Changed leg parameters during vertical perturbations of ground surface height during human walking.

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Introduction

Even though human locomotion is a daily task, which is performed with ease, it still not well understood. These movements are realized by careful interplay between system *actuators, mechanics, sensors* and *control*. In addition, system *mechanics* can be influenced by the *environment*.

Yet, little is known about how humans keep balance in response to sudden changes in ground height such as stepping on uneven ground (e.g. when walking on snow). In particular, it is unclear which sensory information is required as input to the control system, how the control system reacts and which actuators are reacting to cope with the perturbation. A better understanding of the human control loop, especially the *sensory* and *control* components, could help to apply similar adaptation mechanisms to the design and control of robotic or prosthetic systems.

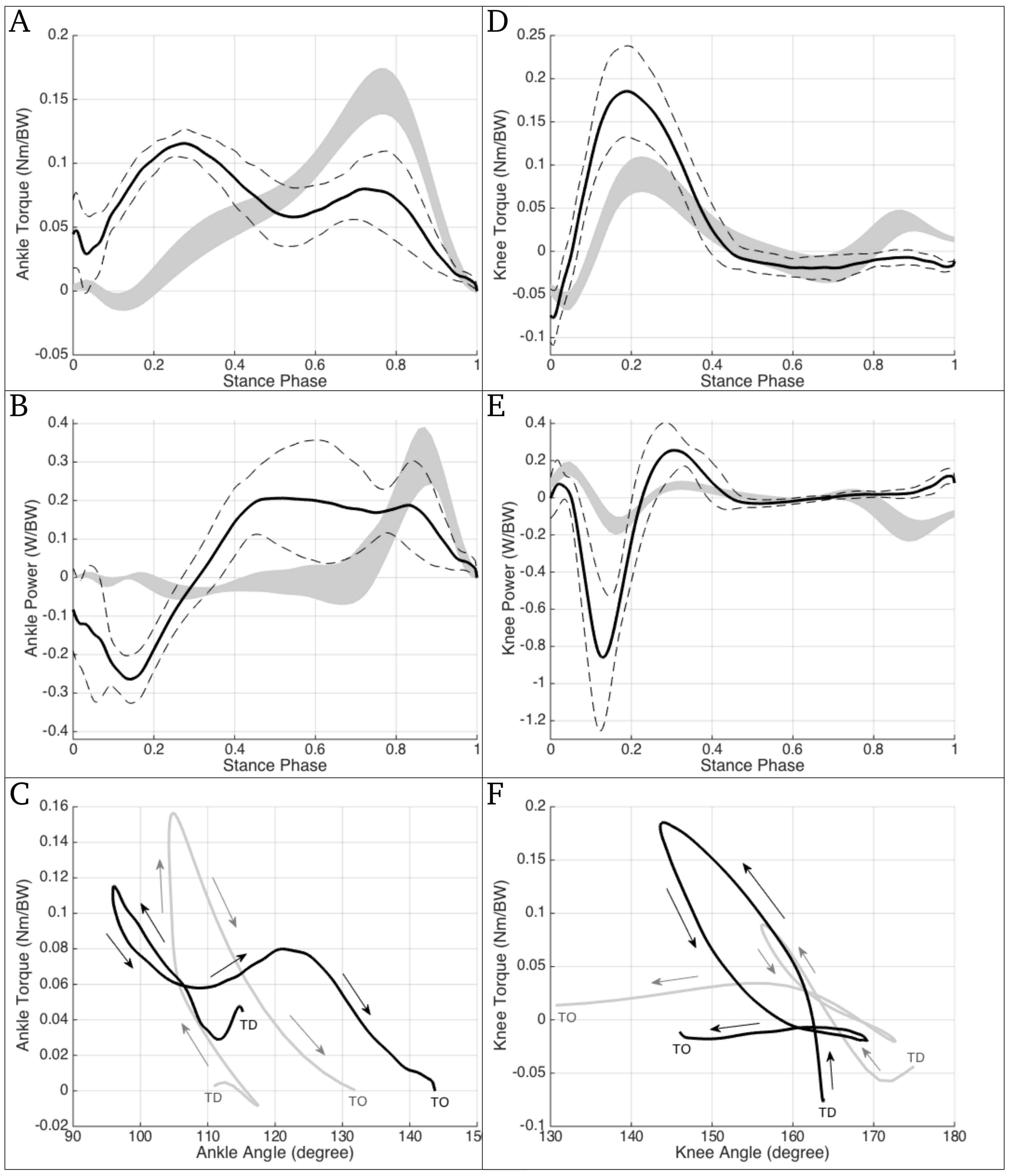

Fig. 2: *Joint torque and power patterns of stance leg during perturbed (-10cm) and unperturbed walking.* ***A-C****: ankle torque, power and torque-angle-relationship* ***D-F****: knee torque, power and torque-angle-relationship.* ***Solid black line****: mean of 11 perturbed steps,* ***dashed lines****: standard deviation,* ***grey****: unperturbed walking data.*

Method

- experimental investigation of humans maintaining balance when vertical perturbations are introduced during level walking
- perturbations (-10, -5, 0, +5, +10cm) were randomly introduced and triggered by heel contact
- perturbed walking data (-10cm) is compared to unperturbed walking data (from Lipfert, 2010)

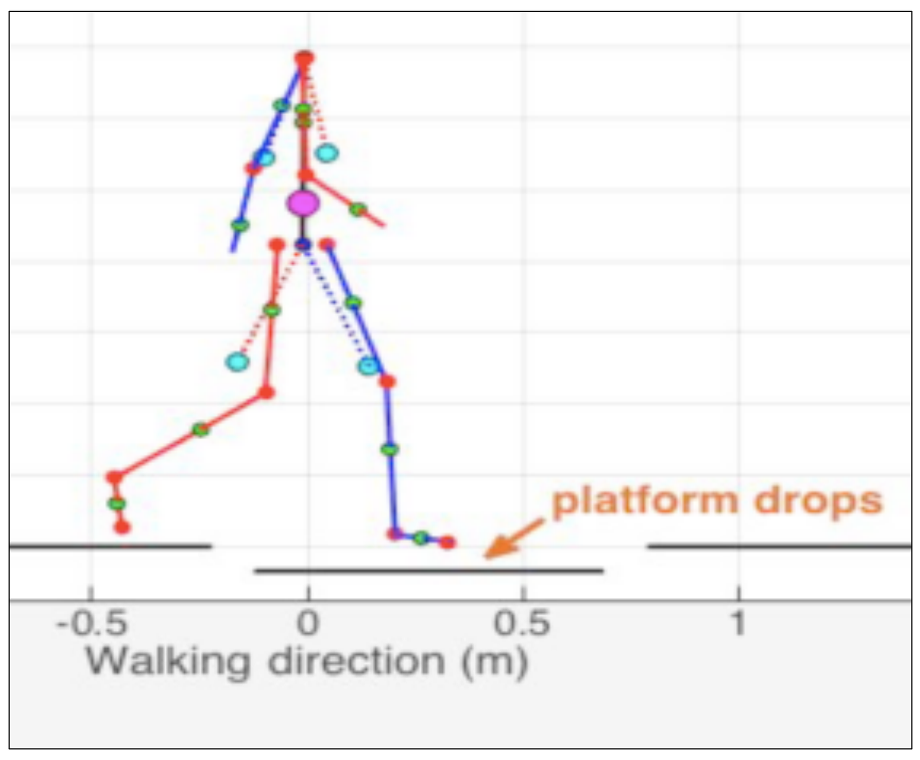

Fig. 1: *Stick-figure of the experimental approach.*

Results

- during the perturbed step down (-10cm) we observed: higher impact knee torques and powers in the case of unexpected drop in ground height
- ankle torque and ankle power patterns (Fig. 2 A+B) show a reduced torque in preparation to push-off in the perturbed leg
- ankle stiffness during loading in the perturbed step is similar to that observed in normal walking (Fig 2. C)
  → a shift (additional rise after peak) during the unloading phase is observed
- higher knee torque and power (Fig. 2 D+E)
- the knee torque-angle relationship (Fig. 2 F) shows larger energy loss and ankle torque-angle relationship (Fig. 2C) shows energy supply

Conclusion

In this study, adaptations in leg parameters during a perturbed step are investigated.

Results from this research highlight human movement strategies to cope with unexpected uneven terrain. This knowledge may help to control devices (e.g. exoskeletons) that support humans during (un-)perturbed locomotion to attain a normal gait.

References

Lipfert, S. W. (2010). *Kinematic and dynamic similarities between walking and running*. Kovač.

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