The influence of ankle versus hip powering on economy and gait robustness

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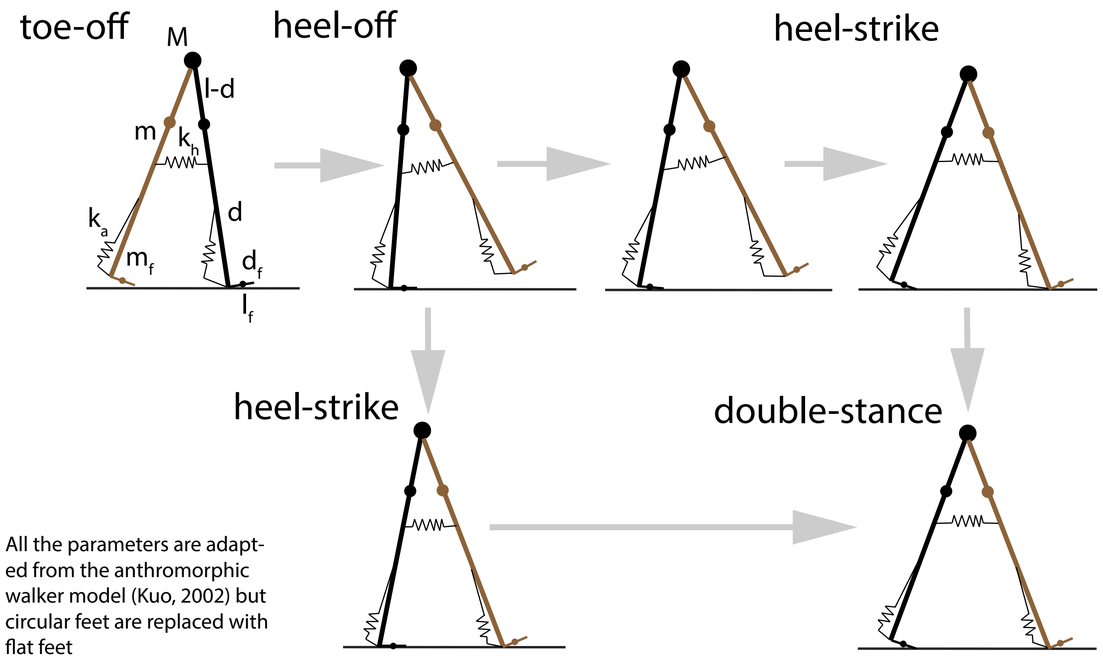
Introduction

Gait in elderly is characterized by decreased ankle push-off and increased hip power. One hypothesis on why elderly rely more on hip than ankle powering is that they prioritize gait robustness over gait economy. This study explores the effects of ankle versus hip powering on economy and robustness using a 2D flat feet walker

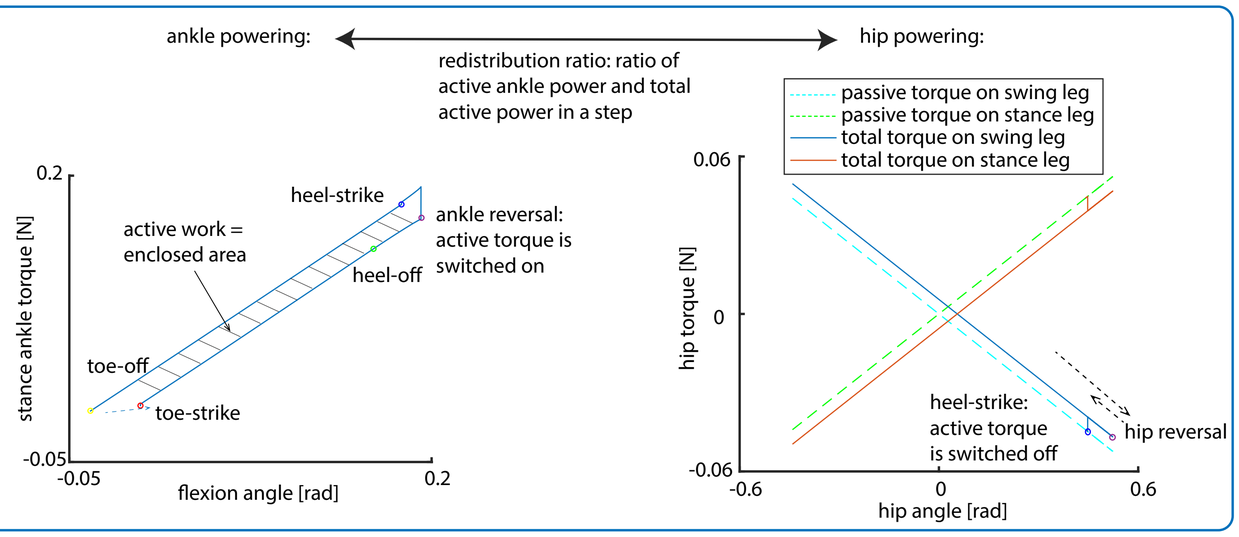
Model: can generate gaits powered by active torque at ankle and/or hip with passive elasticity at both joints

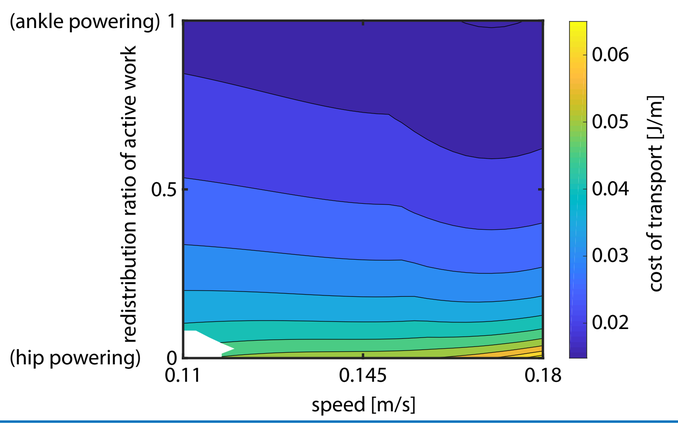
Economy: is evaluated by cost of transport (lower COT, better economy), calculated as positive work produced by ankle and hip per meter travelled

Robustness: is quantified by the largest floor height perturbation the walker can handle without falling

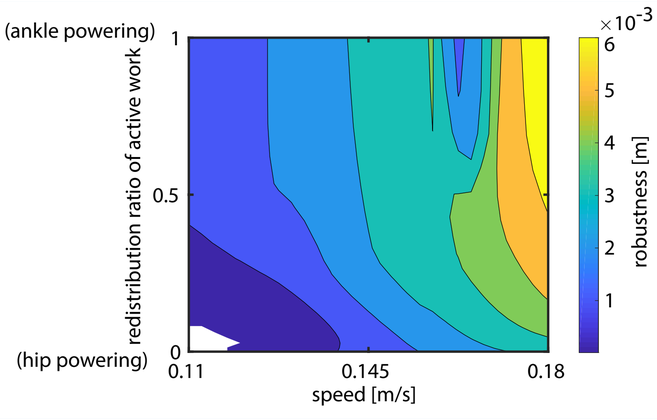


All the parameters are adapted from the anthromorphic walker model (Kuo, 2002) but circular feet are replaced with flat feet





Economy: 1) ankle powering has better economy than hip powering; 2) walking faster leads to worse economy for hip powering, but doesn't substantially change economy for ankle powering



Robustness: 1) the robustness of ankle powering is better than of hip powering, but is as good as of half-ankle-half-hip powering for most velocities; 2) walking faster generally leads to better robustness

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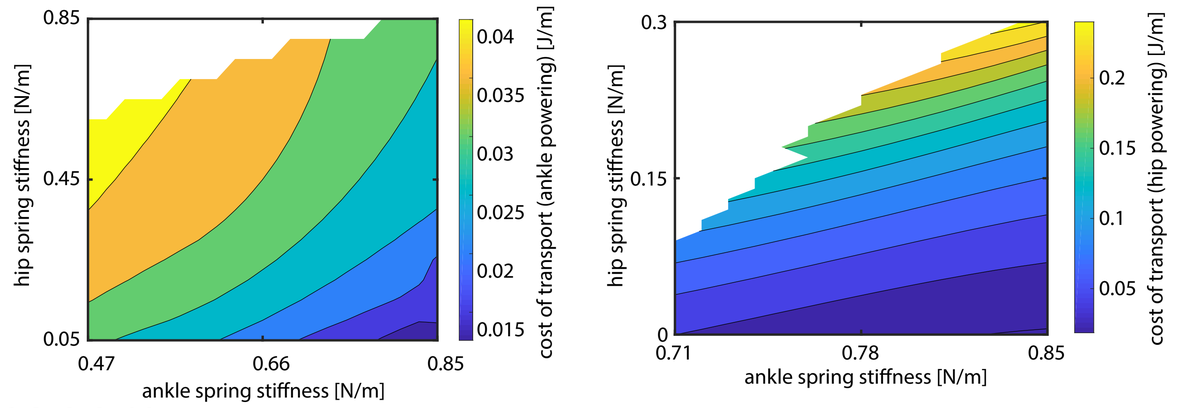
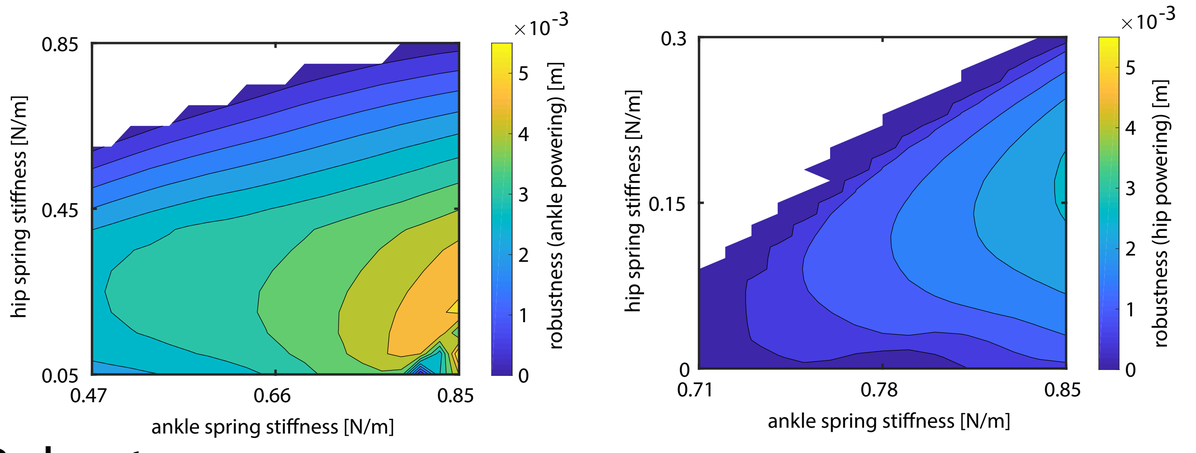
Effect of passive elasticity on COT for ankle powering and hip powering:



Economy: ankle and hip powering have lowest COT both with more stiff ankle spring and less stiff hip spring (speed is chosen freely)

Effect of passive elasticity on robustness for ankle powering and hip powering



Robustness: both ankle and hip spring stiffness can be optimized for a given actuation strategy, so as to obtain the most robust gait

Conclusions:

1) ankle powering is more economical and robust than hip powering; 2) shifting part of ankle powering to hip powering (up to half) does not worsen robustness for most speeds; 3) these simulations may shed light on the effects of shifting ankle powering to hip powering for a more complicated model and human gait