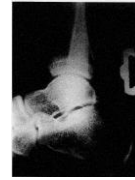


The role of tendon elasticity for sports performance

Jun.-Prof. Kirsten Albracht

Institute of Biomechanics and Orthopaedics
 German Sport University Cologne
 albracht@dshs-koeln.de

Achilles tendon forces during human running



Komi et al. 1992, J Sports Sci

5 – 12 times
 body weight

Sports performance

No series-elastic compliance in all MTUs
 ↓ 26% maximum sprinting velocity
 (Miller et al., 2012, J Biomech)

No series-elastic compliance in the Achilles Tendon
 ↓ 10% maximum walking velocity
 (Sellers et al., 2010, Int J Primatol)

Material properties are important for tendon function

Jumps with a run up



<http://www.iaaf.org/about-iaaf/documents/research>

Source of energy

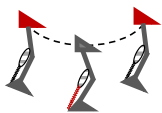


COM
 ‚energy conservation‘

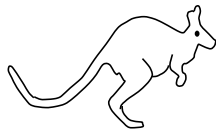
Muscle
 ‚power amplification‘

modified from Roberts & Azizi, 2011, J Exp Biol

Energy conservation

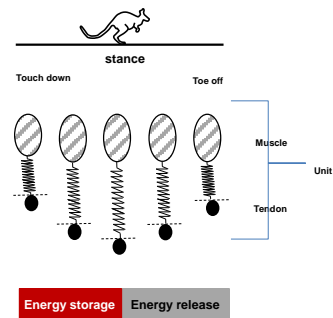


COM
 ‚energy conservation‘



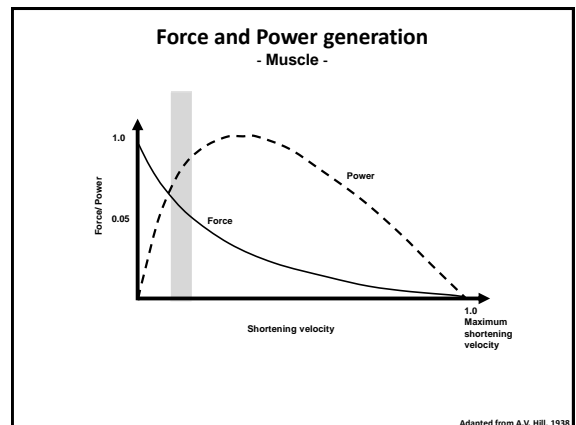
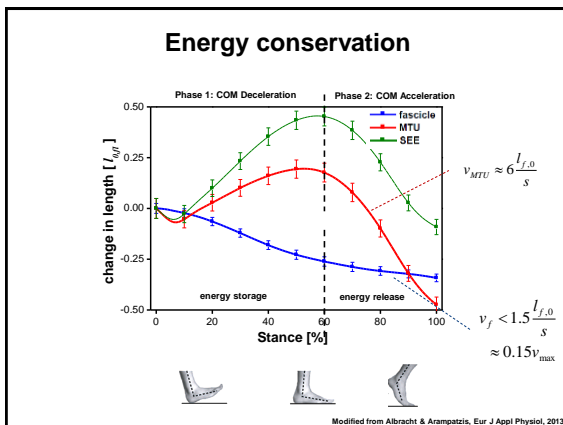
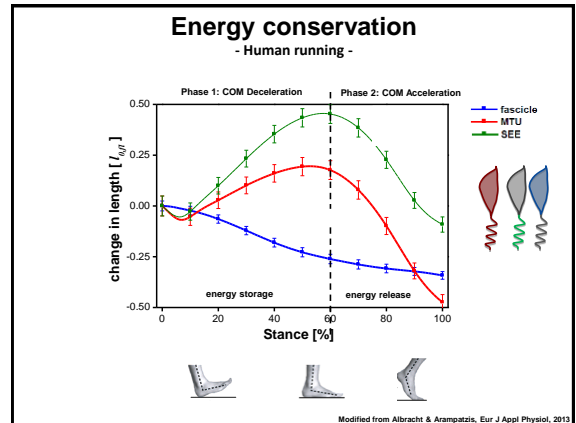
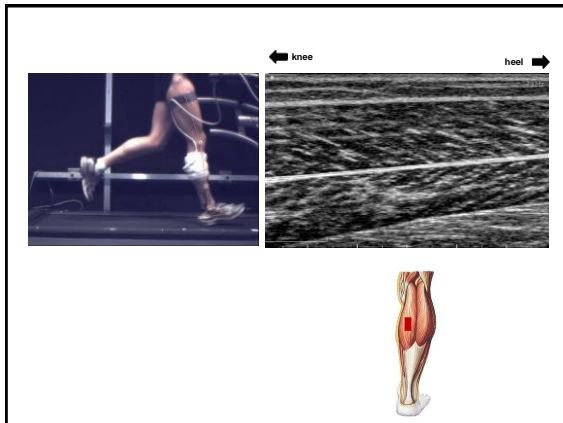
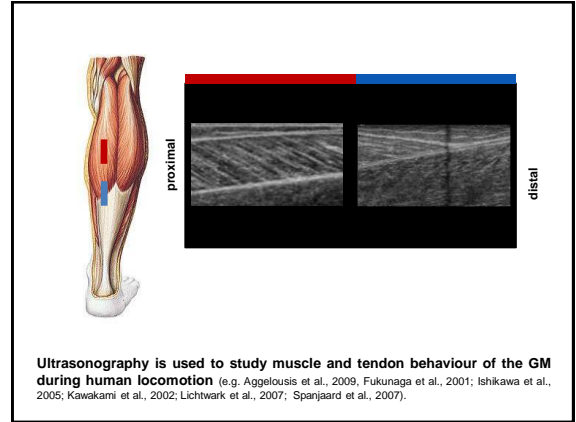
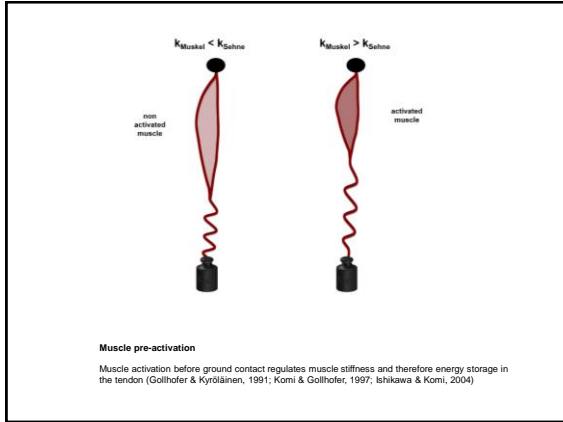
http://www.oeb.harvard.edu/bifilates/cfs/movie/cfs_wallyaby.avi

Biewener et al., J Exp Biol, 1998
 Roberts & Azizi, J Exp Biol, 2011




Energy storage Energy release

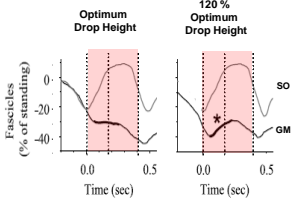
Biewener et al., J Exp Biol, 1998
 Roberts & Azizi, J Exp Biol, 2011



Over-challenging situation



Drop jumps




Optimum Drop Height 120% Optimum Drop Height

Fascicles (% of standing)

Time (sec)

SO

GM




Modified from Ishikawa & Komi, Exercise and Sport Science Reviews, 2008

Tendon function

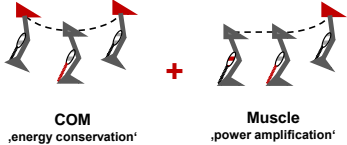
- ↳ Force transmission
- ↳ Energy Storage & Release
- ↳ Decoupling of the muscle from the entire muscle-tendon unit
 - enable the muscle to work at a higher force potential due to the force length and force velocity relationship

Jumps with a run up



<http://www.iaaf.org/about-iaaf/documents/research>

Source of energy

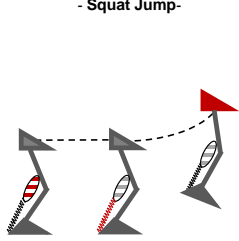


COM 'energy conservation'

Muscle 'power amplification'

Modified from Roberts & Azizi, 2011, J Exp Biol

Power Amplifikation - Squat Jump-




Power = Work / Time

„Catapult effect“

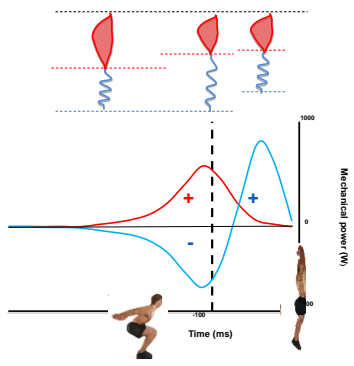
Roberts & Azizi, 2011, J Exp Biol

The catapult mechanism of frog jumping



<http://video.nationalgeographic.com/video/news/frog-muscle-study>

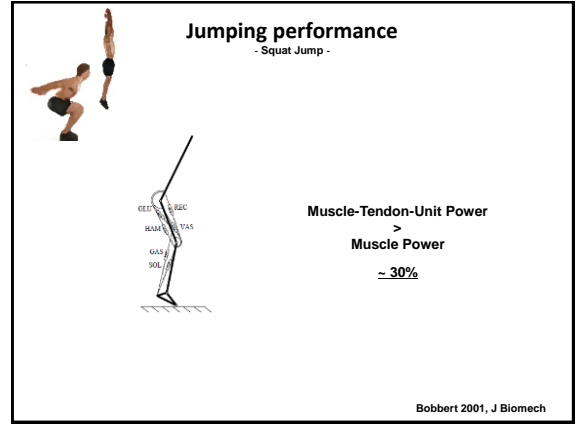
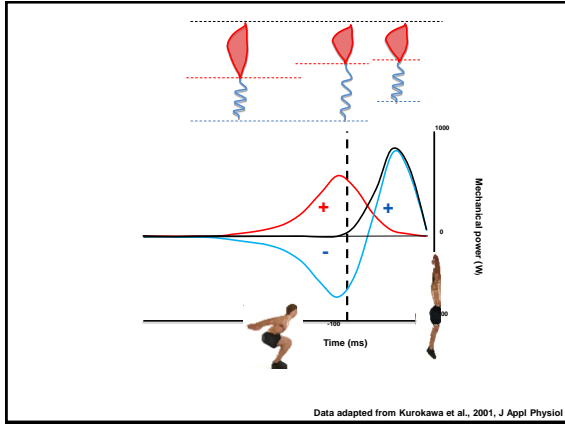
H. C. Astley & T. I. Robert, 2012
Roberts, T. J., Abbott, E. M. and Azizi, E. 2011



Mechanical power (W)

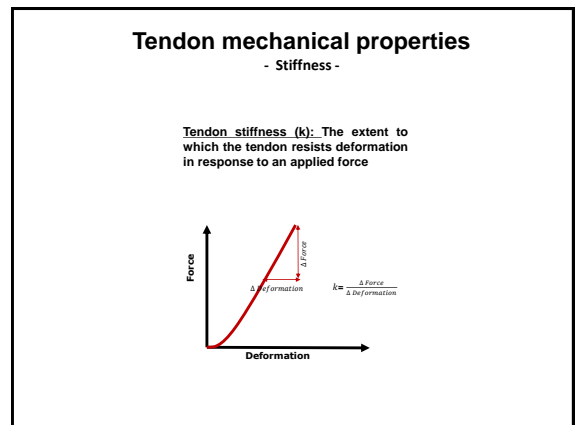
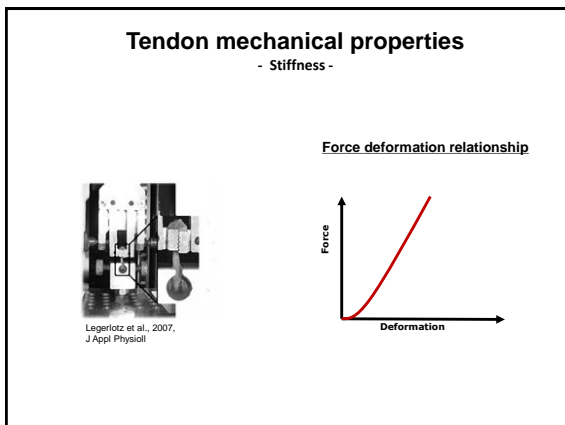
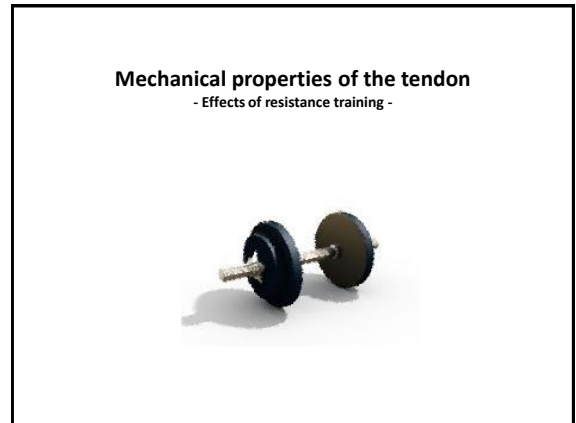
Time (ms)

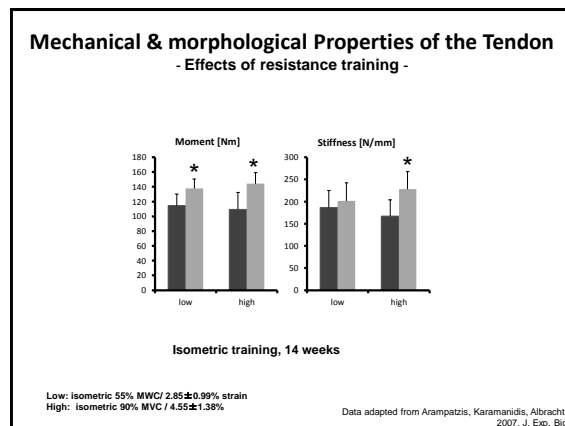
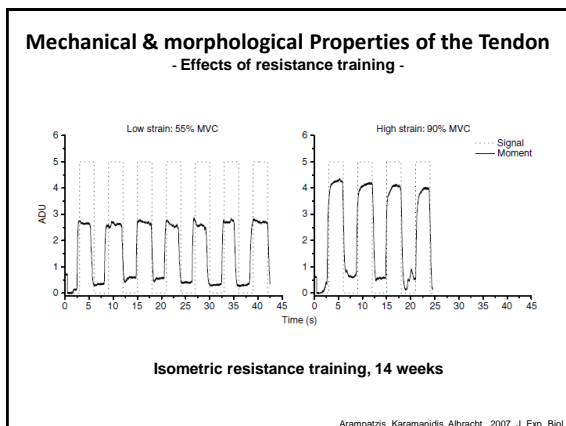
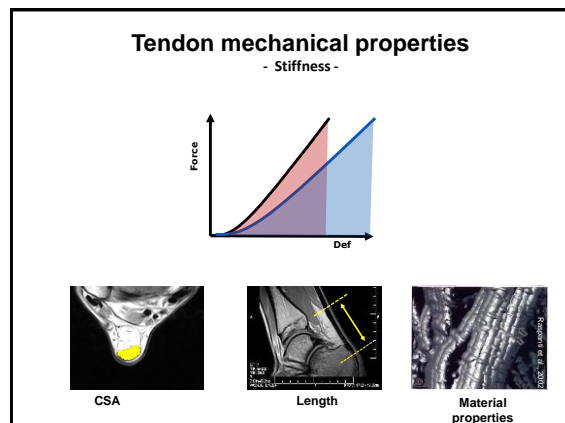
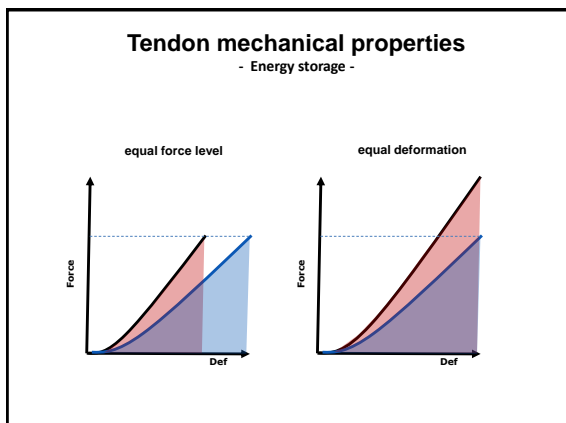
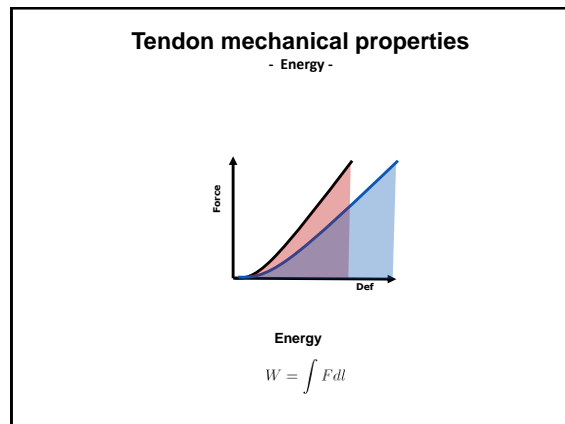
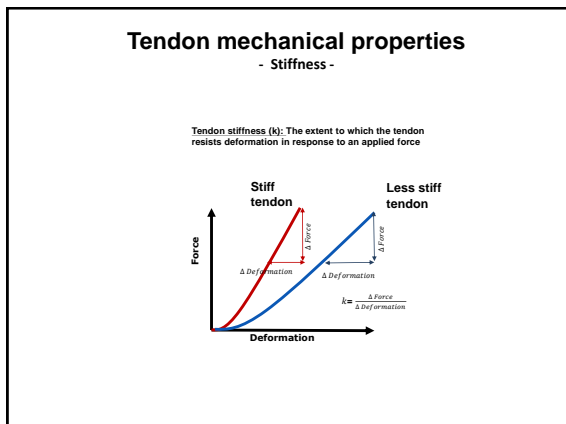
Data adapted from Kurokawa et al., 2001, J Appl Physiol

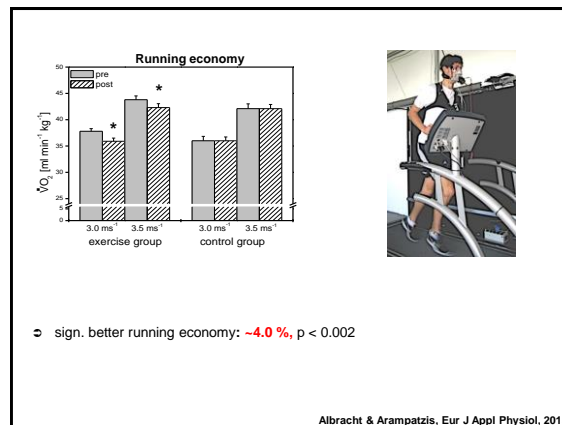
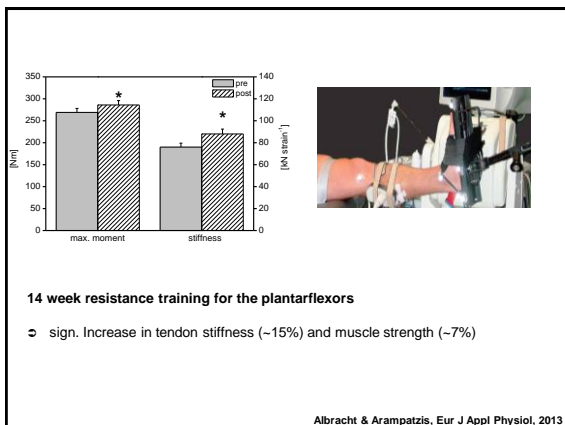
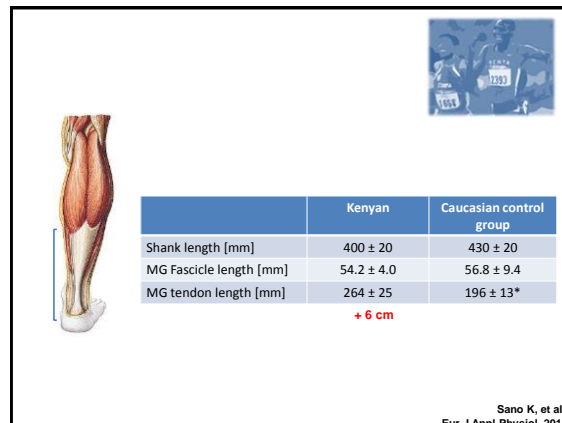
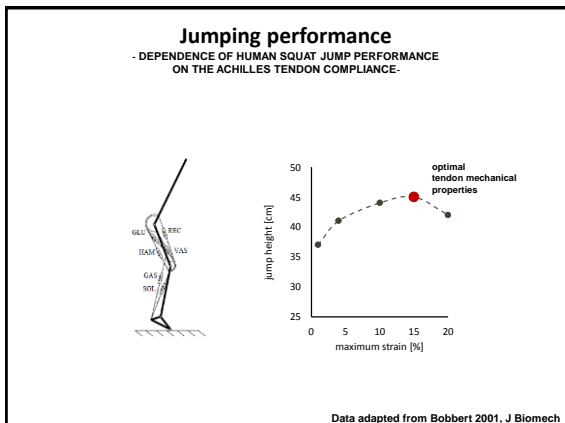
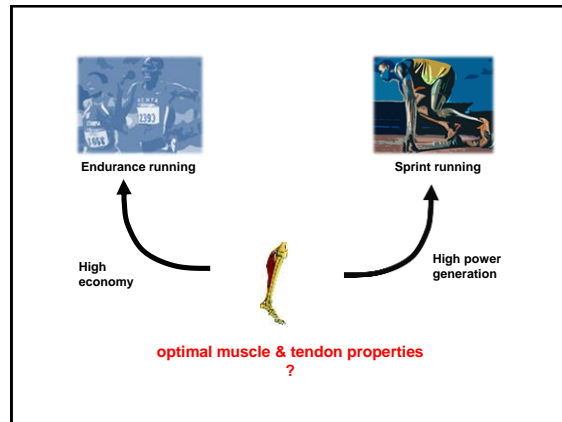
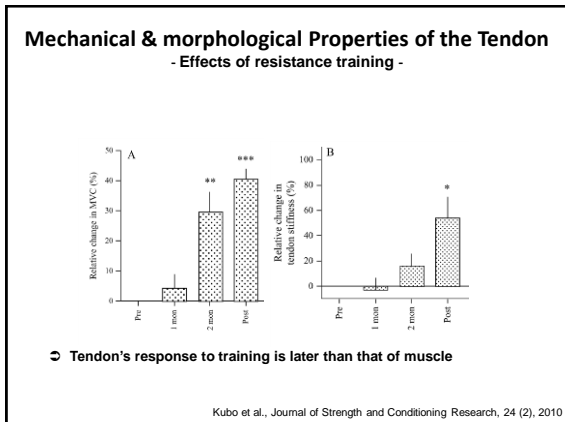


Tendon function

- ↳ Force transmission
- ↳ Energy Storage & Release
- ↳ Decoupling of the muscle from the entire muscle-tendon unit
 - enable the muscle to work at a higher force potential due to the force length and force velocity relationship
 - high power output due to a quick release of the stored energy







Conclusion

- ↳ Tendons material properties play an important role in athletic performance (Bobbert 2001, J Biomech, Miller et al., 2012)
- ↳ Tendons have the potential to adapt (CSA, material properties)
- ↳ Tendons' response to training is later than that of muscle (Kubo, 2008, J Theor Biol)
- ↳ Optimal tendon stiffness is task specific and depends on the mechanical and morphological properties of the MTU (Lichtwark & Wilson, 2008, J Theor Biol)

Thank you for your attention

