In-vivo performance of a Fiberglass Dynamic Elastic Response Feet

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INTRODUCTION

Dynamic elastic response (DER) feet are designed to store and release energy during gait. However, there is little scientific evidence to guide the clinical prescription of DER feet (Hofstad, 2004). Prosthetic guidelines are currently based on clinical consensus among experts (van der Linde, 2004). Comprehensive studies are needed to form a solid basis for prosthetic prescription.

Recently, a new type of DER foot appeared on the market, which is composed of a fiberglass composite material. Therefore, the purpose of this study was to compare the functional performance of individuals with transtibial amputation using two types of prosthetic foot designs: carbon fiber vs. fiberglass.

METHOD

Study Design: The study used a cross-over design. Half of the subjects started on the fiberglass foot (FF) while the others starting on a carbon fiber foot (CF).
Subjects: 10 male subjects with a unilateral transtibial amputation (age: 49+9 years, BMI: 29+7 kg/m^2, 10.4+9.8 years of prosthesis use, K-Level III) were studied after giving informed consent.
Prosthetic Feet: The FF was an Ability Dynamics Rush foot. The CF studied were Otto Bock Triton, Ossur Variflex, Ossur Variflex EVO, Ossur Reflex Shock, Freedom Renegade, Freedom Pacifica, Freedom Thrive with Vertical Shock, Freedom Highlander, and Freedom Agilix.
Procedures: Gait analysis was performed using a 10 camera system (Motion Analysis, Santa Rosa, CA) and 6 force plates (Kistler, AMTI, Bertec). Data was collected over level ground at self-selected and normalized speed controlling for leg length (Froude=0.25) as well as ascending and descending a 10 degree ramp. Patient satisfaction was assessed with the Prosthesis Evaluation Questionnaire (PEQ), a reliable and valid tool (Legro, 1998).
Data Analysis: A multivariate approach was used to compare all conditions (gait data) or subscales (PEQ) simultaneously using a single factor repeated measures ANOVA. Statistical significance was set at p=0.05.

RESULTS

The subjects exhibited increased ankle dorsiflexion ($p<0.01$), similar ankle moments (p=0.07) and increased ankle power generation (p=0.01) when using the fiberglass composite foot (Fig 1). The increased power generation did not affect peak knee flexion ($p>0.19$). The subjects expressed greater satisfaction with the fiberglass composite foot (p=0.02).

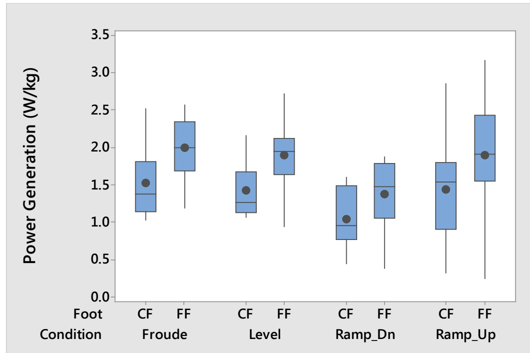

Figure 1. Box plot of ankle power generation during gait for four ground conditions. CF=carbon fiber foot. FF=fiberglass foot. The central line represents the median, the dot represent the mean, the edges of the box are the 25th and 75th percentiles, and the whiskers extend to ±1.5 of the interquartile range. The fiberglass foot (FF) generated significantly more power than the carbon fiber foot (CF) for all walking conditions.

DISCUSSION

Ankle muscles generate and absorb mechanical energy necessary to create movement. The single variable that summarizes that role of the ankle plantarflexors is mechanical power, which is the product of the joint moment of force and joint angular velocity. This study showed that walking with a fiberglass composite foot resulted in a 31% increase in power production (1.79 W/kg with FF vs 1.36 W/kg for CF). However, the power is still 50% lower than that produced by an intact limb (3.4 W/kg) (Winter, 1983). Nonetheless, the subjects reported greater satisfaction when using the fiberglass composite foot as measured by the PEQ. The PEQ is composed of nine validated scales. All scales were improved when using the fiberglass foot, with significant increases reported for appearance and utility.

CONCLUSION

The prosthetic foot made from the fiberglass composite material returned more energy while walking. As a result, the subjects reported they were more satisfied with this foot.

CLINICAL APPLICATIONS

The fiberglass composite foot makes it easier to walk. This will mean that the patient can walk further on a daily basis without fatigue.

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