Assessing asymmetry in post-stroke and prosthetic gait in terms of step-length asymmetry alone is flawed!

Melvyn Roerdink, Peter J. Beek
MOVE Research Institute Amsterdam, Faculty of Human Movement Sciences, VU University Amsterdam

BACKGROUND AND AIM: In pathological gait, step length (SL) typically differs in magnitude between sides. However, the direction of SL asymmetry varies across patients. This study sought to understand directional variations in SL asymmetry in hemiplegic stroke patients and lower-limb amputee patients. Here, paretic/prosthetic (P) SL represents the fore-after distance between non-paretic/non-prosthetic (NP) and subsequent P foot placement positions (vice versa for NP step length). We partitioned SL asymmetry into asymmetries in trunk progression (TP; NP steps are shorter than P steps if the trunk does not displace as far forward of the supporting P than NP foot; Fig. 1A) and forward foot placement relative to the trunk (FFP; a larger NP than P FFP contributes to a longer NP than P step; Fig. 1B). We expected that the identified TP and FFP components account for the observed asymmetry in SL in an additive manner and that their relative contribution is responsible for inconsistencies in the direction of SL asymmetry.

METHODS: 28 hemiplegic stroke patients, 10 lower-limb amputee patients and 9 healthy elderly controls walked at a self-selected comfortable speed on an overground walkway and on a treadmill, the latter with and without projection of symmetric stepping stones. Pelvic and heel marker positions were recorded. SL, FFP, and TP of P and NP steps were quantified, as well as asymmetries therein.

RESULTS: Asymmetry indices varied within individual patients and occasionally fell within control reference ranges, whereas directional variations across patients were observed for asymmetries in SL and FFP only. Despite heterogeneity in asymmetry across patients, SL asymmetry was determined by the sum of asymmetries in FFP and TP. Asymmetries in FFP and TP were negatively correlated (stroke: \( r=-0.64 \); amputee: \( r=-0.44 \)). The magnitude of SL and FFP asymmetries was significantly smaller for symmetrically cued than uncued treadmill walking for stroke and amputee patients alike.

CONCLUSIONS: Variations in SL asymmetry cannot be fully explained by TP and FFP components in isolation. Rather, the magnitude of SL asymmetry was accounted for by the sum of TP and FFP asymmetries whereas their relative contribution accounted for directional variations in SL asymmetry. That is, P and NP steps are of equal length as long as asymmetries in TP and FFP are similar in magnitude but opposite in direction. Likewise, relatively large asymmetries in SL may result from TP and FFP asymmetries that are small in magnitude but similar in direction. Hence, judging the quality of hemiplegic or prosthetic gait from the magnitude of SL asymmetry alone is flawed. An encompassing gait asymmetry evaluation should therefore include an assessment of foot positioning relative to the trunk. Imposing a symmetric SL by using visual cues during treadmill walking decreases asymmetries in SL and FFP, thereby contributing to an overall more symmetric gait in stroke and amputee patients.
Fig. 1. Schematic of determinants of SL asymmetry. (A) SL asymmetry due to asymmetry in TP and (B) SL asymmetry due to asymmetry in FFP