Metabolic Cost Changes with the Amount of Prosthetic Ankle Power Provided

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INTRODUCTION

- Ankle plantarflexors produce a majority of the mechanical power for normal gait, while elastic prostheses only produce $^1/_8$ this power[1]
- People with transtibial amputation have a higher metabolic cost during walking[2]
- Active ankle prostheses reduce metabolic cost[3]
- Does matching ankle prosthesis power to that of a healthy control population optimize metabolic performance?

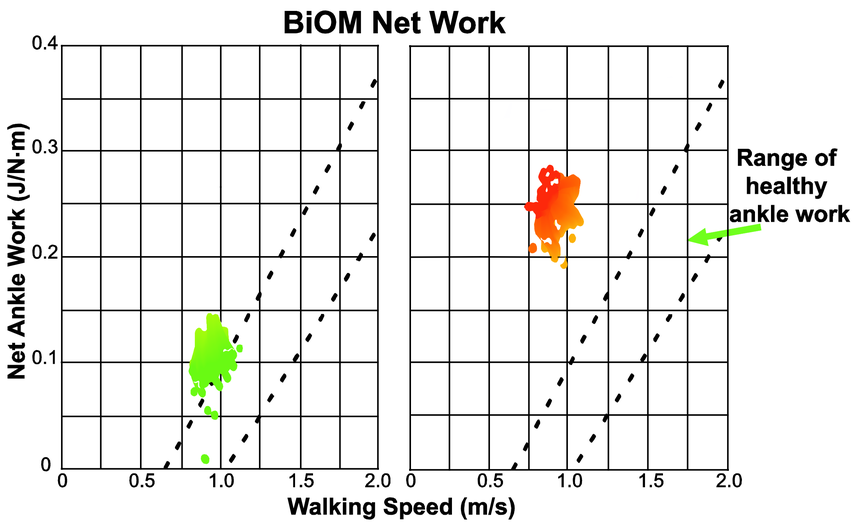

Figure 1. *Example of tuning graph of BiOM with different power settings*

Purpose

Determine how incremental adjustments in prosthetic ankle power affect the metabolic cost of walking

METHODS

- 4 people with unilateral traumatic transtibial amputation (K-3+)
- All participants currently use unpowered prostheses
- Fitted with a powered-ankle prosthesis (BiOM, Bedford, MA) by a certified prosthetist and given 30 minutes to acclimate

Table 1. *Subject demographics*

Subject	Age (yr)	BMI (kg/m^2)	Time since Amputation (yr)
S01	59	28.9	44
S02	24	26.8	15
S03	26	22.5	4
S04	60	36.6	2

Data Collection

- Energy expenditure measured (Cosmed K4b^2, Pensacola, FL) during treadmill walking at 6 ankle power settings: 0%, 25%, prosthetist-chosen (PC), 50%, 75%, and 100% power
- Cost of transport (COT) determined from energy expenditure[3] and treadmill speed

$$COT = \frac{Energy\ Expenditure(W)}{Speed\ \left(\frac{m}{s}\right) \times Mass(kg) \times 9.81\left(\frac{m}{s^2}\right)}$$

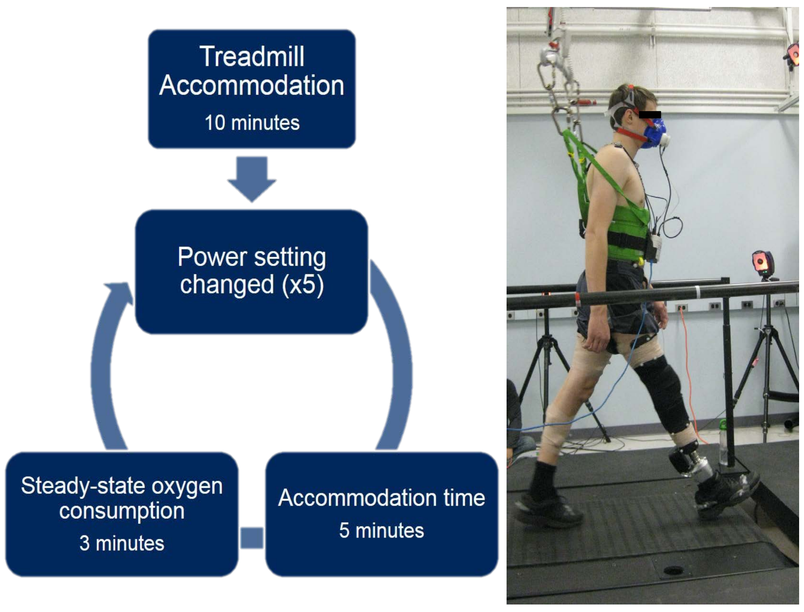

Figure 2. *Collection timeline and depiction of subject set-up*

Reliability Testing

- 15 healthy young subjects
- Steady-state COT measured during 3 trials of walking on 2 separate days
- Within-day and between-day reliability of COT was calculated with a 2-way random model of intraclass coefficient (ICC)[4]
- Minimal detectable change values (MDCs) for within- and between-day were calculated using the standard error and ICCs

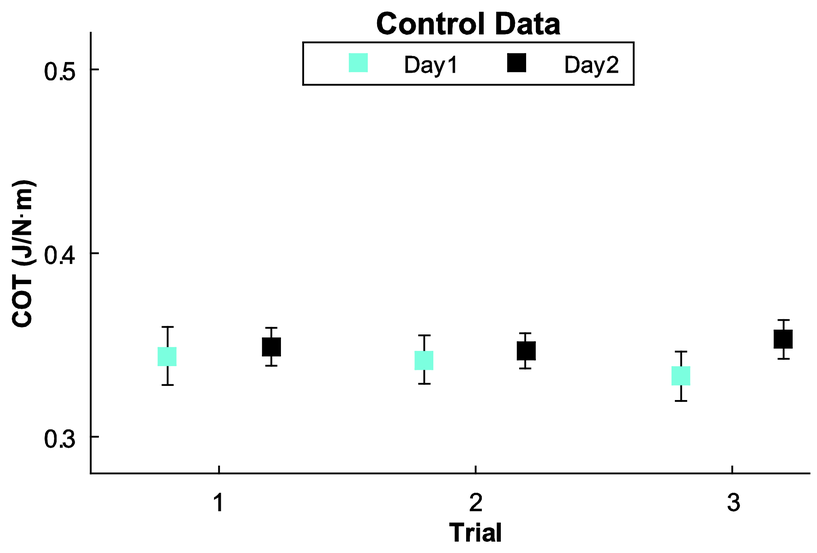

Figure 3. *Average (±SD) COT for healthy subjects over two days over three sessions of walking*

- The **within day** ICC for COT was 0.983, and the MDC was **0.016 J/N.m**
- The **between-day** ICC for COT was 0.878, and the MDC was **0.055 J/N.m**

Statistical Analysis

- COT compared using single-factor (Power) within-subjects ANOVA
- Mean differences in COT for each power setting were compared to the MDC values obtained from reliability testing to determine clinical significance

RESULTS

- There was a significant main effect of power on COT ($p \leq 0.001$)
- 100% power markedly decreased COT when compared to every power setting except 75% (COT difference ≤ 0.001)
- 25% power increased COT when compared to every power setting

Table 2. *Mean difference in COT between 0% power and other power settings. Positive values indicate a decreased COT*

Power (%)	Mean Difference (J/N.m)
25	**-0.028**
50	-0.005
PC	0.009
75	**0.029**
100	**0.028**

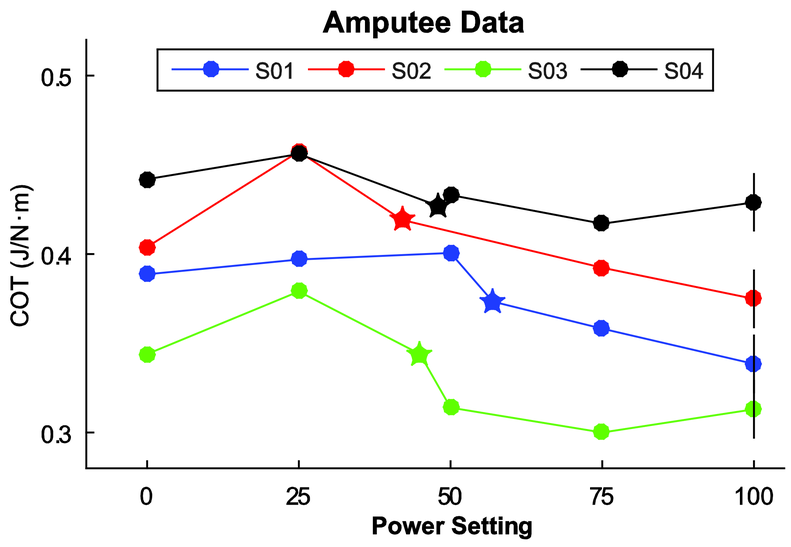

Figure 4. *COT for 3 minutes of steady state walking with a solid line representing ± MDC (0.017 J/N.m) on 100% power and a star representing PC power*

DISCUSSION

- Increasing power supplied by the prosthetic beyond PC power yielded decreases in COT greater than the MDC
- Higher ankle work of the prosthesis may be necessary to compensate for inefficient power delivery
- Prosthesis power may be accommodating for muscular compensations at the residual limb[6] as well as loss of plantarflexors

CONCLUSIONS

- Increased power delivered by the ankle prosthesis was sufficient to reduce COT by measureable amounts
- Examination of these parameters with a larger sample size, as well as studying changes in muscular activity will further clarify the mechanisms of these metabolic cost savings

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ACKNOWLEDGMENTS

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