COMPARISON OF LOWER EXTREMITY ELECTROMYOGRAPHIC (EMG) DEMANDS DURING ICARE TRAINING AND WALKING

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INTRODUCTION

Physical activity is essential to improve function, yet many individuals face barriers to maintaining an active lifestyle due to muscle weakness. Resources used during formal rehabilitation (e.g., robotic therapy) are rarely available in the community. Over the past two years, our team addressed the need for an affordable, accessible tool to help individuals with physical disabilities improve walking and cardiovascular fitness by developing **ICARE**, an **I**ntelligently **C**ontrolled **A**ssistive **R**ehabilitation **E**lliptical trainer and therapeutic program. ICARE includes an intelligently controlled motor to assist leg movements.[1,2] Similarities of kinematic and electromyographic (EMG) patterns between walking and elliptical training[3] suggest that ICARE training also could help individuals regain or retain flexibility and strength required for walking, particularly if the muscle demands could be customized to those with weakness. The current study compared muscle demands across three levels of ICARE motor assistance and while walking. We hypothesized that the Active Assist ICARE mode would reduce muscle demands compared to other activities.

METHODS

Nine individuals without known pathology (mean age, 47 years) and five with varying medical conditions (diabetes, traumatic brain injury, total knee arthroplasty, transfemoral amputation, and hip fracture; mean age 48 years) participated. All ambulated independently. Surface EMG quantified muscle demands of gluteus maximus (**GMax**), gluteus medius (**GMed**), lateral hamstring (**LH**), vastus lateralis (**VL**), soleus (**SOL**) and tibialis anterior (**TA**) across ICARE and walking (**W**) conditions. Simultaneous 12-camera motion analysis and footswitches determined cycle timing for ICARE and walking, respectively. Participants walked at a self-selected speed across a 6-m walkway and then ICARE trained using three levels of motor assistance at similar self-selected speeds: 1) *Active Assist* (**AA**; motor provided adequate force to help client's legs move at self-selected speed); 2) *Active Assist Plus* (**AAP**; motor disengaged whenever client's speed exceeded motor's threshold speed; clients exerted effort at level that maintained elliptical training speed ~2 RPM higher than targeted speed); and 3) *Resistive* (**R**; motor not engaged and not assisting). EMG data were normalized to each muscle's maximal voluntary contraction and expressed as a percentage of maximal voluntary contraction (% MVC).

STATISTICAL ANALYSIS

Separate 4 x 1 ANOVAs with repeated measures identified significant differences in peak and mean amplitude of EMG activation across conditions.

RESULTS AND DISCUSSION

Electromyographic profiles for each muscle are presented in Figure 1. At the hip, **GMax** and **GMed** activation patterns during walking and ICARE training demonstrated notable similarities with the greatest activity occurring in early stance. Peak and mean **GMed** demands diminished in the AA mode compared to AAP (Table 1). Mean **GMed** demands also decreased during AA compared to R. Peak activity of **LH** diminished during AA training compared to walking, while mean **LH** activity reduced during all ICARE modes compared to walking. At the knee, peak and mean **VL** demands were lower during walking compared to R training. Use of the AA mode reduced mean **VL** demands compared to the other two ICARE training modes. At the ankle, the **SOL** demonstrated a similar gradual increase in activity during the first portion of the ICARE movement cycle to that documented during walking, except the maxima occurred earlier. Peak **SOL** activity during W exceeded AA and R levels, and mean W activity also exceeded AAP. Peak and mean **TA** activity were greater during walking than AA and AAP. While mean R was less than walking, it exceeded demands during AA.

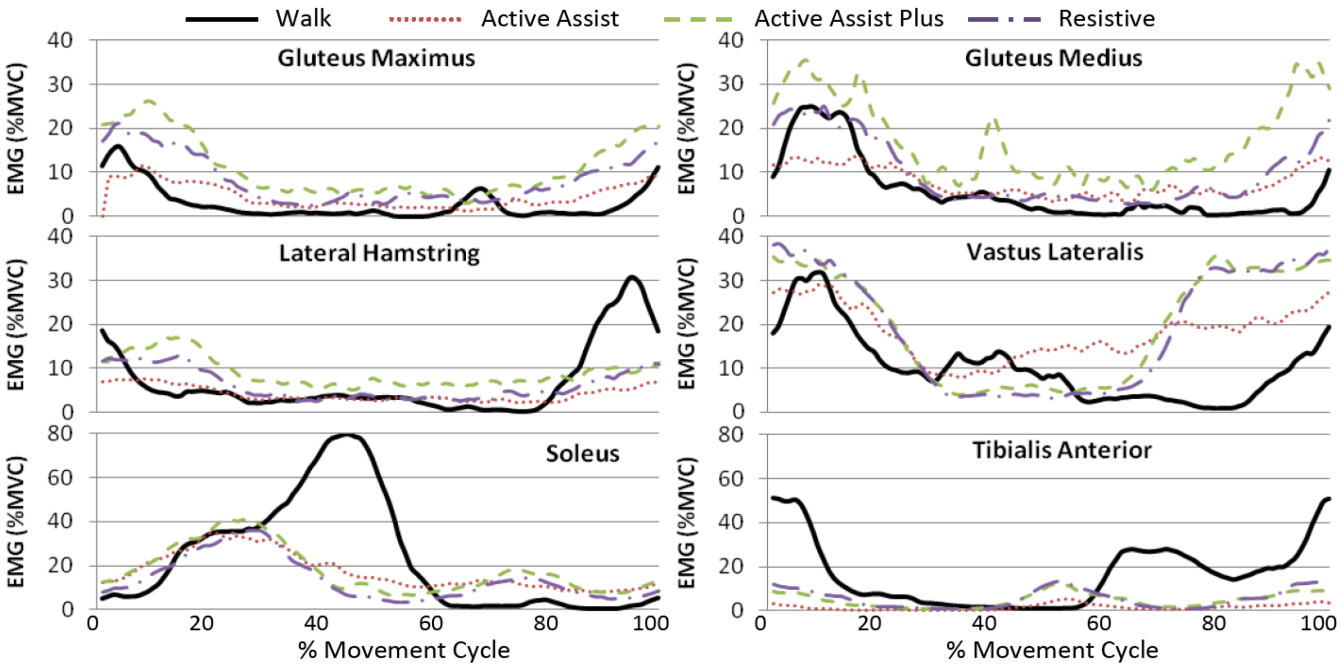

Figure 1. Ensemble averaged (mean) electromyographic (% MVC) plots of select muscles while walking and ICARE training (N=14).

CONCLUSIONS

Individuals with weakness often confront challenges with exercising due to a lack of equipment that appropriately accommodates to the needs of the compromised muscles. Consistent with our initial hypothesis, exercising in the Active Assist ICARE mode decreased muscle demands in 9 of 12 comparisons. Only **GMAX** (peak and mean) and **VL** (peak) demands failed to register significant reductions in amplitude during AA training. The current study's findings suggest that the addition of an intelligent motor system did broaden the range of muscle demands that could be accommodated during ICARE training. Our current research is evaluating practical use of the ICARE trainer during inpatient and outpatient rehabilitation and at a fitness facility.

REFERENCES

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ACKNOWLEDGEMENTS

This work was supported in part by a grant from the Department of Education NIDRR grant number H133G070209.

Table 1. Peak and mean electromyography activity (expressed as % MVC) recorded during walking and ICARE training (n=14)
Key: AA = Active Assist, AAP = Active Assist Plus, R = Resistive, W = Walk

		Walk	Active Assist	Active Assist Plus	Resistive	P values	Main Effect
Gluteus Maximus	Peak	23(24)	21(23)	33(30)	31(23)	0.046	No Significant Difference
	Mean	11(11)	9(9)	15(13)	13(10)	0.069	No Significant Difference
Gluteus Medius	Peak	26(22)	18(18)	40(31)	33(24)	0.034	AA<AAP
	Mean	13(10)	7(6)	14(8)	14(8)	0.019	AA<R,AAP
Lateral Hamstring	Peak	41(26)	15(20)	33(36)	27(26)	0.006	AA<W
	Mean	17(10)	6(8)	13(13)	11(9)	0.003	AA,R,AAP<W
Vastus Lateralis	Peak	34(26)	37(22)	48(19)	52(16)	0.022	W<R
	Mean	15(10)	15(8)	22(9)	24(7)	<0.001	AA<AAP,R; W<R
Soleus	Peak	92(21)	49(25)	59(29)	51(26)	0.002	AA,R<W
	Mean	41(12)	20(10)	24(13)	20(11)	<0.001	R,AA,AAP<W
Tibialis Anterior	Peak	66(26)	12(13)	25(21)	31(26)	<0.001	AA,AAP<W
	Mean	26(11)	6(6)	11(8)	15(13)	<0.001	AA<R,W; AAP,R<W