Impact of the athletes' anthropometry on the optimal acrobatic techniques

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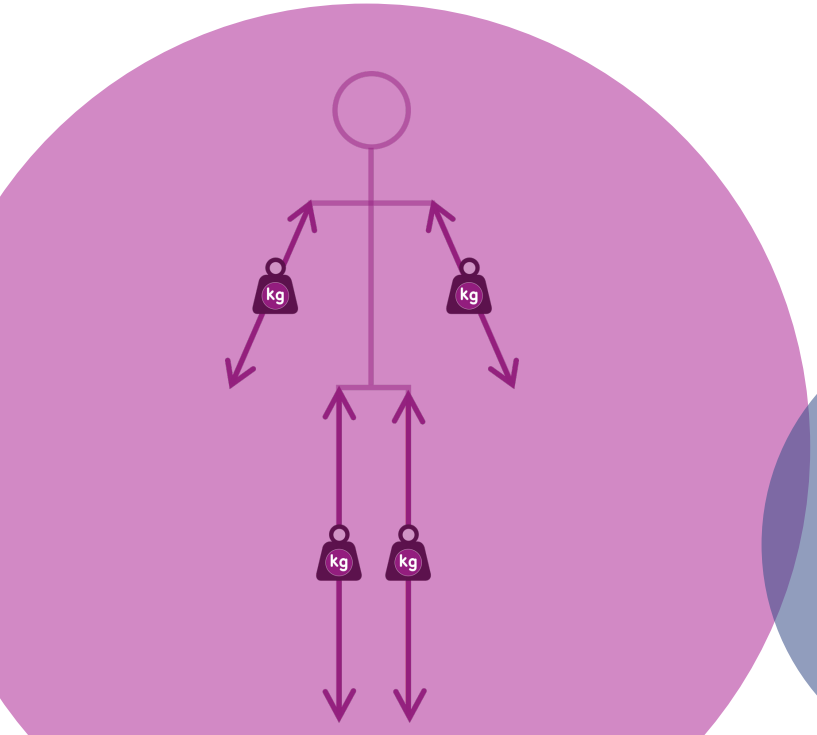

S2M Simulation et Modélisation du Mouvement

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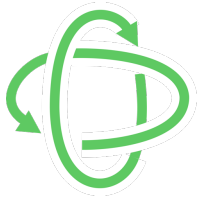
Context



Complex biomechanics

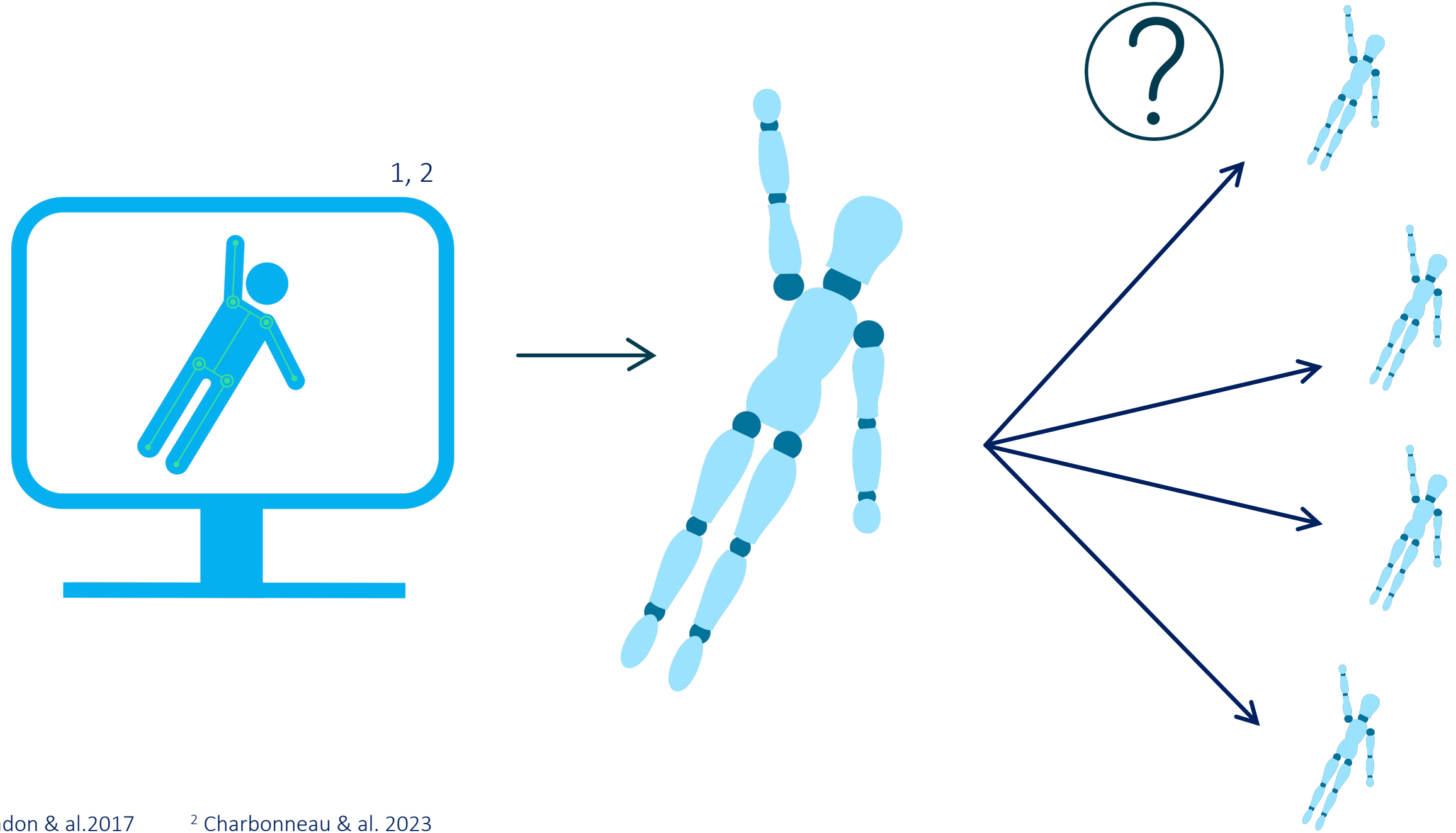
- Hard for coaches to imagine new techniques

Innovation might involve injury risks

- Trial and error is impossible
- Safe and innovative techniques

Predictive simulation is a good alternative

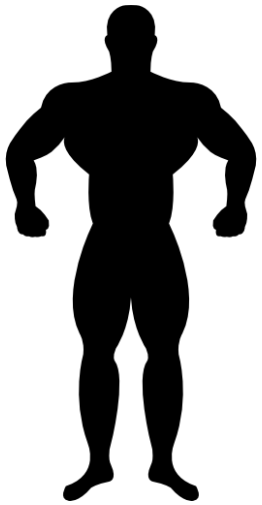
- Brings certainty to the coaches



[1] Yeadon & al.2017 [2] Charbonneau & al. 2023

… we know that anthropometry has an impact on the dynamics

But this effect was never quantified for acrobatic athletes



VS

$$\tau = M(q)\ddot{q} + C(q,\dot{q})\dot{q} + g(q)$$

Objective:

1) Use predictive simulation to evaluate the effect of anthropometry on the optimal solutions
2) Assess the technique modifications athletes should use based on their anthropometry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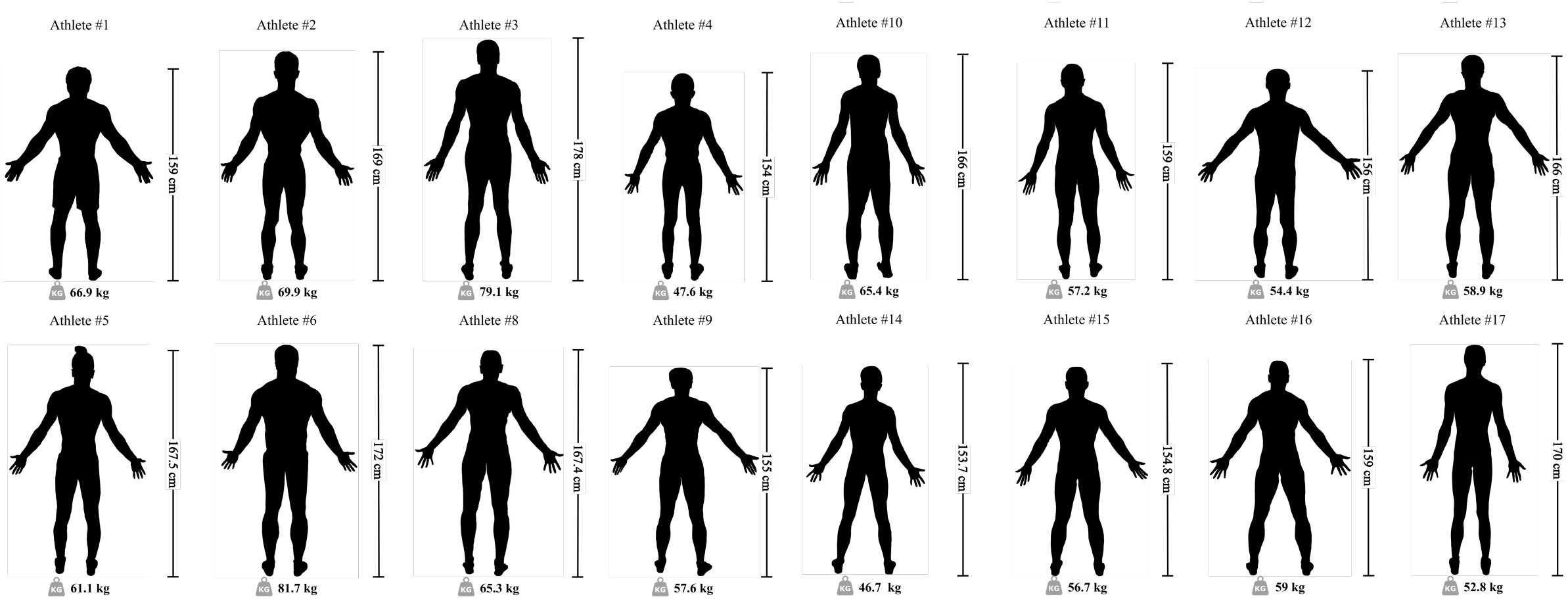
Models of 18 acrobatic athletes

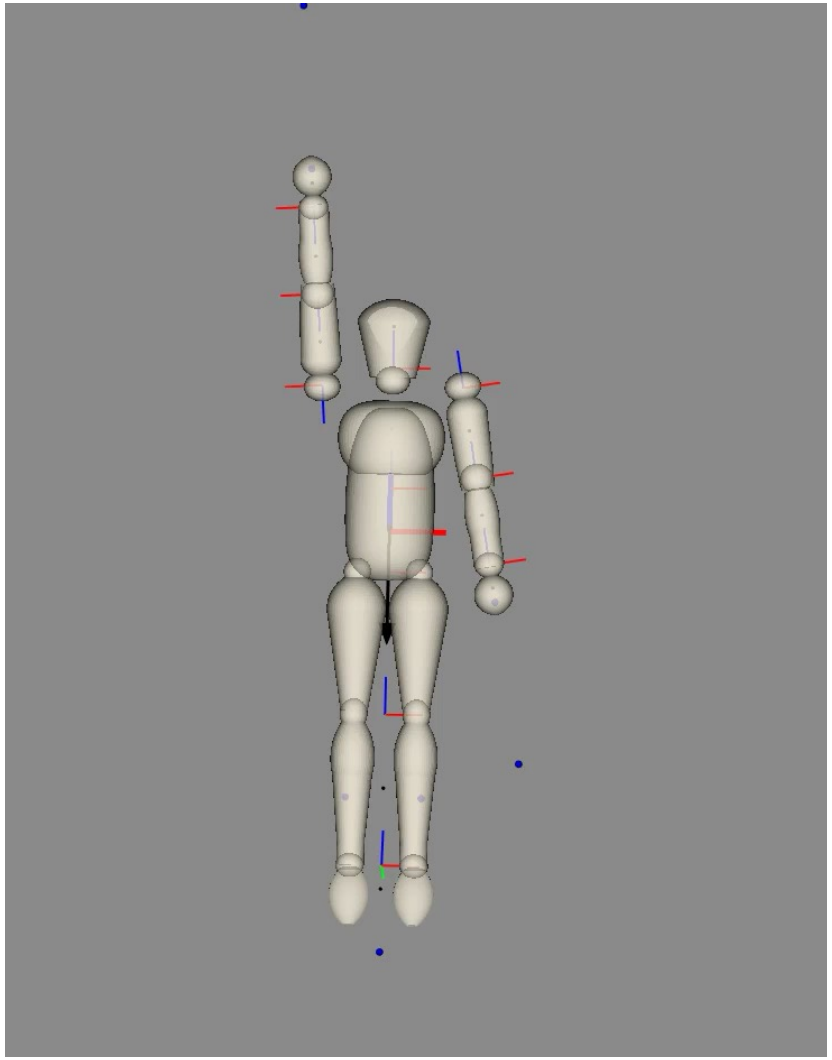
Segment length, perimeter and width were measured to reconstruct Yeandon's model[3]



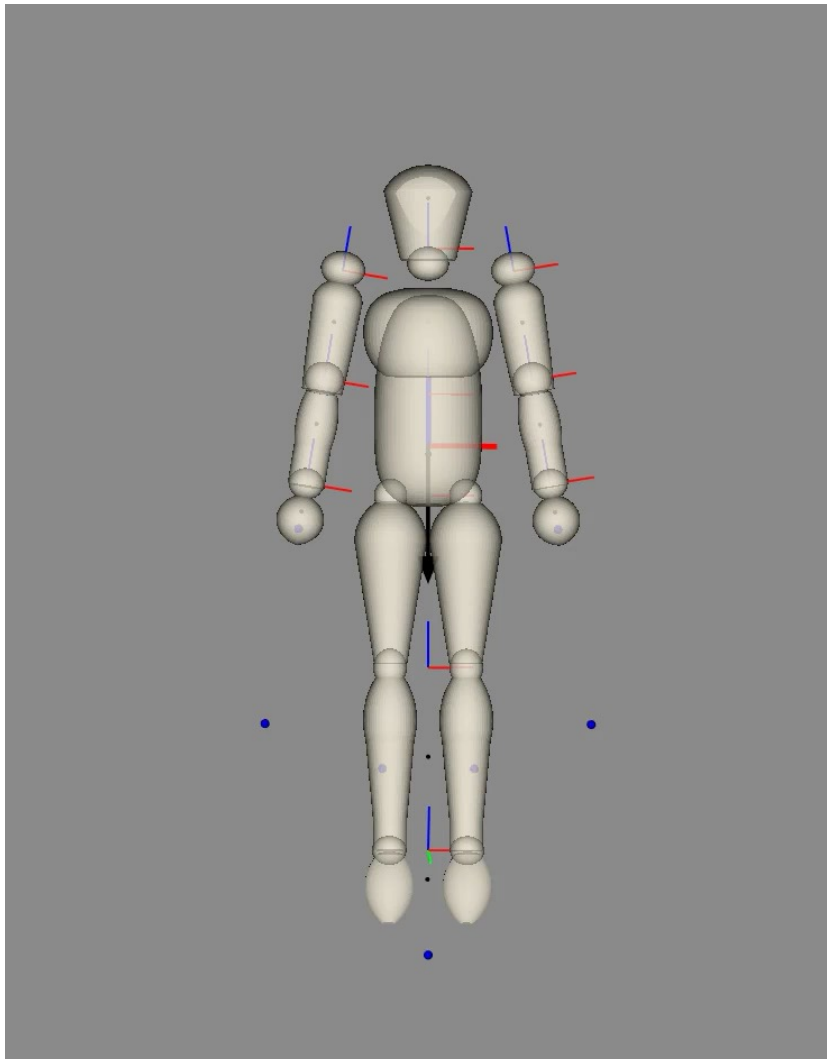
[3] Yeadon & al. 1990

Simulations

1. Simulate with a somersault velocity of 1 rev/s
2. Twist potential [°] is the twist rotation at the end of the simulation



Arms twist potential



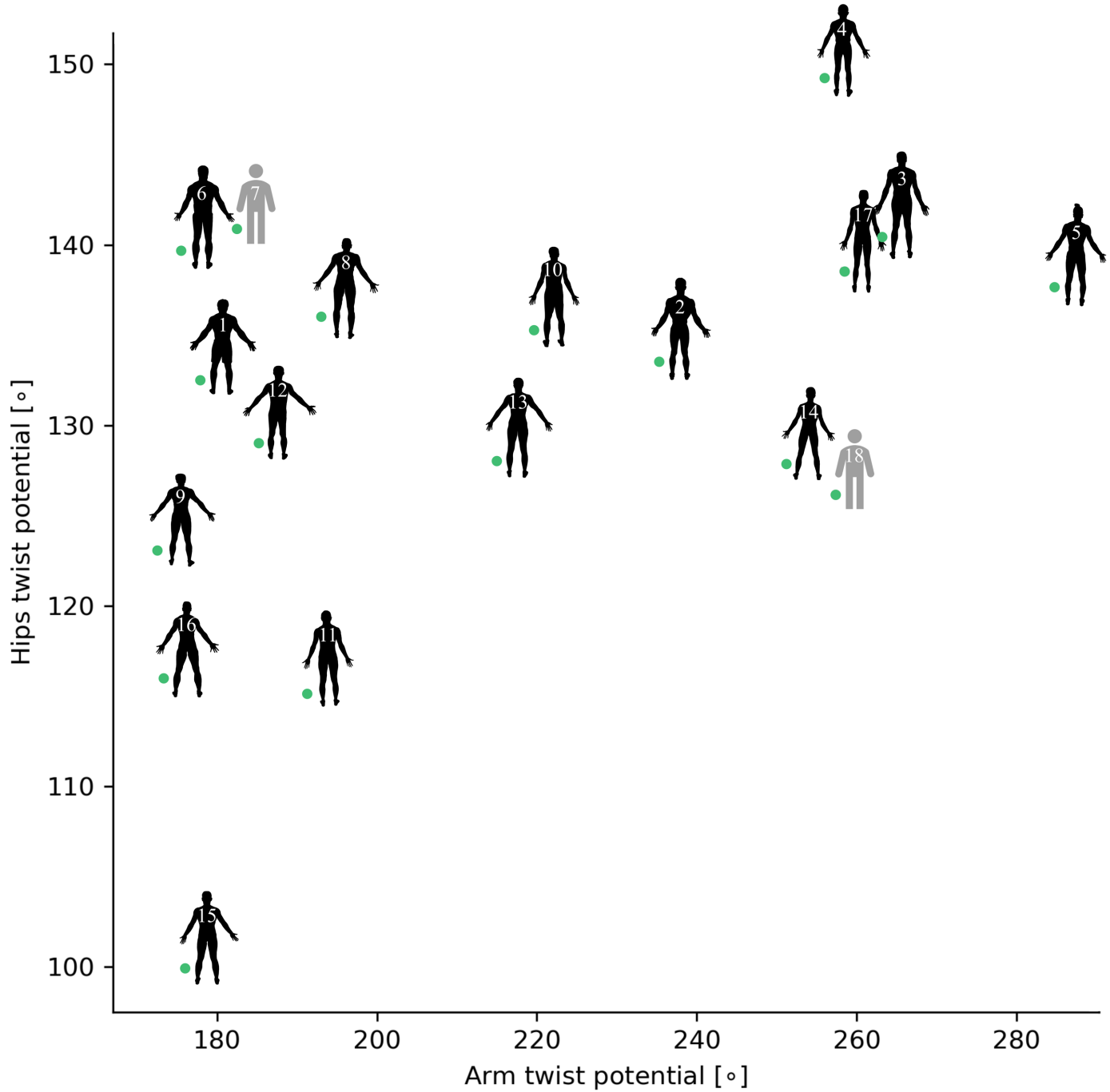
Hips twist potential

Twist potential

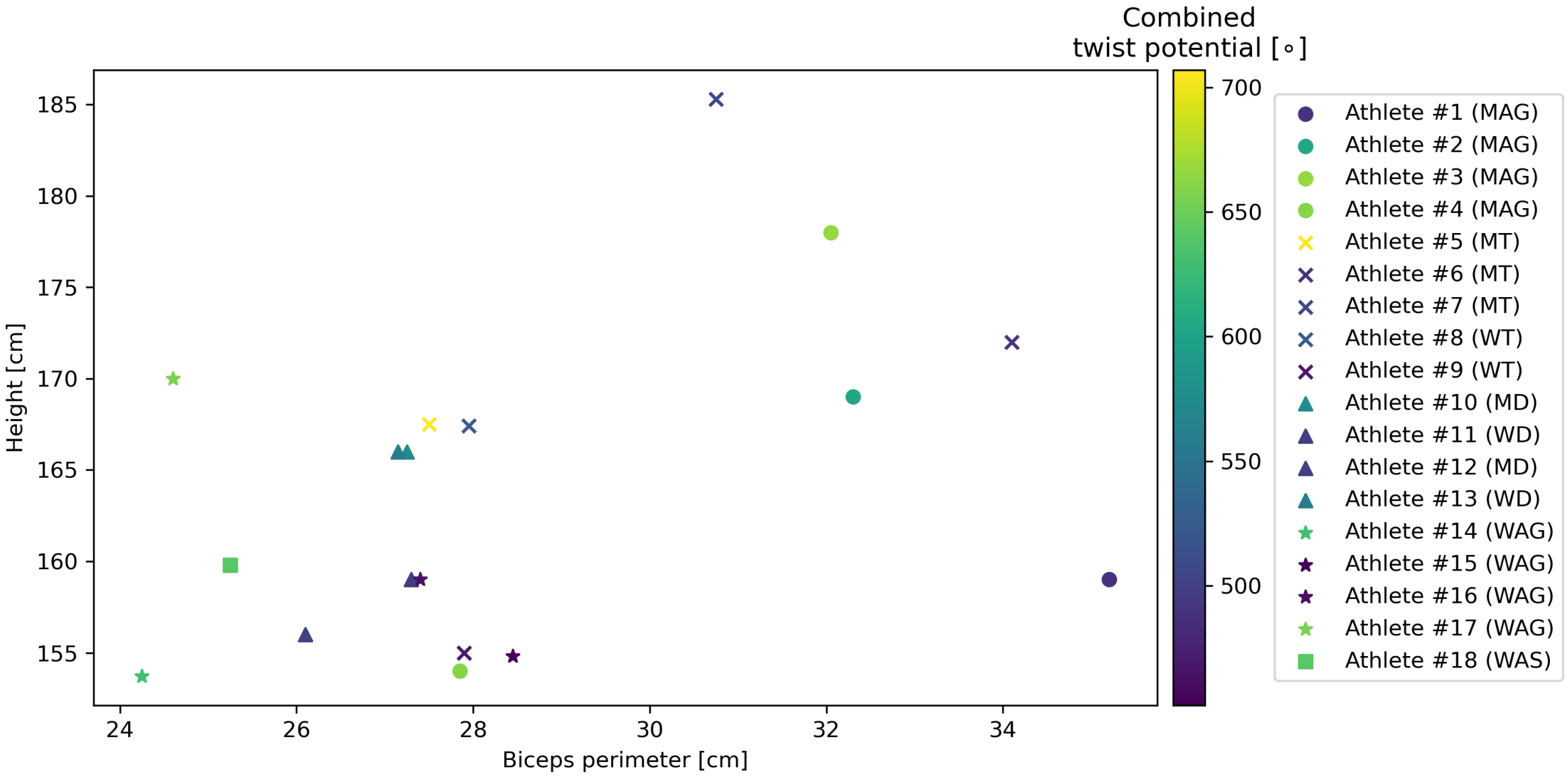
	Simulation lowering the arm			Simulation laterally flexing the hips		
	Somersault	Tilt	Twist	Somersault	Tilt	Twist
Athlete #1	399.6°	1.7°	177.9°	358.3°	8.0°	132.5°
Athlete #2	401.6°	3.9°	235.2°	359.4°	7.2°	133.5°
Athlete #3	411.0°	5.1°	263.2°	357.9°	7.9°	140.4°
Athlete #4	403.7°	4.0°	255.9°	358.4°	7.9°	149.3°
Athlete #5	401.8°	4.2°	284.7°	359.3°	7.0°	137.7°
Athlete #6	409.2°	1.7°	175.5°	356.0°	8.9°	139.7°
Athlete #7	397.2°	1.4°	182.5°	358.3°	7.0°	140.9°
Athlete #8	421.4°	1.7°	193.0°	358.5°	8.8°	136.0°
Athlete #9	388.9°	1.5°	172.6°	360.0°	7.3°	123.1°
Athlete #10	400.2°	3.5°	219.6°	358.8°	7.6°	135.3°
Athlete #11	394.3°	1.7°	191.3°	361.6°	6.3°	115.1°
Athlete #12	392.9°	1.9°	185.2°	359.1°	7.4°	129.0°
Athlete #13	399.3°	2.8°	214.9°	360.6°	6.9°	128.1°
Athlete #14	398.1°	3.9°	251.2°	361.0°	6.8°	127.9°
Athlete #15	393.1°	1.5°	176.0°	362.7°	5.5°	99.9°
Athlete #16	390.2°	1.3°	173.3°	361.2°	6.7°	116.0°
Athlete #17	398.3°	3.6°	258.4°	360.2°	6.9°	138.5°
Athlete #18	396.8°	4.2°	257.4°	360.8°	6.8°	126.1°

More than a
¼ twist difference

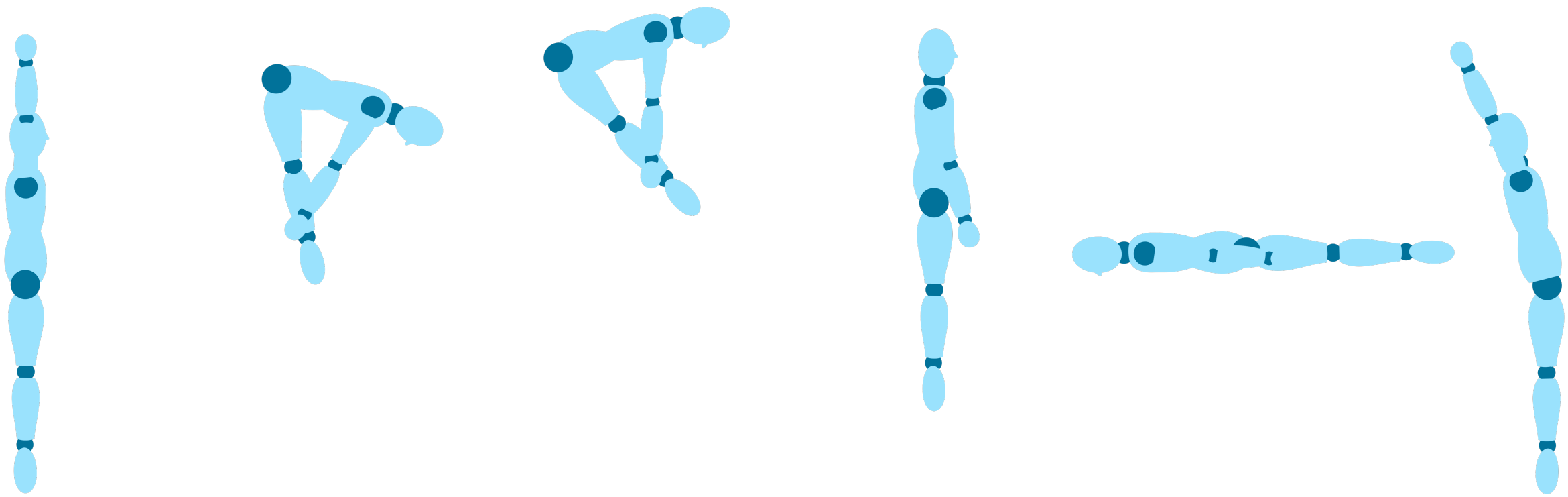
Twist potential



Twist potential

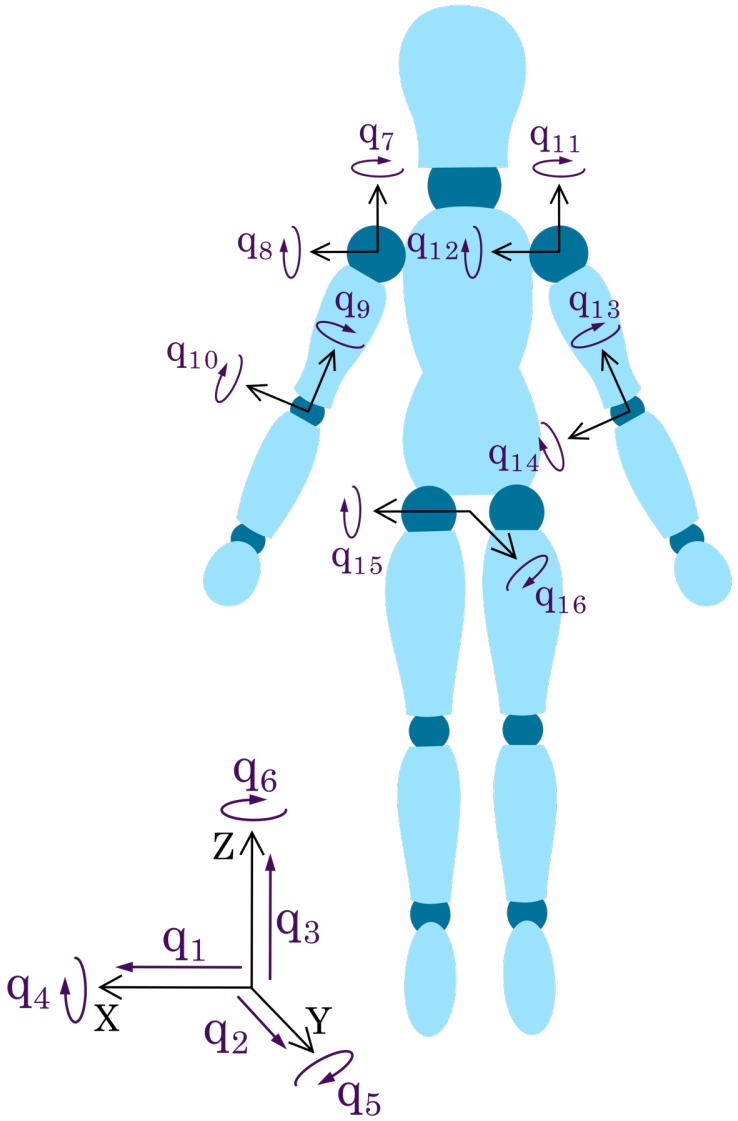


Problem definition



Bioptim
Biomechanical optimal control

Problem definition



Objectives

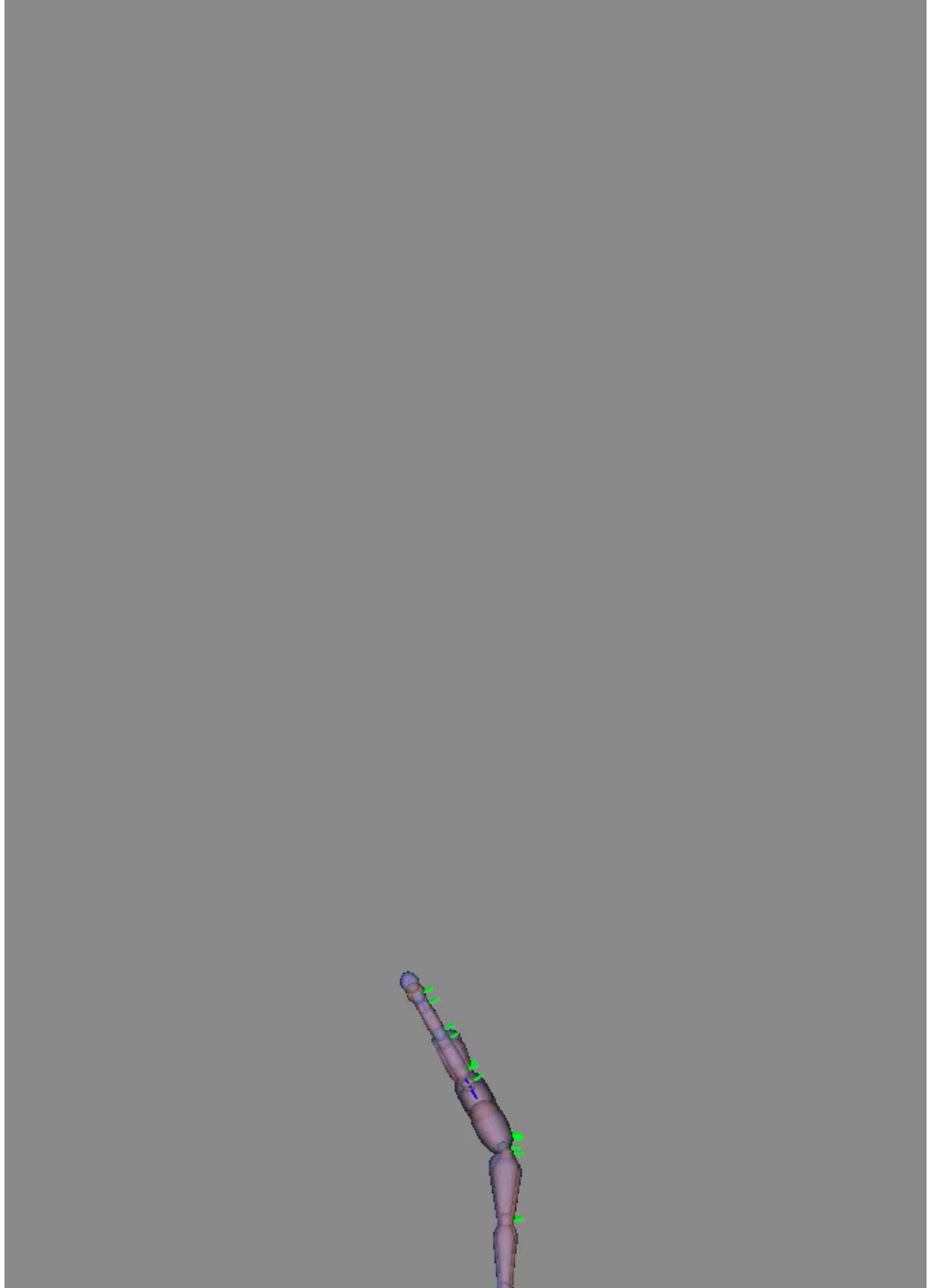
- Minimize joint acceleration
- Minimize phase duration
- Superimpose hands on lower legs (pike position)
- Keep arms straight and aligned with the trunk
- Maximize the kick out speed

Constraints

- Superimpose hands on lower legs (pike position)
- Physiological joints boundaries
- Sport regulations joint boundaries

[4] Michaud & al. 2022

Optimal solutions

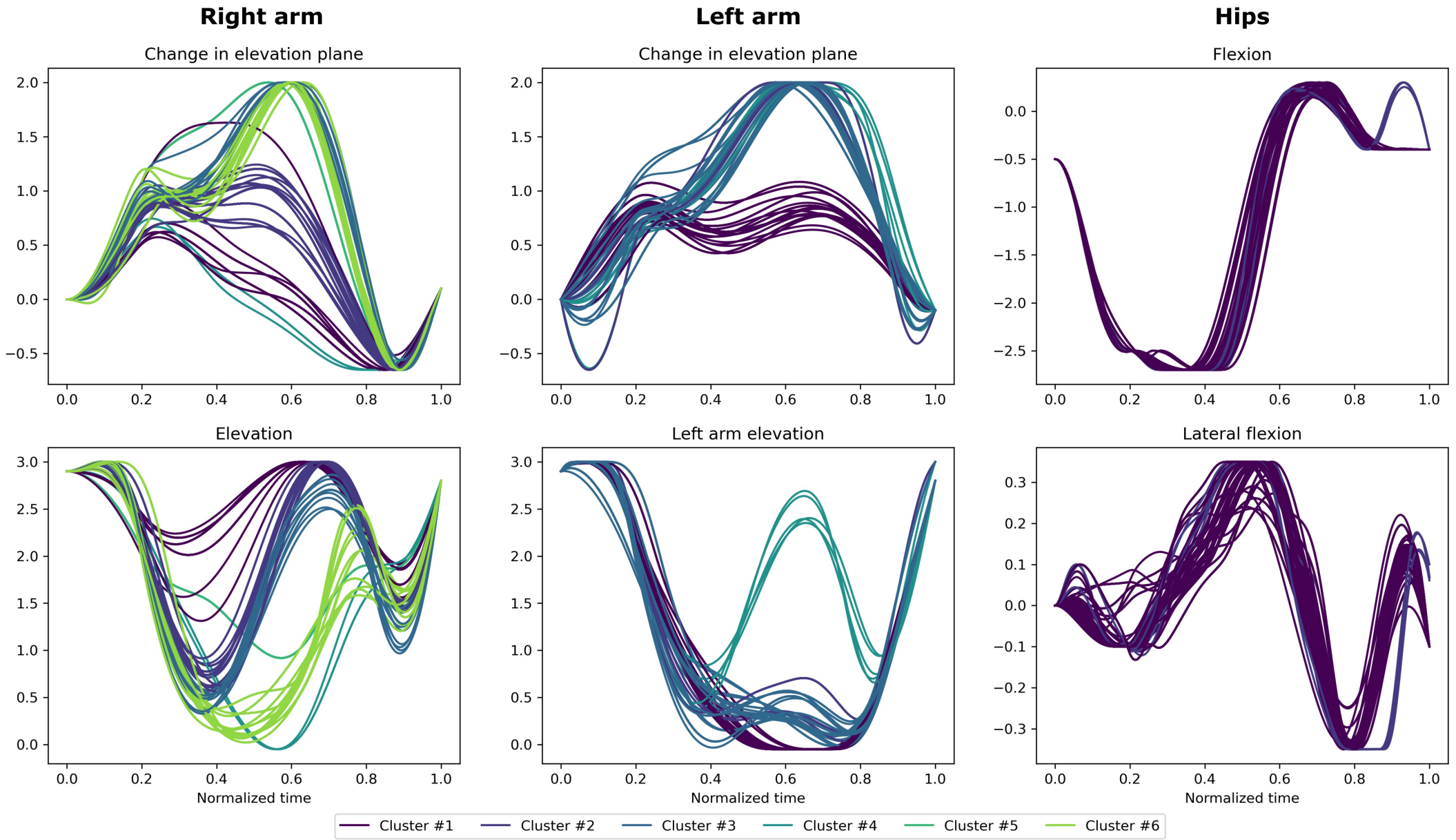


muscled men

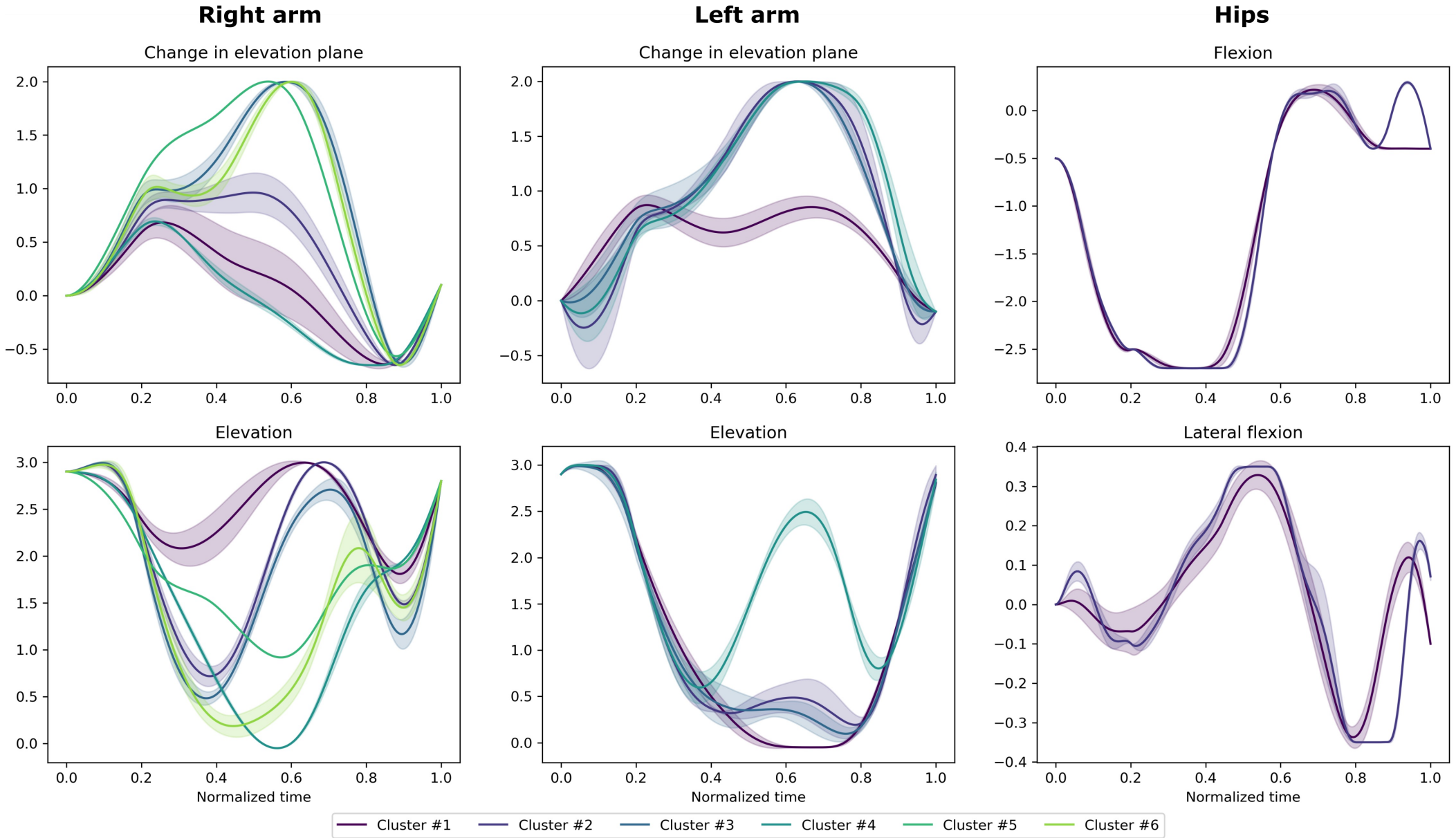
vs

lean women

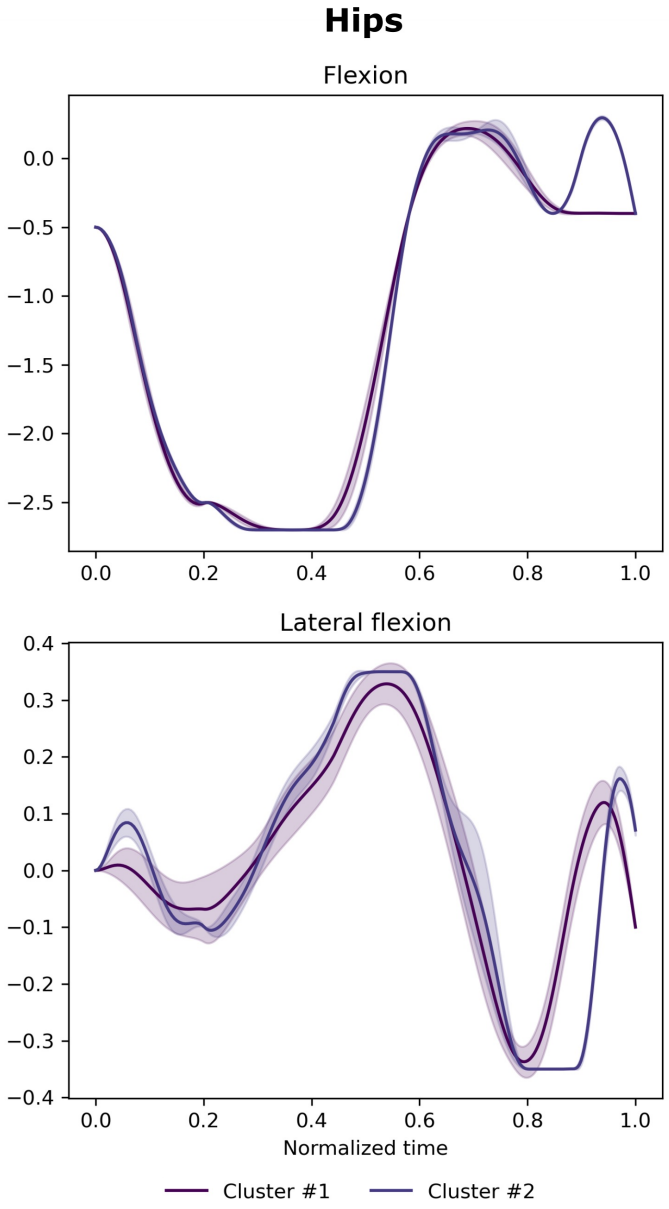
Clusters of solutions



Clusters of solutions



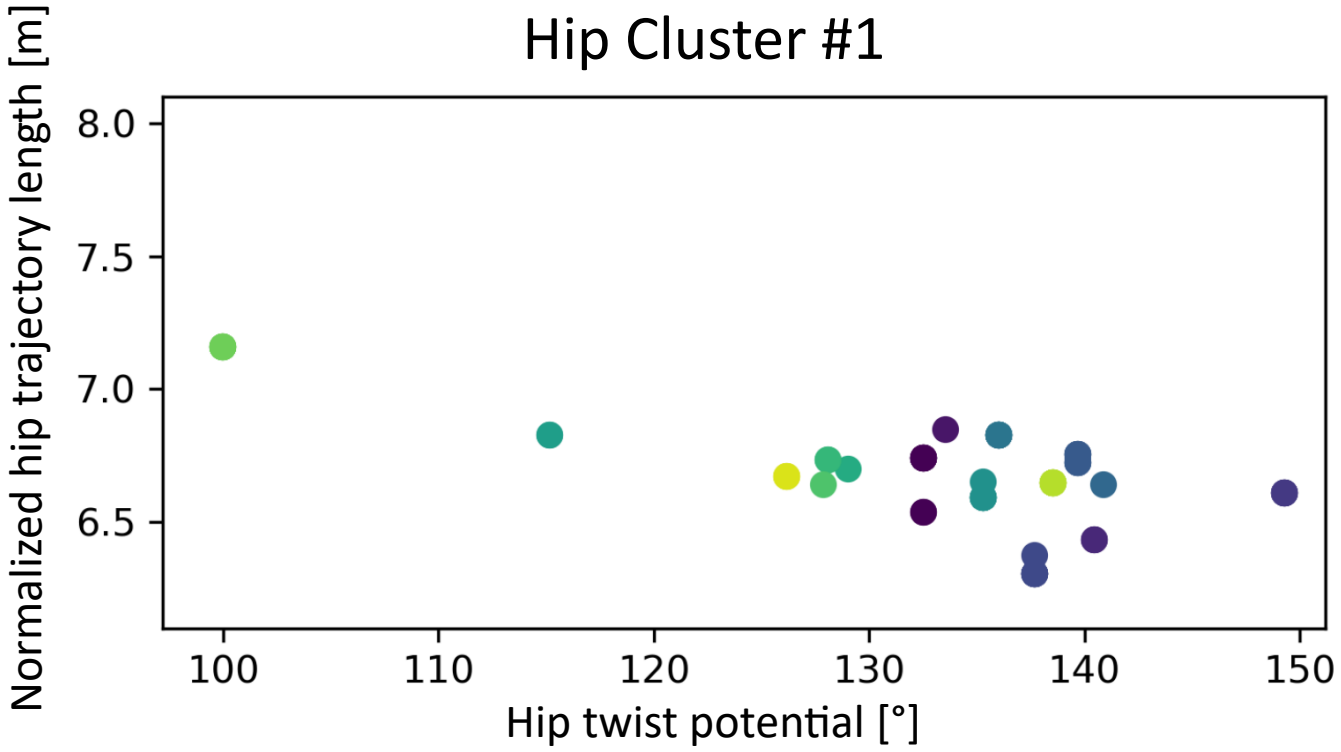
Amplitude modifications inside the clusters



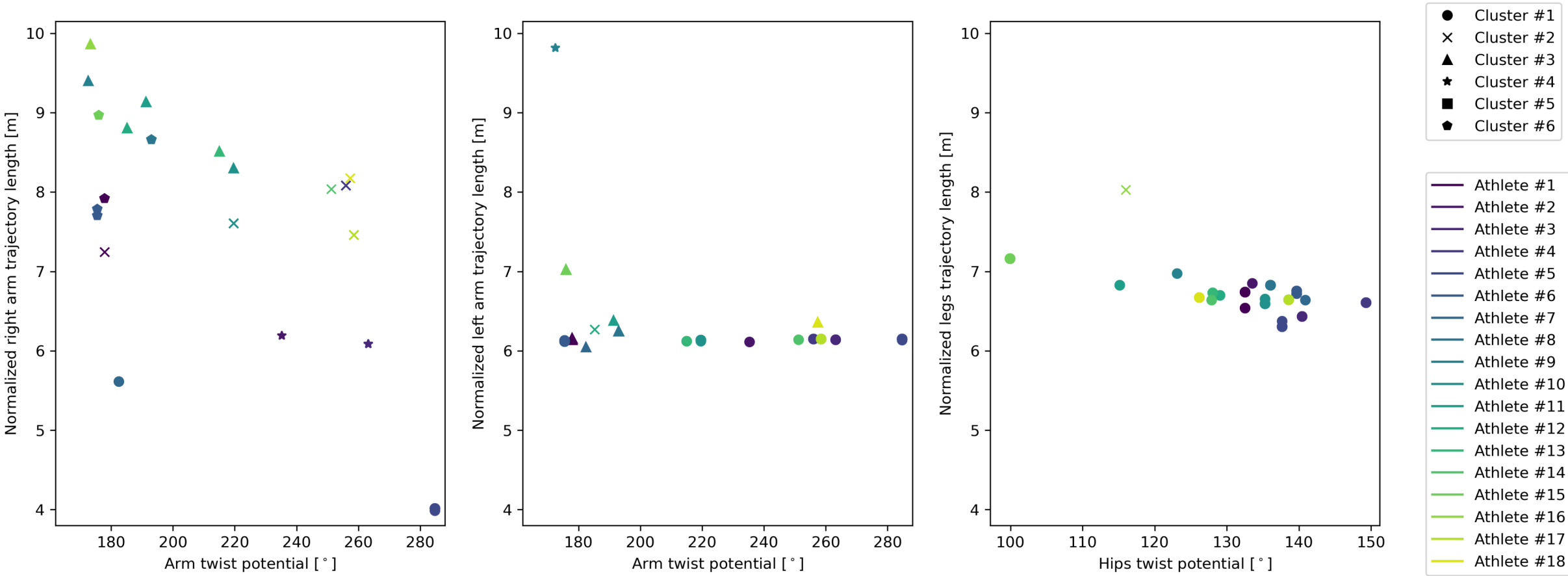
Was used by 17/18 athletes

Hip flexion adaptations of 6% of the movement range

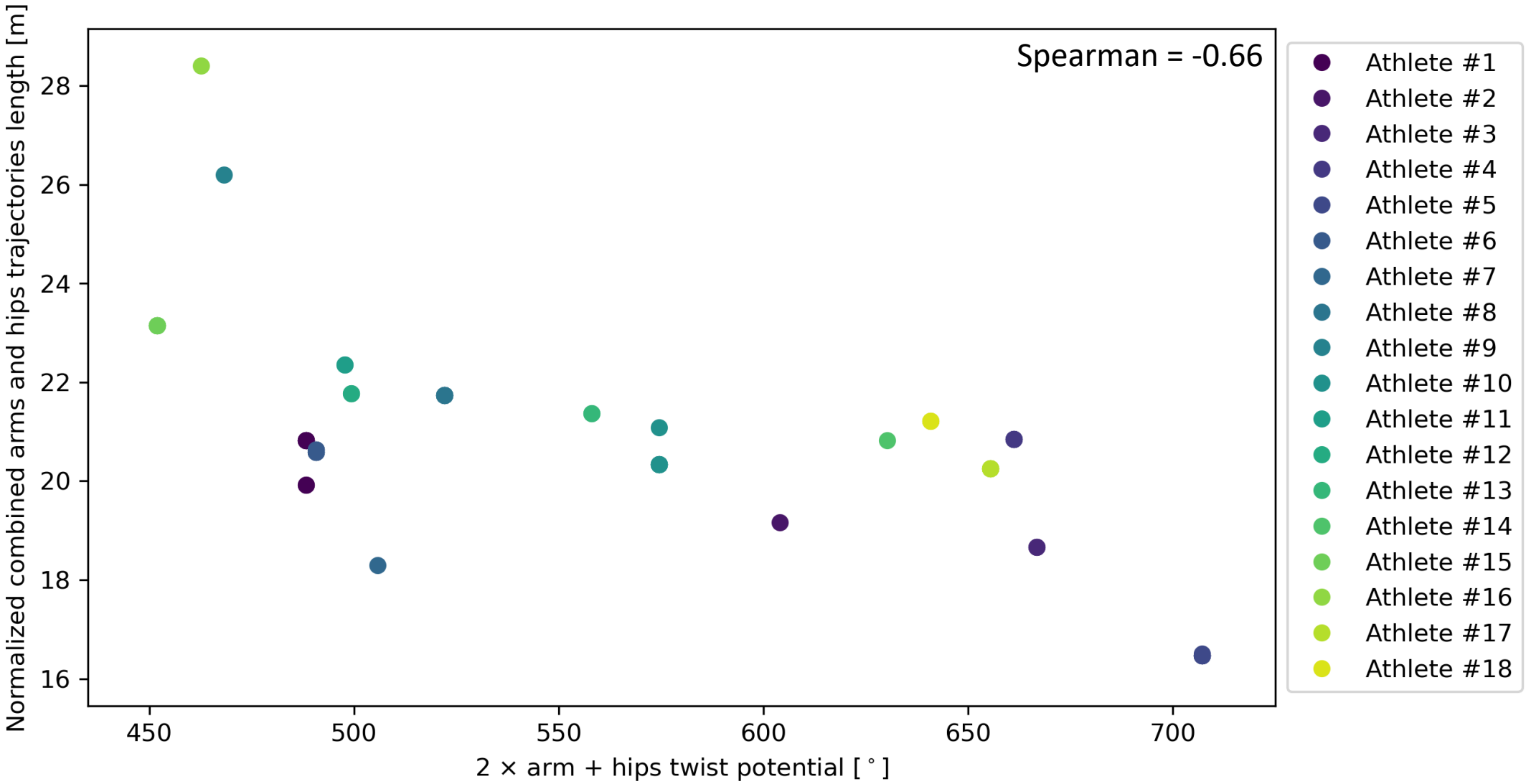
Hip lateral flexion adaptations of 27% of the movement range



Length of segment trajectories



Length of grouped segment trajectories



Conclusion

- There is an impact of anthropometry on the optimal techniques
  - ↳ Coaches should not try to teach every athlete the same strategies
  - ↳ Sport scientists should not draw generic conclusions based on one anthropometry

- Some antropometries are less suited for aerial twists
  - ↳ It might be advantageous for these athletes to use more contact twist
  - ↳ Coaches should consider other less common twisting strategies for these athletes

References

1. Yeadon, M. R., & Hiley, M. J. (2017). Twist limits for late twisting double somersaults on trampoline. *Journal of biomechanics*, *58*, 174-178.
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4. Michaud, B., Bailly, F., Charbonneau, E., Ceglia, A., Sanchez, L., & Begon, M. (2022). Bioptim, a python framework for musculoskeletal optimal control in biomechanics. *IEEE Transactions on Systems, Man, and Cybernetics: Systems*, *53*(1), 321-332.

Acknowledgements

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