Development Of Mediolateral Ground Reaction Force Across Different Running Speeds To Maintain A Straight Running Path In Transfemoral Amputees

Tang Ying Wai[1,2], Akihiko Murai[2,3] and Hiroaki Hobara[2]
[1] University of Tokyo, Kashiwa, Chiba, 277-0882, JAPAN
[2] Human Augmentation Research Center, National Institute of Advanced Industrial Science and Technology, Kashiwa, Chiba, 277-0882, JAPAN
[3] PRESTO, Japan Science and Technology Agency, Kawaguchi, Saitama, 332-0012, JAPAN

Introduction

Due to the differences between affected and unaffected limbs in lower extremity amputees, a high level of mechanical asymmetries during locomotion has been identified [1]. Having an appropriate mediolateral ground reaction force (M-L GRF) profile that realizes a symmetrical mediolateral ground reaction impulse (M-L GRI) between both limbs, is essential to maintain straight running [2]. The purpose of this study was to examine the M-L GRF production across different running speeds in unilateral transfemoral amputees (TFA), and to identify their strategies in maintaining straight running at different submaximal speeds among the population.

Methods

Nine TFAs were recruited for the study. Participants performed running trials at increments of their 100% speed on the instrumented treadmill (FTMH-1244WA; Tec Gihan, Kyoto, Japan), which was defined as the average speed of their best 100-m time in competitions. Trials were set at 30% to 80% speed, with an increment of 10%. Average mediolateral ground reaction force (F_{avg}), M-L GRI, contact time (t_c), step width (SW) were examined. 7 steps from unaffected and affected limbs respectively were analyzed. Two-way repeated ANOVA or Friedmen test with post hoc tests were subsequently conducted to examine the effect of speed and limbs on the variables. Model of running specific prostheses (RSP) were not controlled. Participants were allowed to use their preferred RSP as they were more acclimatized to them. The protocol was approved by local ethics committee and all participants gave informed written consent before participating.

Results and discussions

Referring to Figure 1A, there was no main effect of speed on SW. Figure 1B showed that there was only a significant main effect of limbs ($p < 0.05$) on F_{avg}. Posthoc test showed a significantly higher F_{avg} on the unaffected limbs at 50% ($p = 0.02$) and 70% ($p < 0.05$) . Figure 1C showed a significant main effect of speed ($p < 0.01$) but not limbs on M-L GRI. Generally, M-L GRI was smaller at faster running speeds. Figure 1D showed a significant main effect of speed and limbs on t_c ($p < 0.01$). In both limbs, the t_c were similar at slower speed. As speed increased, t_c of affected

Corresponding author email: TA0006AI@e.ntu.edu.sg

limbs were significantly longer than unaffected limbs ($p < 0.05$). This study showed that unilateral TFA sprinters were able to maintain a symmetrical M-L GRI profile through mediation of relevant M-L GRF variables to maintain a straight running path. Despite the similar F_{avg} across all speeds and limbs, the more than proportionate decrease in t_c resulted in an decrease in M-L GRI at higher speeds. This implied that maintenance of straight running was easier at faster speed. Range of motion on the affected side was reduced due to amputation [3]. As step width development is related to hip movement [4], the restriction of hip abduction has affected the ability of TFA to mediate SW. The similar SW values implied that the strategies for maintenance of straight running path are similar across all speeds.

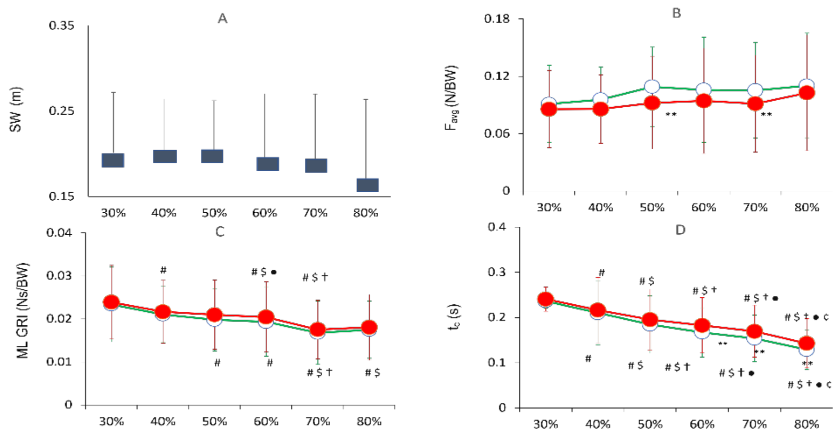

Fig. 1: SW (A), F_{avg} (B), M-L GRI (C) and t_c (D) of the unaffected (*white circles*) and affected (*red circles*) limbs across 6 different running speeds. ** represents significant differences between limbs at each speed at $p < 0.05$. #, $, †, ●, ¢ represent significant differences from 30%, 40%, 50%, 60% and 70% speed trials at $p < 0.05$ respectively.

Conclusion

This study has shown that despite the asymmetries between the F_{avg} profile between limbs, TFAs were able to maintain symmetrical ML GRI profile, through similar strategies across all running speeds tested in this study.

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Corresponding author email: TA0006AI@e.ntu.edu.sg