Orthotics and Prosthetics

Development of Quantitative Algorithms for Improved Prosthesis Prescription

There are currently no science-based, objective methods for optimizing running-specific prosthesis prescription. Existing practices can waste time, money, and resources and do not necessarily provide the best prosthetic prescription. Due to the severity of impairment caused by a leg amputation resulting from blast injuries or otherwise and the healthcare costs sustained over the lifetime of a person with an amputation, it is extremely important to improve running-specific prosthesis (RSP) prescription so that Service members and Veterans with amputations can regain the greatest possible level of functional ability and return to active duty, if they choose. Researchers at the University of Delaware (Newark, Delaware), Veterans Affairs Eastern Colorado Healthcare System (Denver, Colorado), and the University of Colorado Boulder (Boulder, Colorado), conducted a study to develop tools for clinicians to prescribe running-specific leg prostheses that facilitate optimal function for Service members and Veterans with transtibial amputations.

The researchers systematically varied the stiffness and height of distance-running RSPs and measured the biomechanical and metabolic effects of running at the speed required for a subject's age/sex 50th percentile Physical Fitness Test two mile run and at one standardized speed (three meters per second) (*Beck, Taboga, and Grabowski 2017*). They also systematically varied the stiffness and height of sprint-running RSPs and measured the biomechanical and performance effects of running across a range of speeds. These tests were performed with 30 human subject participants with transtibial amputations (*Beck, Taboga, and Grabowski 2016*).

By combining results from distance-running and sprint-running prostheses, the researchers determined that prosthetic stiffness varies with the magnitude of applied force (*Beck, Taboga, and Grabowski 2017*). They also found that manufacturer recommended prosthetic stiffness varies between models and the height of J-shaped RSPs is inversely related to the stiffness (Figure 1).

Additional analysis is ongoing to develop clinically relevant, quantitative algorithms for prosthetic stiffness and height prescription based on a subject's weight, amputation level, limb segment lengths, and desired running speed.

Optimizing RSP prescription for Service members and Veterans with transtibial amputations will improve and expedite rehabilitation; save time, money, and resources; facilitate aerobic conditioning, reduce injury risk, and improve performance.

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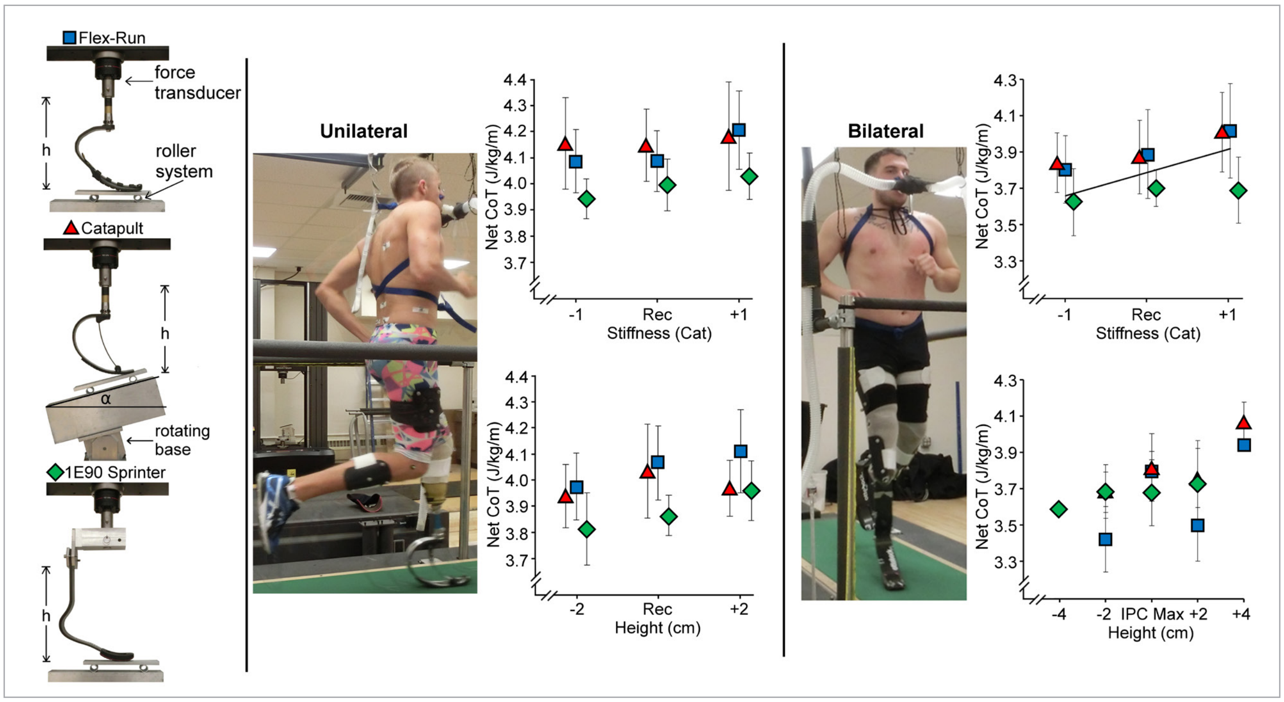

FIGURE 1: The prosthetic stiffness of three different running-specific prostheses was measured using a materials testing machine. From top to bottom, Össur Flex-Run (blue square), Freedom Innovations Catapult FX6 (red triangle), and Ottobock 1E90 Sprinter (green diamond) RSPs. Then, each prosthetic model was used in a study to determine the optimal prosthetic configuration. Middle Column: Average net cost of transport (CoT) from 10 athletes with unilateral transtibial amputations using each of the prosthetic models at different stiffness categories (Cat) (top graph) and heights (bottom graph). "Rec" is the manufacturer and prosthetist recommended stiffness Cat and height. Net CoT is the metabolic power per unit distance subtracting the cost of standing. Right Column: Average net CoT from five athletes with bilateral transtibial amputations using each of the prosthetic models at different stiffness Cats (top graph) and heights (bottom graph). "IPC max" is the maximum height that each athlete with bilateral transtibial amputations could use to compete in International Paralympic Committee sanctioned events in 2016. Error bars indicate standard error. Neither prosthetic stiffness ($p=0.180$) nor height ($p=0.062$) affected net CoT for athletes with unilateral transtibial amputations. Reduced prosthetic stiffness decreased (improved) net CoT ($p<0.001$), such that for 1 stiffness Cat reduction, net CoT was 3.7 percent lower for athletes with bilateral transtibial amputations. Prosthetic height did not affect net CoT for athletes with bilateral transtibial amputations ($p=0.089$). (Figure used with permission from the authors)

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