COMPARISON OF LOWER EXTREMITY ELECTROMYOGRAPHIC DEMANDS DURING ICARE TRAINING AND WALKING

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Introduction

Physical activity is essential for improving function, yet many face barriers to maintaining active lifestyles due to muscle weakness. Resources used during formal rehabilitation (e.g., robotic therapy) are rarely available following discharge. Over the past two years, our team developed **ICARE**, an **I**ntelligently **C**ontrolled **A**ssistive **R**ehabilitation **E**lliptical trainer, a motor-driven adapted elliptical that assists leg movement when needed.[1,2] Similarities of kinematic and electromyographic (EMG) patterns between walking and elliptical training[3] suggest that ICARE training could help individuals regain strength and endurance in key muscles required for walking, particularly if motor assistance could be customized to the individual needs of those with weakness.

Purpose

To compare muscle demands while training at three levels of ICARE assistance/resistance and walking.

Methods

Participants

Nine individuals without known pathology and five with varying medical conditions (diabetes, traumatic brain injury, total knee arthroplasty, transfemoral amputation, and hip fracture) participated.

	Age (y)	Height (m)	Mass (kg)
No Disability	47 (21)	1.74 (0.11)	74 (14)
With Disability	48 (17)	1.78 (0.11)	80 (16)

Instrumentation
- ICARE Trainer
  - Base model (SportsArt E870)
- Qualisys Motion Analysis System
  - 12 Oqus infrared cameras
  - 120 Hz
- Electromyography (Delsys, Bagnoli 16)
  - Surface EMG electrodes
  - 1200 Hz
- Foot-Floor Contact Patterns (B&L Engineering)
  - Bilateral compression-closing footswitches
  - 1200 Hz

Procedures
Participants walked (W) and ICARE trained at 3 levels of motor assistance/resistance:
- Active Assist (AA)
- Active Assist Plus (AAP)
- Resistive (R)

Data Analysis
- EMG normalized to each muscle's maximal voluntary contraction.
- Peak and mean EMG expressed as percentage of maximal voluntary contraction (% MVC).
- Duration expressed as percentage of movement cycle (% MC).
- Foot pedal kinematics and footswitches determined cycle timing for ICARE and walking, respectively.

Statistical Analysis
Separate 4 x 1 ANOVAs with repeated measures identified significant differences in EMG activation (peak, mean, duration) across conditions.

Results
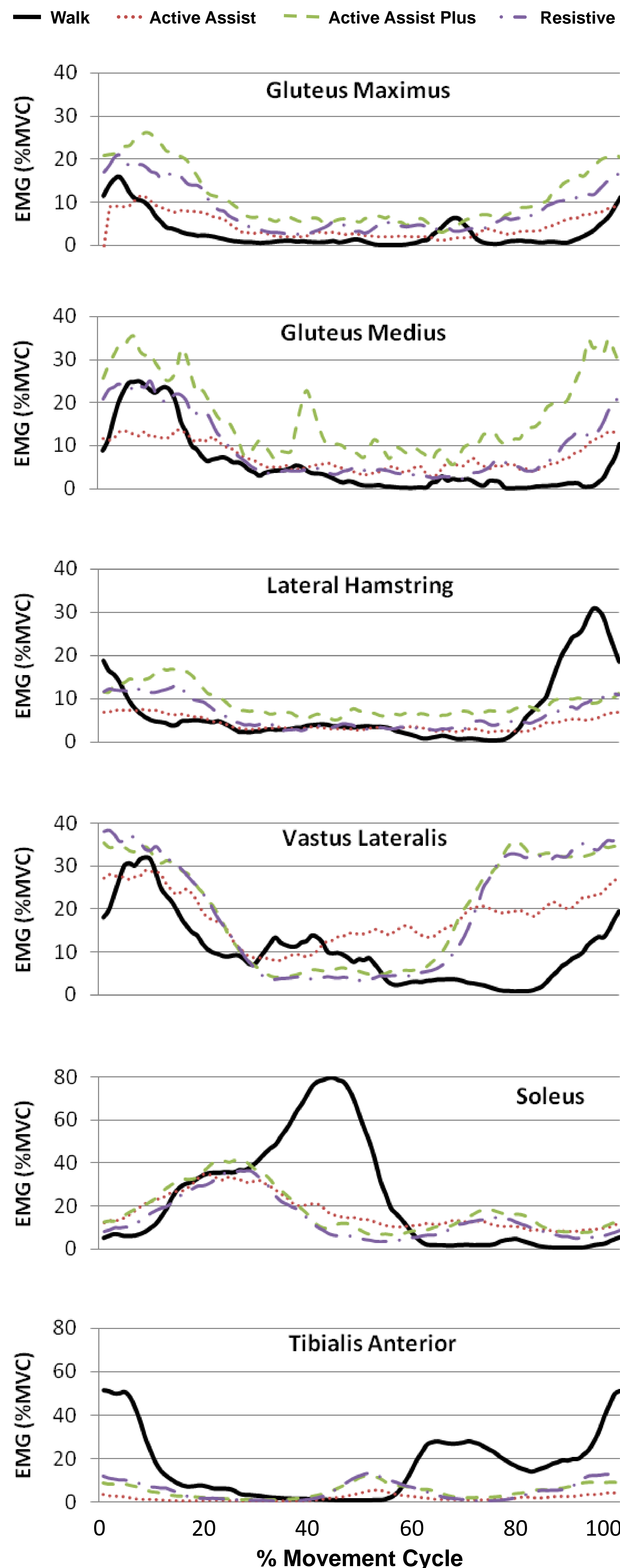
Figure 1: Ensemble averaged (mean) electromyographic plots of six leg muscles while walking and ICARE training (n = 14).

Results (Continued)

		NW	AA	AA+	R	Significance (P – value)
Gluteus Maximus	Peak	23	21	33	31	NS
	Mean	11	9	15	13	NS
	Duration	12	25	37	34	AA+, R > NW (p = 0.002)
Gluteus Medius	Peak	26	18	40	33	AA+ > AA (p = 0.034)
	Mean	13	7	14	14	AA+, R > AA (p = 0.019)
	Duration	18	31	46	36	AA+ > NW (p = 0.013)
Lateral Hamstring	Peak	41	15	33	27	NW > AA (p = 0.006)
	Mean	17	6	13	11	NW > AA+, R, AA (p = 0.003)
	Duration	26	24	38	31	NS
Vastus Lateralis	Peak	34	37	48	52	R > NW (p = 0.022)
	Mean	15	15	22	24	R > NW, AA AA+ > AA (p < 0.001)
	Duration	32	70	72	67	AA, AA+ > NW (p = 0.002)
Soleus	Peak	92	49	59	51	NW > R, AA+ (p = 0.002)
	Mean	41	20	24	20	NW > AA+, AA, R (p < 0.001)
	Duration	51	65	67	55	NS
Tibialis Anterior	Peak	66	12	25	31	NW > AA+, AA (p < 0.001)
	Mean	26	6	11	15	NW > R, AA+, AA R > AA (p < 0.001)
	Duration	57	11	28	27	NW > AA (p = 0.001)

Table 1. Peak, mean (expressed as % MVC) and duration (expressed as % movement cycle) electromyography activity recorded during walking and ICARE training (n=14)

Key: AA = Active Assist, AA+ = Active Assist Plus, R = Resistive, NW = Walk, NS = Not Significant

Discussion & Conclusions

The variability documented in muscle demands across ICARE training conditions could be used to facilitate increases in strength and endurance in clients with lower extremity weakness. Further work is underway to identify the impact of training speed and partial body weight support on lower extremity muscle demands during ICARE training.

References

1. Burnfield JM et al. (2010). *RESNA 2010 Annual Conference.*
2. Shu Y et al. (2010). *RESNA 2010 Annual Conference.*
3. Burnfield JM et al. (2010). *Phys 1. Ther. 90(2): 289-305.*

Acknowledgements