The effects of prosthesis mass on metabolic cost of ambulation in non-vascular trans-tibial amputees

R S. Gailey, M.S. Nash, T.A. Atchley, R.M. Zilmer, G.R. Moline-Little, N. Morris-Cresswell and L.I. Siebert
Division of Physical Therapy, Department of Orthopaedics and Rehabilitation,University of Miami School of Medicine, Florida, USA

Abstract
The effect of prosthesis mass on the metabolic cost of steady-state walking was studied in ten male non-vascular trans-tibial amputees (TTAs) and ten non-amputee controls. The subjects underwent four trials of treadmill ambulation, with each trial performed for nine minutes at level grade and 76 m/min. Twenty minutes of seated rest followed each trial. During trials numbers one and two, TTAs ambulated without mass added to their prosthesis. During the third and fourth trials, either 454 or 907 grammes mass (1 or 21bs mass respectively) were randomly assigned and added to either the prosthesis or the leg of the non-amputee control. Subjects were blinded to the amount of mass added to their limb. Within-group comparisons across the four trials showed significant differences in oxygen consumption (VO2) and heart rate (HR) between the two non "mass added" trials, but no effect for addition of mass. The V O 2 of TTAs was only 0.6ml/kg/min (4.7 percent) greater during walking following the addition of 907 grammes to the prosthesis than without mass addition at all, while HR averaged only 1.4 beats/min. higher under the same testing condition. Pearson-product moment correlations echoed these findings, as moderate, but in all cases, negative correlations were observed for associations among the factors of subject age, stump length, and prosthesis-shoe weight, and both VO2 and HR. It was concluded that adding up to 907 grammes mass to a non-vascular TTA's prosthesis will not significantly increase the energy expenditure or HR at a normal walking speed, and that elevated energy cost of ambulation in repeated measures testing without mass added may reflect task familiarisation and not an added burden of prosthesis mass.

Conclusion
In conclusion, the addition of up to 907g of mass to the prostheses of non-vascular transtibial amputees does not alter the energy cost of ambulation at steady-state pace. Differences between unloaded trials result from habituation to the testing conditions. These findings suggest that prosthetists can design limbs using heavier components without significant increasing the amount of energy necessary to ambulate. The inclusion of components such as rotators, ankle joints, shock absorbers or more durable covers including exoskeletal designed limbs may allow traumatic trans-tibial amputees to improve their gait and function without compromising the energy cost of ambulation.

Group	Means	Trial 1 (0g)	Trial 2 (0g)	Trial 3 (454g)	Trial 4 (907g)
Amputee group (n=10)	VO_2 (ml/kg/min)	13.7±2.3	12.8±2.1	13.1±2.5	13.4±2.6
	HR (bpm)	108.5±17.8	105.4±17.7	105.8±17.7	106.8±18.8
Control group (n=10)	VO_2 (ml/kg/min)	11.4±1.2	11.2±1.2	11.8±1.3	11.7±1.0
	HR (bpm)	80.6±9.3	80.6±9.3	81.1±9.1	81.4±9.2

Table 4. Amputee and control group VO2 and HR means.

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