Deutsche Sporthochschule Köln
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Mechanik der linearen Beschleunigung

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Mechanik der linearen Beschleunigung

A novel guideline for the analysis of linear acceleration mechanics – outlining a conceptual framework of 'shin roll' motion

Tobias Alt, Tom J Oeppert, Marvin Zedler, Jan-Peter Goldmann, Bjoern Braunstein & Steffen Willwacher

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(A) shin block — shin segment changes its rotation direction

shin alignment →

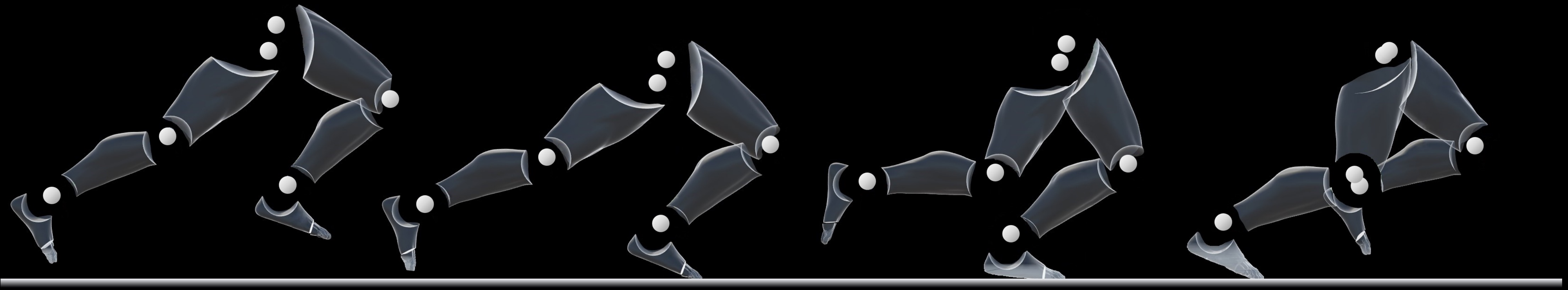
(B) touchdown — initial ground contact

ankle rocker →

(C) heel lock — lowest position of the ankle

shin drop →

(D) propulsion pose — smallest absolute change of shin angle



Alt et al. (2022)

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Ziel der (initialen) Beschleunigung im Sprint

?

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Zeit bis zu spezifischer Distanz?

Unmittelbare KSP-Geschwindigkeit an spezifischer Distanz?

Bezodis et al. (2010)

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Zeit bis zu spezifischer Distanz?

A) Zeit: 2 s

B) Zeit: 2,1 s

Unmittelbare KSP-Geschwindigkeit an spezifischer Distanz?

A) Geschwindigkeit: 7,5 $m \cdot s^{-1}$

B) Geschwindigkeit: 7,65 $m \cdot s^{-1}$

Bezodis et al. (2010)

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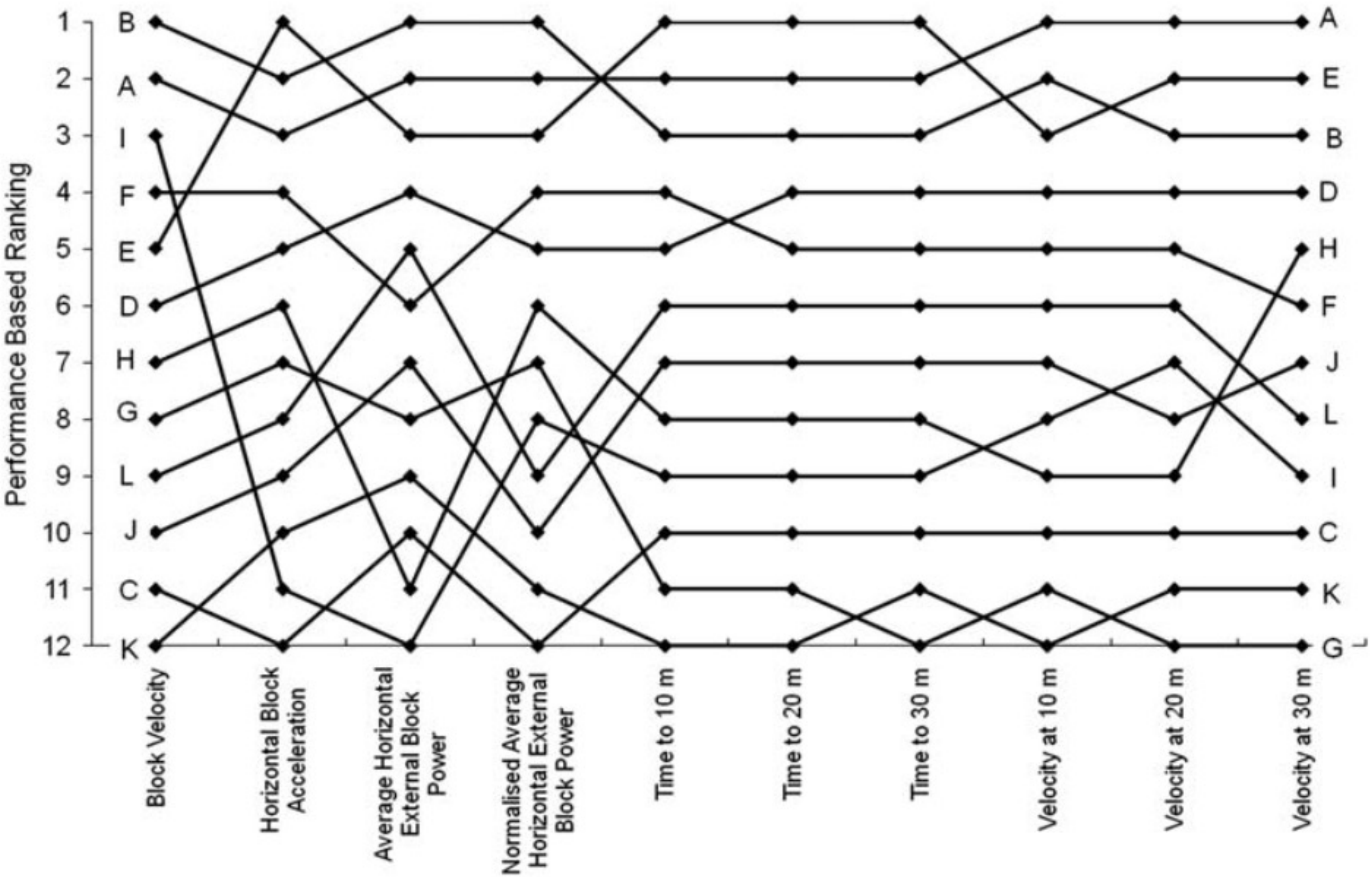

Bezodis et al. (2010)

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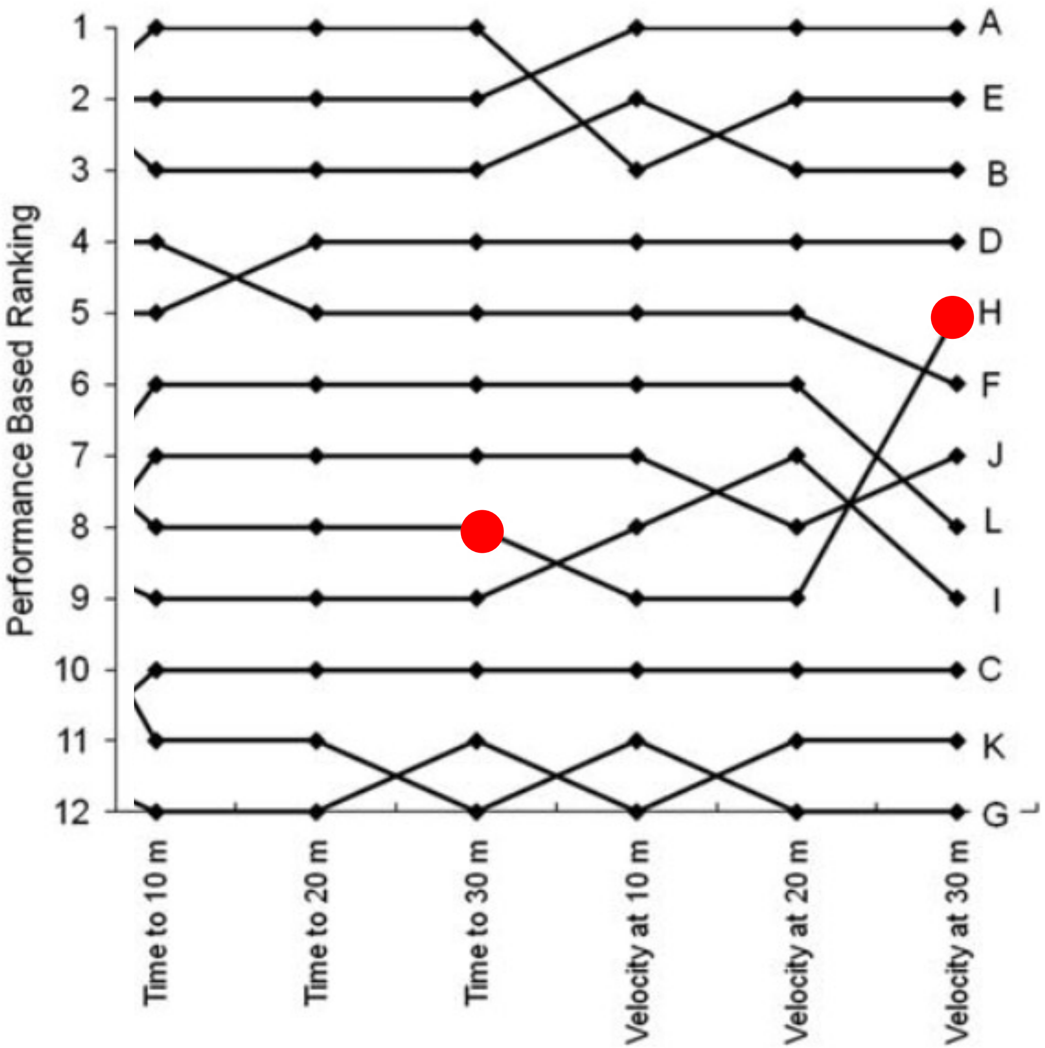

Alternativen

Ratio of Forces

NAHEP

Normalized average horizontal external power

Bezodis et al. (2010)

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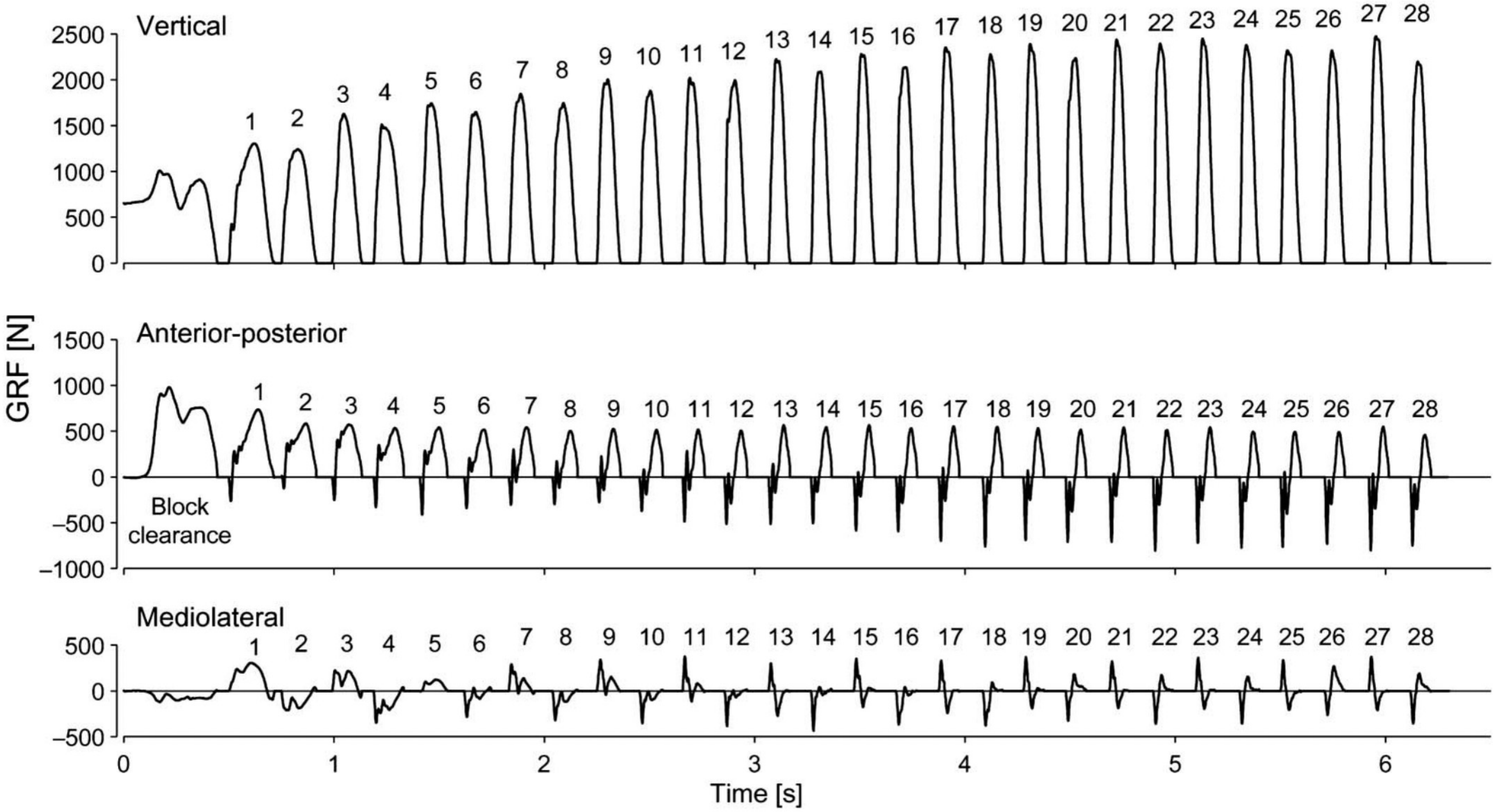
Sprint



Nagahara et al. (2018)

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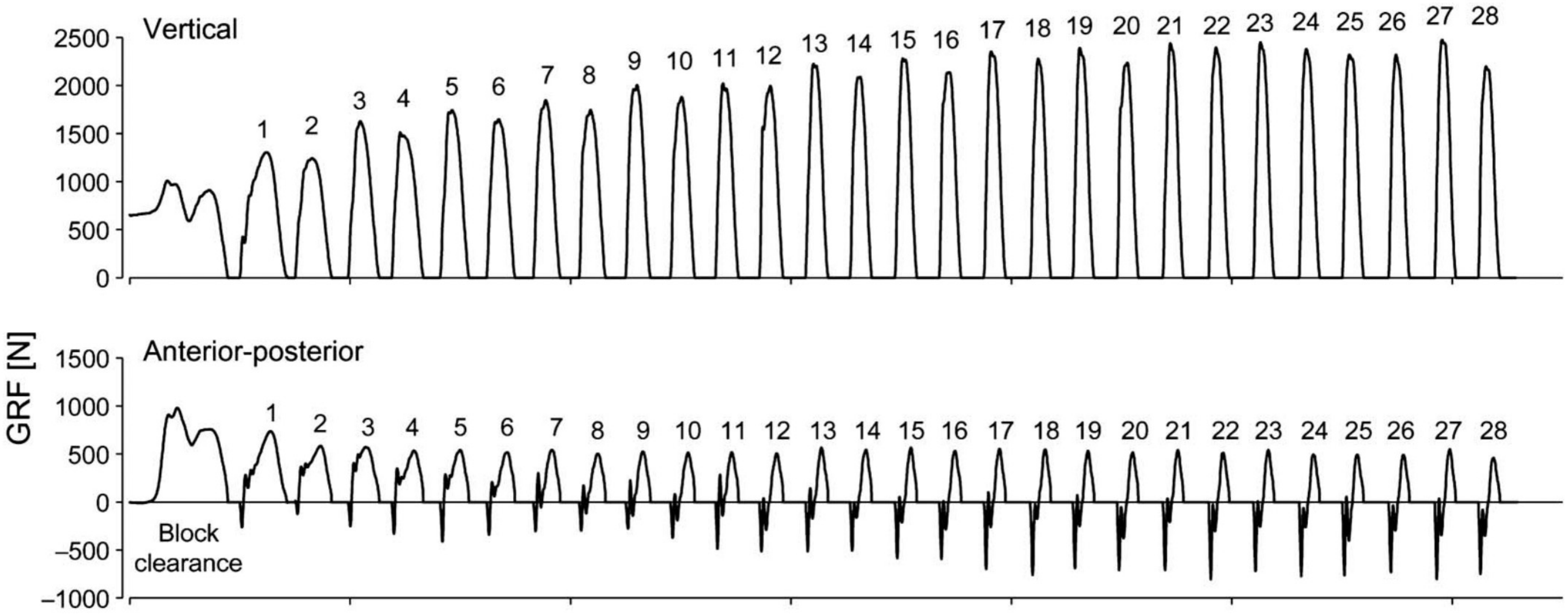
Sprint



Nagahara et al. (2018)

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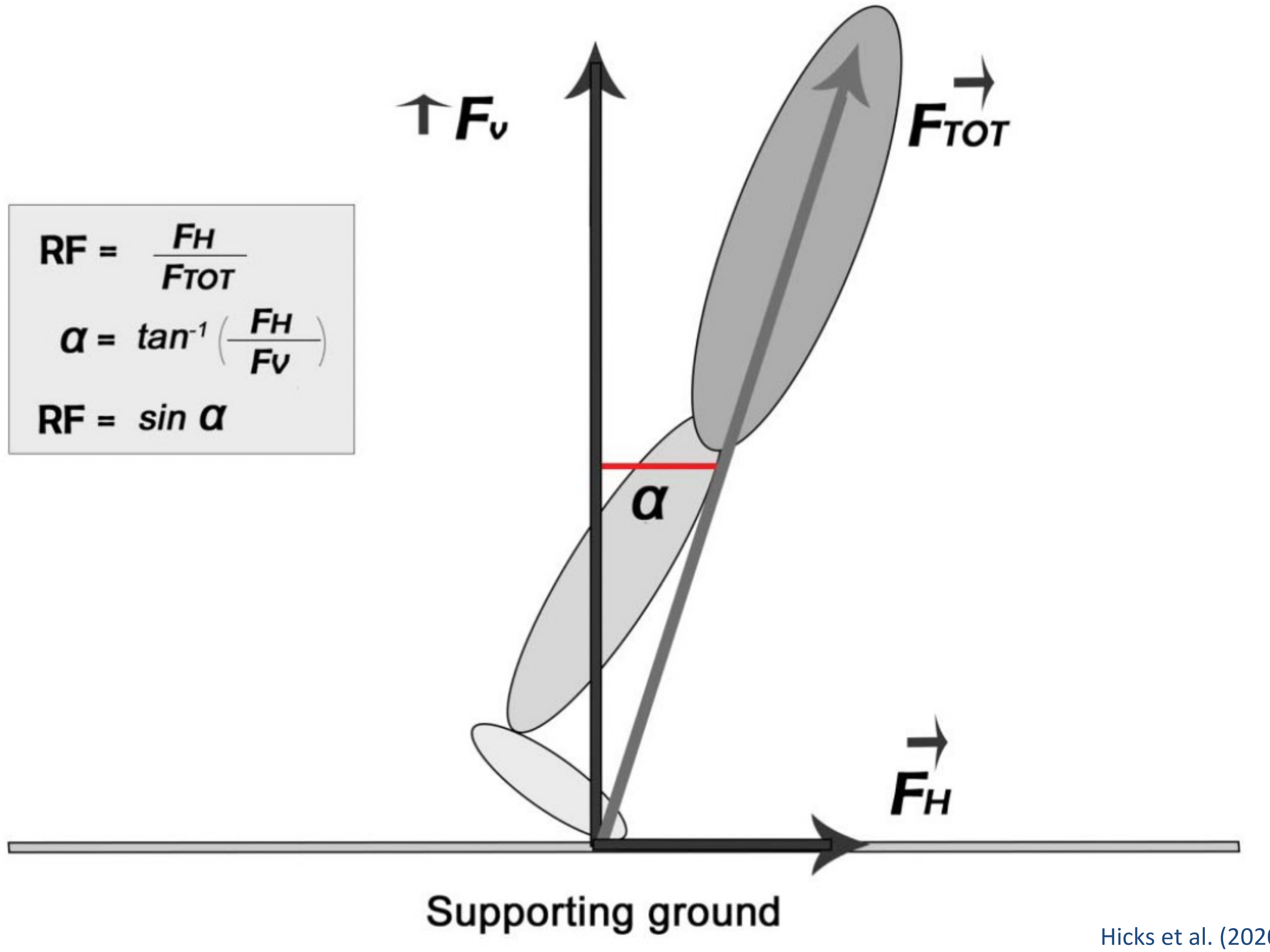
Ratio of Forces



Hicks et al. (2020)

Morin et al. (2011)

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Deskriptive Analyse

Table 1. Group-wide summary of the kinematic and kinetic variables from each of the three steps of interest (mean ± SD).

	Step 3	Step 9	Step 19
n	28^	20	13
Step velocity [m/s]	5.72 ± 0.23	8.37 ± 0.38	9.74 ± 0.48
NAHEP	0.67 ± 0.11	0.55 ± 0.13	0.23 ± 0.10
Anteroposterior Δ velocity [m/s]	0.72 ± 0.05	0.30 ± 0.04	0.09 ± 0.03
Anteroposterior Δ velocity (BP) [m/s]	−0.03 ± 0.02	−0.08 ± 0.03	−0.18 ± 0.03
Anteroposterior Δ velocity (PP) [m/s]	0.76 ± 0.05	0.38 ± 0.03	0.27 ± 0.03
Vertical Δ velocity[m/s]	0.69 ± 0.16	0.99 ± 0.17	1.17 ± 0.11
Vertical Δ velocity (BP) [m/s]	−0.03 ± 0.02	0.23 ± 0.15	0.67 ± 0.13
Vertical Δ velocity (PP) [m/s]	0.72 ± 0.15	0.76 ± 0.19	0.50 ± 0.14
Average anteroposterior force [BW]	0.49 ± 0.07	0.27 ± 0.05	0.10 ± 0.04
Average anteroposterior force (BP) [BW]	−0.25 ± 0.11	−0.32 ± 0.13	−0.44 ± 0.07
Average anteroposterior force (PP) [BW]	0.56 ± 0.07	0.44 ± 0.05	0.46 ± 0.06
Average vertical force [BW]	1.47 ± 0.13	1.88 ± 0.18	2.18 ± 0.17
Average vertical force (BP) [BW]	0.79 ± 0.16	1.80 ± 0.33	2.61 ± 0.15
Average vertical force (PP) [BW]	1.53 ± 0.13	1.88 ± 0.22	1.86 ± 0.26
Average resultant force [BW]	1.59 ± 0.13	1.97 ± 0.18	2.27 ± 0.17
Peak braking force [BW]	−0.44 ± 0.23	−0.81 ± 0.22	−1.19 ± 0.18
Peak vertical force [BW]	2.23 ± 0.24	3.00 ± 0.34	3.70 ± 0.31
Peak propulsive force [BW]	0.89 ± 0.09	0.83 ± 0.09	0.80 ± 0.10
Peak resultant force [BW]	2.33 ± 0.24	3.01 ± 0.34	3.71 ± 0.31
Ratio of force [%]	31.0 ± 3.2	13.5 ± 2.2	4.2 ± 1.6
Average centre of mass angle [°]	70.1 ± 1.7	78.9 ± 1.1	84.1 ± 1.3
Contact time [s]	0.152 ± 0.013	0.116 ± 0.011	0.102 ± 0.009
Braking time [s]	0.012 ± 0.004	0.028 ± 0.010	0.042 ± 0.009
Propulsive time [s]	0.140 ± 0.012	0.088 ± 0.005	0.060 ± 0.004
Flight time [s]	0.079 ± 0.015	0.107 ± 0.012	0.125 ± 0.015
Step length [m]	1.32 ± 0.09	1.86 ± 0.14	2.21 ± 0.20
Step frequency [Hz]	4.34 ± 0.33	4.50 ± 0.28	4.42 ± 0.32

BP: Braking phase; PP: Propulsive phase; ^one participant did not produce braking forces on step 3. Therefore, for variables involving the braking phase n = 27.

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Kinetik

	STEP 3	STEP 9	STEP 19
Average anteroposterior force [BW]	0.49 ± 0.07	0.27 ± 0.05	0.10 ± 0.04
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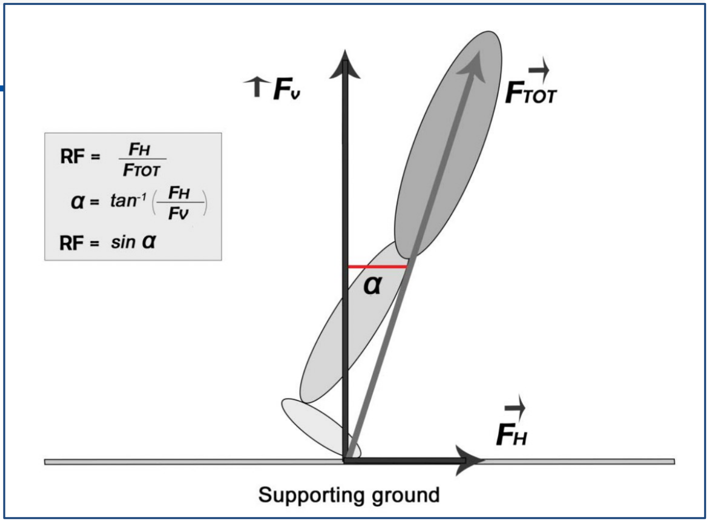
„Technical Ability“



von Lieres und Wilkau et al. (2020)

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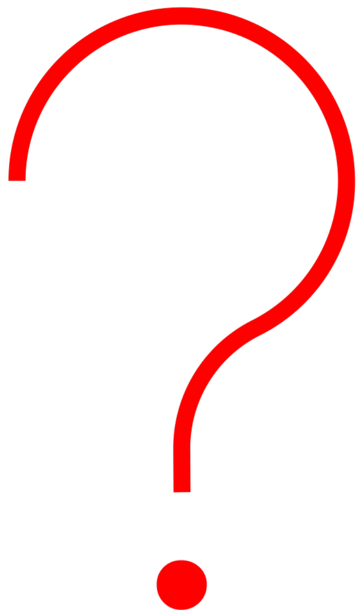
Kinematik / Technikmodelle?



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Kinematic factors associated with start performance in World-class male sprinters

Thigh Seperation Angle

Trunk Angle

Takeoff

GC1 NAHEP (R^2 = 0.89)

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Kinematic factors associated with start performance in World-class male sprinters

Thigh Seperation Angle

Trunk Angle

Takeoff =

GC1 NAHEP (R^2 = 0.89)

„Knee Split“

Walker et al. (2021)

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German Sport University Cologne

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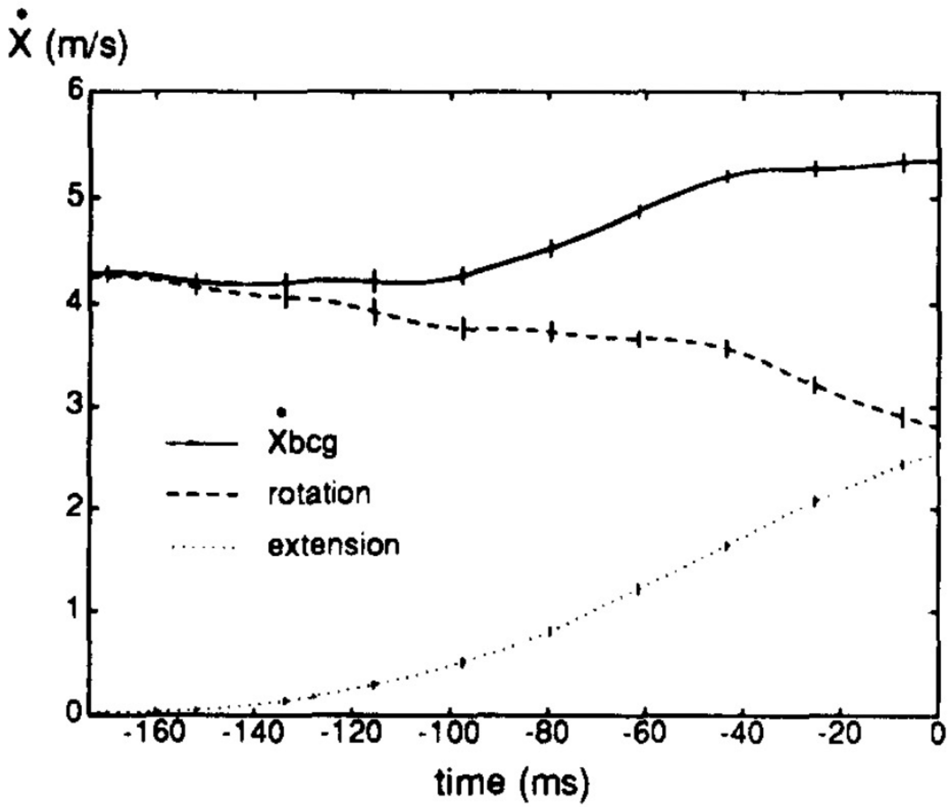

Fig. 3. Mean curves of the contribution of the extensional and rotational components to the horizontal velocity of bcg ($\dot{X}_{bcg}$). Time is expressed relative to the instant of toe-off. Vertical bars indicate S.E.M. ($n = 7$).

Jacobs & van Ingen Schenau (1992)

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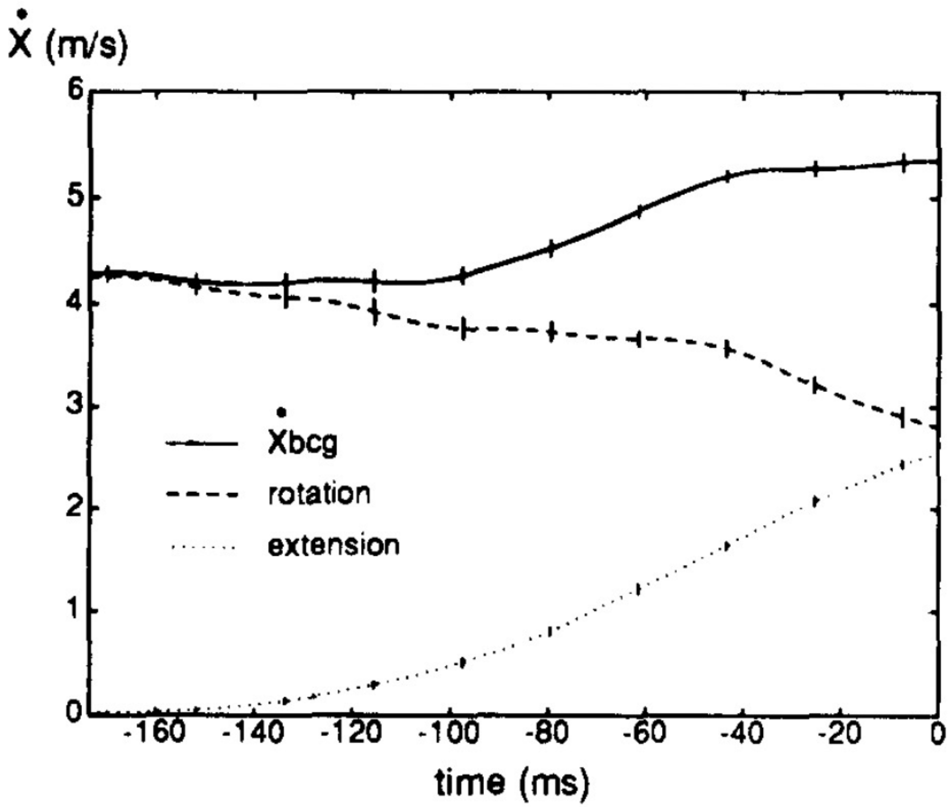

„In the **beginning of the stance phase** only **rotation** is useful (...) while during the stance (...), extension is increasingly useful while rotation becomes less effective.“

Jacobs & van Ingen Schenau (1992)

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A novel guideline for the analysis of linear acceleration mechanics – outlining a conceptual framework of 'shin roll' motion

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(A) **shin block** — shin segment changes its rotation direction

shin alignment →

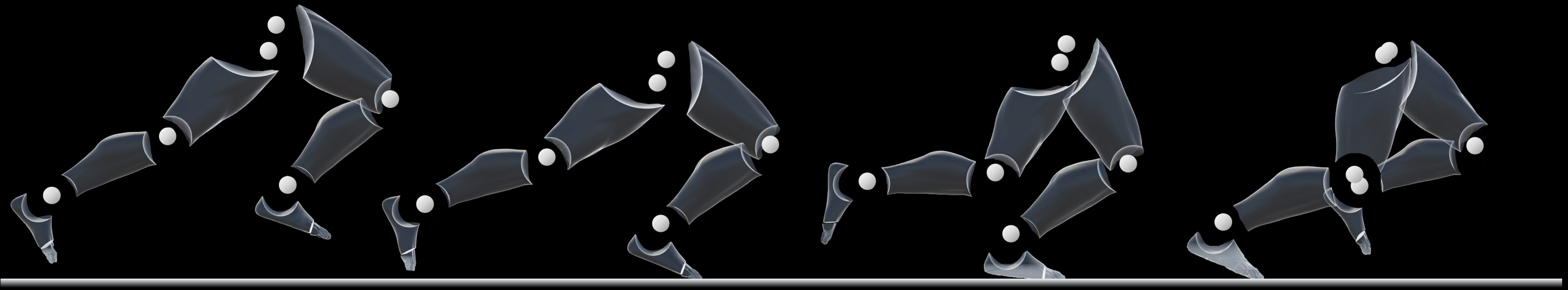
(B) **touchdown** — initial ground contact

ankle rocker →

(C) **heel lock** — lowest position of the ankle

shin drop →

(D) **propulsion pose** — smallest absolute change of shin angle



Alt et al. (2022)

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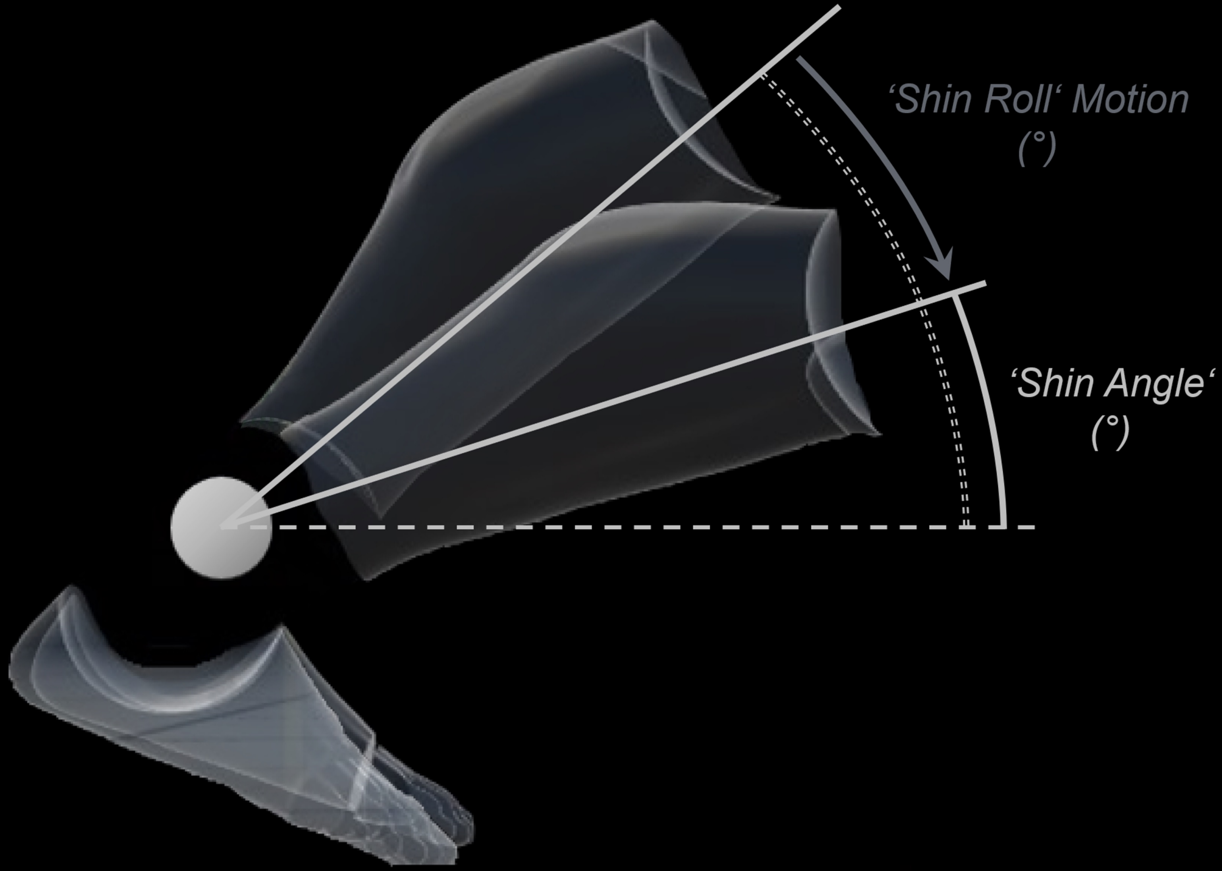

Alt et al. (2022)

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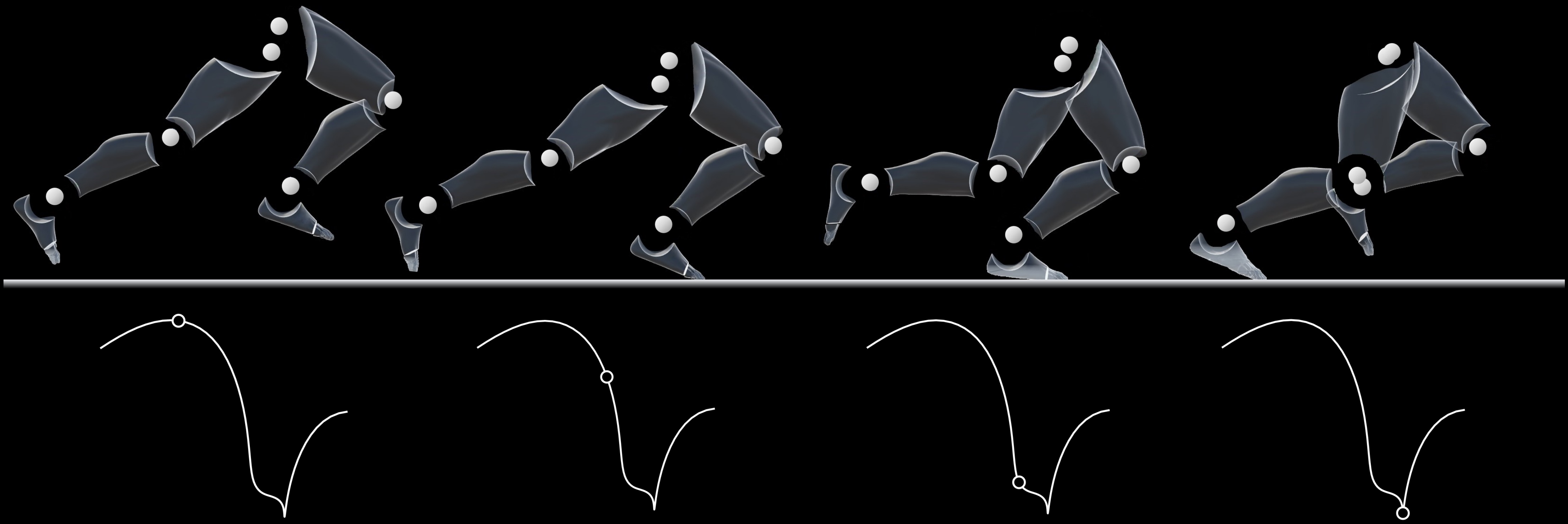

sagittal knee joint trajectory

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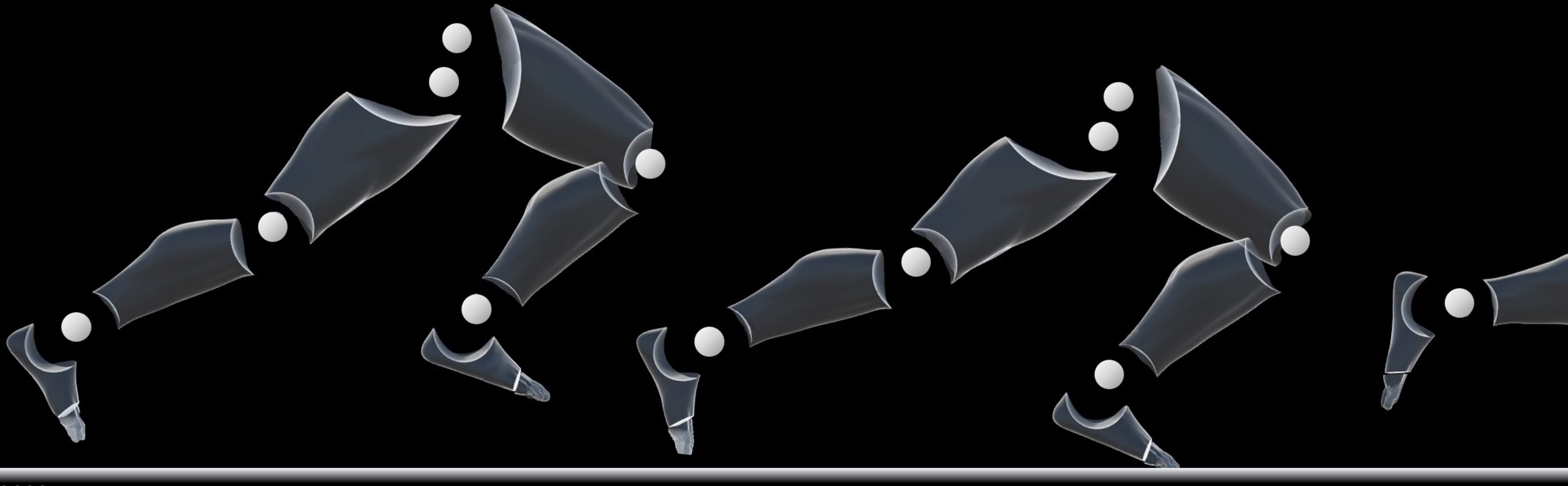
(A) *shin alignment* (B) *ankle rocker*

shin block → touchdown →

shin segment changes its rotation direction

initial ground contact



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Shin Alignment

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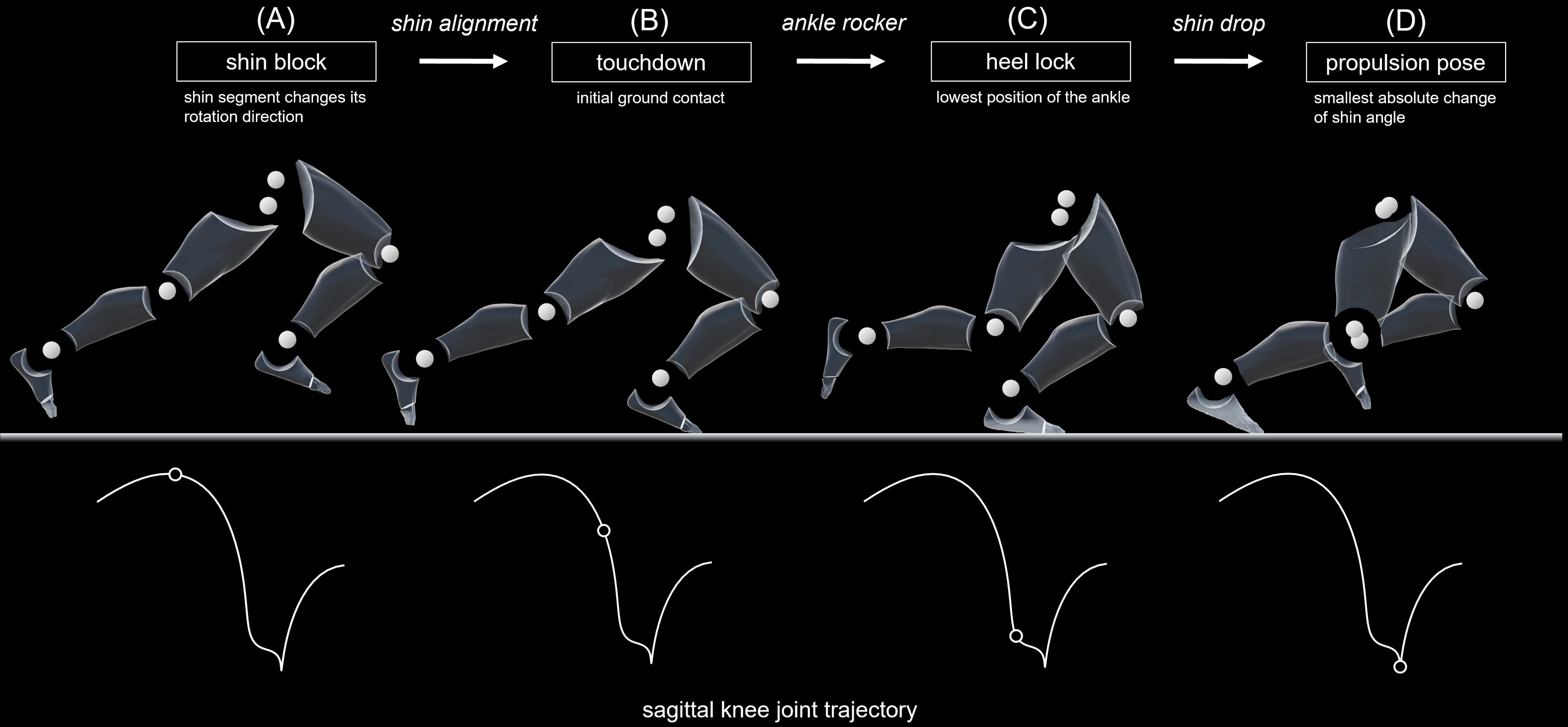

Alt et al. (2022)

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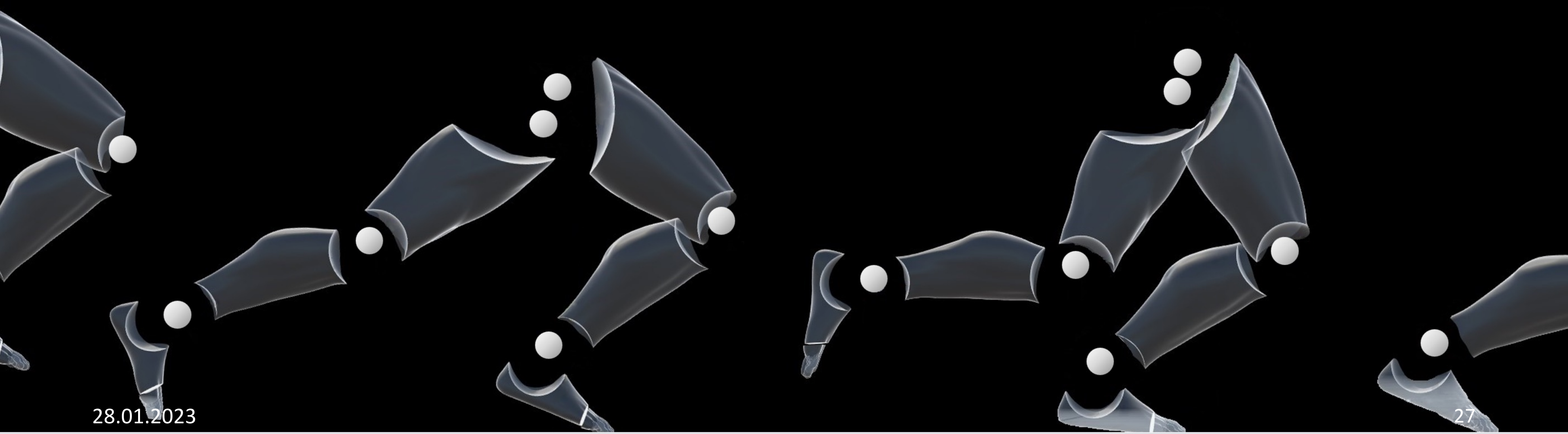
ck — *shin alignment* → (B) touchdown — *ankle rocker* → (C) heel lock — *shin drop* →

nges its

initial ground contact

lowest position of the ankle



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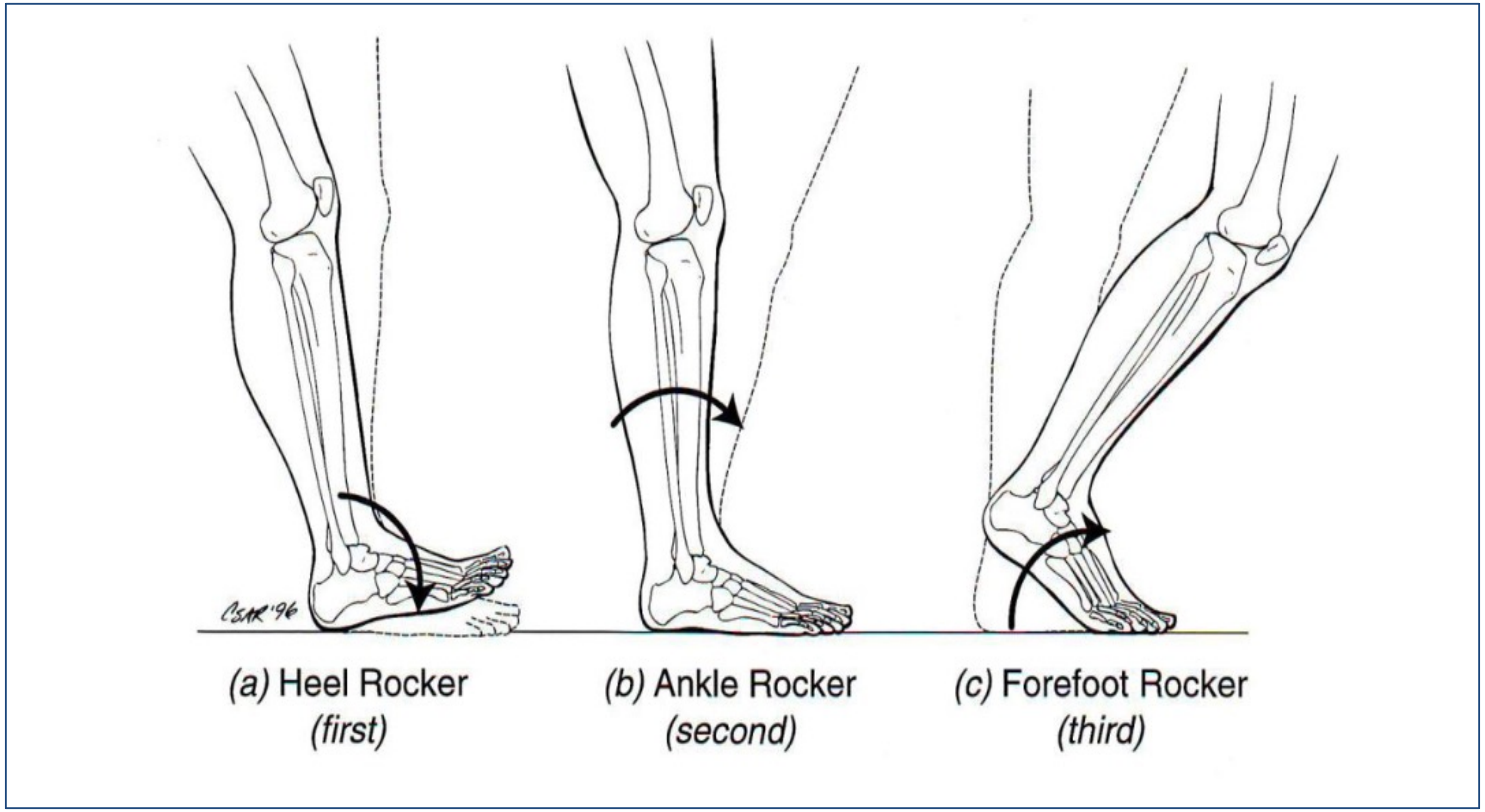
Horizontal ankle rocker



Abu-Faraj et al. (2015)

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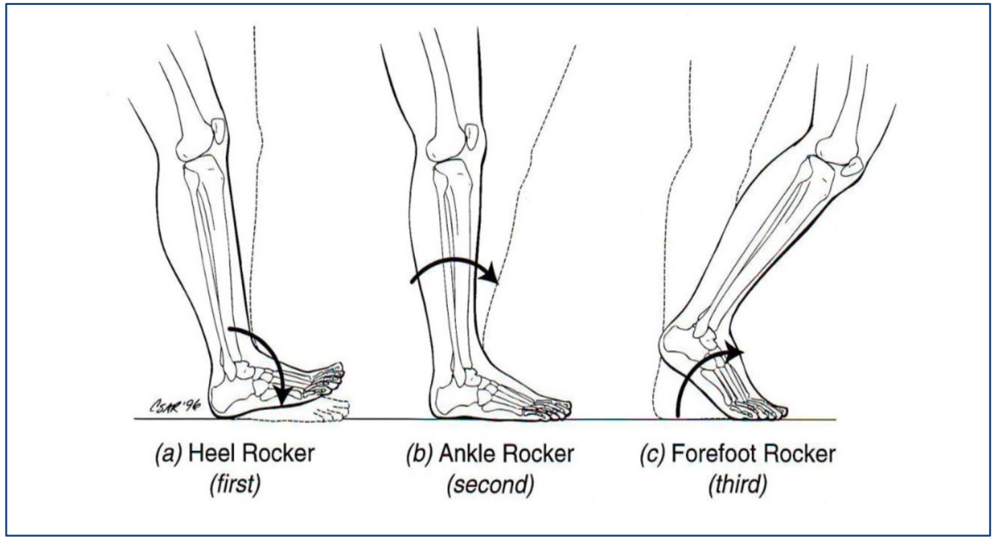
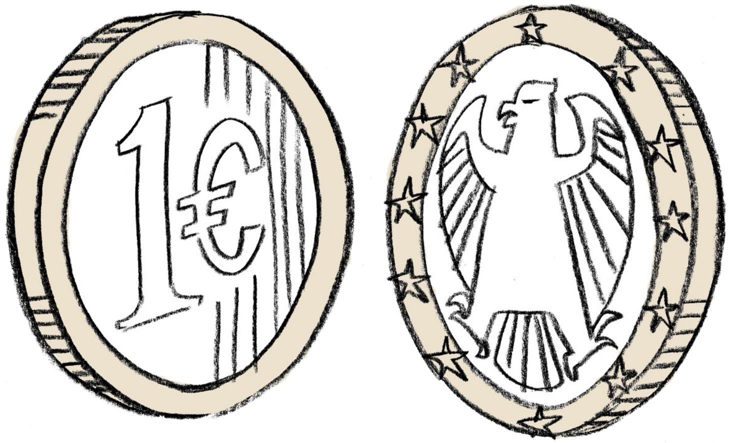
Horizontal ankle rocker



Vertikales Absinken verhindern

⇩

Steifigkeit



Elastische Deformation

⇩

Bewegungsfreiheit

Abu-Faraj et al. (2015)

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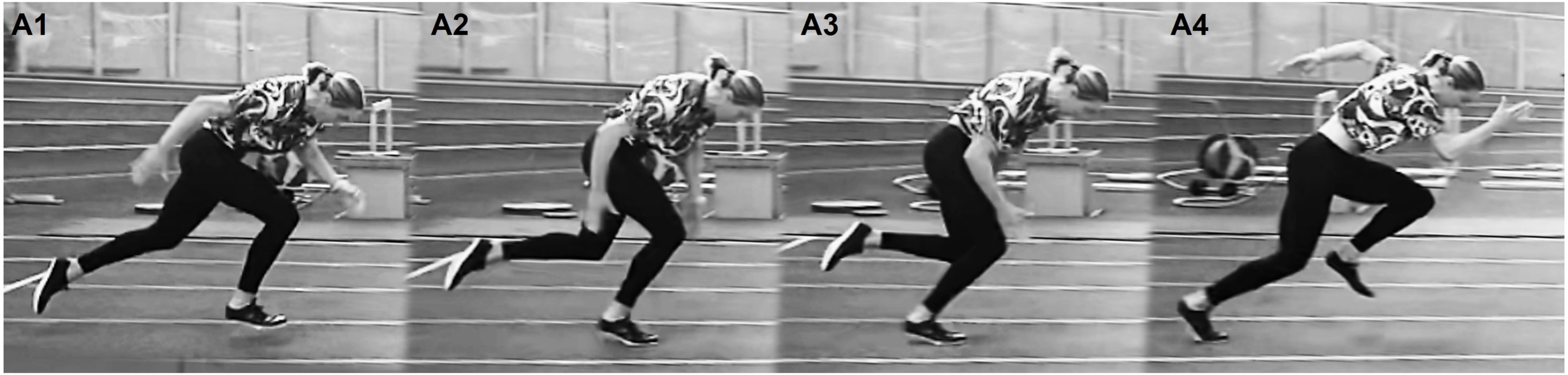

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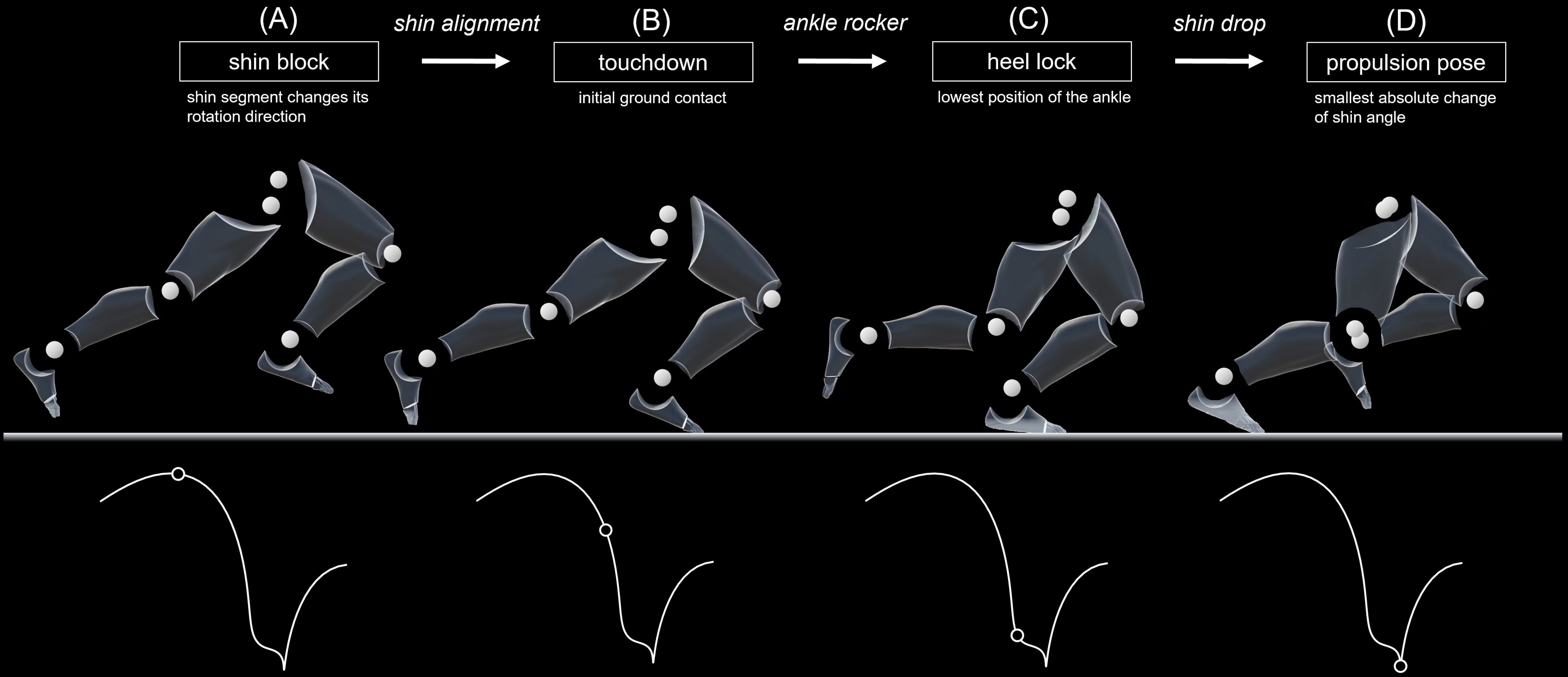

sagittal knee joint trajectory

Alt et al. (2022)

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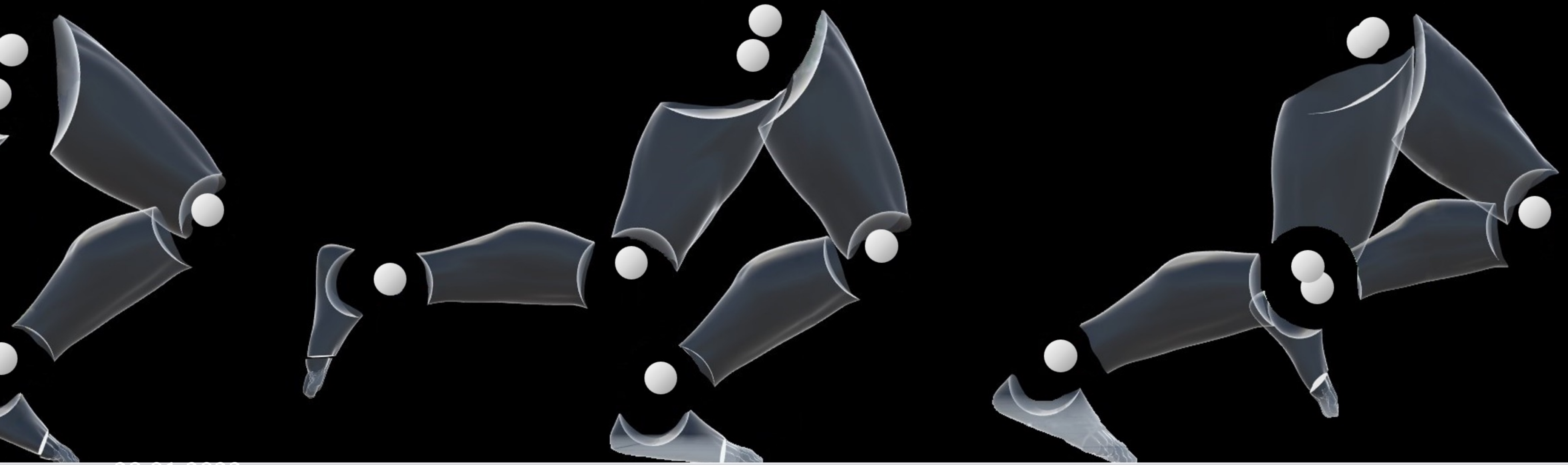
)	*ankle rocker*	(C)	*shin drop*	(D)
down	→	heel lock	→	propulsion pose
d contact		lowest position of the ankle		smallest absolute change of shin angle



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Shin Drop & Propulsion Pose

Streckreserve
(Delayed Knee Extension)

Proximale zu distale Extension

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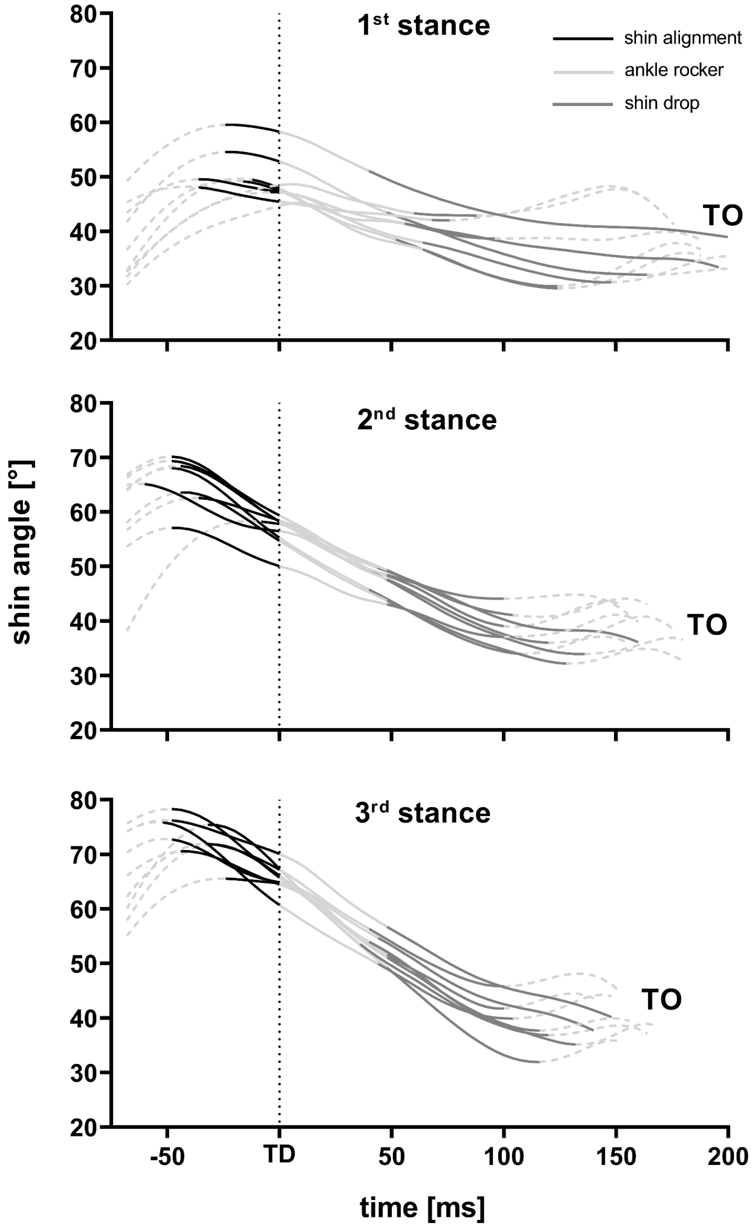

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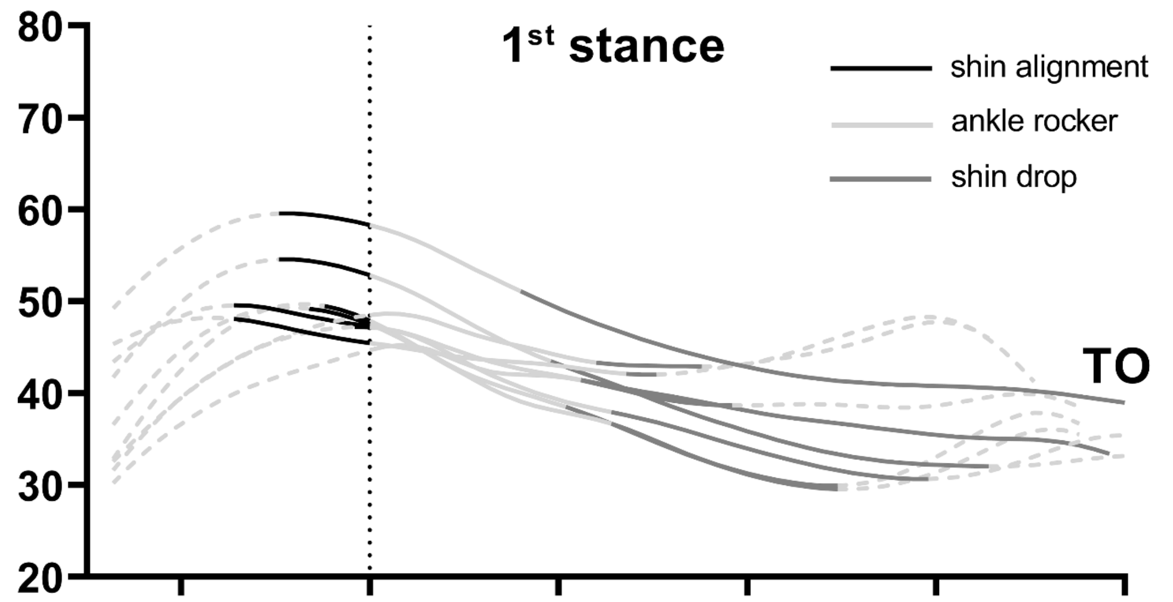

Alt et al. (2022)

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Table 1. Proposal for a set of biomechanical parameters quantifying the 'shin roll' motion of athletes during linear acceleration.

Amplitude Parameters	Description
'shin block' angle (°)	angle between shin segment and ground at the 'shin block' event
'touchdown' angle (°)	angle between shin segment and ground at the 'touchdown' event
'heel lock' angle (°)	angle between shin segment and ground at the 'heel lock' event
'propulsion pose' angle (°)	angle between shin segment and ground at the 'propulsion pose' event
'shin roll' motion late swing (°)	change in shin orientation (RoM) between 'shin block' and 'touchdown' event
'shin roll' motion early stance (°)	change in shin orientation (RoM) between 'touchdown' and 'heel lock' event
'shin roll' motion midstance (°)	change in shin orientation (RoM) between 'heel lock' and 'propulsion pose' event
ankle angle at 'shin block' (°)	ankle joint angle at the 'shin block' event
ankle angle at 'touchdown' (°)	ankle joint angle at the 'touchdown' event
ankle angle at 'heel lock' (°)	ankle joint angle at 'heel lock' event
ankle angle at 'propulsion pose' (°)	ankle joint angle at 'propulsion pose' event
ankle motion late swing (°)	change in ankle angle (RoM) between 'shin block' and 'touchdown' event
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ankle motion midstance (°)	change in ankle angle (RoM) between 'heel lock' and 'propulsion pose' event
ankle moment early stance (Nm/kg)	average ankle joint moment between 'touchdown' and 'heel lock' event
ankle moment midstance (Nm/kg)	average ankle joint moment between 'heel lock' and 'propulsion pose' event
ankle siffness early stance (Nm/kg/°)	average ankle joint stiffness between 'touchdown' and 'heel lock' event
ankle stiffness midstance (Nm/kg/°)	average ankle joint stiffness between 'heel lock' and 'propulsion pose' event
ankle power early stance (W/kg)	average ankle joint power between 'touchdown' and 'heel lock' event
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Timing Parameters	**Description**
swing time (s)	duration of swing phase preceeding the stance phase under consideration
stance time (s)	duration of stance phase under consideration
'shin block' timing (%)	relative timing of 'shin block' event (relative to 'touchdown' and normalized to stance time)
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Average Shin Roll Angular Velocity	**Description**
'shin alignment' velocity (°/s)	average angular velocity of the shin segment between 'shin block' and 'touchdown' event
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Alt et al. (2022)

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'shin drop' velocity (°/s)	average angular velocity of the shin segment between 'heel lock' and 'propulsion pose' event

4 Key Positions

- **Winkelstellung**
- **Winkelveränderung:**

Total, Flug, Bodenkontakt (TD-PP)

- **Winkelgeschwindigkeiten**
- **Prozentualer Anteil der Bewegungsstrategien**

Alt et al. (2022)

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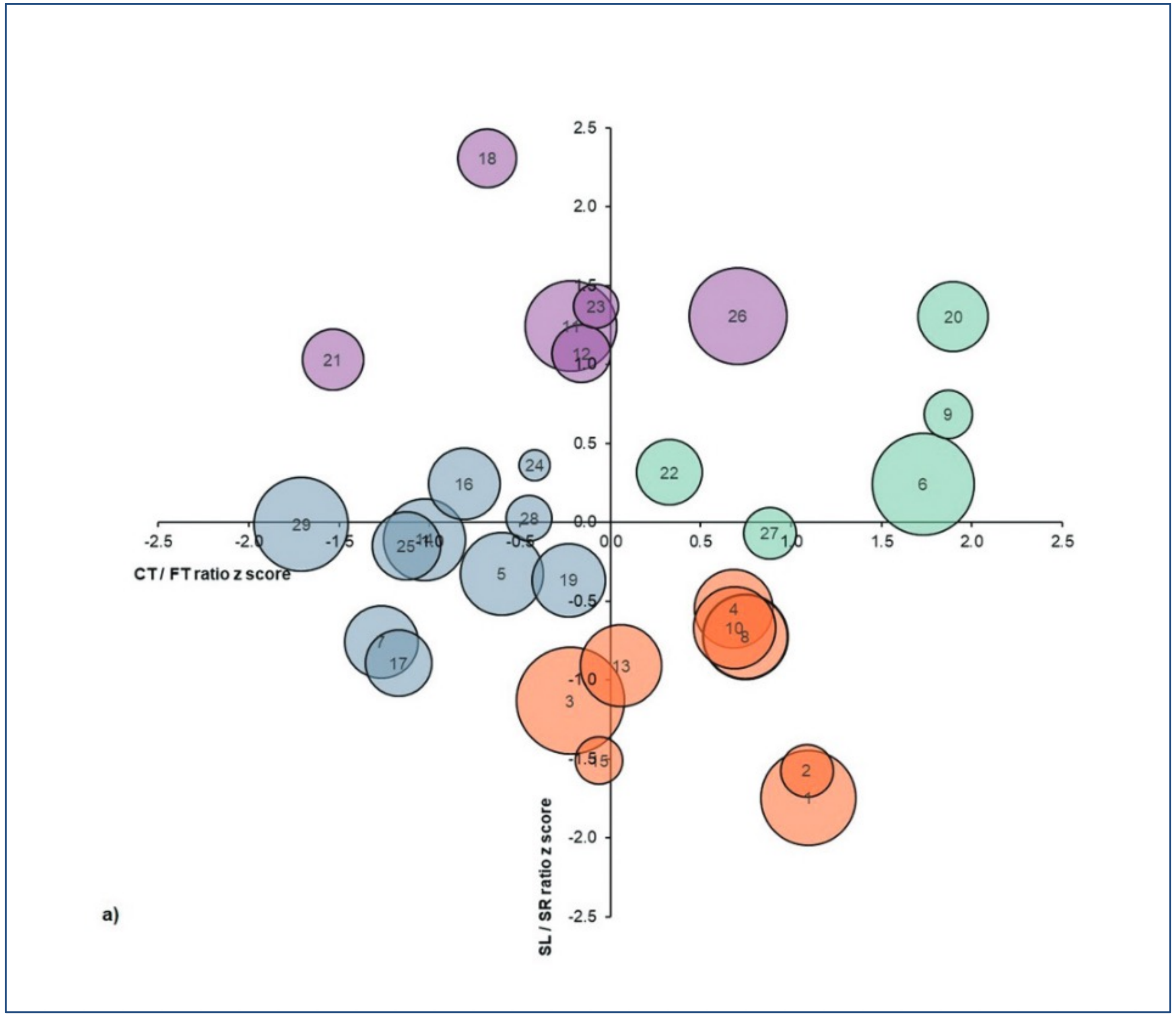
Individualisierung



Wild et al. (2021)

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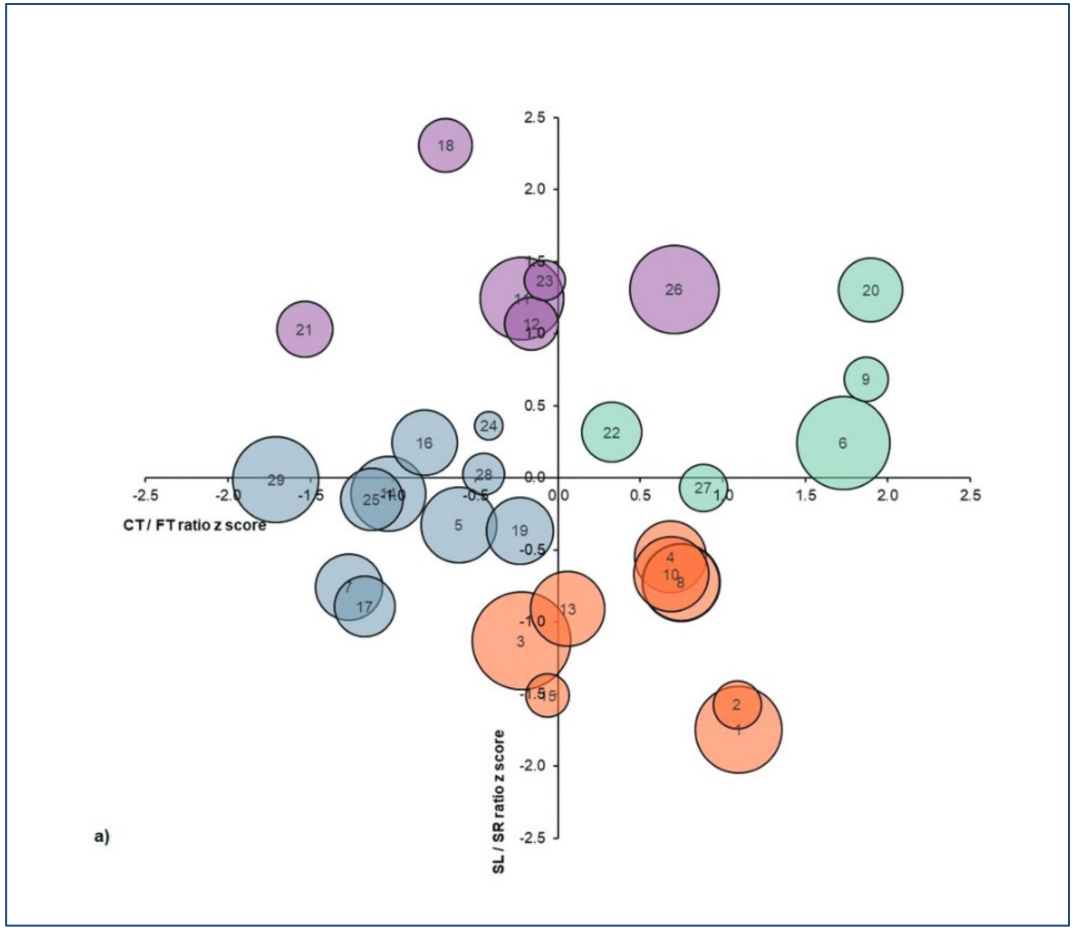
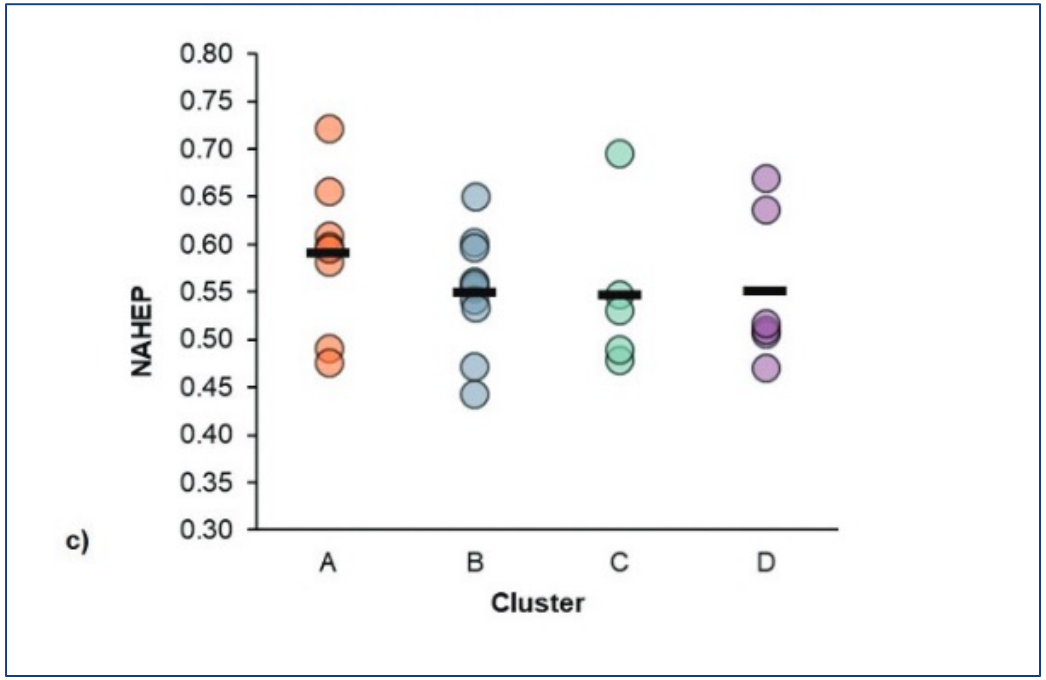
Individualisierung





Wild et al. (2021)

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„Theory in research and education meets practice“

Deutsche
Sporthochschule Köln
German Sport University Cologne

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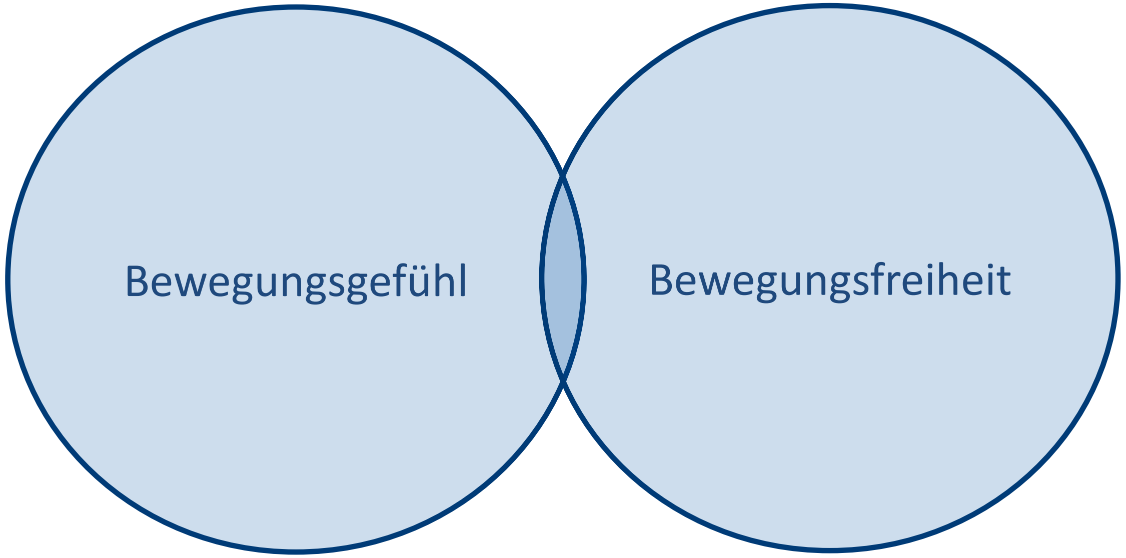
„Theory in research and education meets practice“



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Bewegungsgefühl

https://dshs-koeln.sciebo.de/s/bfm8Ze1IMQg8Bua

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Bewegungsfreiheit

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Rotation vor Extension (Geduld)

Bewegungsstrategien

- Rock `n´ roll
- Delayed Knee Extension
- Knee Split

Biologische Kapazität

- Oberschenkelrückseite (shin alignment)
- Sprunggelenk: Mobilität & Kraft

Individualisierung (Find your range)

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Vielen Dank für ihre Aufmerksamkeit!

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Future Research

Shin Roll
↕
BRK

Anteil der Strategien
↓
KSP Beschleunigung

Sprunggelenk-Mechanik
↓
Bremskraftstoß