Do Prosthetic Running Feet Give Transtibial Amputee Runners an Unfair Advantage Compared to Non-amputee Runners?

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INTRODUCTION

Increased energy costs of ~ 5-33% during walking are reported for transtibial amputees (TTA) (Hsu, 2000; Ganguli, 1973). However, few studies have reported energy costs for TTA during running (Brown, 2009). Recently there has been controversy that running-specific energy storing and return (ESAR) "blade" prosthetic feet, provide amputee runners an unfair biomechanical and energy expenditure advantage. Although scientific evidence is scarce, Brown (2009) reported that TTA using running-specific ESAR feet had similar energy costs and obtained similar peak running speeds as non-amputees. The purpose of this study was to a.) Compare energy costs of walking & running for TTA runners using traditional & ESAR prosthetic feet to matched non-amputee runners; b.) Clarify potential performance benefits of ESAR prosthetic feet.

METHOD

Subjects: 3 male, unilateral, TTA runners; 3 male, non-amputee runners matched by age, physical characteristics & physical activity levels. Each TTA subject tested with 3 prosthetic feet conditions: 1. Solid Ankle Cushioned Heel (SACH) – Traditional prosthetic foot; 2. Renegade™ (Freedom Innovations) - general purpose ESAR foot; 3. Nitro™ (Freedom Innovations) - run-specific ESAR foot. Order of testing randomized & balanced.

Measurements: Oxygen Uptake (VO_2): Continuous breath-by-breath gas exchange analysis. Heart Rate: Continuous 12-lead electrocardiography (ECG). Rating of Perceived Exertion (RPE) each min. For TTA, body weight & composition measurements were determined without prosthesis.

Procedures: Continuous treadmill walking & running: 2 min increments; Start @ 40.2 $m*min^{-1}$; Increased speed each increment by 13.4 $m*min^{-1}$; Test stopped by subject at maximal effort; Included self-selected walking & running speeds.

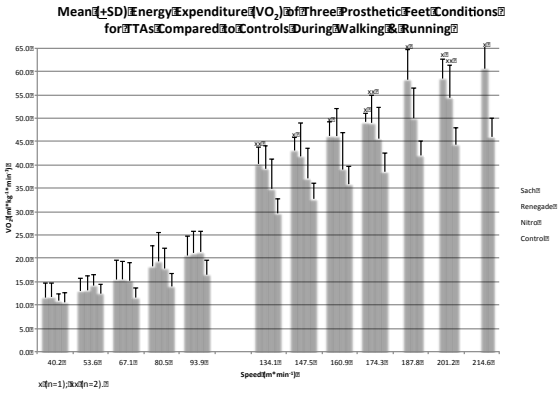
Data Analysis: Paired *t*-tests were used to compare physical characteristics & peak performance between TTA and non-amputees. A mixed model ANOVA was used for a comparison of prosthetic feet and to compare TTA to non-amputees at each speed. Statistical significance was set at $p \leq 0.05$.

RESULTS

TTA and non-amputee subjects were closely matched in physical characteristics (except body weight) and had similar VO_2peak values. Peak running speed of TTA was slower than non-amputees.

	TTA	Control
Age (yr)	35.3 ± 10	35.3 ± 9.0
Height (cm)	174.6 ± 10.6	175.5 ± 10.2
Weight (kg)	68.6 ± 9.9*	79.4 ± 8.2
% Fat	18.7 ± 6.6	17.2 ± 4.8
VO_2peak	51.6 ± 7.8	50.7 ± 9.3
Peak Speed ($m*min^{-1}$)	201.2 ± 13.4*	232.5 ± 15.5
Peak Grade (%)	0.0 ± 0.0	2.0 ± 2.0

*p ≤ 0.05



DISCUSSION

Walking: Data indicates small differences in energy costs between prosthetic feet. Energy expenditure was greater (4-38%) for TTA than non-amputees and dependent on the type of foot and speed.

Running: Difficult to run with SACH foot; Fastest running obtained with Nitro™ foot; Energy expenditure greater (9-38%) for TTA than non-amputees; Energy costs less with Nitro™ compared to SACH & Renegade™ feet. However, we observed energy costs for TTA using the Nitro™ foot were greater & peak running speed slower than non-amputees.

CONCLUSION

Energy costs of walking and running are increased for unilateral TTA runners compared to non-amputee runners. Run-specific ESAR feet do not provide unilateral TTA runners an unfair energy expenditure advantage compared to non-amputee runners.

CLINICAL APPLICATIONS

For TTA clients interested in running the most energy efficient foot, is a run-specific ESAR foot.

REFERENCES

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