Author
Scharr, Sara (None DE)
Orthopädische Universitätsklinik Heidelberg - Bewegungsanalytik

Title
The role of the stump muscles in prosthesis control: a new measurement protocol to investigate stump muscles activity during walking

Coauthors
Leboucher J., Alimusaj M., Heitzmann D. W. W., Wolf S. I.

Summary
Prosthesis control represents a challenging research topic. This study focuses on the role of stump muscle activity, which has not been explored in depth yet. Based on an ultrasound analysis of the stump, electromyography electrodes are integrated in a test socket and 3D gait analysis is conducted.

Introduction
Muscle control is one of the main aspect to be investigated in prosthesis control in persons with transfemoral amputation (TFA). As described by Jaegers et al. (1995), the morphology of the hip muscles of the residual limb changes after amputation: atrophic modifications were reported particularly in bi-articular hip muscles. Structural alterations in stump muscles, such as atrophy and fatty degeneration, were also described by Putz et al. (2017). Regarding the stump muscles activity, a first study conducted by Wentink et al. (2013) showed differences between unimpaired subjects and TFA during gait mainly in the pre-swing phase by applying electromyography (EMG) electrodes in the socket. However, to our knowledge no further literature deals with this topic. For this reason, the aim of this study is to analyze to a greater extent the role of the stump muscles of prosthesis users during walking on different surfaces, such as even ground and ramps.

Methods
The measurement protocol includes two appointments. The first one focuses on the stump muscles analysis: muscles position is defined for each TFA using ultrasound. Afterwards, EMG electrodes are placed on the stump and reflective markers on the pelvis and lower limbs. Participants stand on the preserved leg and selectively contract muscles as well as execute

various movements to confirm electrodes position. 3D motion analysis system (Vicon, UK) and Nexus 2.8 (Vicon, UK) as well as in-house tools are used to record and post-process data. Muscles positions are going to be transferred on a test socket made of transparent PETG Simolux (Simona AG, Germany). During the second appointment conventional 3D gait analysis with EMG of the stump muscles is performed. Snap-on metal electrodes are integrated in the socket and connected to the wireless EMG sensors (Myon, Switzerland) to record muscle activity during walking. At present, the stump muscles analysis was performed on two TFA (see Table1).

Results

Both participants had a medium-length stump with a cylindrical shape. A normal soft tissue coverage as well as no skin abnormalities could be recognized. A 10° hip flexion contracture with limitation of joint ROM was identified in TFA1. Muscles strength was rated 5/5 of the MRC scale in flexion/extension direction and adduction/abduction direction in both TFA. Subjects reported no stump pain during everyday life, but TFA2 complained about phantom limb pain. During ultrasound examination, it was possible to define the muscle belly position for the following muscles in both patients: rectus femoris, vastus lateralis as well as the hamstrings group. Afterwards, EMG standard electrodes were placed. Both participants contracted stump muscles groups selectively during hip flexion and extension while standing using walking aids to maintain balance. However, at the end of the range of motion a coactivation of agonists and antagonists was noticed. Due to these first results, the following measurement protocol steps are planned.

Conclusion

The presented measurement protocol requires an intensive cooperation between prosthetists and researchers: technicians share their experience in choosing materials and take care of the laborious construction of the test socket. On the other hand, the execution of the measurement protocol with the participants requires about 2 and 3 hours respectively for the first and second appointment. Although ultrasound examination is time consuming, this investigation allows researchers to gain a more precise impression of the stump and its peculiarities. Further, muscles belly position for EMG electrodes can be defined more reliably and interpersonal differences due to amputation can be taken into account. The first two measurements show that subjects are able to contract muscles groups selectively depending on the requested movement. For this reason, in the next months the research team will proceed with the building of the test sockets as well as with the recruiting of further study participants.

References

Jaegers, S. M. et al. (1995): Changes in hip muscles after above-knee amputation. In: Clinical Orthopaedics and Related Research (319), S. 276–284.

Putz, C., J. Block, S. Gantz, D. W. W. Heitzmann, T. Dreher, B. Lehner, M. Alimusaj, S. I. Wolf and S. Muller (2017). Structural changes in the thigh muscles following trans-femoral amputation. Eur J Orthop Surg Traumatol 27(6): 829-835.

Wentink, E. C. et al. (2014): Detection of the onset of gait initiation using kinematic sensors and EMG in transfemoral amputees. In: Gait & posture 39 (1), S. 391–396.

Image: Table1_Information about study participants_2573.JPG

Table 1: Information about the study participants.

	TFA 1	TFA 2
Age (years)	58	43
Height (cm)	183	178
Mass (kg)	89.5	76
LCI	44 (Max 56)	55 (Max 56)
Time since amputation	2 years	11 months