



Sport surfaces: Performance enhancement and injury protection

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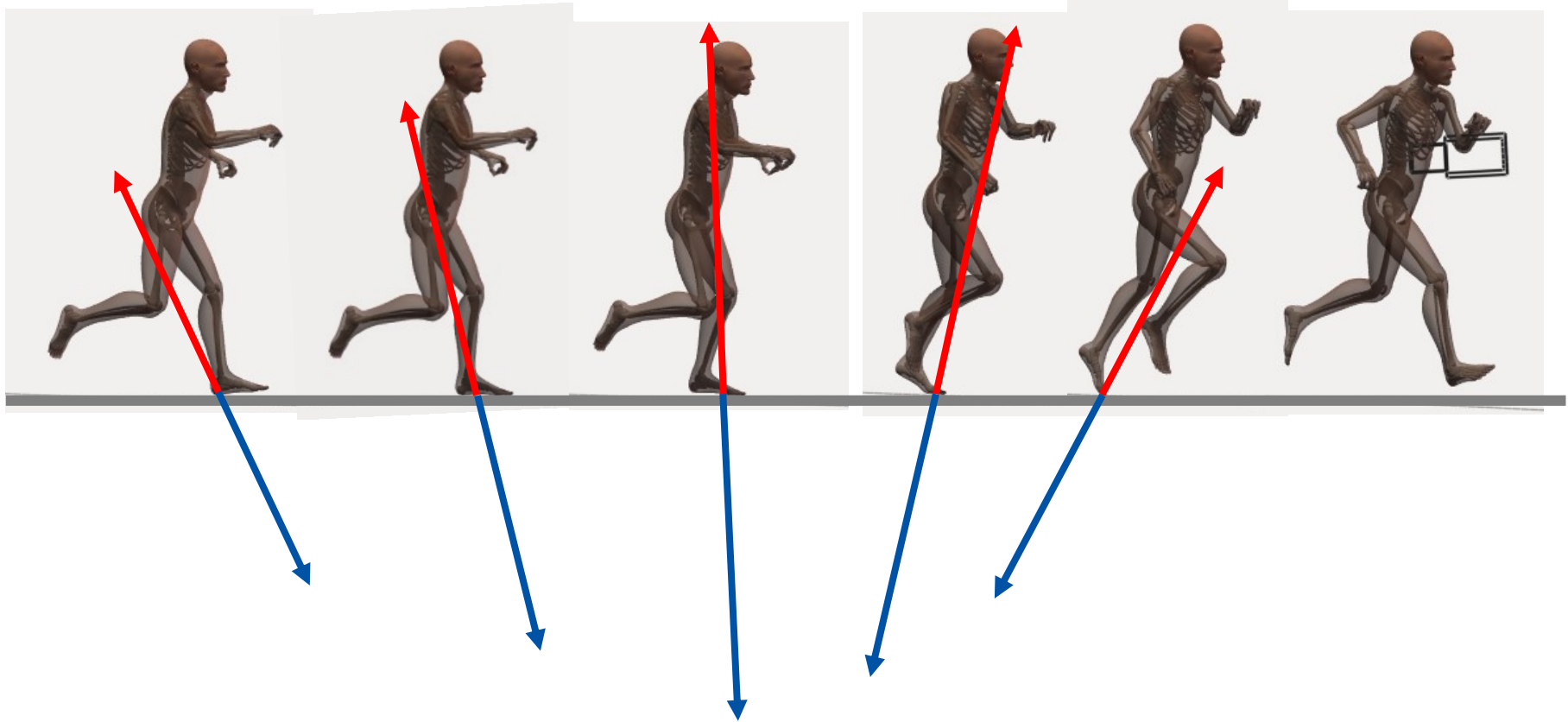
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Athlete surface interaction in sport



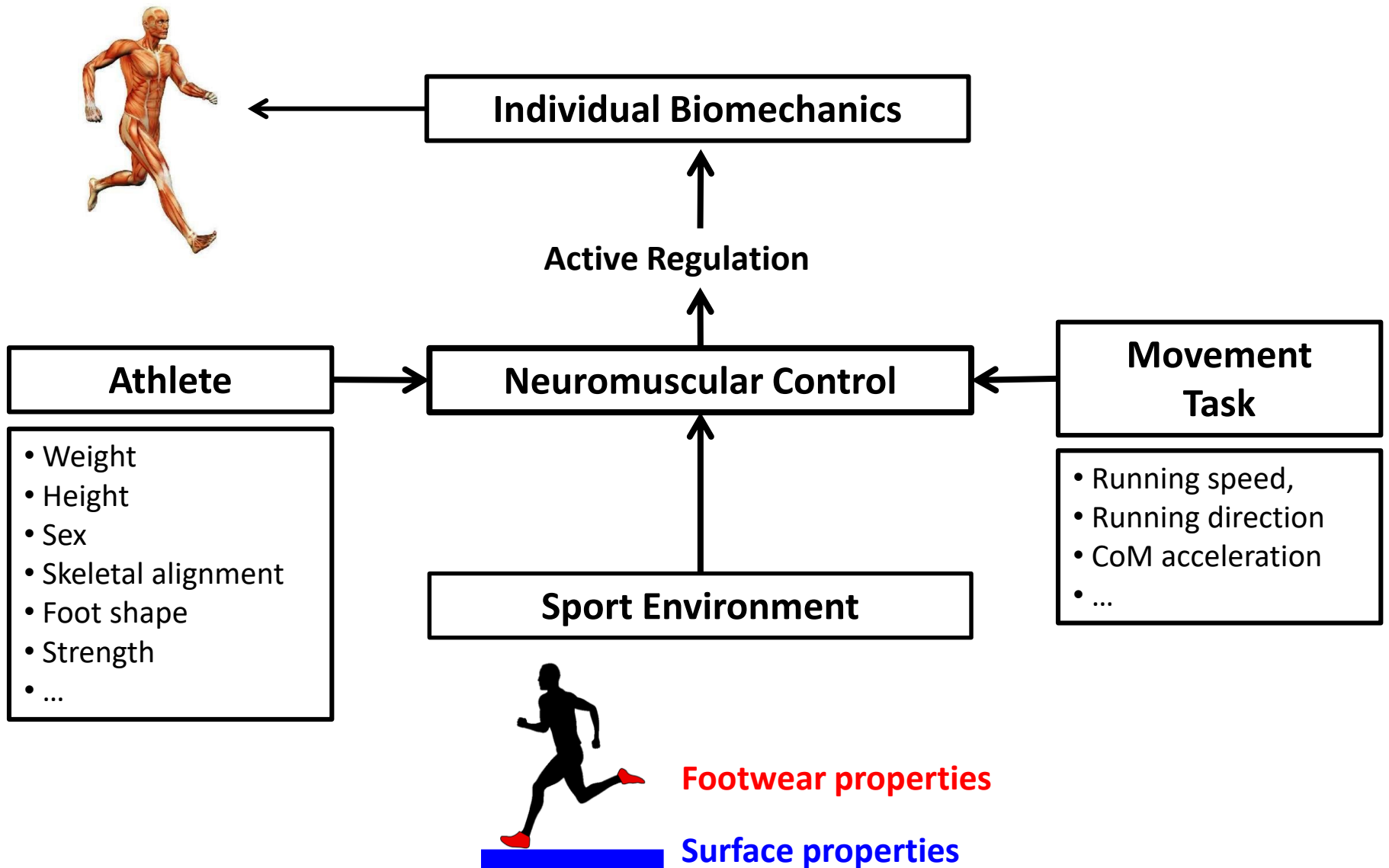


Contact phase →

Application of ground forces

(acceleration, deceleration, change of direction, jumping landing, ...)

Reaction forces acting on body (injury development)



**Surface / Footwear
Characteristics
(e.g. Traction, Stiffness)**

Performance



**(Joint) Loading
Injury Development**



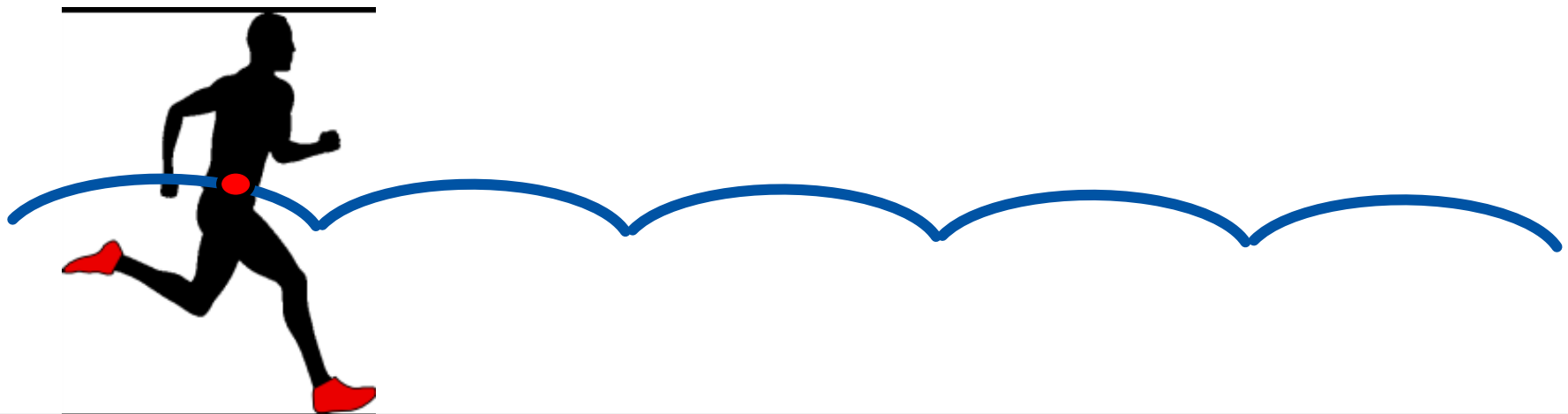
Biomechanical differences between barefoot and shod (neutral cushioned running shoe) running?

Surface effects?



Shod vs. Barefoot Running – Kinematic Differences

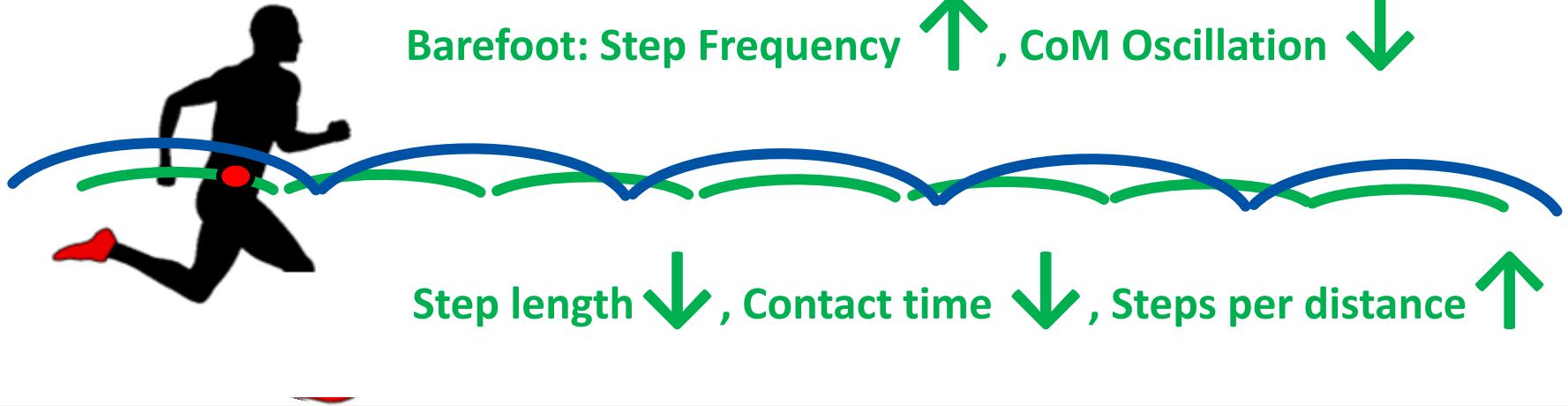
Shod



Shod vs. Barefoot Running – Kinematic Differences

Shod

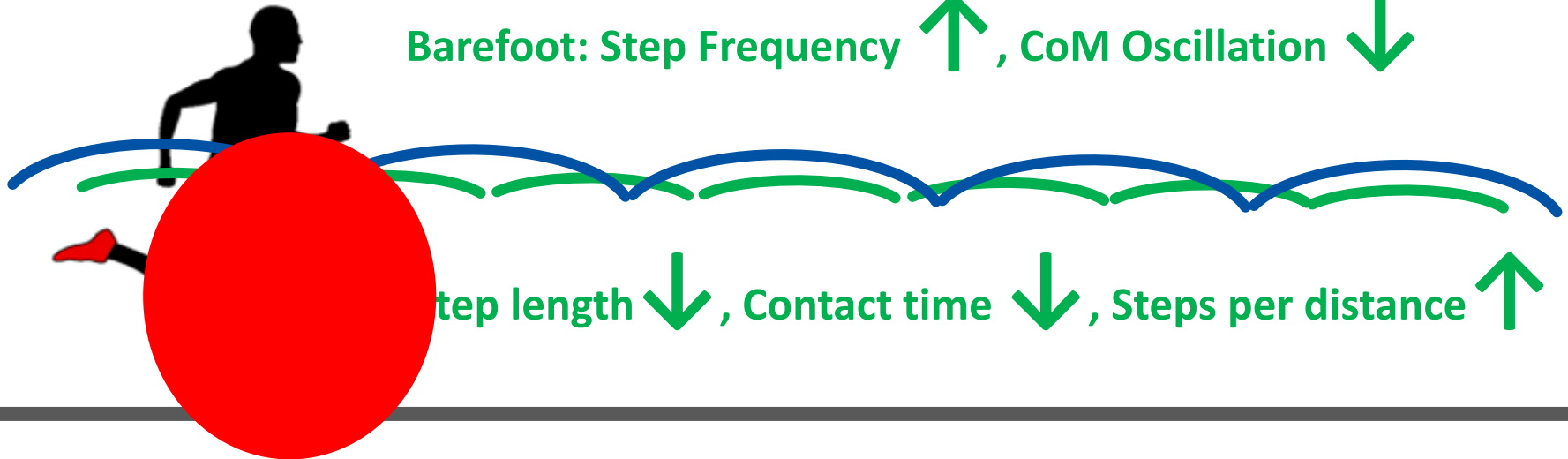
Barefoot: Step Frequency \uparrow , CoM Oscillation \downarrow



Shod vs. Barefoot Running – Kinematic Differences

Shod

Barefoot: Step Frequency \uparrow , CoM Oscillation \downarrow

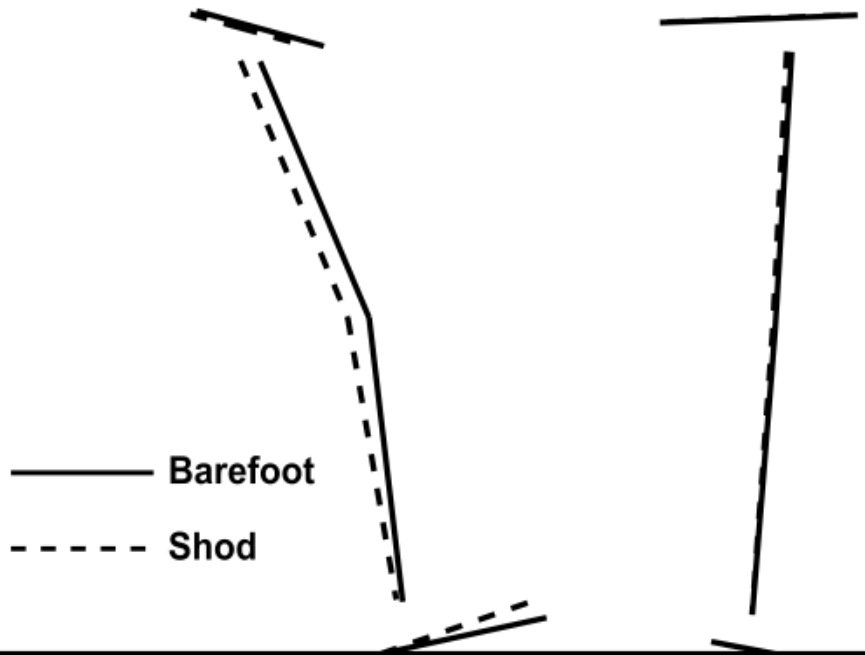


Shod vs. Barefoot Running – Kinematic Differences

Leg geometry at touchdown

Sagittal plane

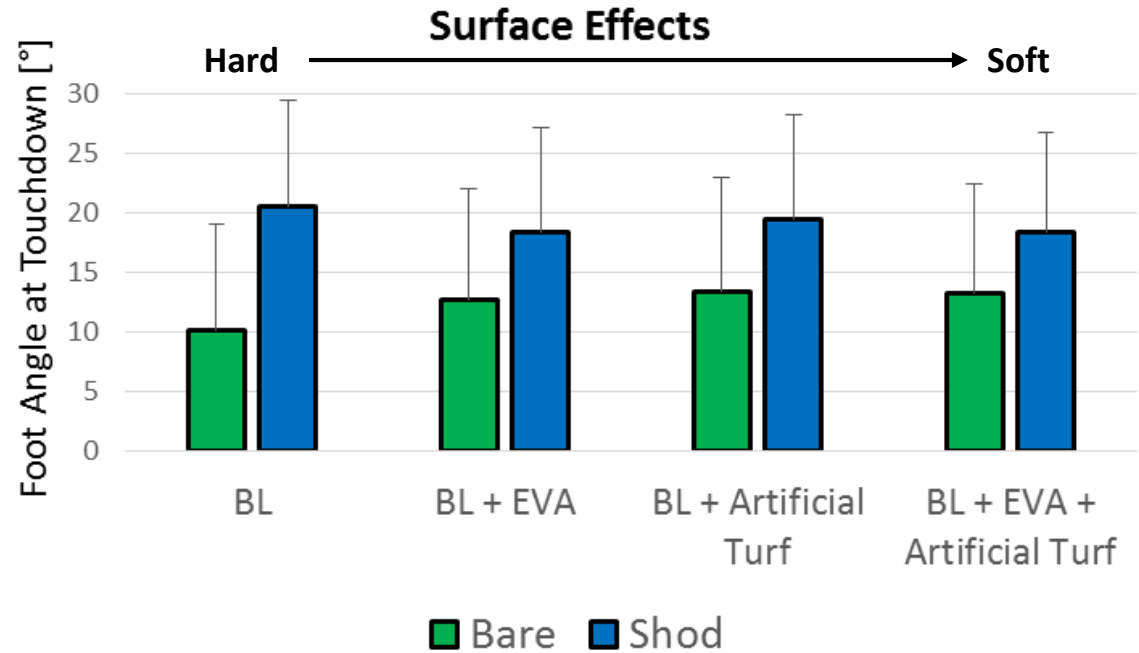
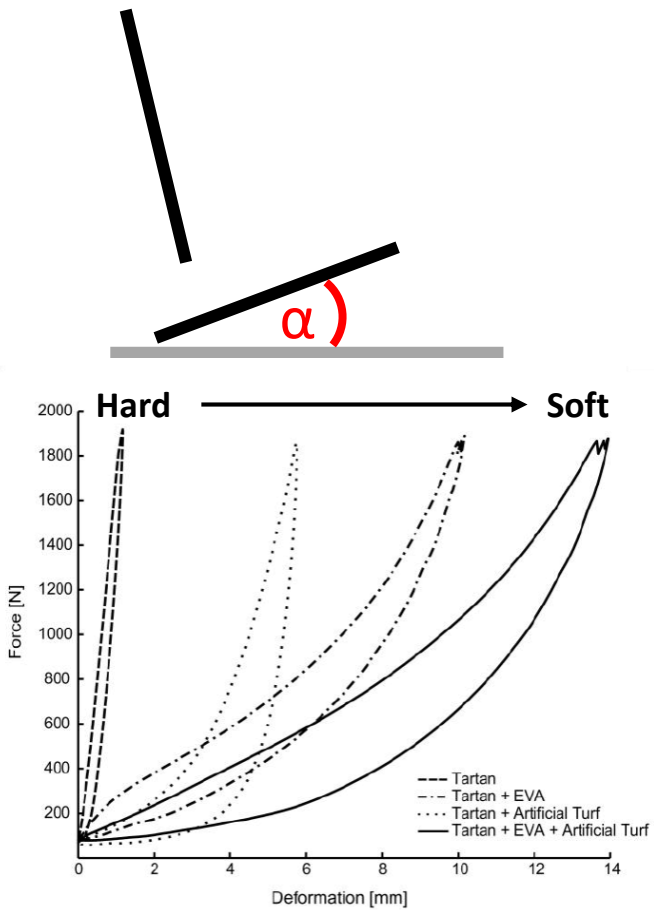
Frontal plane
(dorsal view)



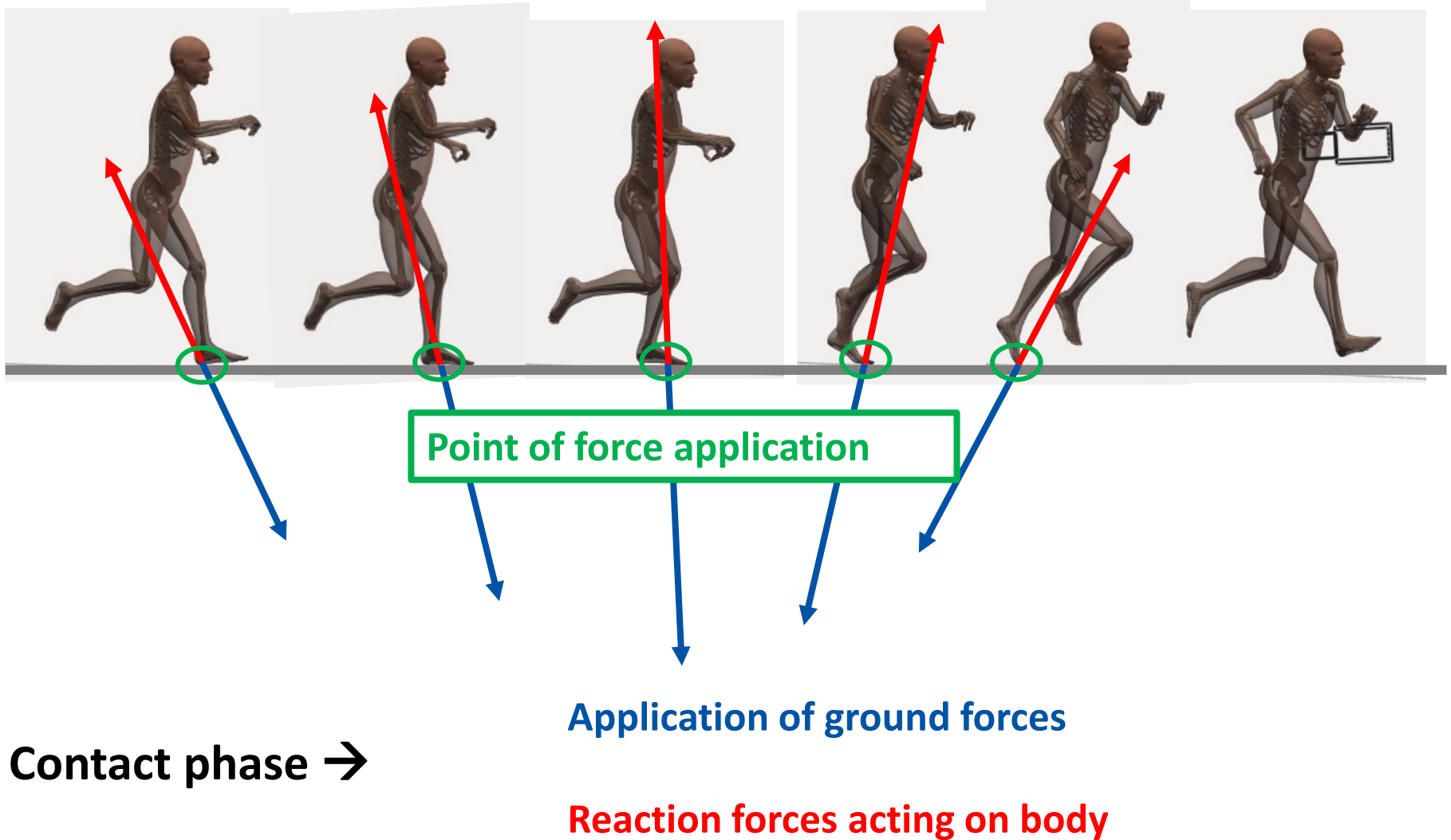
Average over different
running surfaces!

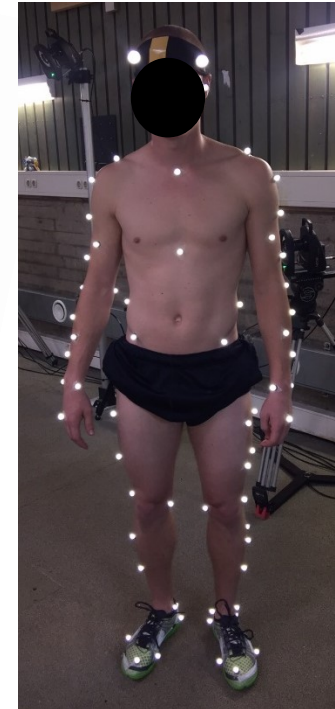
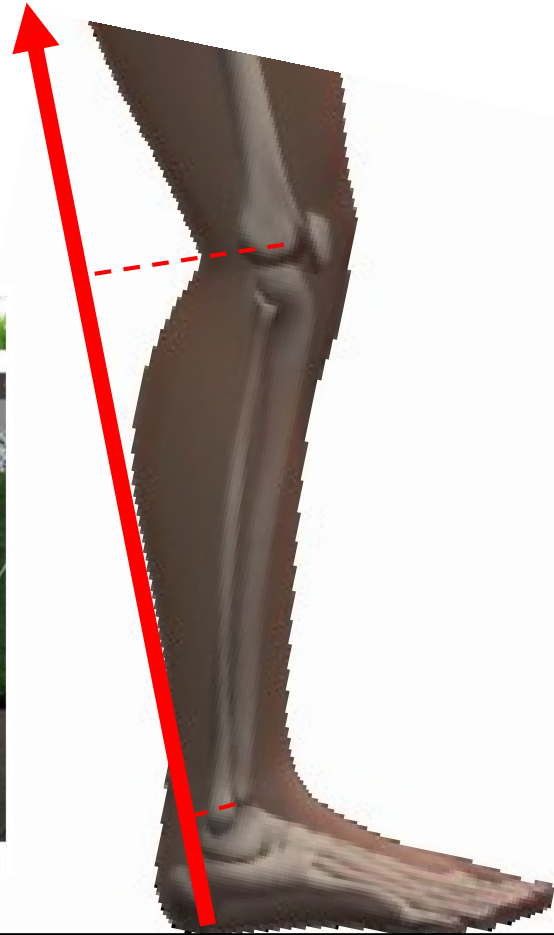
N = 39 (20 ♂, 19 ♀); Running speed = 3.5 m/s

Willwacher et al. 2013



N = 39 (20♂, 19♀); Running speed = 3.5 m/s





Forceplate

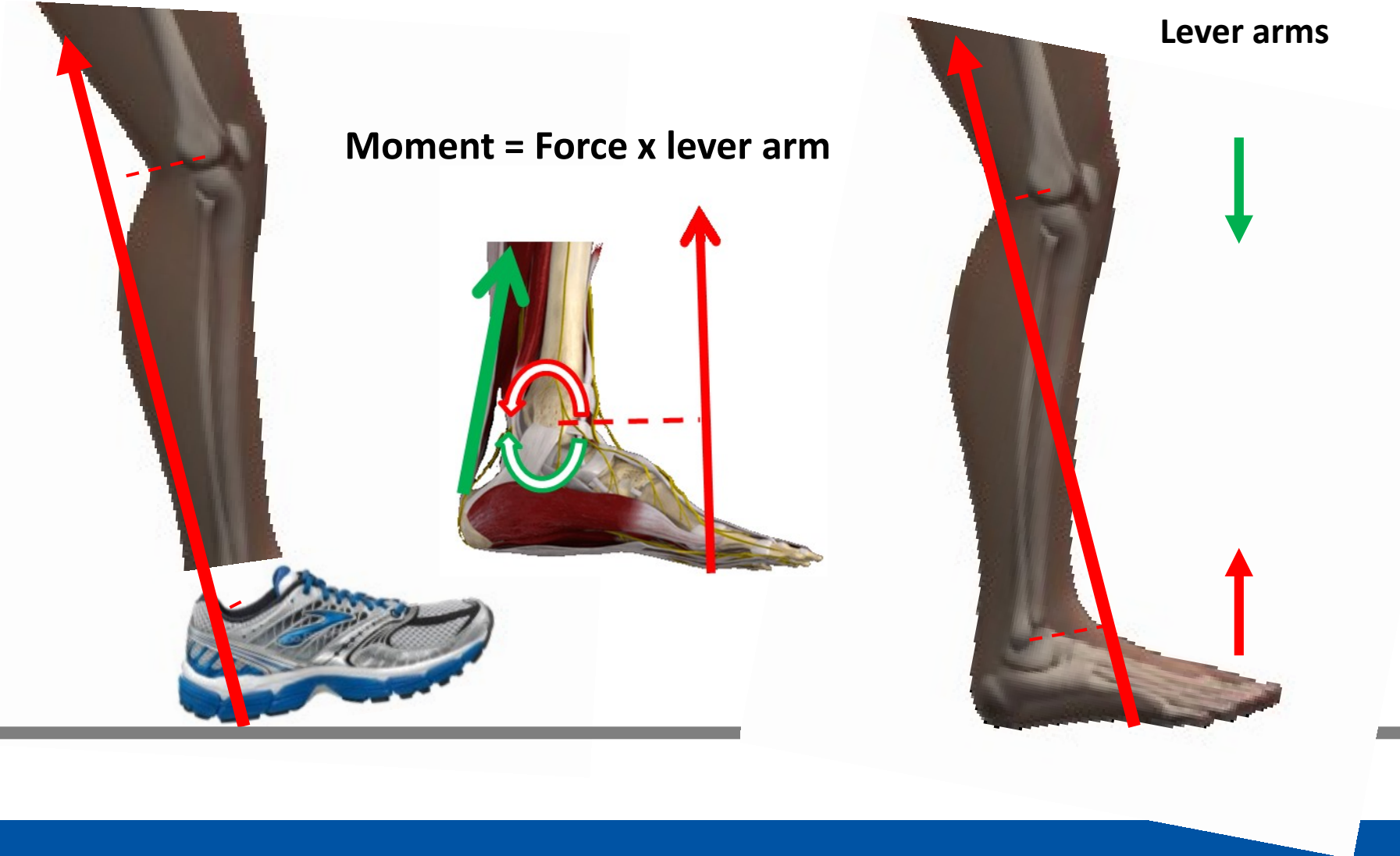
External joint moments:

- are induced by external, inertial and gravitational forces
- are counteracted by **internal joint moments**, mainly created by muscle tendon unit, ligament and bone to bone contact forces
- Provide an estimate of the net loading of these structures

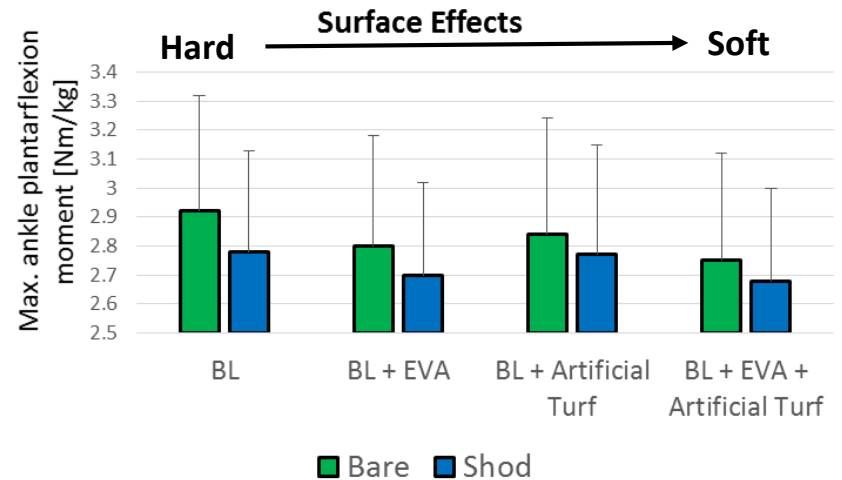
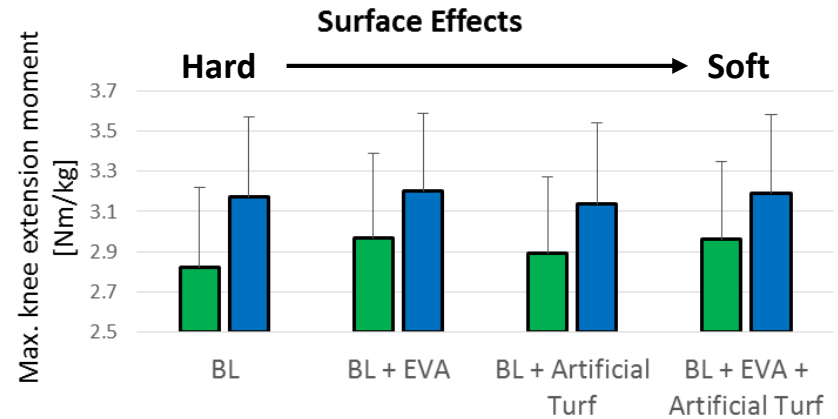
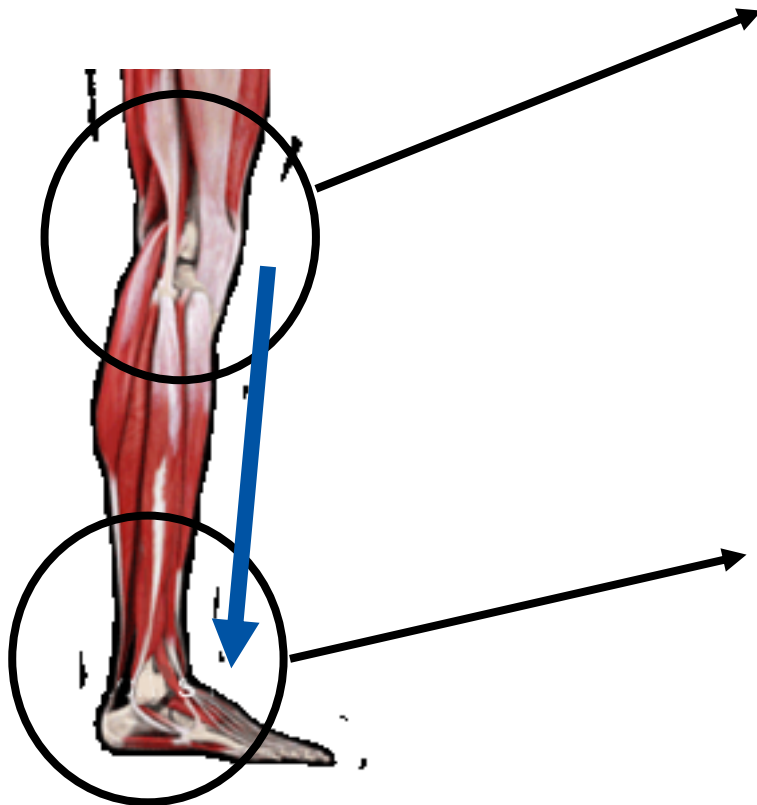


Moment = Force x lever arm

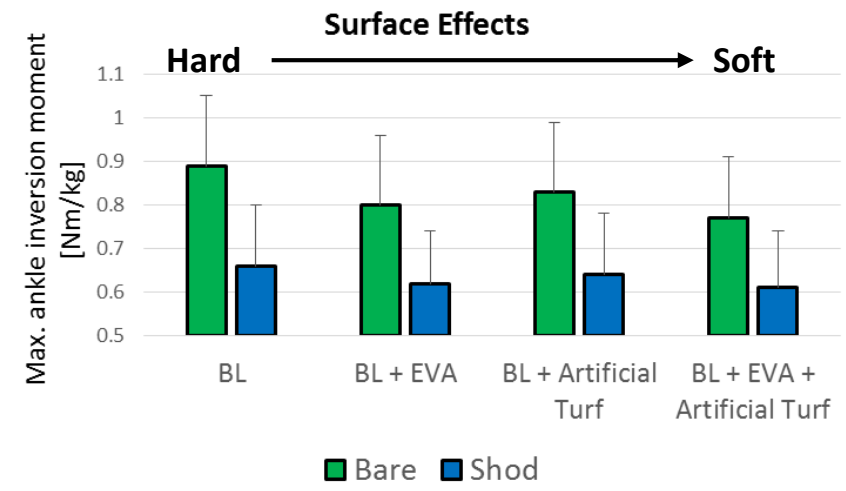
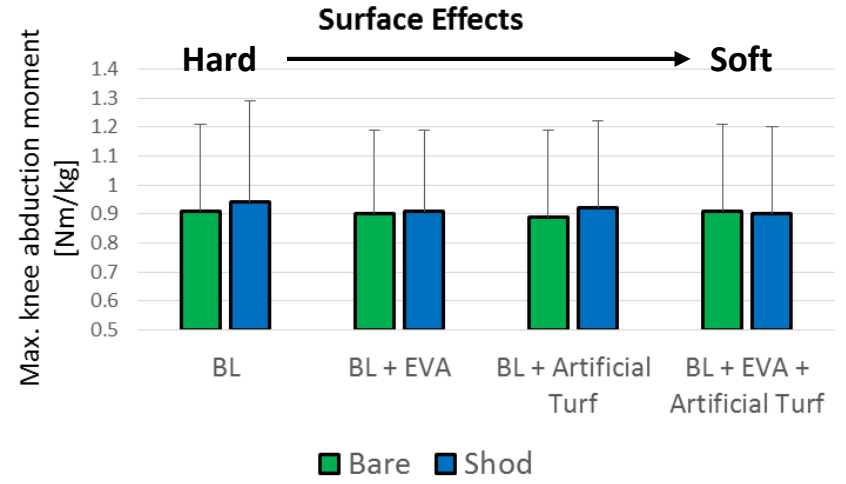
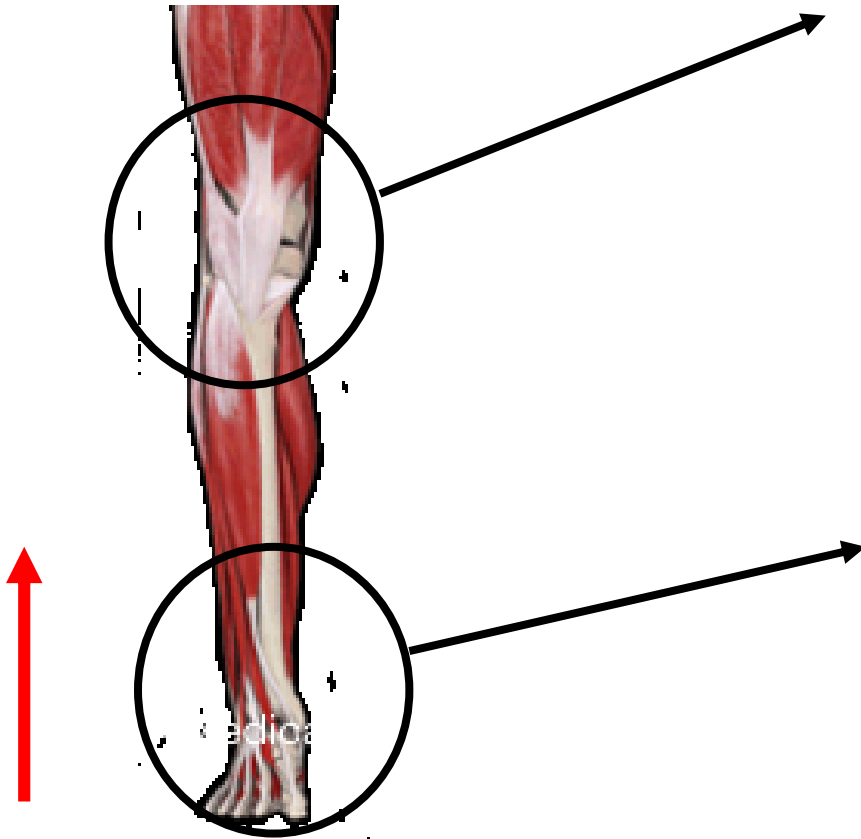
Lever arms



Joint moment response - Sagittal Plane -



Joint moment response - Frontal Plane -



Joint moment response

- Sagittal Plane -

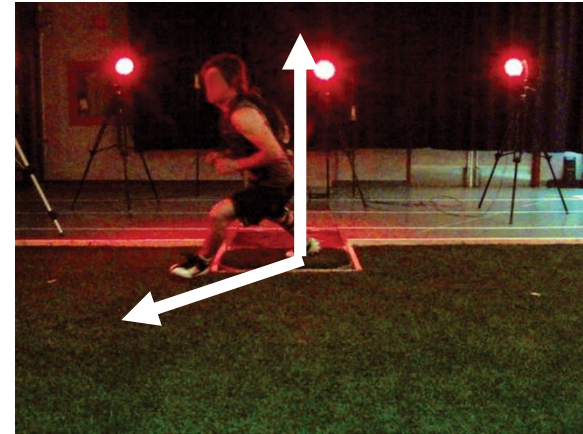


Altered mechanical
stimulus
for
musculoskeletal system

- Frontal Plane -



Surface traction



Mechanically available traction

- Depend on the material properties of two contacting surfaces
- **Mechanical testing**

Utilized traction

- **Horizontal / vertical force ratio** during between footwear and playing surface during sports movement
- Force plates

Linear traction

Traction coefficient: τ

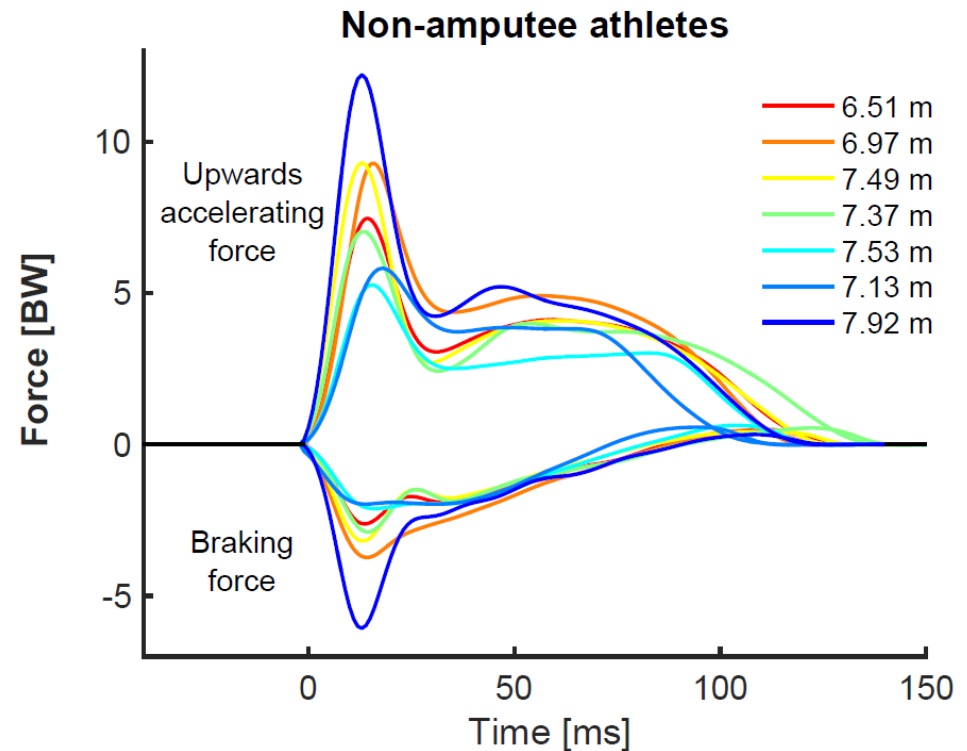
$\tau = \text{traction force} / \text{normal force}$

Typical values for utilized (linear) traction:

Walking (0.15-0.3)

Running (0.6-0.7)

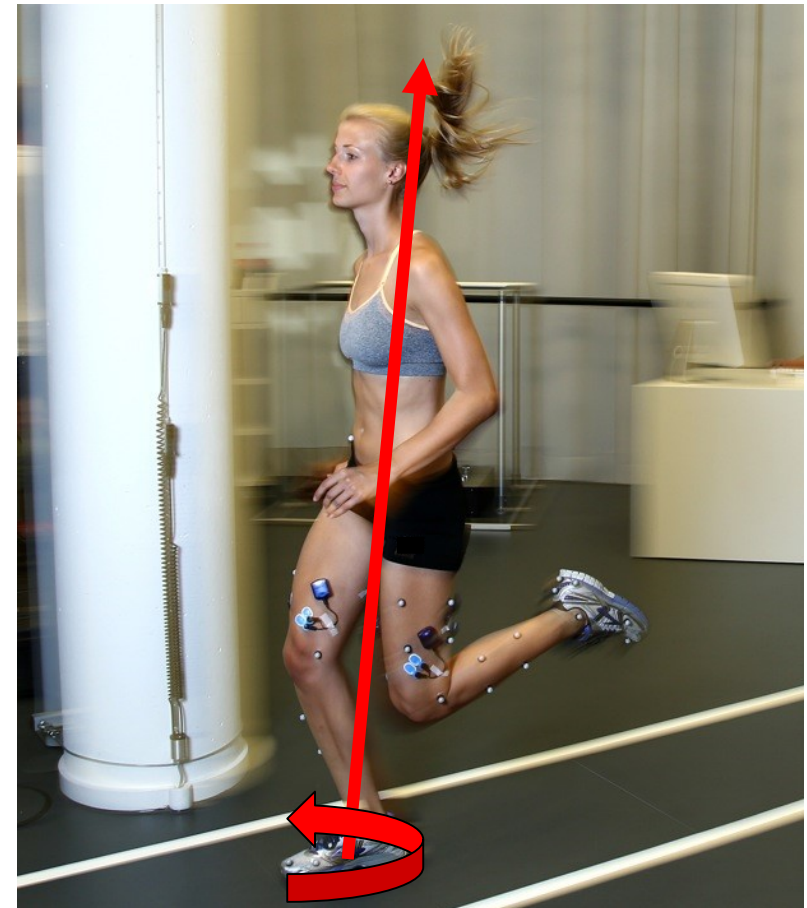
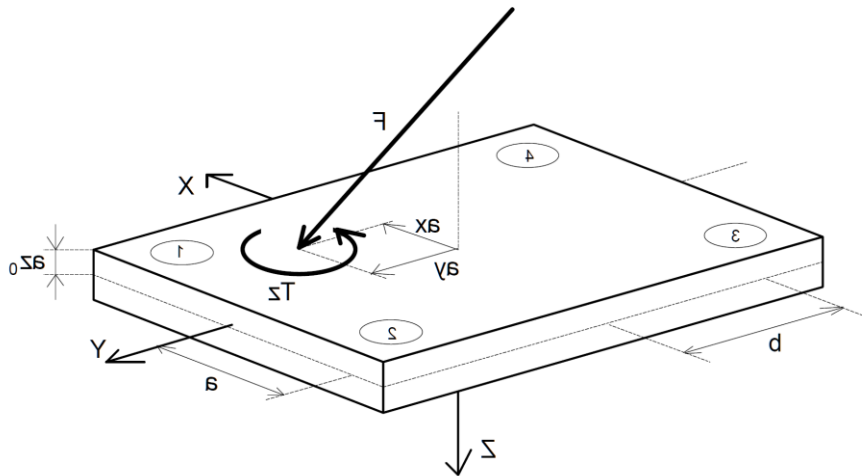
Maximum effort cutting (1.2)



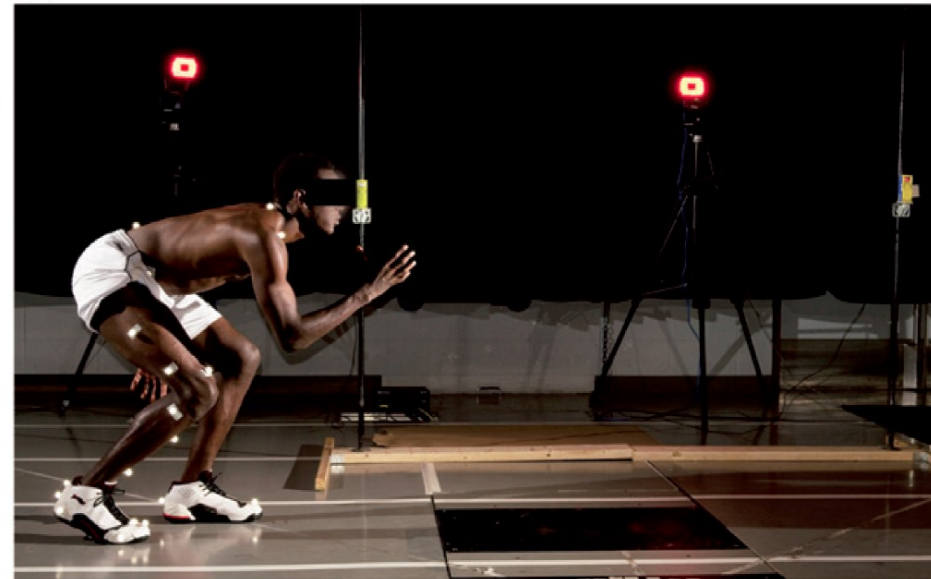
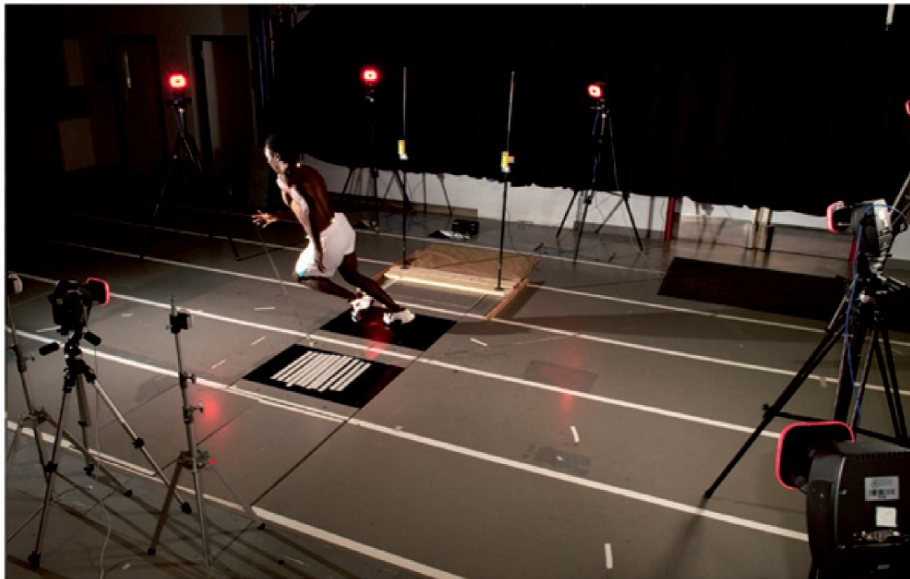
Rotational traction

Rotational traction

Free moment applied to the ground



Luo & Stefanyshyn (2011)



Footwear

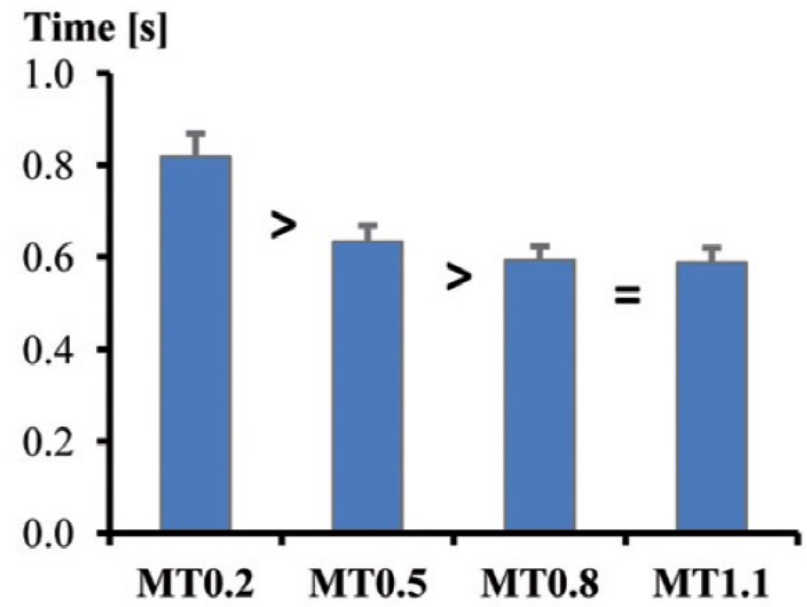
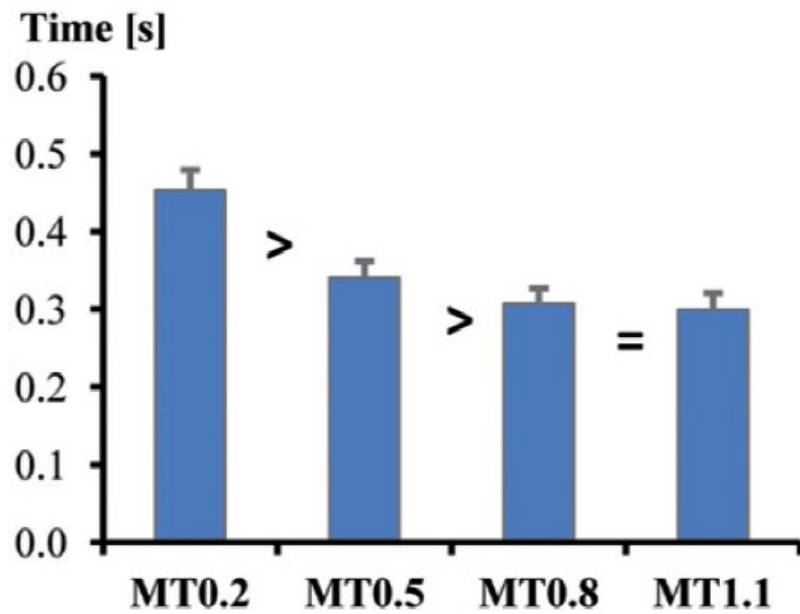
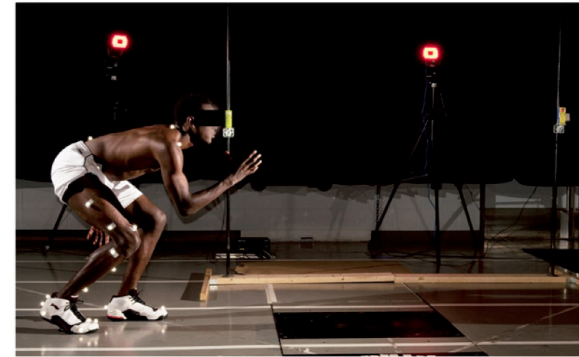
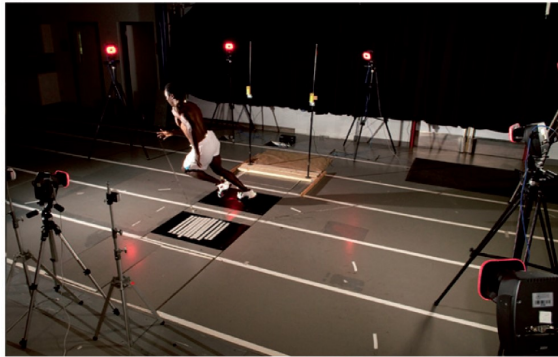
Mechanically available traction:

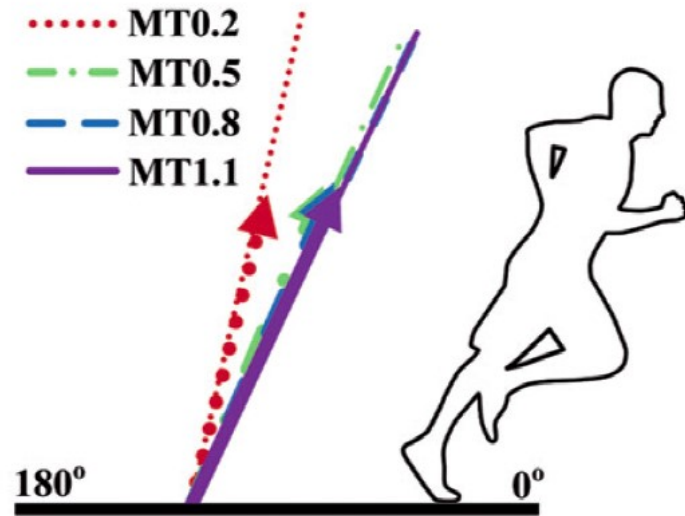
MT0.2

MT0.5

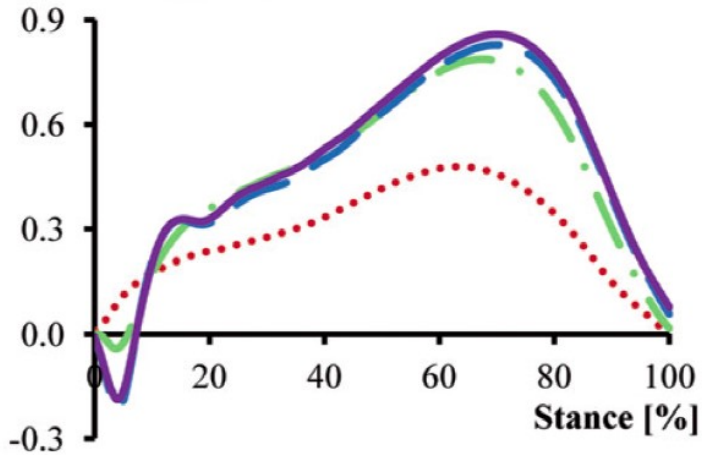
MT0.8

MT1.1



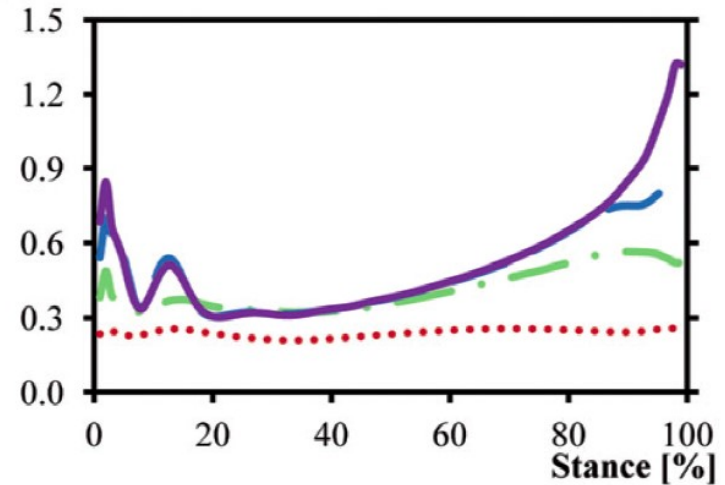


(a) GRF_h [BW]

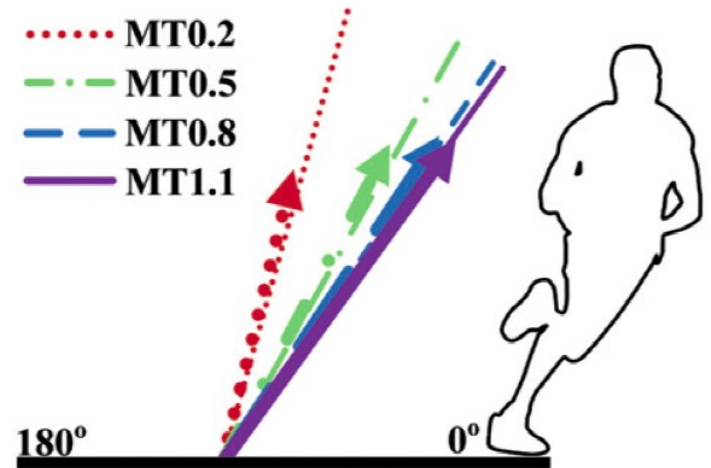
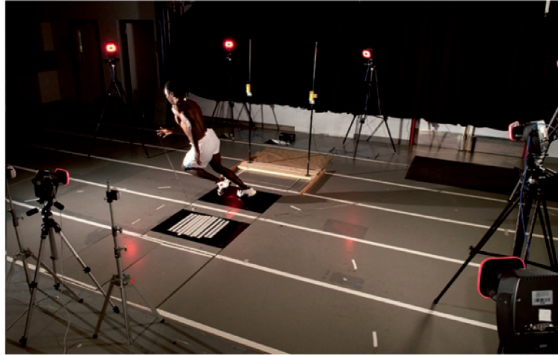


..... MT0.2 - . - . MT0.5

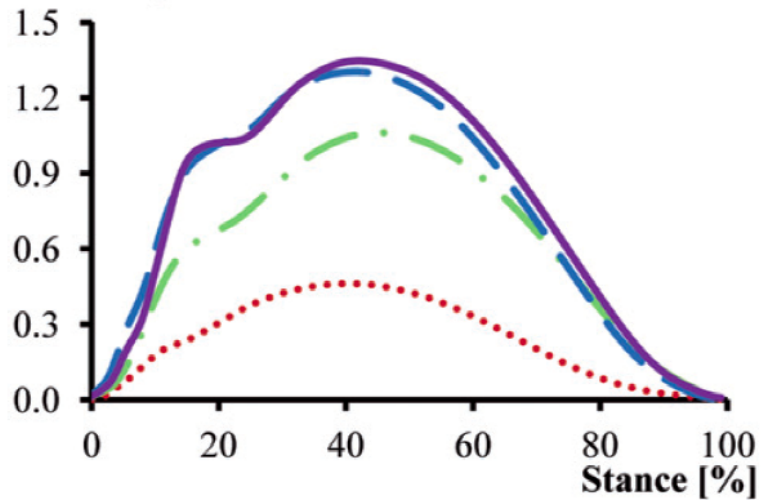
(b) Traction Coefficient



—— MT0.8 —— MT1.1



(a) GRF_{cpt} [BW]



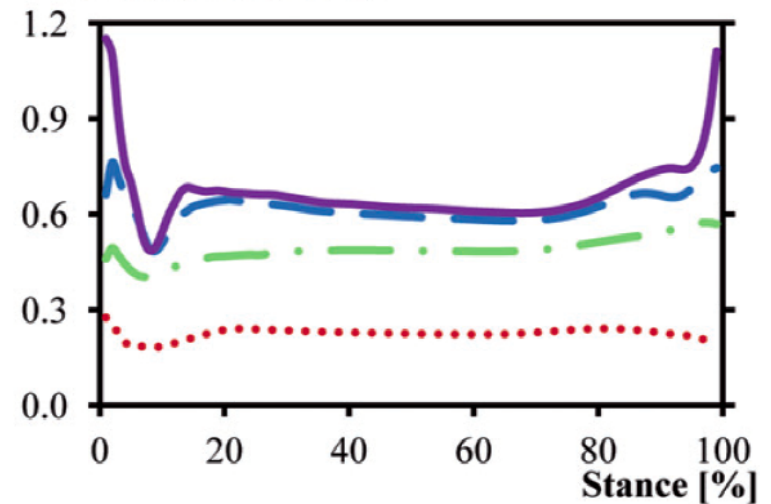
..... MT0.2

-.-.- MT0.5

- - - MT0.8

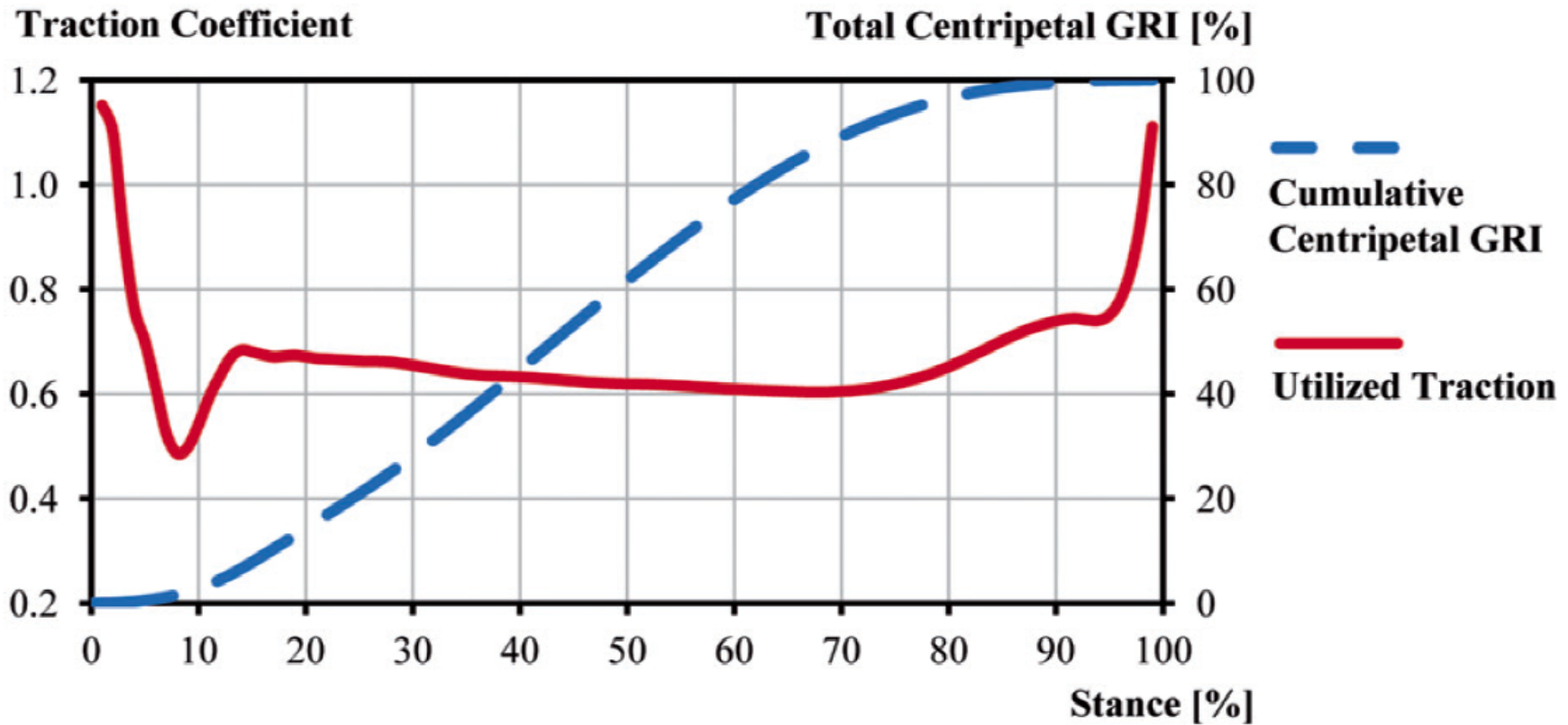
———— MT1.1

(b) Traction Coefficient

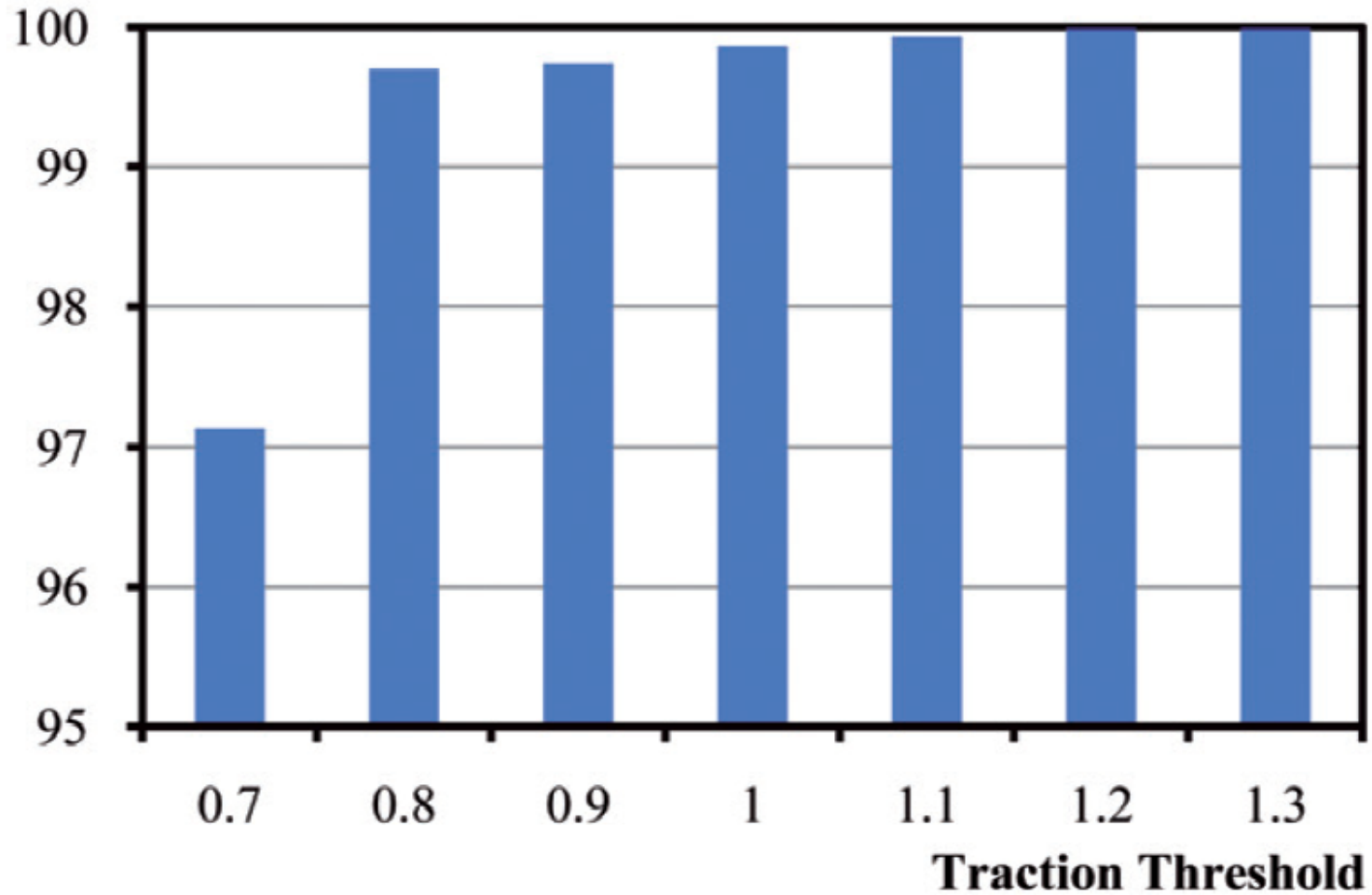


- - - MT0.8

———— MT1.1

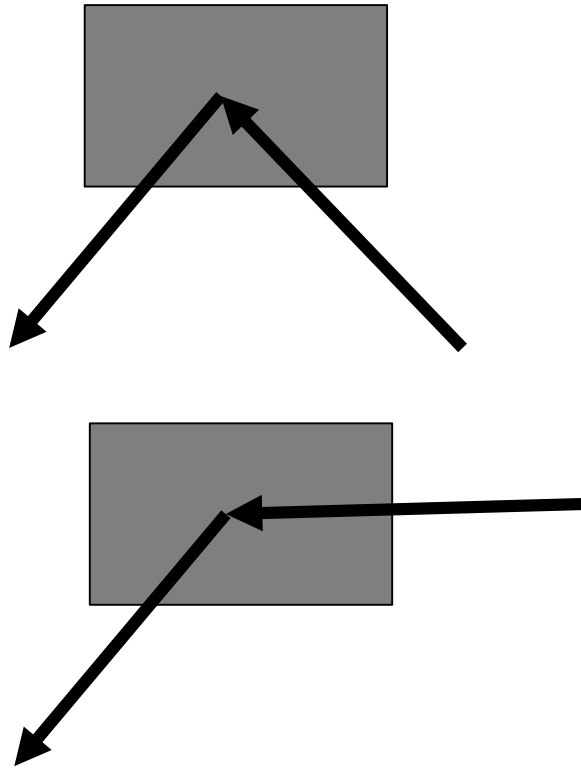


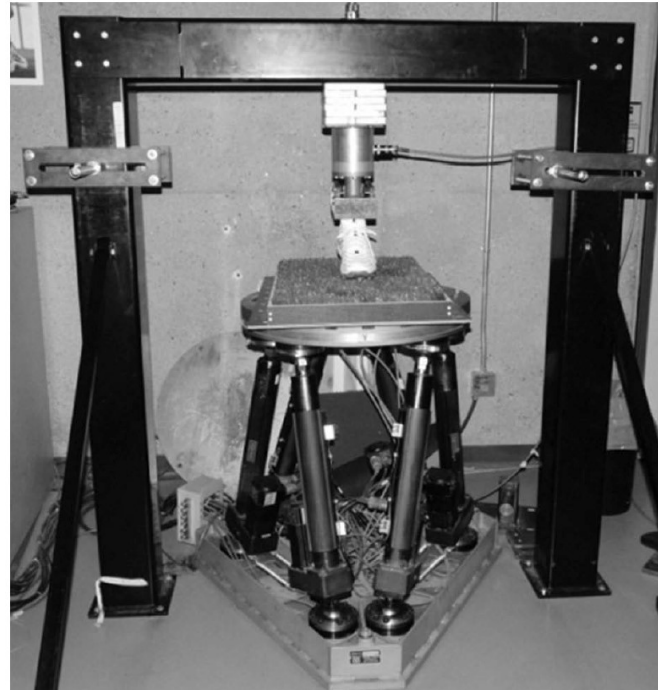
Total Centripetal GRI [%]



Traction should be optimal, not maximal!

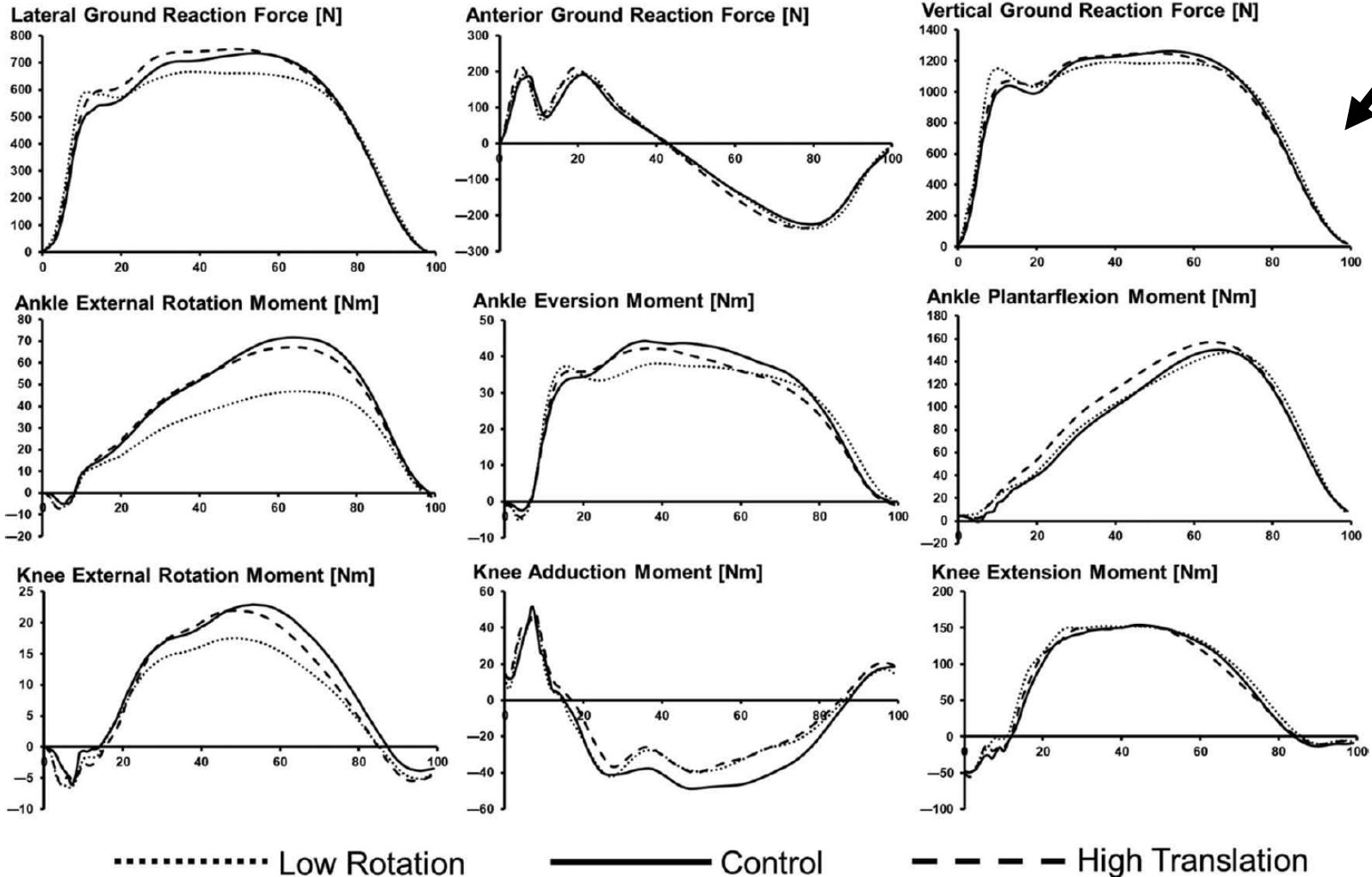
Wannop & Stefanyshyn (2016)



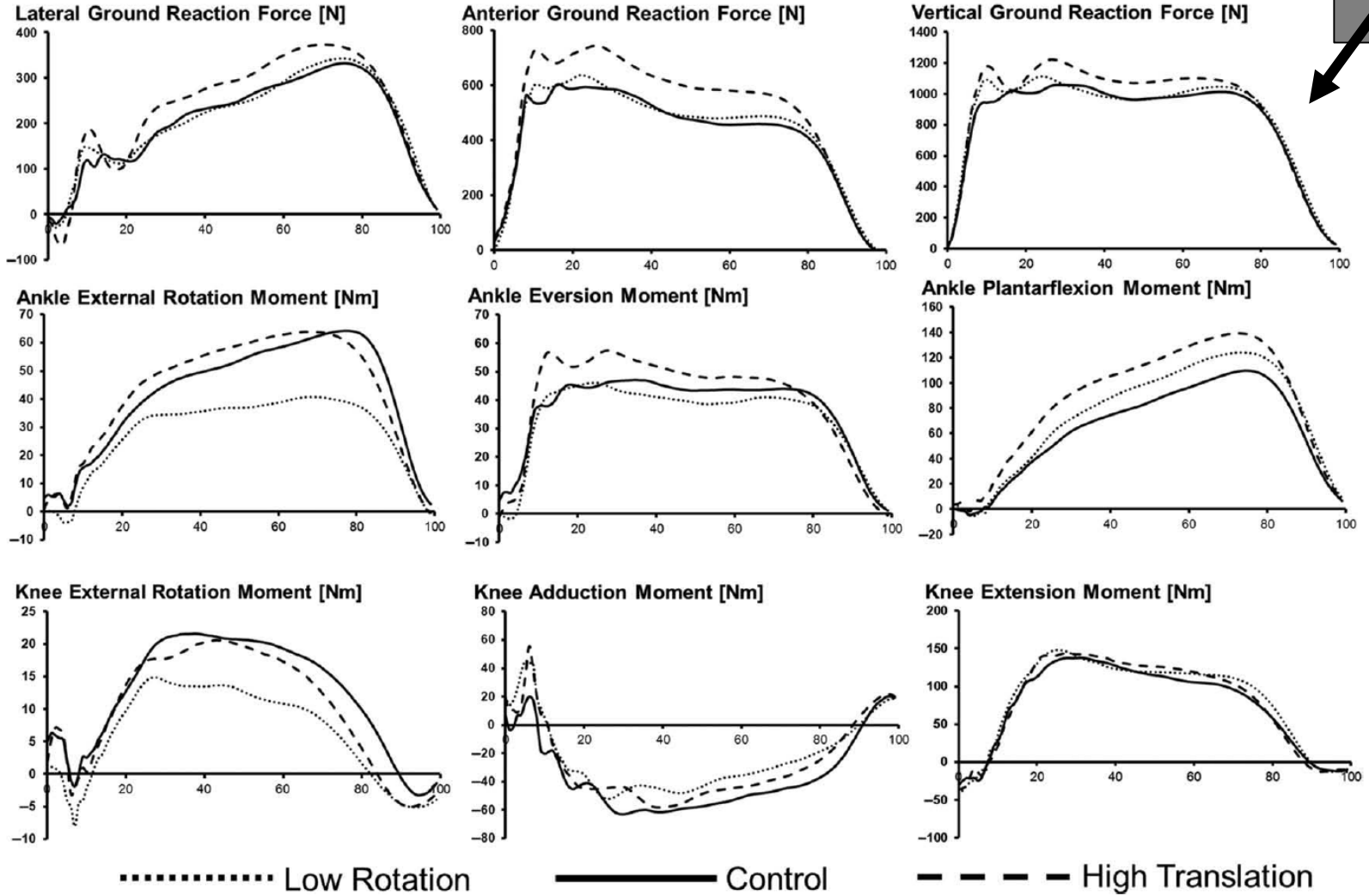


	Translational traction coefficient	Rotational traction [Nm]
Low rotation	0.79 (0.03)	18.1 (1.3)
Control	0.77 (0.02)	30.0 (2.5)
High translation	1.10 (0.02)	31.1 (2.6)

V-Cut



S-Cut



Traction can affect loading of lower extremity joints!

Wannop, Luo & Stefanyshyn (2013)

Prospective study

N = 555 high school footballs



TABLE 3. Number of injuries, exposures, and corresponding injury rate when athletes were divided into three equal groups based on their footwear traction.

	Traction	Noncontact, Lower Extremity Injuries	No. Game Exposures	Injuries per 1000 Game Exposures (95% CI)	No. Athletes
Translational coefficient	0.480–0.685	19*	1415	13.4 (7.4–19.5)	177
	0.686–0.719	31 [†]	1328	23.3 (15.1–31.5)	177
	0.720–0.970	7* [†]	1397	5.0 (1.3–8.7)	177
Rotational (N·m)	15.0–30.9	6* [†]	1417	4.2 (0.9–7.6)	184
	31.0–38.9	24*	1364	17.6 (10.6–24.6)	184
	39.0–54.9	28 [†]	1459	19.2 (12.0–26.3)	183

* · [†] Significant differences ($P < 0.05$) as determined by the chi-square test.

It is recommended that athletes consider selecting a surface / footwear combination with the lowest rotational traction values for which no detriment in performance results.

**Thank you for your
attention !**