Adapting to change: Influence of a microprocessor-controlled prosthetic knee on gait adaptations.

Individuals with an above-knee amputation have to change the way they walk. This is mainly caused by the fact that prosthetic components, until now, cannot provide a full substitution of the amputated body part. Over the last decades, developments in prosthetic knee design have led to the introduction of microprocessor-controlled prosthetic knees. These prosthetic knees incorporate different sensors such as a knee angle, knee angular velocity, and force sensor. Based on information from the sensors a control algorithm determines the amount of knee damping. It is hypothesized that the variable damping that microprocessor-controlled prosthetic knees offer is beneficial for individuals with an above-knee amputation. With this research we tested this hypothesis. For this, we had two key objectives: study the gait adaptations that are seen in individuals with an amputation and study how the use of a microprocessor-controlled prosthetic knee influences these gait adaptations.

The objective regarding the gait adaptations that are associated with the an above-knee amputation was addressed with two studies. First we performed a systematic review regarding gait adaptations in terms of the amount of energy that is generated or absorbed across joints (joint power and joint work) of both the amputated and intact leg. We found that the gluteus maximus muscle of both legs and the plantar flexors of the intact leg performed more joint work when compared to the leg of an individual without an amputation. This seems to be the consequence of the lack of ankle function of the prosthetic foot and ankle. The second study we performed was the quantification of muscle activity patterns of both muscles of the residual leg and the intact leg during walking. Were there were parallels, the results of this study confirmed our findings of the systematic review. In addition, we found that the majority of muscles in the residual leg became active during the step-to-swing phase transition. This is probably a mechanism to increase socket fit. Finally, we found increased co-activation of the muscles of the lower intact leg. We believe that this is a mechanism to improve ankle joint stability.

Based on the second objective, we performed a randomized cross-over trial in which we included ten participants that currently walked on a non-microprocessor-controlled prosthetic knee. This type of prosthetic knee has more or less fixed damping properties. By measuring them once with their own prosthetic knee and once with the Rheo Knee II (a microprocessor-controlled prosthetic knee) we could study the added value of variable knee damping. We performed biomechanical analysis of several tasks, including walking at different speeds, starting and stopping of gait, and the recovery after evoked balance perturbations. We found a limited influence of the Rheo Knee II on gait adaptations during walking at different speed and the starting and stopping of gait. However, we found that the use of the Rheo Knee II enabled participants to use the strategies that were also used by individuals without an amputation to cope with the balance perturbations. These include, amongst others, a decreased forward placement of the leg which decreases the chance of a backwards fall. This strategy was not seen in the non-microprocessor-controlled prosthetic knee condition. We also studied the effect of the Rheo Knee II on prosthesis-related quality of life, balance confidence and the execution of functional tasks. The effect of the Rheo Knee II on these outcome parameters was limited.

In conclusion we found that the Rheo Knee II had an influence on gait adaptations during the most complex tasks we studied, whereas on tasks with less complexity no differences were found. This might suggest that we need to study complex tasks that have a clear relation with activities of daily living. We suggest that future research could focus on investigating prosthetic technology using ambulant gait analysis in a meaningful context.