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EFFECT OF GAIT-SYNCHRONIZED FUNCTIONAL ELECTRICAL STIMULATION DURING EXOSKELETON-ASSISTED AMBULATION ON CARDIORESPIRATORY DEMANDS IN INDIVIDUALS WITH CHRONIC INCOMPLETE SPINAL CORD INJURY

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Introduction

- Regaining gait function is an important priority for people with incomplete spinal cord injury (iSCI) *(Ditunno, Patrick, Stineman, & Ditunno, 2008)*
- Overground exoskeleton therapy has beneficial effects on gait function *(Bach Baunsgaard et al., 2018)*
- Given the difficulty in recruiting muscle fibers below the level of injury after iSCI, there is potential for enhanced recruitment with functional electrical stimulation (FES)

Objective: To evaluate the impact of gait-synchronized FES during exoskeleton-assisted ambulation on cardiorespiratory demand in individuals with incomplete spinal cord injury.

Methods

- **Sample:** 11 participants *(Tab. 1)* with chronic iSCI and partial walking ability
  Intervention: Ekso + gait-synchronized FES for quadriceps, hamstring, glutaeus maximus and triceps surae (Ekso + FES) *(Fig. 1)*
- **Control:** Ekso without FES (Ekso) *(Fig. 1)*
- **Setup** *(Fig. 2)*:
  - EksoNR, Ekso Bionics, Richmond, CA, USA
  - RehaMove2, Hasomed, Magdeburg, Germany
  - K5 wearable metabolic system, COSMED, Rome, Italy
- **Primary outcome:** Within-subject difference in oxygen consumption per kilogram body weight (VO_2/kg) *(Fig. 3)*

Characteristics of study sample (n = 11)	
Age [years], mean ± SD	49.1 ± 15.3
Sex, n (%)	
Male	9 (82)
Female	2 (18)
Neurological Level of Injury (NLI) and severity of injury, n (%)	
T1–S5 AIS A, B, C	2 (18)
All AIS D	9 (82)
Type of injury, n (%)	
Traumatic	6 (55)
Non-traumatic	5 (45)
Time since injury [years], mean ± SD	6.5 ± 6.9

Tab. 1 *Participant characteristics*

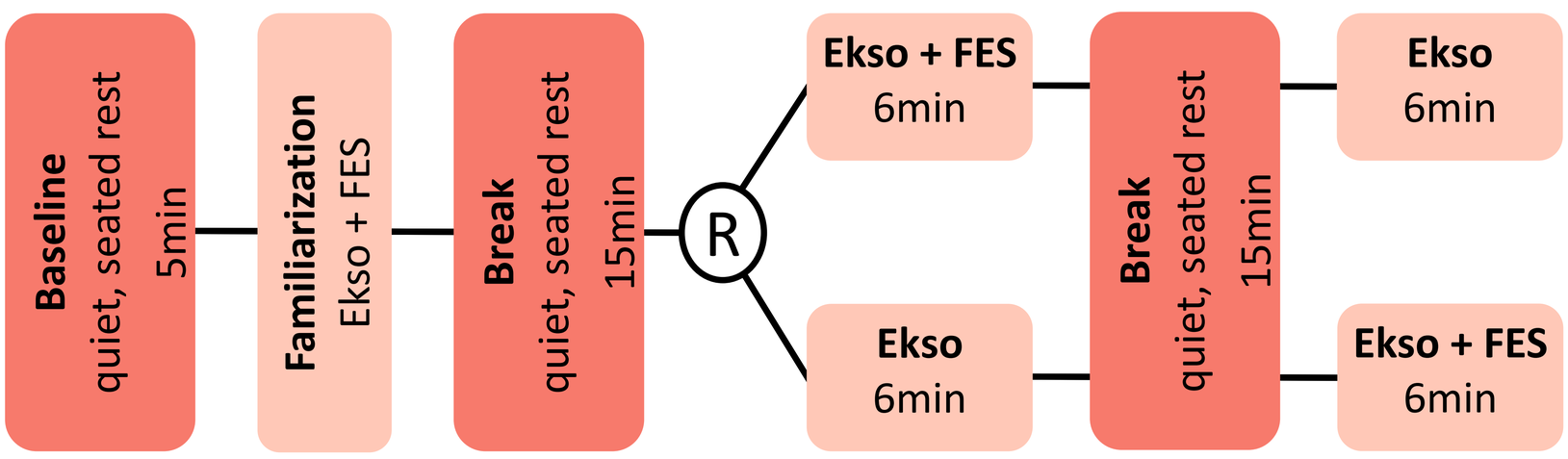


Fig. 1: *Randomized crossover arrangement of measurements*



Fig. 2: *Ekso therapy with FES and K5*

Results

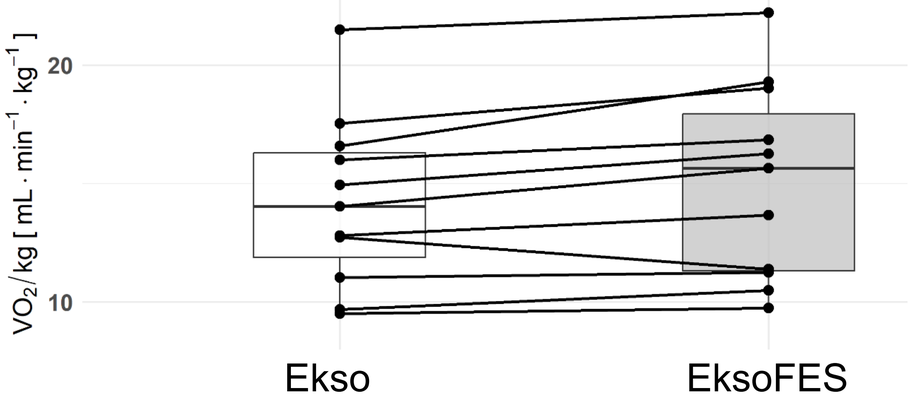


Fig. 3 *VO2/kg increased by 6% with FES compared to Ekso without FES (β = 0.86, SE = 0.31, t(10) = 2.82, p = 0.02)*

Variable	Condition	Mean (± SD)	Estimate, β	Standard error, SE	t	p-value
Minute ventilation	Ekso	31.96 (± 7.75)				
[L/min]	Ekso FES	34.69 (± 9.16)	2.74	1.02	2.70	0.02
Heart rate	Ekso	95.84 (± 15.89)				
[bpm]	Ekso FES	98.53 (± 16.03)	2.68	1.06	2.52	0.03
Distance	Ekso	127.3 (± 40.3)				
[m]	Ekso FES	130.5 (± 43.4)	3.18	3.04	1.05	0.32
Borg 6-20	Ekso	11.45 (± 2.11)				
	Ekso FES	11.27 (± 2.37)	-0.18	0.96	-0.19	0.85

Tab. 2 *Secondary outcome parameters*

Conclusion

- Gait-synchronized FES during exoskeleton-assisted gait therapy increases cardiorespiratory demand *(Fig. 3 & Tab. 2)* in individuals with chronic iSCI
- Suggesting potential for higher training intensity during robotic gait therapy.

References

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