Non-rigid work in human walking: Are hard collisions in fact soft?

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Walking is typically studied using rigid-body models to estimate work done rotationally about joints by muscles and tendons.

Other soft tissue deformations throughout the body may also perform substantial work in walking, but we are unable to measure it directly.

Hypothesis: Work is performed by soft tissues during collisions after heel-strikes and increases with speed.

Methods: We measured healthy subjects (N=10) walking on an instrumented treadmill at 0.7–2.0 m/s. We calculated:
- Total mechanical power of the whole-body due to motion of the center-of-mass (COM), which makes no rigid assumptions, and due to motion of segments relative to the COM.
- Summed rotational joint power of the ankle, knee and hip from inverse dynamics.
- Inter-segmental foot power encompassing all energy flow out of the foot, including due to ankle rotation, deformation of ankle, foot and shoe and unmodeled joints in the foot.
- Rotational ankle power from standard inverse dynamics.

We estimated soft tissue contributions as all the non-rigid work and power, defined as that not captured by rotational joint estimates.

We integrated powers over the Collision phase of gait, the region of negative total mechanical power immediately following heelstrike.

Walking Collisions are “soft”: 60% of total Collision work is done by soft tissue deformations throughout the body, 15% by deformations of foot, ankle and shoe.

Soft tissues cushion collisions by dissipating energy, which could shield joints and muscles from high loading, but might also cause injuries in soft tissues themselves.

Acknowledgements: NSF, DoD