapore; 2. Lee Kong Chian School of Medicine, Nanyang Technological University, Singapore; 3. Clinical Research and Innovation Office, Tan Tock Seng Hospital Singapore; 4. Nanyang Business School, Nanyang Technological University, Singapore; 5. Articares Pte Ltd, Singapore.

BACKGROUND & AIMS

Post-stroke upper extremity (UE) impairments often persist into the chronic phase.[1] The majority of UE recovery occurs beyond hospital discharge when intensity of rehabilitation interventions needed to drive neuroplasticity wanes.[1] Minimally-assisted Robotics-assisted therapy (RAT) may provide effective solutions.[2,3] We evaluated the feasibility, safety, efficacy and cost effectiveness analysis (CEA) of clinic-to-home telerehabilitation using a 2D portable planar arm robot.

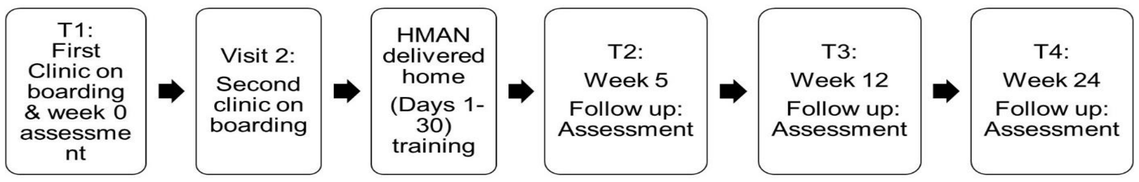
MATERIALS and METHODS

A prospective pilot study was carried out from 3 March 2022 to 1 June 2023 in a rehabilitation outpatient clinic and participants' homes. The HMAN® (www.articares.com), was deployed in participants' homes (HMAN@Home) for 30 consecutive days under carers' supervision. Cloud-based telemonitoring was performed twice-weekly to monitor training duration & intensity by occupational therapist (OT) and patients did not visit the clinic during these 30 days. (Figure 1)

Inclusion criteria were medically-stable stroke >28 days, hemiparetic UE weakness (Fugl-Meyer Motor Assessment (FMA) 10-60/66), presence of caregiver and stable home situation. Exclusion criteria were arm pain >4/10, elbow flexors modified Ashworth scale (MAS) spasticity >2 or sitting tolerance <60 minutes.

Outcome measures at baseline, weeks 5 (end-training), 12 & 24 included FMA, Action Research Arm Test (ARAT), Jamar dynamometer grip strength (kg), WHO-SSQOL and Upper Limb Self-Efficacy Test (UPSET). (Figure 1)

Figure 1. Study protocol



Total, direct and indirect cost components comparing conventional occupational therapy (COT) and RAT@Clinic were computed based on participants' retrospective billed clinical programme costs during study duration. Direct costs included onboarding & home visits and outcomes/telemonitoring by OT, HMAN@Home and supporting furniture rental. Indirect costs included participants' and carers' transportation, clinic waiting & payment time, home-related carers' time, utilities and WiFi. (Table 1)

Table 1: Comparison of component costs (SGD) by programme type (N=12)

Mean(SD) S$/ participant	COT Matched to RAT@ clinic	RAT@Clinic	HMAN@Home Current intervention
Total (A+B)	**3,191.04 (1,258.50)**	**3,282.14 (1,386.05)**	**2,416.92 (253.26)**
(A) Direct costs	2,826.12 (1,173.91)	2,917.22 (1,312.51)	2,187.61 (262.62)
-Programme cost	2,826.12 (1,173.91)	2,917.22 (1,312.51)	2,050.39 (232.71)
-Telemonitoring cost	0.00	0.00	137.22 (83.99)
(B) Indirect costs	364.92 (125.34)	364.92 (125.32)	229.31 (53.56)
-Waiting Time	0.00*	0.00*	29.53 (55.20)
-Transportation	364.92 (125.34)	364.92 (125.32)	92.03 (35.30)
-Home related**	0.00	0.00	107.75 (30.75)

Legend: *not available due to retrospective collection; ** home-related carer's time, utilities & WiFi

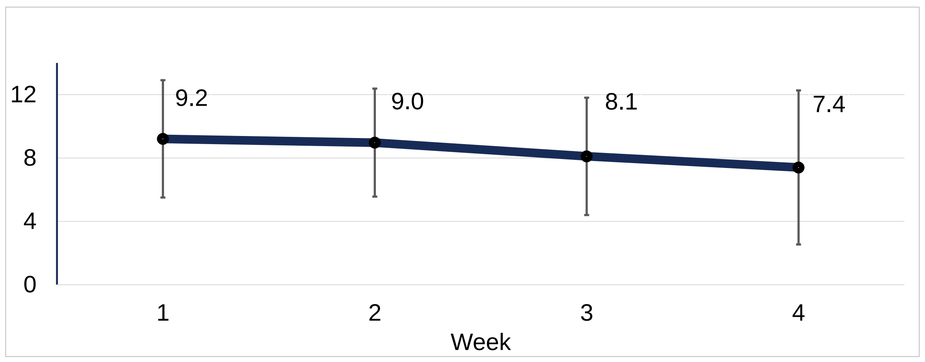
Statistical analyses:
Adjusted clinical effect sizes (FMA) for HMAN@Home, COT and RAT@Clinic were calculated using multivariate mixed random effect models and clinically important variables were adjusted in the models. CEA was carried out using model-based, estimated individual predicted clinical effect sizes, and direct, indirect and total costs for 3 unique treatment pathways.

RESULTS

Altogether, 12 stroke participants were enrolled; 9 (75%) males, 8 (66.7%) infarcts, mean (SD) age 59.4 (9.5) years, mean stroke duration 88.5 ± 137.2 (13.4 – 501) weeks, baseline FMA 42.1 (13.2) and ARAT 25.4 (19.5). Mean (SD) total home game play duration / day was 1.04 ± 0.35 hour (cloud data, Figure 2).

Significant post-training gains were observed; ΔFMA 2.4 at end-training week 5, ($P < 0.05$) and Δ FMA 3.7 at follow-up week 24 ($P < 0.05$); ΔARAT 2.6 at end-training week 5 ($P < 0.05$) and ΔARAT 4.8 at follow-up week 24 ($P < 0.05$).

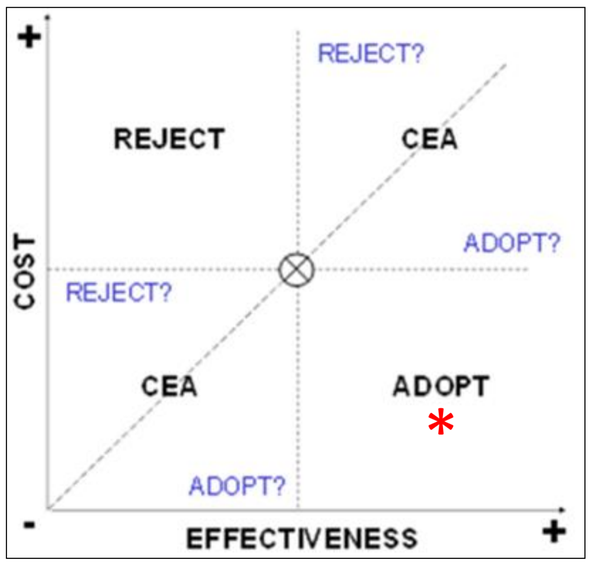
Figure 2. HMAN training duration by week (hours) based on cloud data (N=12)



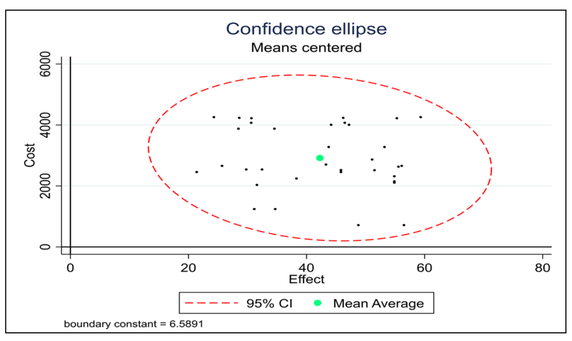
Mean individual cost savings by programme of **-24.3%** were observed for HMAN@Home (SGD2,416.92) compared to RAT@Clinic (SGD3,282.14), ($P = 0.62$)] (table 1) The adjusted predicted mean values of FMA for HMAN@Home, COT (control) and RAT@Clinic were 45.75 (95% CI: 40.53 – 50.97), 40.36 (95%CI: 36.28 – 44.44) and 45.52 (95%CI: 40.98 – 50.06) respectively. (Figure 3)

CEA analysis comparing HMAN@Home with COT (control) demonstrated that HMAN@Home resulted in a positive incremental effect of **ΔFMA+5.4** with a negative incremental cost effectiveness ratio (ICER) **of -143.73 SGD** per cure. These results indicated that HMAN@Home was not only cost-effective but cost saving.

Figure 3 Cost-effectiveness savings comparing HMAN@Home and COT



FMA Outcome
Cost = - 774.14 (-ve cost/cost saving) (2416.92 – 3191.06)
Effect = +5.39 (+ve gain) (45.75 – 40.36)
ICER = -143.73/cure (cost saving): 6 weeks duration



DISCUSSION & CONCLUSION

Our study findings support the preliminary feasibility, safety, efficacy and cost-effectiveness of HMAN@Home compared with COT. Telerehabilitation robotics may potentially provide an adjunctive stroke rehabilitation pathway.

References:
1. van Vliet P, Tavener M, van Wijck FM, Alt Murphy M. Editorial: Home-based training to reduce upper limb functional impairment post-stroke. Front Neurol. 2023 Oct 24;14:1309954. doi: 10.3389/fneur.2023.1309954. PMID: 37941575; PMCID: PMC10628668.
2. Budhota A, Chua KSG, Hussain A, et al. Robotic Assisted Upper Limb Training Post Stroke: A Randomized Control Trial Using Combinatory Approach. Front Neurol. 2021 Jun 2;12:622014. doi: 10.3389/fneur.2021.622014
3. Wagner TH, Lo AC, Peduzzi P, Bravata DM, Huang GD, Krebs HI, Ringer RJ, Federman DG, Richards LG, Haselkorn JK, Wittenberg GF, Volpe BT, Bever CT, Duncan PW, Siroka A, Guarino PD. An economic analysis of robot-assisted therapy for long-term upper-limb impairment after stroke. Stroke. 2011 Sep;42(9):2630-2. doi: 10.1161/STROKEAHA.110.606442. Epub 2011 Jul 14. PMID: 21757677; PMCID: PMC4445835.