RADIUS OF GYRATION AS POSSIBLE PARAMETER FOR ADJUSTING STIFFNESS OF PROSTHETIC FEET

S.F.E. Praet[1], L. Peeraer[2], D. deClercq[3], R-J. Willems[4]

[1]*Dept. Orthopaedic Surgery/SportMedicine, St. Joseph Hospital Veldhoven, Netherlands;*
[2]*Fac. Physical Education & Physio Therapy, KU Leuven, University Hospital, Belgium;*
[3]*Dept. Biomechanics, State University Ghent, Belgium;*
[4]*Fac. Physical Therapy, Polytechnic of Utrecht, The Netherlands*

Outdoor and indoor sports such as skiing, jogging, athletics, tennis and basketball have become better accessible for amputees. This can be attributed to the improvement of prosthetic design and rehabilitation programs. Today prosthetic feet used by below knee amputees are so called energy-storing prosthetic feet (ESPF). Stiffness determines the foot deformation during load bearing and may be important for energy storing and release during the progress of weight bearing [1]. Therefore it will have a strong effect on e.g. walking or running performance both in paralympics and daily life. However, choosing and tuning a foot prosthesis depends highly on the skills and experience of the Certified Prosthesist Orthotists (CPO). The purpose of this study was to find an appropriate and objective parameter for adjusting the stiffness of a prosthetic foot.

Two below knee amputees fitted with three Masterstep® and three Modular III® prosthetic feet (each adjusted to a different stiffness) were tested in a random order during unshod walking and unshod running over a 15 m walkway with build in force plates and pressure plates. Tuning of the feet was done by a CPO. Stiffness A: normal tuning, B: stiff tuning, and C: soft tuning. Using a new method described by Nevin and Wilssens (2000) a single set of axes, so called principle axes, were calculated for each condition.[2] With this method also the Radius of Gyration was calculated using the formula:
$r_{og} = \sqrt{(I_{max} + I_{min})} / \int dF/dP$.

Figure 1 is an example of the Radius of Gyration curve for three stiffness setting in the Masterstep foot prostheses. Analysis of the Center of pressure (COP) revealed that a progression stop (wobble) was the only timing-parameters which differentiated between the different stiffness levels of the Masterstep prosthetic foot. Moreover, during walking and running the COP-progression stop (wobble) corresponds with a temporary stop of the calculated radius of gyration. The RoG curves of the Modular III prosthesis showed quite a different but consistent pattern between the three stiffness setting. Here the stiffness correlated with the steepness of the RoG curve after the heel came of the ground. No clear stop in COP or wobble was seen in this type of foot.

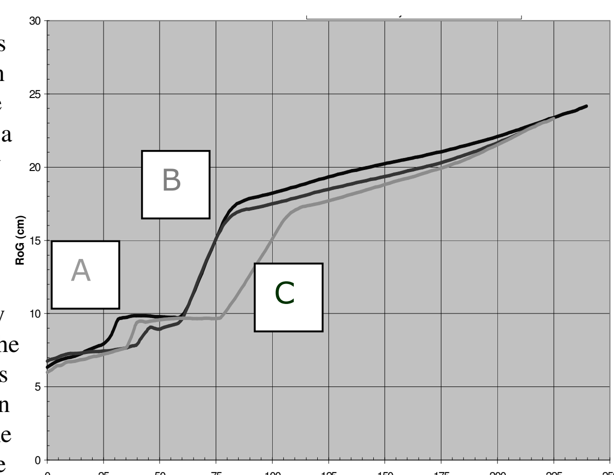

Fig 1: Radius of Gyration of subject X running with Masterstep Prosthesis at stiffness B, A and C.

Combining the curves of radius of gyration with the curves of center of pressure (COP) velocity makes it possible to look objectively at the behavior of the prosthetic foot. This could be used as a tool to tune prosthetic feet, especially in highly dynamic sitations such as running.

In this study the specific property tested is stiffness. Other indications for this type of analysis are hysteresis or energy storage and release.

REFERENCES
[1] Van Jaarsveld HW et al. Prosthet Orthot Int 1990;14:117-24.
[2] Nevin C and Wilssens J.P. J Eur. Patent Application 00200568.4; 2000.