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Medial-lateral centre of mass displacement and base of support are equally good predictors of metabolic cost in amputee walking

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ABSTRACT

Amputees are known to walk with greater metabolic cost than able-bodied individuals and establishing predictors of metabolic cost from kinematic measures, such as centre of mass (CoM) motion, during walking are important from a rehabilitative perspective, as they can provide quantifiable measures to target during gait rehabilitation in amputees. While it is known that vertical CoM motion poorly predicts metabolic cost, CoM motion in the medial-lateral (ML) and anterior-posterior directions have not been investigated in the context of gait efficiency in the amputee population. Therefore, the aims of this study were to investigate the relationship between CoM motion in all three directions of motion, base of support and walking speed, and the metabolic cost of walking in both able-bodied individuals and different levels of lower limb amputee. 37 individuals were recruited to form groups of controls, unilateral above- and below-knee, and bilateral above-knee amputees respectively. Full-body optical motion and oxygen consumption data were collected during walking at a self-selected speed. CoM position was taken as the mass-weighted average of all body segments and compared to each individual's net non-dimensional metabolic cost. Base of support and ML CoM displacement were the strongest correlates to metabolic cost and the positive correlations suggest increased ML CoM displacement or Base of support will reduce walking efficiency. Rehabilitation protocols which indirectly reduce these indicators, rather than vertical CoM displacement will likely show improvements in amputee walking efficiency.

1. Introduction

It is known that lower limb amputees walk less efficiently than able-bodied individuals, with progressively worse efficiency as the level of amputation increases [1–4]. To assess walking, and in particular walking efficiency in lower limb amputees, a range of biomechanical and physiological parameters have been used, including Centre of Mass (CoM) displacement and various respiratory measures [5]. Specifically, the respiratory measure considered most related to walking efficiency is the metabolic cost of walking and has been used to assess over-ground and treadmill walking [6–8] when comparing between able-bodied individuals or between amputee groups [1,2,9–11] or between different prosthetic devices within amputee groups [12–15]. To avoid confusion, this study considers more efficient gait to be when the metabolic cost, defined as the metabolic energy expended to move a unit distance, decreases.

As it is not always possible to obtain metabolic data, studies have sought to establish other predictors of the cost of walking, such as walking speed [16] or vertical CoM displacement [17,18]. This follows the work of Saunders et al. [19] who presented the six determinants of gait which were seen to influence CoM motion, the main biomechanical parameter historically believed to be related to the energetic cost of walking. This idea was based on the observation that pathological gait deviated from what was considered "normal". In particular, the observed greater CoM displacements in pathological gait suggested more mechanical work was being performed compared to a "normal" gait pattern,

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Appendix A. Supplementary data

Supplementary data associated with this article can be found, in the online version, at http://dx.doi.org/10.1016/j.gaitpost.2016.09.024.

Conflicts of interest

None

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