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Real-World Comparison of Exoskeleton, End-Effector, and Sequential Robotic Therapy After Stroke

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BACKGROUND

- Upper limb impairment is a common consequence of stroke and a major determinant of limitations in activities of daily living and social participation.
- Robot-assisted upper limb rehabilitation has been widely adopted as an intervention capable of delivering repetitive and intensive training; however, evidence regarding the comparative effectiveness of different robot types and their sequential use in real-world clinical settings remains limited.

OBJECTIVES

- This study aimed to compare the effects of an exoskeleton robot (Armeo Power), an end-effector robot (IMT)
- and their sequential use on upper limb recovery in patients with stroke under real-world clinical allocation.

METHODS & MATERIALS

- This retrospective cohort study included 74 patients with stroke who received robot-assisted upper limb rehabilitation.
- Participants were allocated to three groups according to clinical practice: Armeo Power alone (n = 21), IMT alone (n = 43), and sequential use of IMT followed by Armeo Power (n = 10).

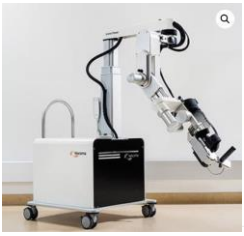

Figure1. Exoskeleton robot(Armeo Power)

Figure2. End-effector robot (IMT)

- The primary outcome was the Fugl–Meyer Assessment for Upper Extremity (FMA-UE).
- Secondary outcomes included the Mini-Mental State Examination (MMSE), Jebsen Hand Function Test (JHFT), and Modified Barthel Index (MBI).
- Analysis of covariance (ANCOVA) was performed to compare post-intervention outcomes among groups after adjusting for baseline values, and within-group changes were examined using paired t-tests.

RESULTS

- All three groups showed significant improvements in FMA-UE scores after the intervention ($p < 0.01$).
- However, no significant differences were observed among the groups in post-intervention FMA-UE scores after baseline adjustment ($p = 0.349$).
- Among secondary outcomes, a significant between-group difference was found for JHFT scores ($p = 0.041$), whereas MMSE and MBI scores did not differ significantly across groups.
- Within-group analyses demonstrated overall improvements in functional outcomes across all treatment strategies.

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RESULTS (cont.)

Table1. Characteristics of Stroke patients

	Total (n=74)	Armeo Power (n=21)	IMT (n=43)	Armeo Power→IMT (n=10)	p-value
Age (y)	55.77±17.52	55.95±19.63	57.30±15.46	48.80±21.29	0.389
Sex					
Male	49(66.2)	11(52.4)	31(72.1)	7(70.0)	0.283
Female	25(33.8)	10(47.6)	12(27.9)	3(30.0)	
Affected side					
Rt.	40(54.1)	11(52.4)	23(53.5)	6(60.0)	**0.918**
Lt.	34(45.9)	10(47.6)	20(46.5)	4(40.0)	
Onset(m)	7.08±6.51	5.71±8.31	7.56±5.55	7.90±6.35	0.525
Sessions	66.05±50.00	76.38±62.71	62.60±47.79	59.20±22.90	0.531
Baseline					
MMSE	23.52±6.83	26.00±3.96	22.62±7.95	22.20±5.37	0.144
JHFT	1.07±5.32	2.05±6.48	0.81±5.34	0.10±0.32	0.572
FMA-UE	15.26±12.27	21.29±15.60	10.93±9.38	21.20±7.45	0.001
ADL (MBI)	41.36±22.25	46.90±22.20	36.51±22.06	50.60±19.28	0.078

Table2. Comparisons of post-intervention among groups

	ArmeoPower (n=21) (mean ± SE)	IMT (n=43) (mean ± SE)	ArmeoPower →IMT (n=10) (mean ± SE)	p-value†
FMA-U/E	30.12±2.44	25.67±1.71	26.65±3.46	0.349
MMSE	25.74±0.75	26.42±0.51	25.62±1.07	**0.671**
JHFT	15.20±3.75	3.72±2.61	11.16±5.42	0.041*
MBI	70.60±3.18	63.57±2.23	63.71±4.62	0.185

Table 3. Within-group pre–post changes

	ArmeoPower (n=21)		p-value	IMT (n=43)		p-value	ArmeoPower →IMT (n=10)		p-value
	pre (mean ± SD)	post (mean ± SD)		pre (mean ± SD)	post (mean ± SD)		pre (mean ± SD)	post (mean ± SD)	
FMA-U/E	21.29 ±15.60	36.76 ±19.36	0.000	10.93 ±9.38	20.91 ±14.87	0.000	21.20 ±7.45	33.20 ±15.86	0.007
MMSE	26.0 0±3.96	26.90 ±2.77	0.196	22.63 ±7.95	26.00 ±5.27	0.000	22.20 ±5.37	25.00 ±4.45	0.068
JHFT	2.05 ±6.47	16.38 ±27.08	0.020	0.81 ±5.34	3.42 ±10.76	0.060	0.10 ±0.32	10.00 ±20.79	0.164
MBI	46.90 ±22.20	73.95 ±21.79	0.000	36.51 ±22.06	60.63 ±17.95	0.000	50.60 ±19.28	69.30 ±20.67	0.006

CONCLUSIONS

- end-effector robot therapy, exoskeleton robot therapy, and their sequential use were all effective in improving upper limb function in patients with stroke in a real-world clinical setting.
- No single robot type demonstrated consistent superiority, suggesting that robot selection and application strategies should be individualized according to patients' baseline functional status and stage of recovery.
- This study provides practice-based evidence supporting flexible and stage-specific use of upper limb rehabilitation robots in routine clinical care.

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