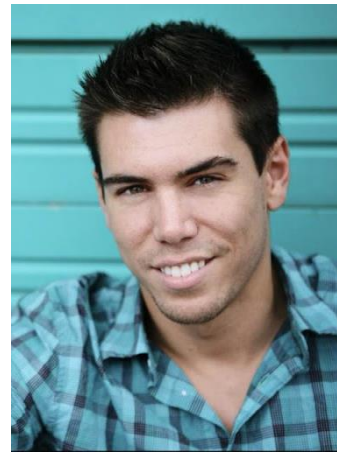


Reducing the energy cost of human walking using an unpowered exoskeleton



[Collins, Wiggin & Sawicki (2015) *Nature*]

Steve Collins

Associate Professor

Mechanical Engineering & Robotics Institute

Carnegie Mellon University



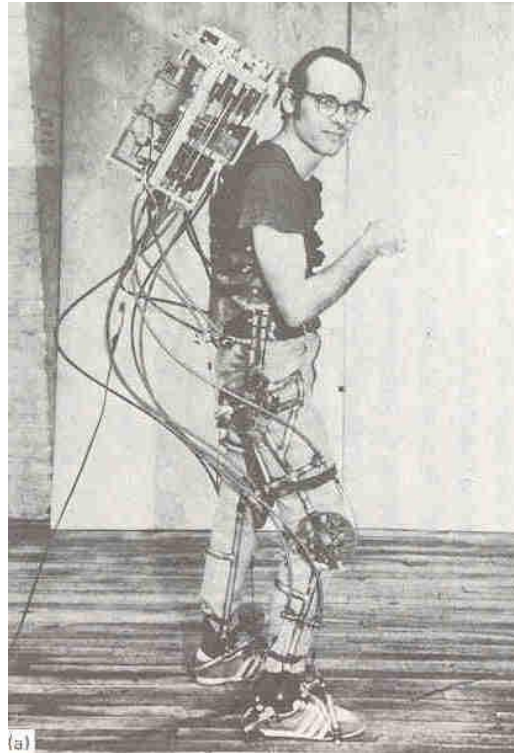
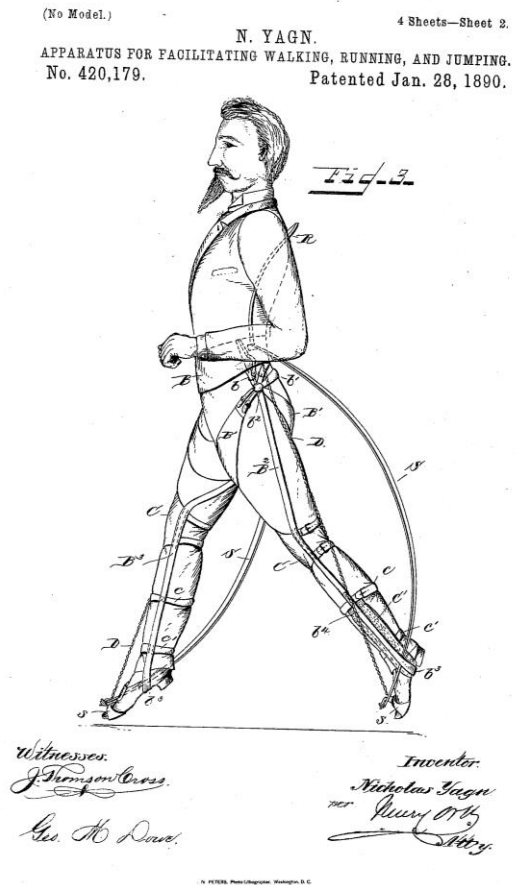
**Carnegie
Mellon
University**

Humans are expert at walking efficiently.

Walking is still most energy-intensive activity.

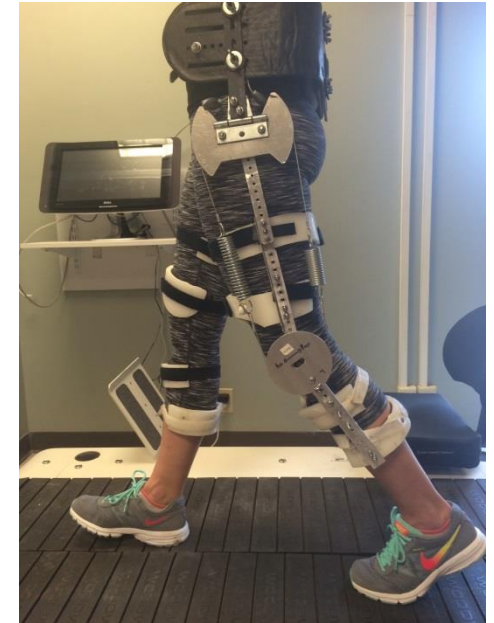
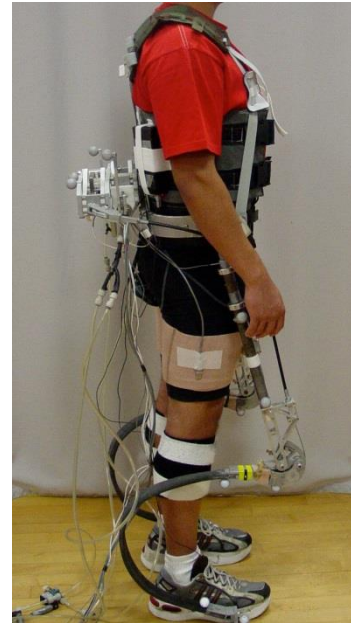
Challenge: Reduce energy cost of normal walking.

Initial attempts, 1800's and 1900's



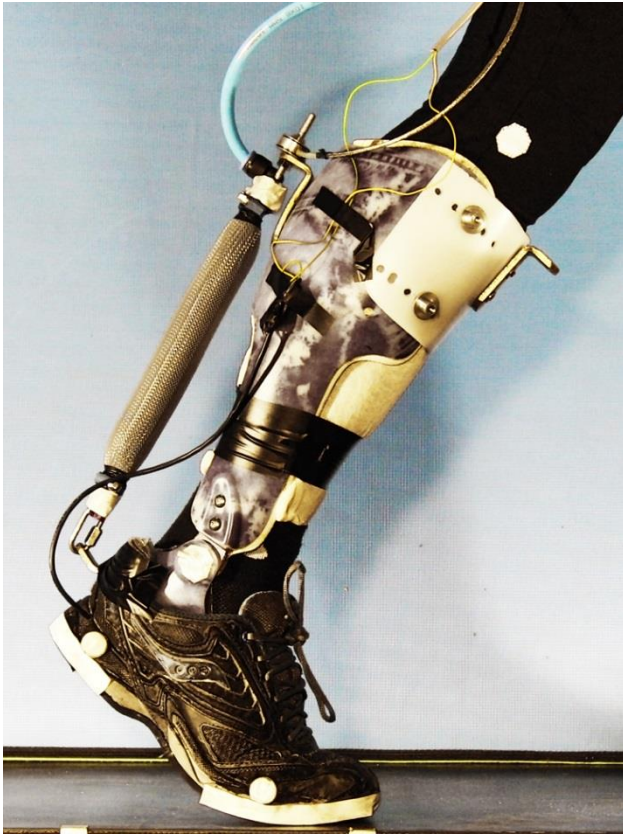
[Yagn (1890) Patent; Seireg (1971); GE Hardiman (1965)]

Recent serious attempts



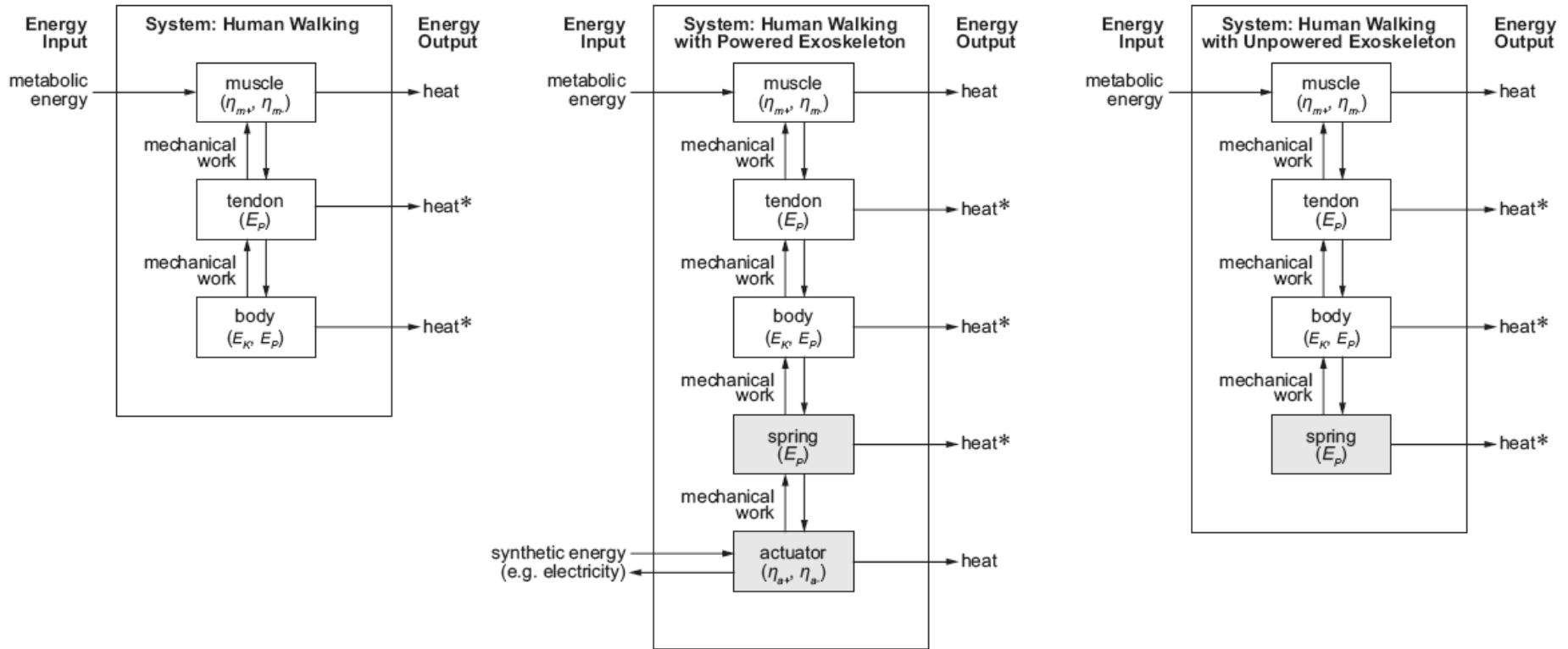
[Zoss et al. (2006); van Dijk et al. (2011); Cherry et al. (2009); Charalambous et al. (2012)]

Success with powered devices, 2013—2014



[Malcolm et al. (2013); Mooney et al. (2014)]

Energy flow in steady-state, level walking



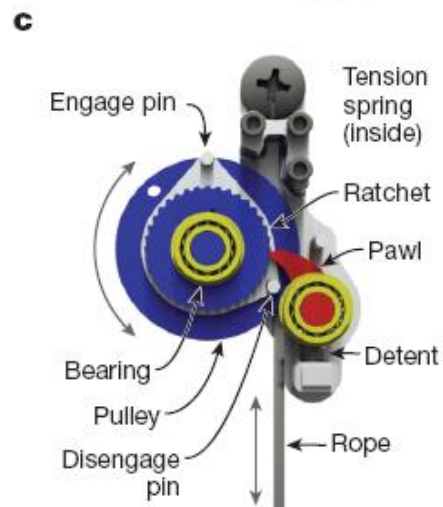
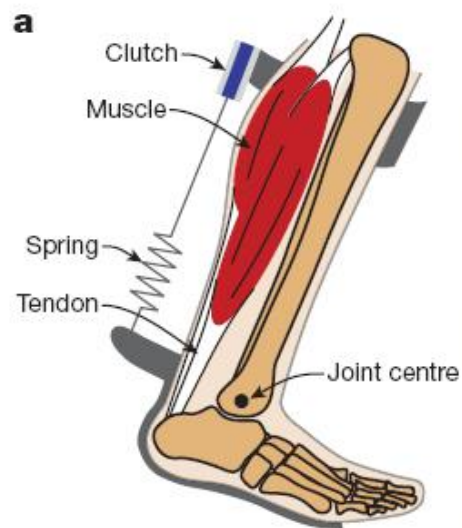
Wasted energy: Muscle inefficiencies.

Related unpowered successes, 2006—2012



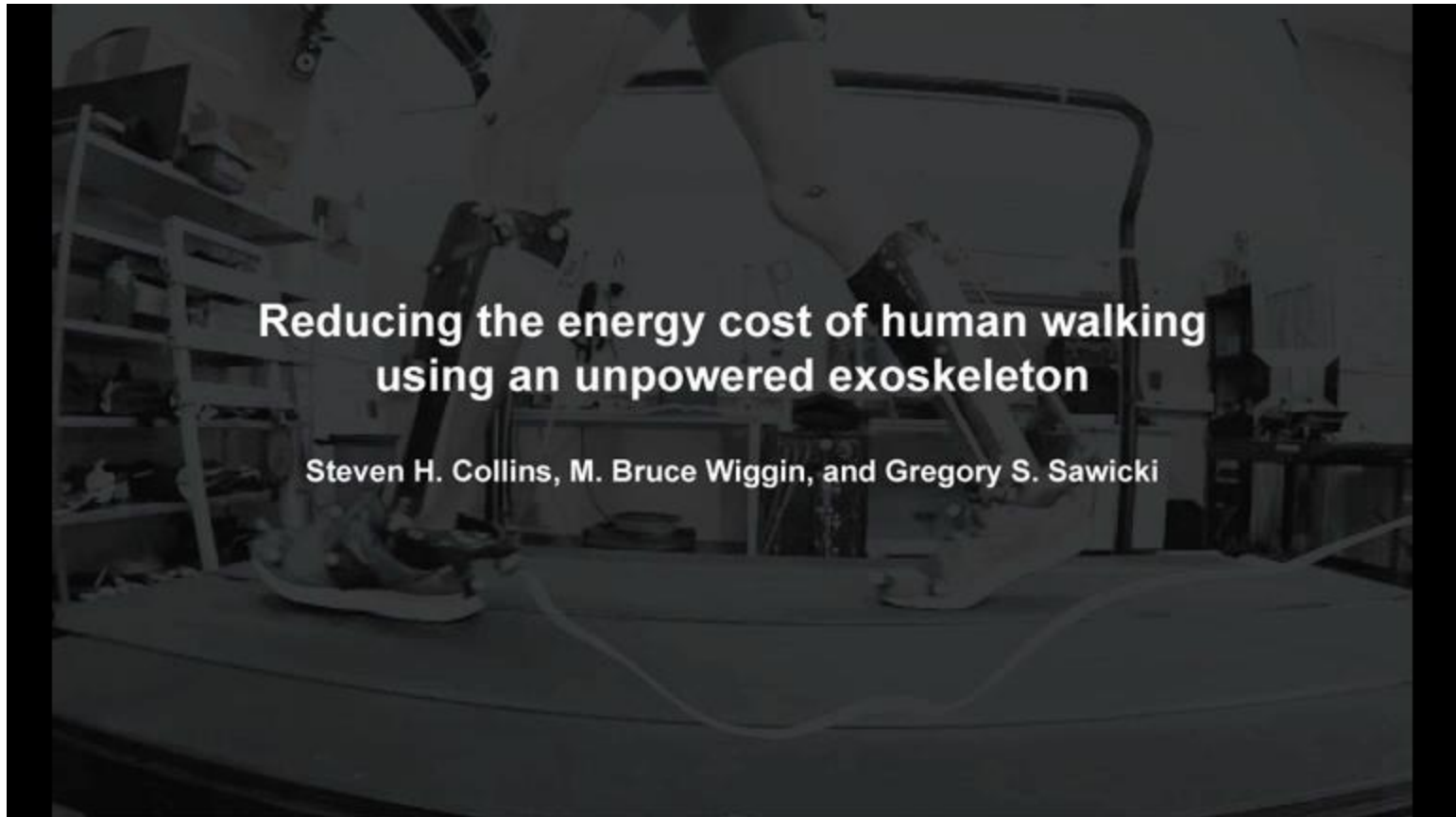
[Rome et al. (2006); Franz et al. (2012); Donelan et al. (2008); Grabowski et al. (2009)]

Our Device: Passive Exoskeleton Targets Calves



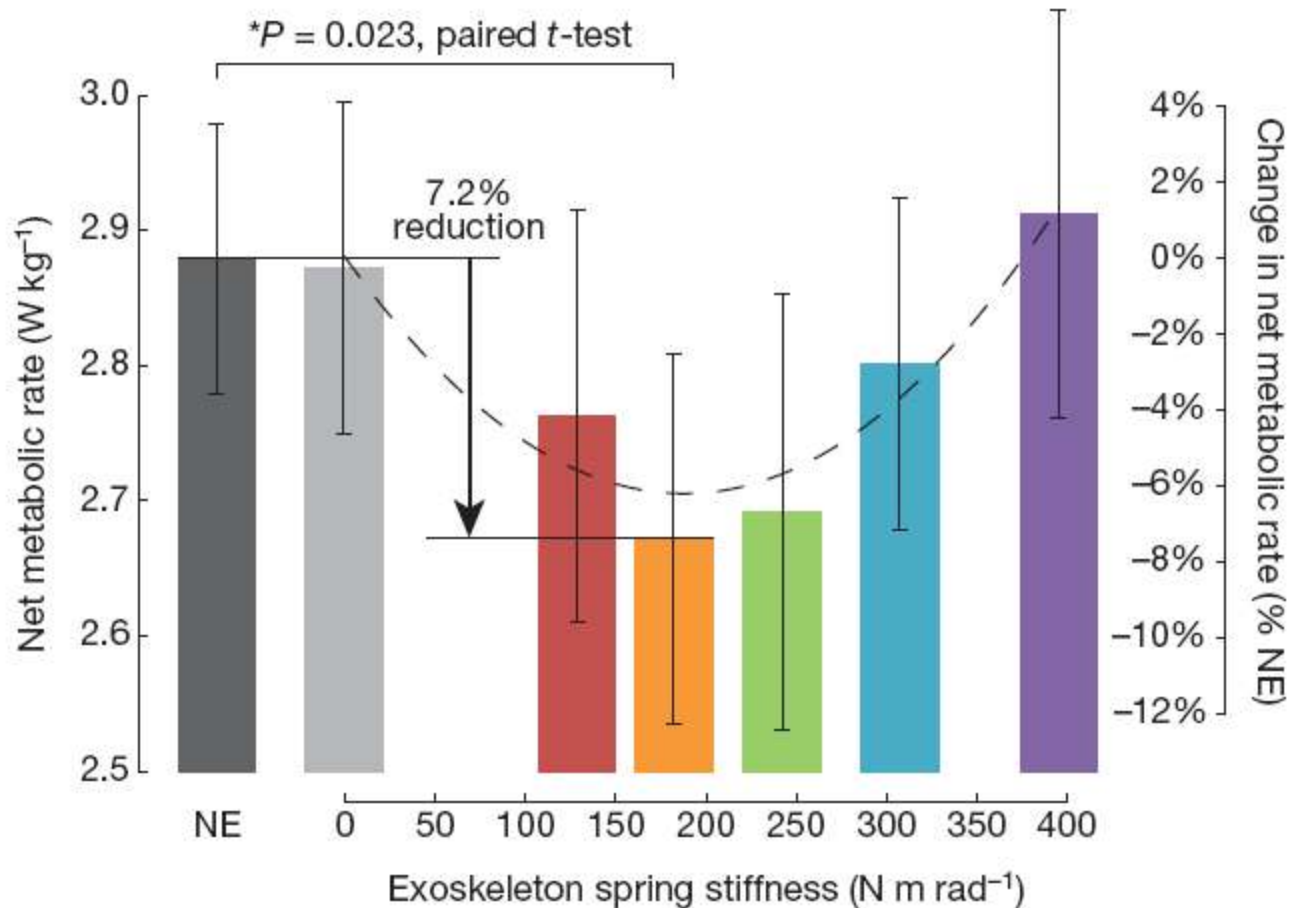
[Collins, Wiggin & Sawicki (2015) *Nature*]

Our Device: Passive Exoskeleton Targets Calves



[Collins, Wiggin & Sawicki (2015) *Nature*]

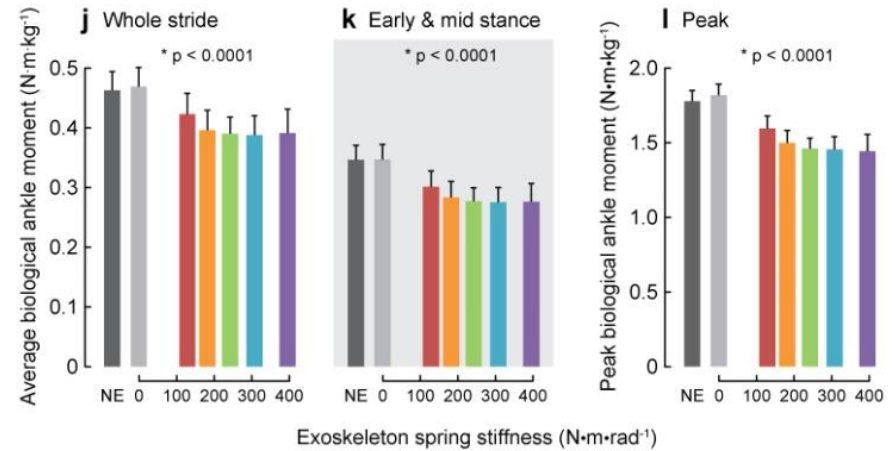
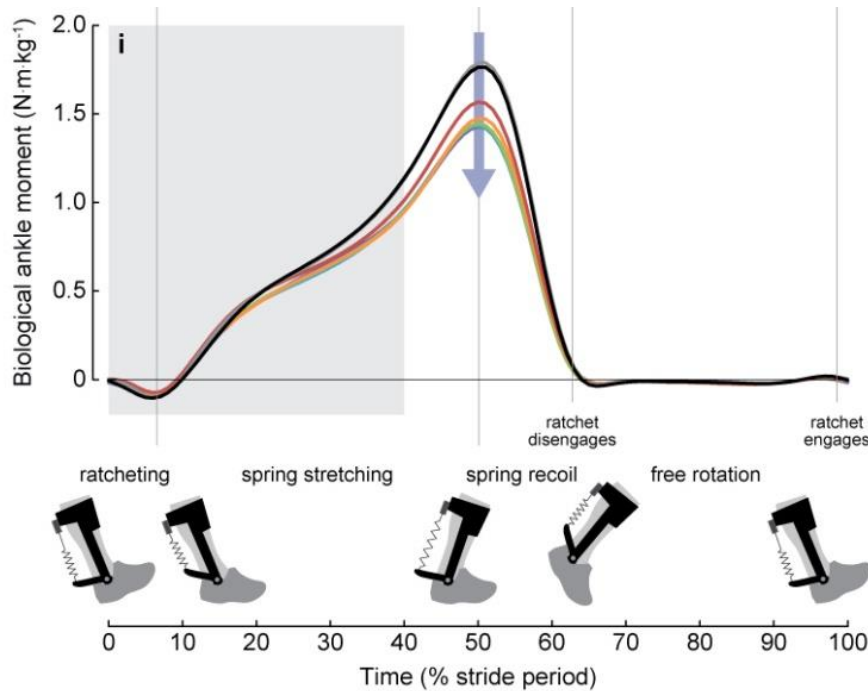
Beating evolution: More efficient walking



[Collins, Wiggin & Sawicki (2015) *Nature*]

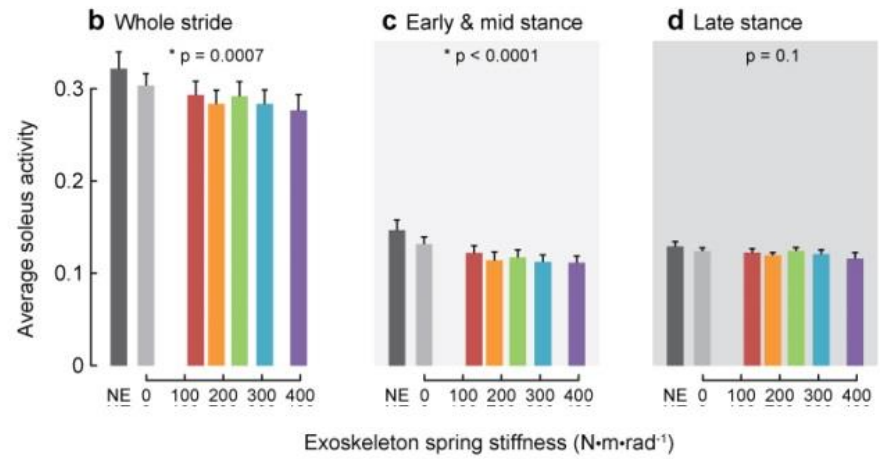
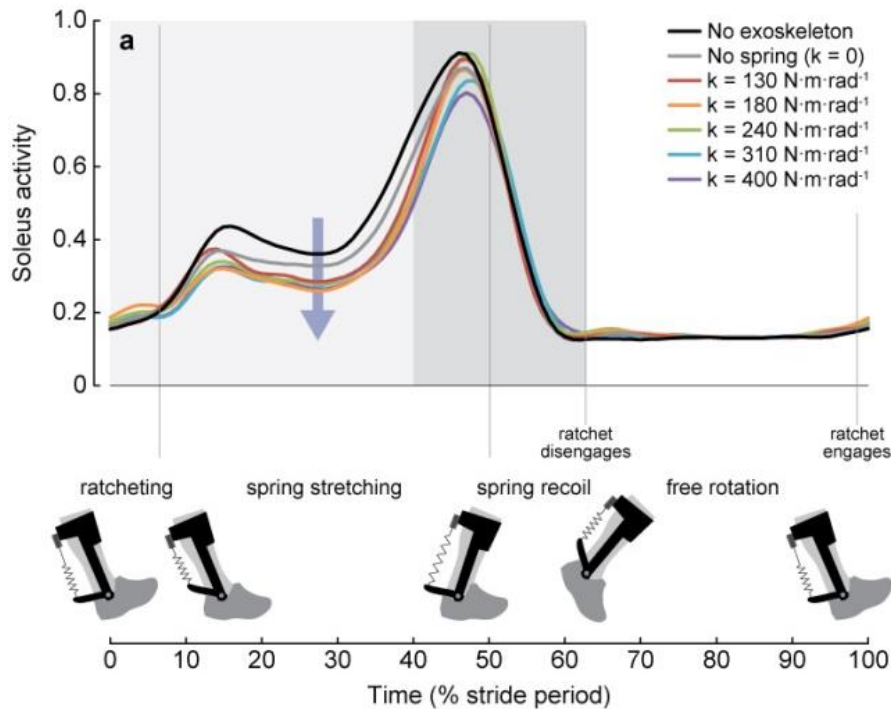
Does 7% matter?: Yes.

How? Reduced muscle force



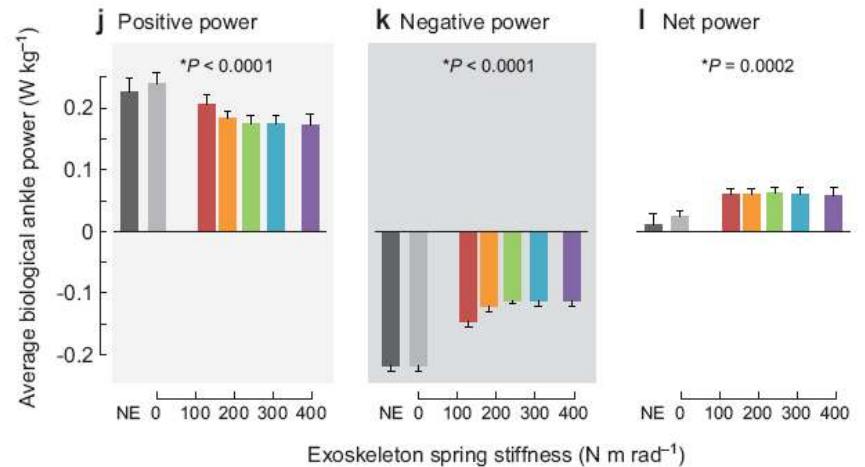
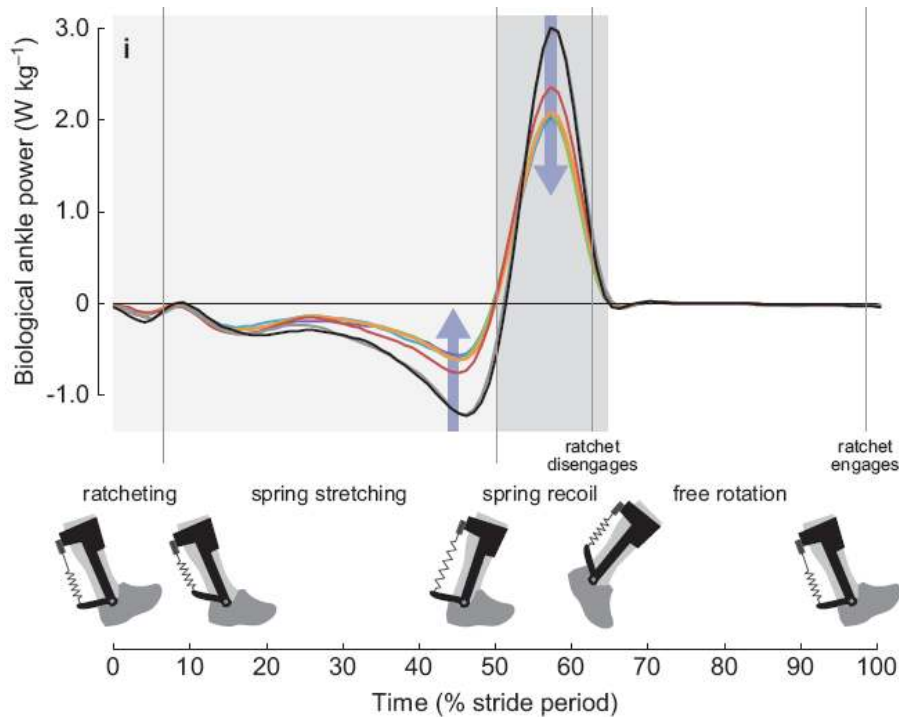
[Collins, Wiggin & Sawicki (2015) *Nature*]

How? Reduced muscle activation



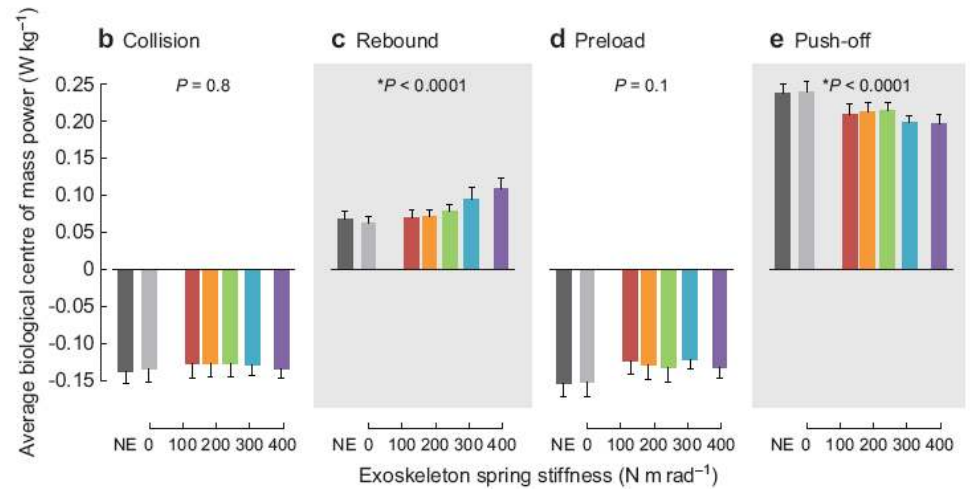
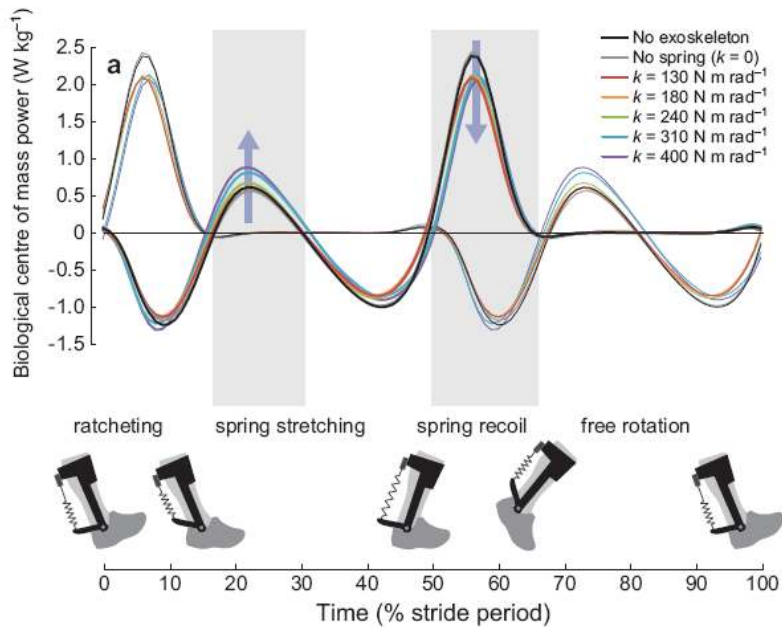
[Collins, Wiggin & Sawicki (2015) *Nature*]

How? Probably not muscle work



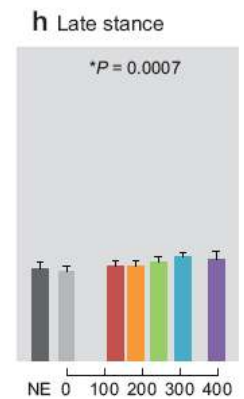
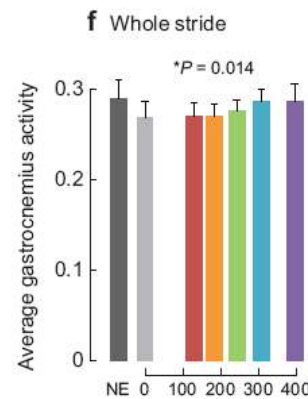
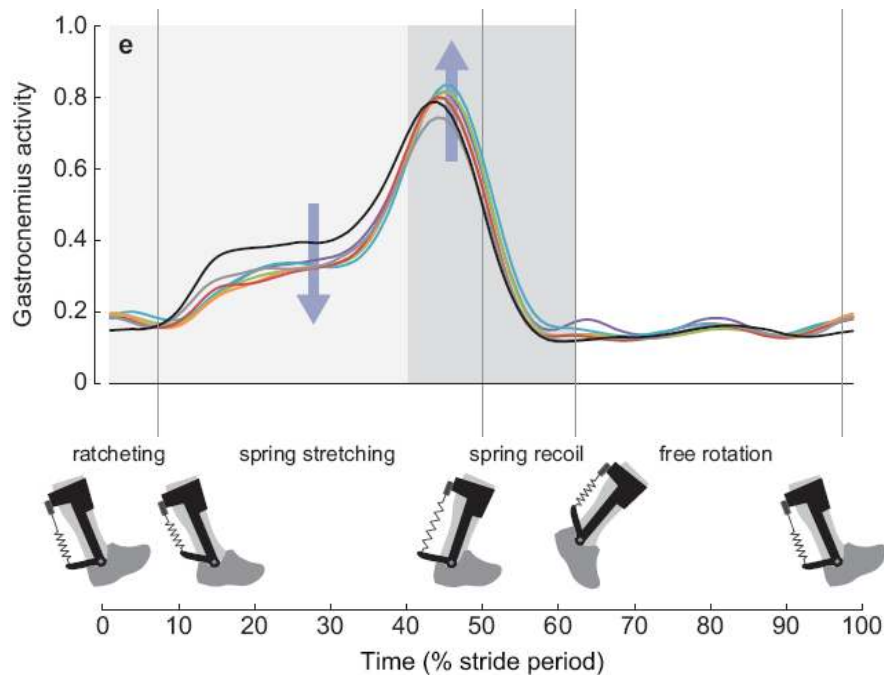
[Collins, Wiggin & Sawicki (2015) *Nature*]

How? Not center of mass work



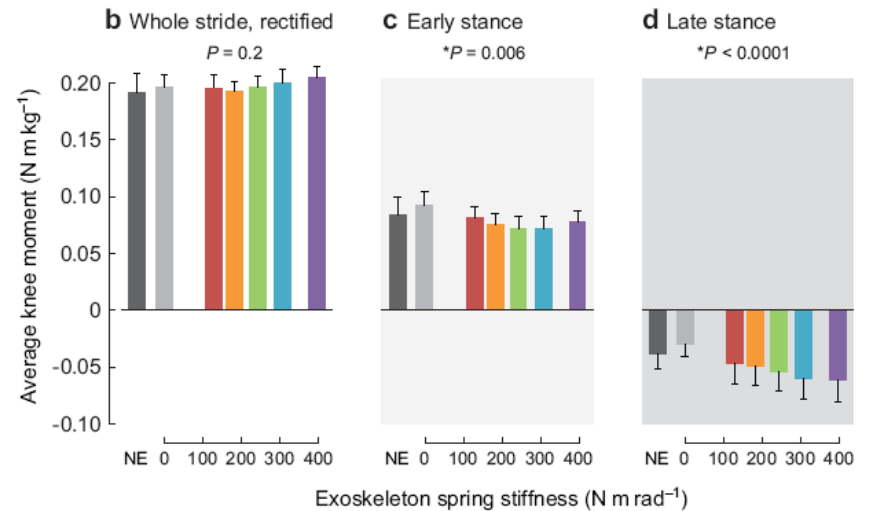
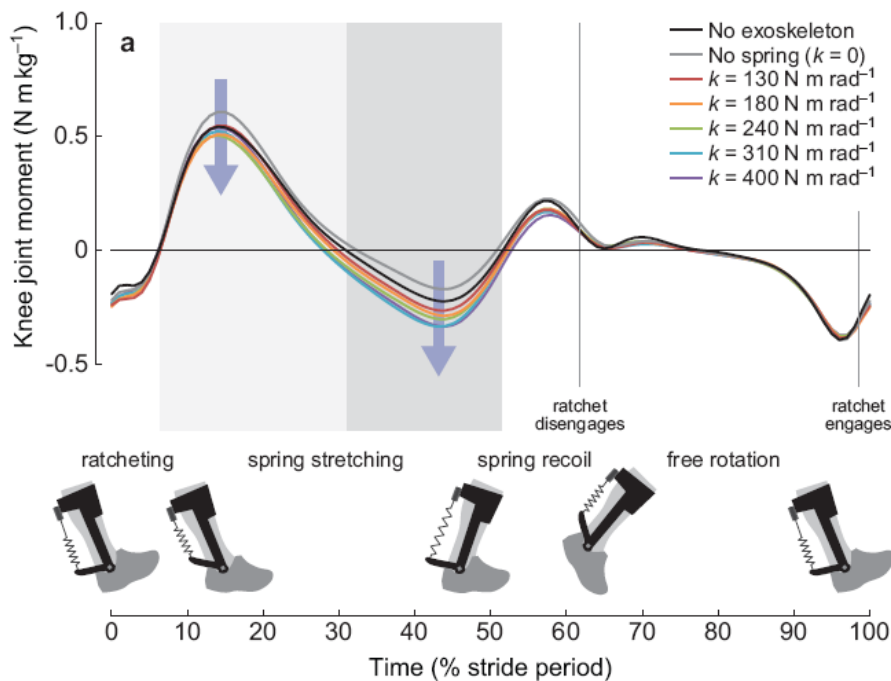
[Collins, Wiggin & Sawicki (2015) *Nature*]

Why back up? Calf muscle-tendon dynamics



[Collins, Wiggin & Sawicki (2015) *Nature*]

Why back up? Knee moments



[Collins, Wiggin & Sawicki (2015) *Nature*]

Conclusions:

1. Efficiency of human gait **can** be improved
2. Key: biomechanics knowledge (not tech)
3. Formula: lightweight + medium force (+ work)

Discussion.



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University**

Discussion.



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