motion between NA and TF could be shown. In both groups, the range of motion is the lowest with the mid velocity. For TF the motion pattern changed slightly with changing speed, showing greater compensatory mechanisms when walking at slow and fast self-selected speed. With a similar use of a marker on the C7 and the sacrum Köhler et al. showed that this parameter could be useful to determine a suitable socket adduction position in the frontal plane [4]. In the latter, no segment was defined. An angle calculation was used based on the projection of the markers onto the frontal plane of the global coordination system. Nevertheless, the pattern and range of motion are comparable to the results of the 3D calculation method in the current study.

Significance: The lateral trunk lean analysed with a segment using the C7, the sacrum and the center of pelvis shows a relevant compensatory mechanism of TF amputees and could be used for determining prosthetic aspects.

Disclosure: Eva Pröbsting, Michael Ernst, Thomas Maximilian Köhler, Thomas Schmalz and Malte Bellmann are full time employees of Ottobock.

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Design and fitting of a custom-made carbon-fiber ankle foot orthosis for sprinting

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Introduction: Ankle Foot Orthoses (AFOs) are commonly prescribed to improve gait in patients with foot drop disorder[1]. However, their application for sport activities in subjects with spastic hemiplegia is rare. This study describes the design and fitting of a custom-made carbon-fiber composite AFO for sprinting to be used in combination with conventional spiked sprinting shoes, for a 26-year-old female paralympic athlete with an acquired right spastic hemiplegia. The athlete came to our observation after rejecting a traditional AFO with neutral ankle alignment (0° ankle flexion) which did not conform to her ankle attitude during running and lacked sufficient foot frontal plane stability, causing her foot to continuously slip out of her shoe, and eventually leading to the formation of an edema to her lateral malleolus. The custom-made AFO had to fulfill the following requirements: satisfactory energy storage and return (ESR) exploiting the non-spastic range of motion; sufficient forefoot flexion; stability of the foot on the frontal plane; avoiding knee hyperextension.

Methods: To maximize energy storage and return, the AFO was designed to allow ankle flexion well outside the subject spastic range, i.e. from 10° of ankle plantarflexion to any degree of dorsiflexion. Therefore, during casting, the AFO neutral position was set to around 40° of ankle plantarflexion, to allow the athlete to take advantage of 30° range of flexion for ESR. Moreover, to promote ESR, the AFO was designed with an anterior shell[2]. The carbon fiber layup was designed to create different areas of stiffness. The AFO insole heel and posterior bar (area 1) had to be stiffer to allow most ESR, while the forefoot insole plate (area 2) had to be more flexible to ensure a metatarsophalangeal flexion of over 40° without breaking, which is the value that we measured on the athlete during sprinting start. The AFO was integrated in a commercially available and certified sprinting shoe with spikes for track (Figure 1): the AFO insole plate was covered with anti-slippery material and inserted in the shoe through a cut performed in the shoe heel counter.

The behavior of the AFO was assessed through high-speed video analysis during training and competition (sprinting), and through a full indoor biomechanical assessment with force plates and an optoelectronic mock-up system during

Figure 1. AFO integrated in a sprinting shoe with spikes.

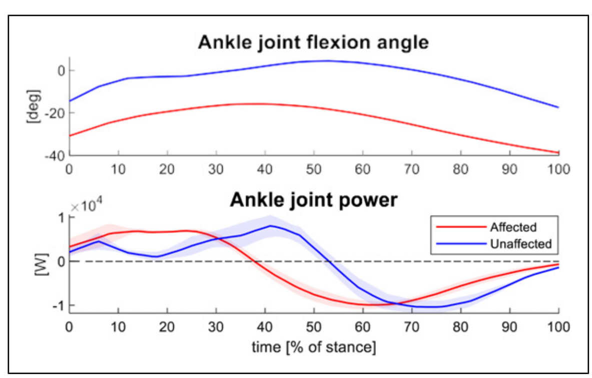

Figure 2. Ankle dorsi(+) / plantar(-) flexion and ankle power (compression(+) / extension(-)) normalized to stance time.

skipping, to assess a high force, high frequency condition. Results of the biomechanical assessment are reported in the results section.

Results: The AFO mold was digitally rectified and carved in polyurethane foam. The AFO was then manufactured with prepreg carbon fiber, modulating the stiffness by adjusting the layup in the 2 areas: 7 unidirectional plies (area 1); 1 unidirectional ply between 2 twill plies (area 2).

The subject gave a positive response to the custom-made AFO in terms of stability, not reporting any pain, and was able to successfully use it for the Tokyo 2020 paralympic games. No failures were reported in more than 6 months of use.

Results of the biomechanical assessment of skipping are reported in Figure 2 and refer to 3 body weight (1800N) of maximum vertical load. The ankle joint angles display a similar trend and range (20°) with an angular offset of around 20°, illustrating how the AFO is effective in mimicking the unaffected trend while keeping the affected ankle outside the spastic range. There is also a similarity in the power trend between affected and unaffected side.

Conclusion: The custom-made AFO with anterior shell and two different stiffness areas proved to be effective for the athlete, allowing her to compete at national and international levels.

Significance: This study could provide a reference for the design and construction of custom-made AFO for subjects with spastic hemiplegia aiming to engage in athletics track competitions.

Disclosure: None.

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Effect and benefit of ankle foot orthoses for patients with weakness of the plantar and dorsiflexors: Biomechanical comparison of different orthotic concepts.

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Introduction: Patients with both plantar and dorsiflexor weakness often show abnormal knee loading in addition to instabilities of the ankle joint. This can be treated using ankle-foot orthoses (AFO) that utilize effects of the ground reaction force (GRF) [1,2]. Options are jointless carbon fibre orthoses (JLO) and articulated orthoses, which can be further differentiated into AFOs with conventional ankle joints (small ROM, rigid stops – CAJ) and those with expanded ROM and customizable resistance to both movement directions ("reactive- dynamic ankle" – RDA [3]). The aim of the present study was to compare the effectiveness of different AFO concepts for supporting movement patterns of daily living using biomechanical parameters.

Methods: Seven patients (91±15kg, 1.85±0.10m, 57±15y) with plantar and dorsiflexor weakness resulting from various neurological conditions (manual muscle test grades 1-3 [4]) were enrolled in the study. All patients currently use an RDA-AFO (4 bilaterally, 3 unilaterally) and have previous experience with either JLO or CAJ. Four orthotic configurations (RDA, CAJ, JLO, no orthosis - WO) were studied during the following movement patterns: self-paced level walking at medium speed, walking up and down an incline (10°), and standing on an incline (+10°, 0°, -10°). Kinematic data was measured with an optoelectronic system (VICON) coupled with two force plates (KISTLER) to measure GRF.

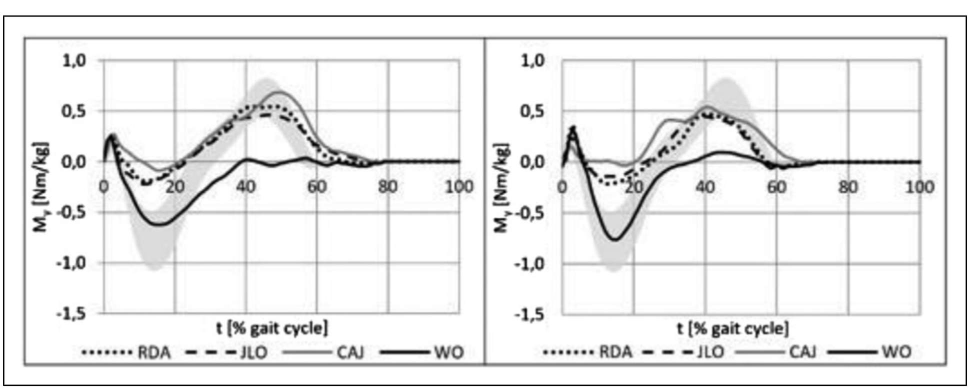

Figure 1. External orthotic side sagittal knee moment walking up an incline. Group mean curve of bilaterally (left) and unilaterally (right) affected patients. Norm data of healthy control group shown as grey shaded area.