Walking with a Load on Wheels: Potential Effects of Bidirectional Springs on Walking Economy

Hiva Razavi[1] & Philippe Malcolm[1]
[1]Department of Biomechanics, University of Nebraska at Omaha, Omaha, NE, USA
email: hrazavi@unomaha.edu

Have you ever noticed how your arms alternatively flex and extend when pushing a heavy shopping cart? Accelerating and decelerating heavy masses, such as a shopping cart, can require much effort. During walking, we alternatively accelerate and decelerate our Center of Mass (COM) in every gait cycle, which can require even more effort if we accelerate and decelerate a load while walking. Theoretically, this effort can be reduced by timing the acceleration and deceleration of the load's mass opposite to the individual's COM. Previous studies have demonstrated that this antiphase oscillation between an individual and a load can decrease the energy consumption of carrying a backpack. Achieving antiphase oscillation in the anteroposterior direction between the individual's and the load's mass can be accomplished by connecting them with a spring. This study assessed the impact of attaching a person to a cart using springs on energy consumption and Ground Reaction Forces (GRF). We hypothesized that connecting the cart with springs may offer greater efficiency than walking with a rigidly attached cart.

We designed the cart (weighing half of the participant's mass) that connects to the participant's waist with bidirectional springs that allow the cart to oscillate while walking. We evaluated six conditions: springs with four different stiffnesses, no-spring (rigid connection), and no-cart (normal walking). We asked the participants to walk for 5 minutes on the ground in each condition and measured their metabolic energy consumption. We also measured the GRF in each condition by having one participant walk on the treadmill while attached to the cart.

Energy consumption increased significantly in all conditions compared to the no-cart condition. There were no apparent differences between springs and no-spring conditions. However, the propulsion peak was slightly higher in the no-spring condition compared to all other conditions, and one of the spring conditions showed the lowest propulsion and breaking peaks.

Some participants reported forward-backward motion of the waist belt in the no-spring condition, which was absent in spring conditions. This may suggest that even though the connection between the cart and the participant was intended to be rigid, there was some oscillation. In other words, the rigid condition might have functioned like another oscillating spring condition. Further investigation is needed to optimize the design of such interventions to reduce energy consumption and GRF when walking with wheeled loads.