Sport

AS-0521

GROUND REACTION FORCES IN ELITE UPPER-LIMB AMPUTEE RUNNING

Stefan Litzenberger [1,*] Franziska Mally [1] Steffen Willwacher [2] Bjoern Braunstein [2,3] Anton Sabo [1] Gert-Peter Brueggemann [2]

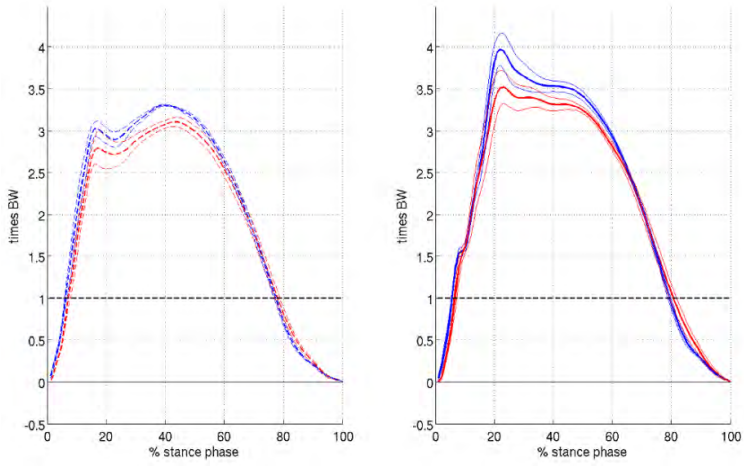
[1]Department for Sports Engineering & Biomechanics, University of Applied Sciences Technikum Wien, Vienna, Austria, [2]Institute of Biomechanics and Orthopaedics, German Sport University, [3]German Research Centre of Elite Sport, Cologne, Germany

Introduction and Objectives: Whereas able-bodied athletes can easily be compared to each other without any further regulations, disabled athletes have to be ranked regarding their impairment to avoid inequality within a group. The International Paralympic Committee (IPC) mostly bases its classification process on experience and scientific work. For upper-limb amputees, however, there has been a recent change in classification, which was partly based on scientific work conducted almost three decades ago with methods no longer considered state-of-the-art and done with able-bodied athletes at running speeds significantly lower than those of disabled elite athletes [1,2,3,4,5,6]. From these studies it was concluded that no difference in net vertical momentum between impaired and sound side would be found because during running both arms act synchronously in their upward- and downward movement, respectively, which ultimately would lead to no differences in ground reaction force (GRF) between both feet. Until now no research has been done with upper-limb amputees at elite-level running speeds. We hypothesized that contrary to findings of studies so far, differences in the GRF of an upper-limb amputee athlete can be observed.

Methods: For this research an elite paralympic 400m and 800m runner (PB 400m: 0:48,45, PB 800m: 1:50,92) with a below elbow amputation on the right upper-limb was tested. GRFs were collected with four floor level mounted Kistler force plates aligned consecutively along the running track sampling at 1000 Hz. The subject was advised to do runs at two running speeds (8m/s and 5.4m/s) until four valid ground contacts were recorded for each foot and speed. Stance phase (SP) duration in ms was obtained and data for each ground contact were time normalized to 100% of SP duration and amplitude-normalized to times body weight (BW). Mean and standard deviation as well as maxima and occurrence of the maxima in the SP of vertical, antero-posterior and medio-lateral GRF were calculated and statistically evaluated.

Results: Stance phase duration between left and right foot did not differ significantly for both running speeds (5.4m/s: left: 174 ± 3 ms, right: 181 ± 8 ms ; 8m/s: left: 127 ± 2 ms, right: 125 ± 2 ms). Minor differences in the mean GRF for antero-posterior but not for medio-lateral were found for both running speeds. Maxima of vertical GRF, however, revealed statistically highly significant (alpha = 95%) differences between left and right foot for 5.4 m/s (l: 3.3 ± 0.01 BW, r: 3.1 ± 0.02 BW) and significant differences for 8 m/s (l: 3.97 ± 0.08 BW, r: 3.52 ± 0.05 BW). Furthermore the characteristics of the vertical GRF changed between the two running speeds (Fig.). Whereas the maximum vertical GRF at 5.4 m/s could be observed at approx. 40% of SP it was located at approx. 22% for a running speed of 8 m/s.

Figure:



Caption: Mean vertical GRF (GRF_z) in times BW plotted over % of stance phase, thick: mean, thin: ± SD, left: 5.4m/s, right: 8m/s, blue: left foot, red: right foot

Conclusion: The data obtained in this research shows that there are significant differences in vertical GRF between the sound and impaired side of an upper-limb amputee athlete. Hence the hypothesis investigated can be verified. The data confirms that the difference is significant and increases with increasing running speed (difference at: 5.4 m/s: 6%, 8 m/s: 11%). This leads to the assumption that the vertical momentum of both arms is significantly different depending on whether the impaired or sound arm is in backward or forward motion and whether intial contact (or toe off) is made with the ipsilateral or contralateral leg, respectively.

The outcome of the presented research strongly supports the hypothesis that - especially for middle distance running - the contribution of the arms is an important factor. It is furthermore an addition and an update with state-of-the-art measurement systems to the ground-breaking work of [1] and [2].

However, it has to be pointed out that the present study was only performed with one amputee athlete and hence results cannot be generalized. A comparison of a higher number of amputee athletes is rather difficult to perform given the relatively small number of athletes competing on world-class level with this special impairment.

Nonetheless it could be shown that upper-limb amputation has a significant impact on the running mechanics which is not considered in the IPC's classificaton process.

References: [1] Hinrichs et al., Int. J. Sport Biomechanics, 3: 222-241, 1987.

[2] Hinrichs, Int. J. Sport Biomechanics, 3: pp. 242-263, 1987.

[3] Li et al., Journal of Experimental Biology, 204.1:47-58, 2001.

[4] Miller et al. Journal of biomechanical engineering, 131.12, p. 124502, 2009.

[5] Pontzer et al., J. of Exp. Biology, 212.4: 523-534, 2009.

[6] Tweedy & Bourke. IPC Athletics Classification Project for Physical Impairments: Final Report-Stage 1. *Bonn: IPC Athletics, 104,* 2009.

Disclosure of Interest: None Declared