The high cost of swing leg circumduction during gait

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1) Motivation

During normal walking people tend to first swing their leg inwards towards their stance leg before swinging the leg out to position the foot for the next step. In this work we hypothesize that the in-swing of the leg during normal walking reduces the reaction torque at the stance leg. Additionally, we hypothesize that increased circumduction will result in increased metabolic cost that is caused by greater active muscle work. This muscle work is used to both circumduct the leg, and generate stance leg torque to oppose moments created by changes in angular momentum caused by circumduction.

2) State of the art

The reason for in-swing is not immediately obvious, but previous work has shown human walking is a highly optimized task. How an individual swings their arms and places there feet (e.g. step width, step length, step frequency) can significantly affect energetic cost during gait [1-3]. As such, it is reasonable to assume that the in-swing of the leg serves a purpose during gait.

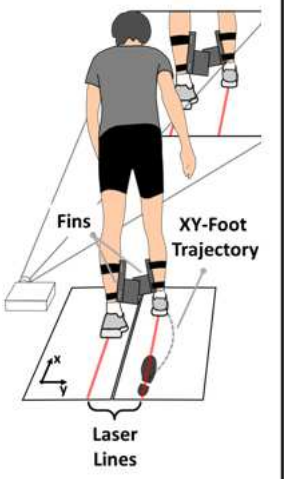

Fig 1 Shank obstacles and constrained step width used to modify swing leg trajectories.

3) Our Approach

To investigate this question we constructed foam fins (2, 3, and 4in wide; 11g each) worn on each shank and used constrained step width to impose increasing amounts of circumduction on the swing leg, Fig 1. Metabolic cost, ground reaction forces and moments, and body kinematics were collected during walking experiments with healthy young adults during constrained and unconstrained trials. Increased vertical ground reaction moments and arm swinging used to offset the motion of the leg during circumduction, along with an increased metabolic cost would support our hypothesis.

4) Current Results

Results from three subjects demonstrate that the shank obstacles and constrained step width generate larger swing leg circumduction and increased metabolic cost, Fig 2. Further, the data shows that circumduction resulted in increased arm movement and larger stance leg torque when the arms were constrained.

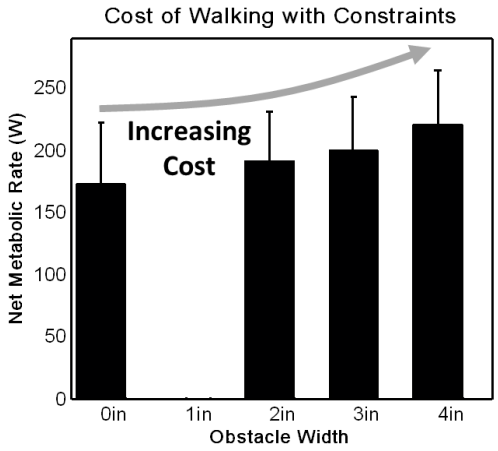

Fig 2 Obstacles, as measured from the medial shank, increase circumduction and metabolic cost (n=3).

5) Best possible outcome

The exponential trend present in the metabolic data will continue as we test more subjects. Additionally, metabolic cost will be increased when arm use is restricted, and the subjects will employ increased stance leg torque in place of increased arm movement to compensate for the imposed circumduction.

Acknowledgments

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References

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