Biomechanical Investigation of Currently Available Microprocessor Controlled Prosthetic Feet: First Results

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Introduction

Since the introduction of microprocessor controlled knee joints in the nineties their market share has constantly increased. Advantages such as the functional range and the safety have been proven repeatedly. These knee joints are accepted by users and technicians and have become an indispensable part of today's prosthetic treatment options of the lower limb. Considering, however, the development of electronically controlled prosthetic feet, acceptance and use is significantly lower. The study investigates the performance of microprocessor controlled prosthetic feet currently available on the market. The feet are compared with each other and with the conventional everyday feet of the subjects as well.

Methods

Five microprocessor controlled prosthetic feet and the everyday feet (all of them carbon spring feet, different models) of the subjects are tested. The prosthetic alignment is standardized and documented. The study is performed with 10 subjects (5 transfemoral, 5 transtibial). The focus is on everyday situations such like level walking at different walking velocities, walking on ramps, on stairs, on changing terrain, walking with small steps, walking with different heel heights, walking backwards and stepping on objects. In addition swaying is measured during standing on 10° inclines. For the measurements a stationary gait analysis system with 12 Vicon Bonita cameras and 2 Kistler force plates is used. All tests are documented by video. Finally, the users complete a questionnaire to give their subjective assessment of the tested component.

Results

First results suggest that some features of these microprocessor controlled prosthetic feet such as speed adaptation play a rather secondary role. Considerung the measuring data and the user feedback any clear positive effects cannot be identified. Other characteristics, however, such as ramp adaptation show clear effects and a functional gain. The same applies to the heel height adaptation and to standing on inclined ground. In addition to the individual functional range, the feet basically differ from each other in the real time adaptation to the terrain and in the incremental adaptation whereas the real time adaptation offers clear advantages.

In contrast to the functional gain, disadvantages of these microprocessor controlled prosthetic feet can be identified too. The required electrical power supply and the extra weight compared to conventional prosthetic feet should be mentioned here primarily.

Conclusion

The new generation of prosthetic feet shows a clear functional gain with respect to terrain and heel height adaptation. Dependent on the functional principle, however, the quality and thus the usability of the new functions strongly differ from each other.

Considering the disadvantages - power supply and extra weight - there seems to be considerable potential for optimization by improved energy supply technologies. More serious is the problem of the extra weight. The additional weight is located distally to the prosthesis probably limiting the prosthetic socket system to vacuum systems.

For prosthesis users often moving on changing terrain or often varying their heel height (other shoes, walking barefoot), microprocessor controlled prosthetic feet of high functional quality offer a high potential to make a contribution to an improved prosthetic treatment and to an increased quality of life.