

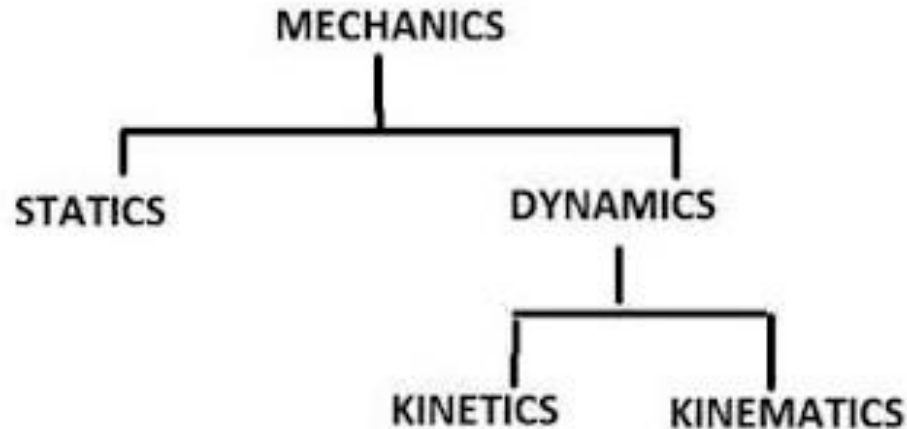
# Kinetics of Foot and Ankle during Gait


Yoon Kim, MD, MMSc

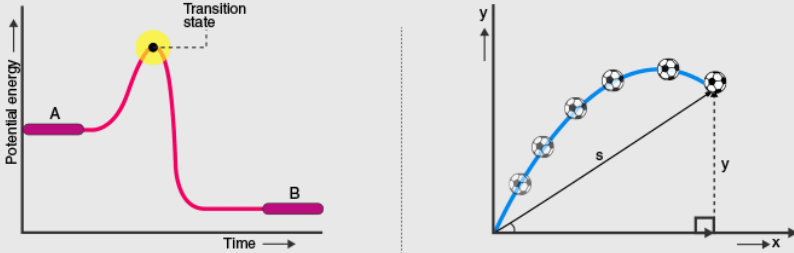
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# Kinematics? Kinetics?

- Kinematics: 운동학: describe motion using equations of motion (mass -, force -)
- Kinetics: 운동역학: explains how a body responds when a force or torque is applied to it (mass +, force +)



**DIFFERENCE BETWEEN KINETICS AND KINEMATICS** 

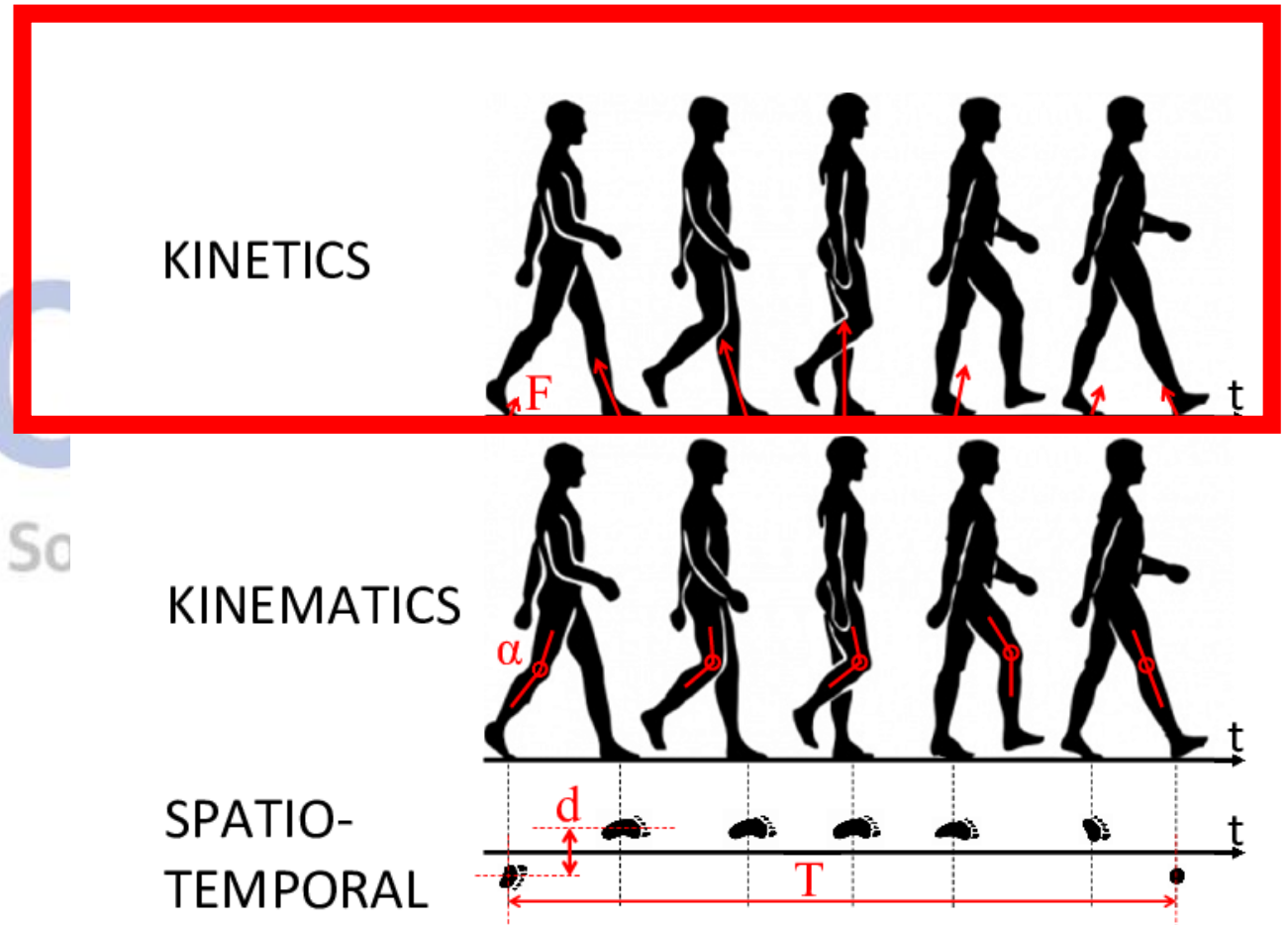


**KINETICS**  
IT IS THE STUDY OF FORCES THAT ARE ACTING ON AN OBJECT UNDER A PARTICULAR MECHANISM.

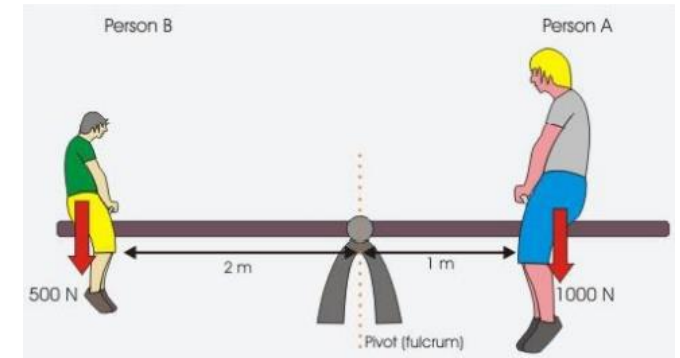
**KINEMATICS**  
THE BRANCH OF MECHANICS CONCERNED WITH THE MOTION OF OBJECTS WITHOUT REFERENCE TO THE FORCES WHICH CAUSE THE MOTION.

# Kinematics? Kinetics?

- Kinematics: 운동학: describe motion using equations of motion (mass -, force -)
- Kinetics: 운동역학: Korean So explains how a body responds when a force or torque is applied to it (mass +, force +)

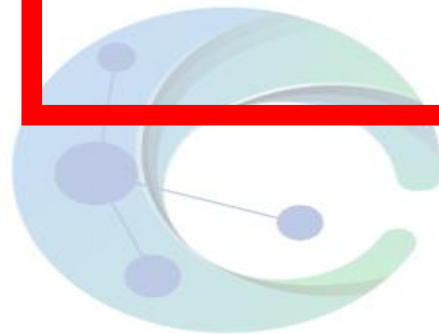
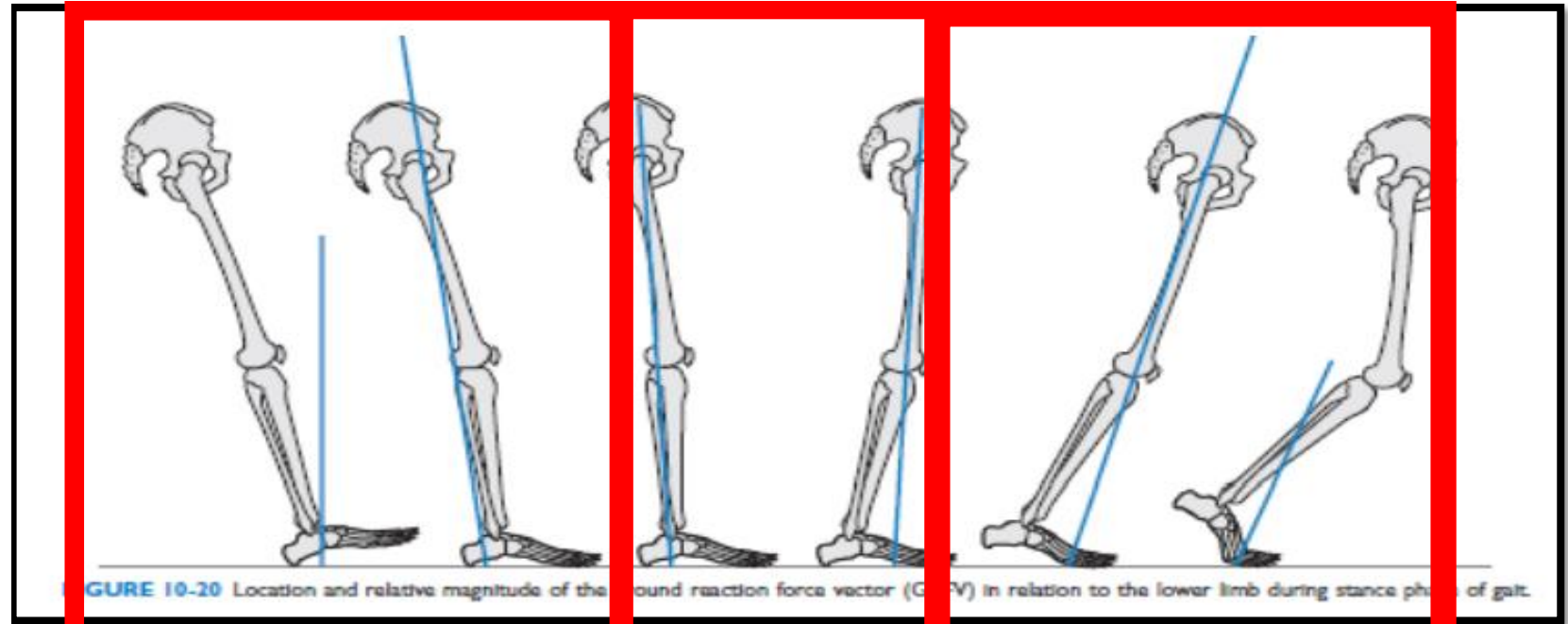
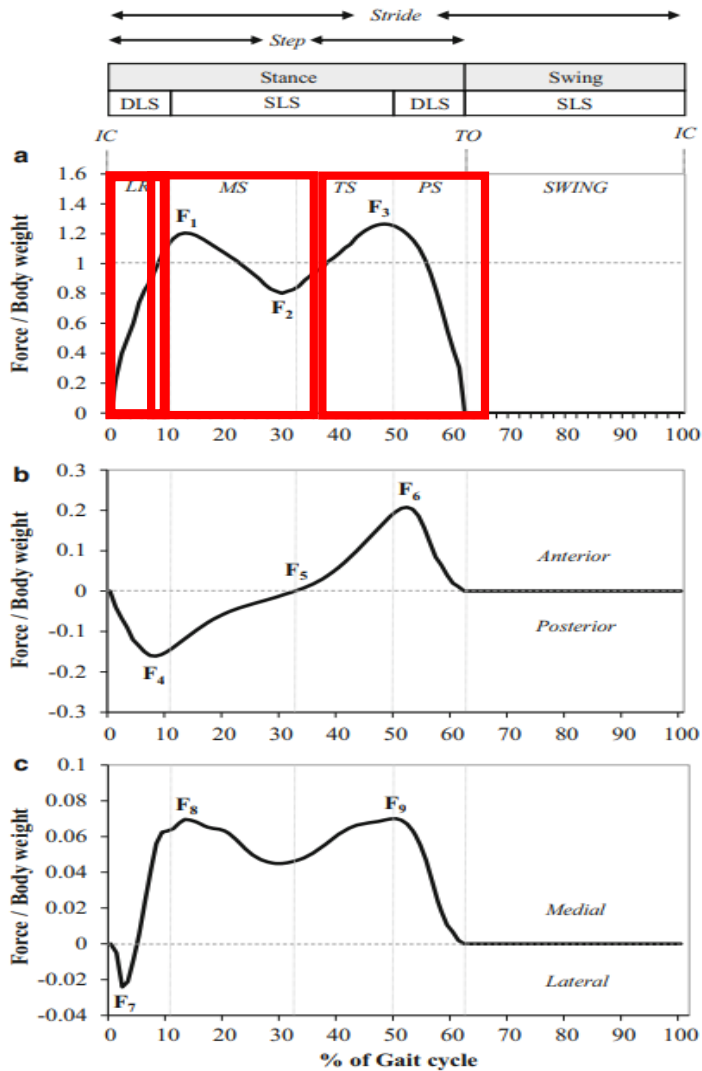


# Joint Kinetics

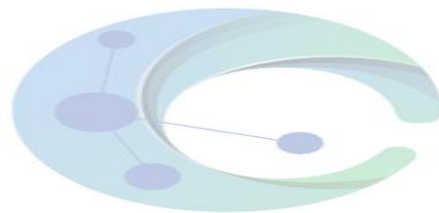
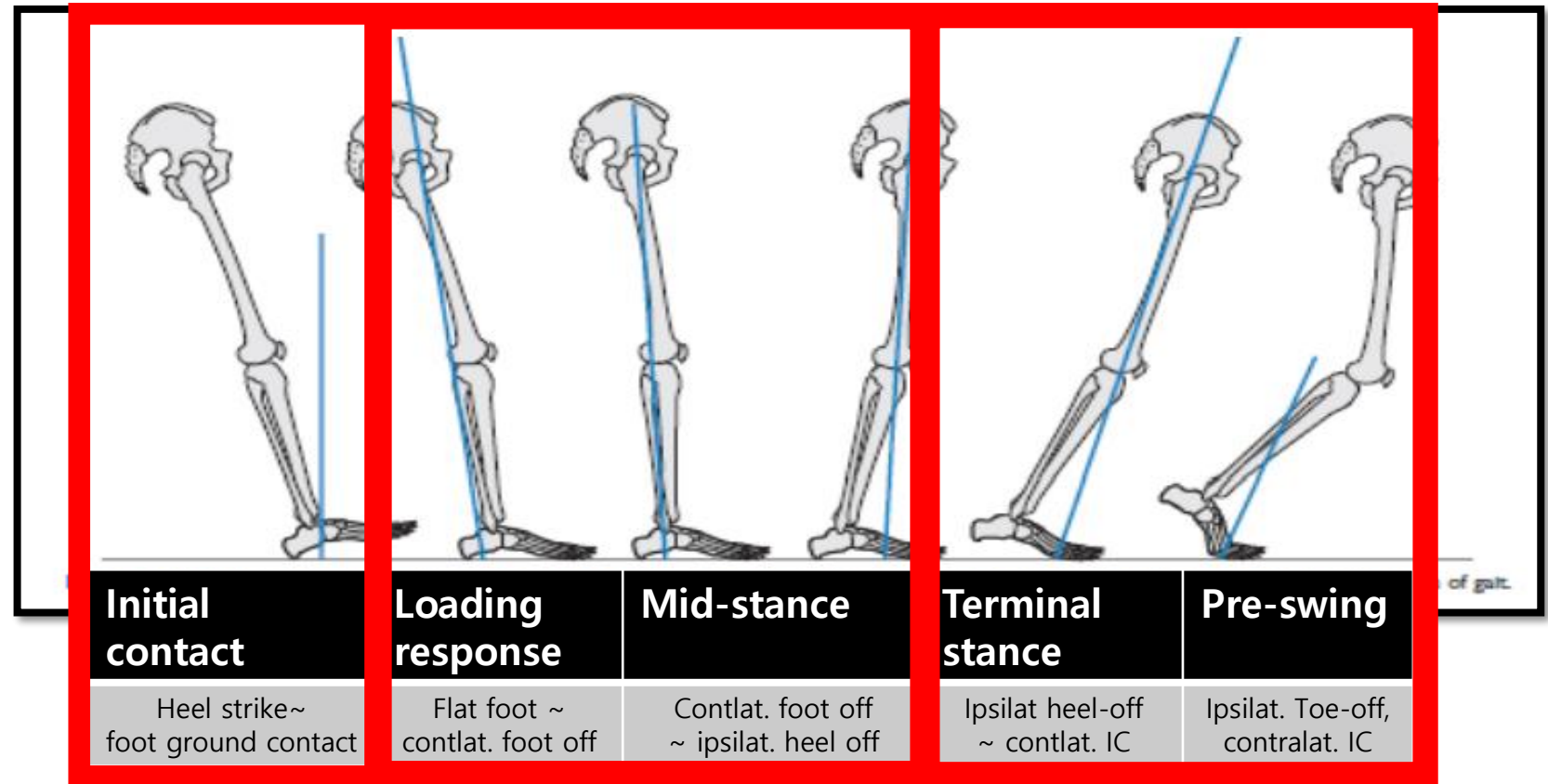
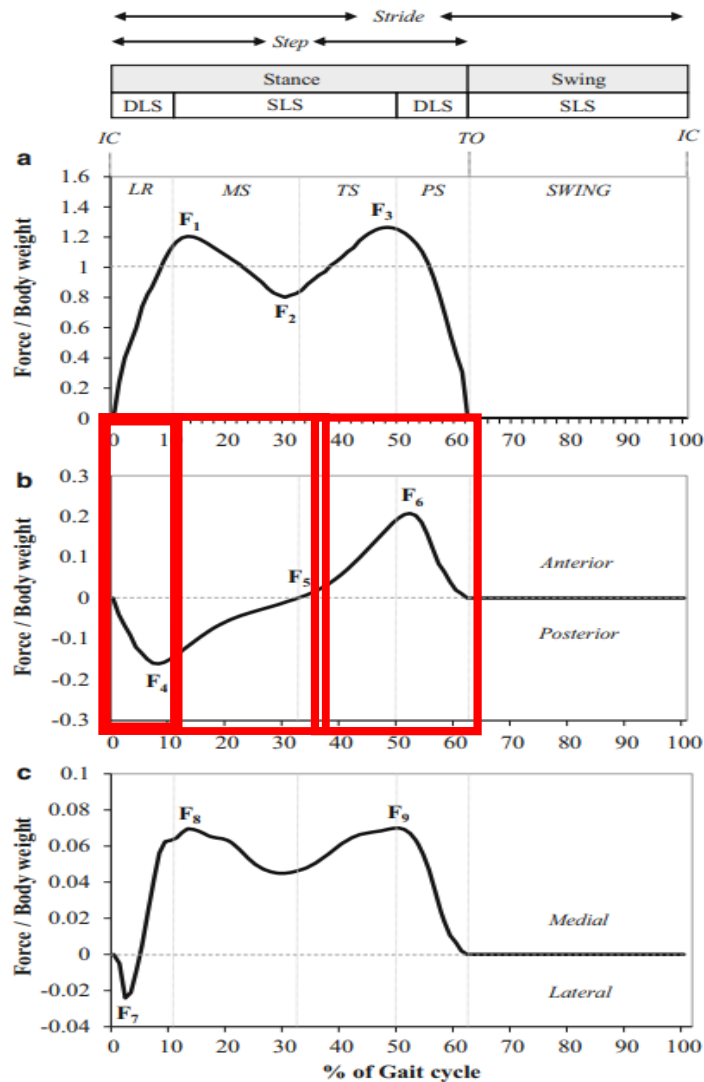


- GRF (Ground Reaction Force)
  - Force provided by a supporting horizontal surface (vertical, AP, ML)
- COP (Center of Pressure)
  - The point where the resultant of all GRF act (average location of pressure)
- Joint moment = force X moment arm
  - Net sum of all internal moments delivered by all internal structures around a joint
  - (ex: mainly muscles, but toward the end ROM, by ligamentous or bony tissue)
- Joint power = internal muscle force X muscle angular velocity
  - Net rate, amount, and timing of energy generation and absorption of all muscles and ligaments around a joint
- Equipment
- Force plate

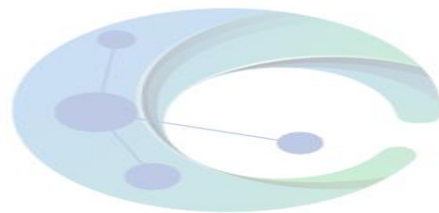
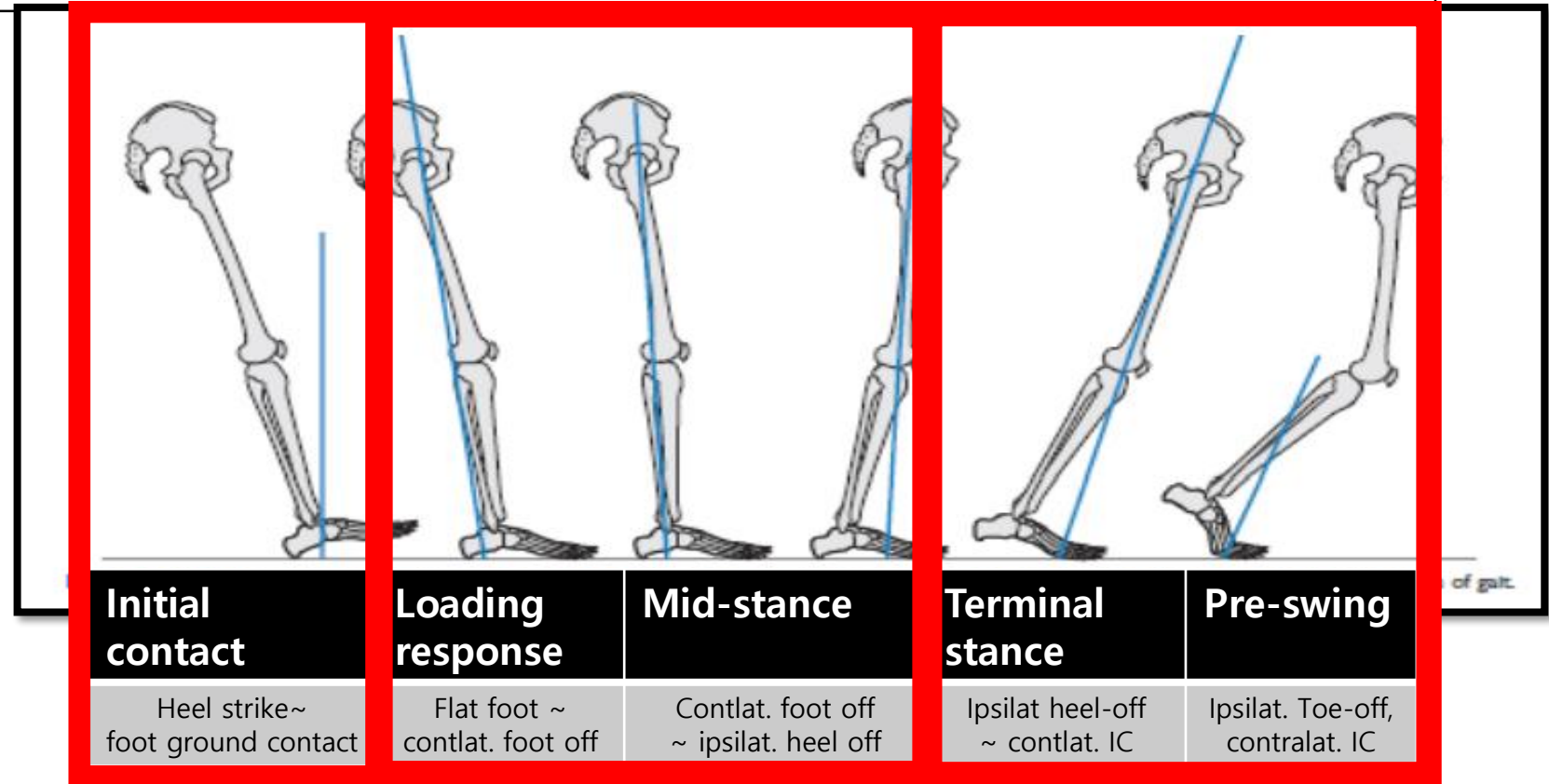
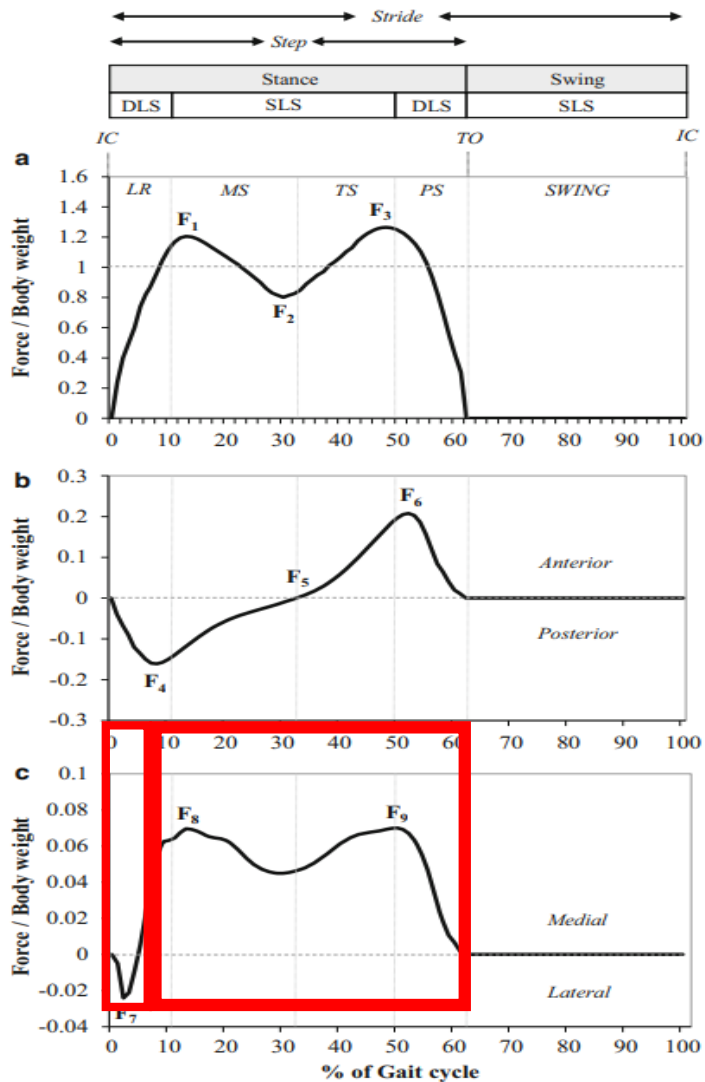
# Ground Reaction Force during Gait



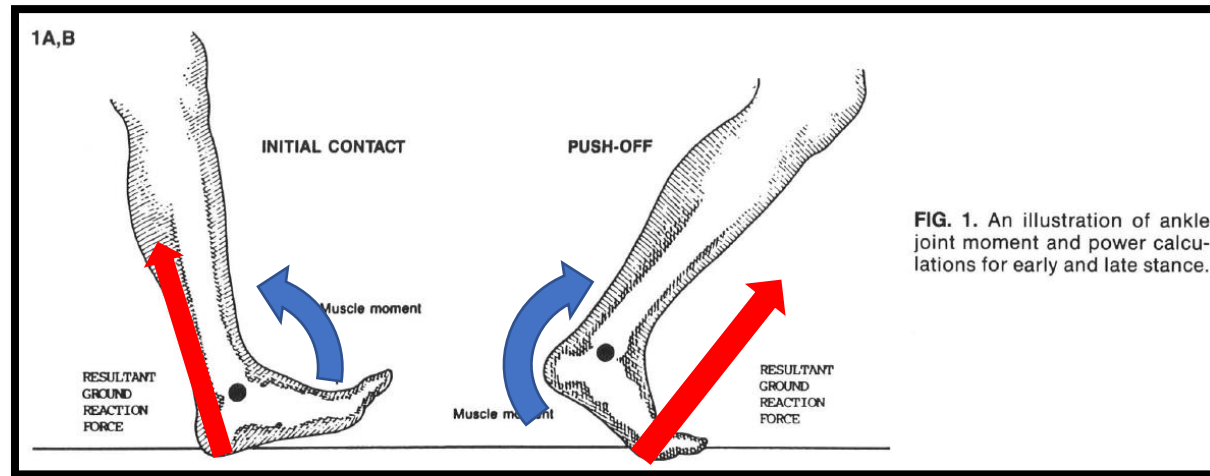
# Ground Reaction Force during Gait



# Ground Reaction Force during Gait



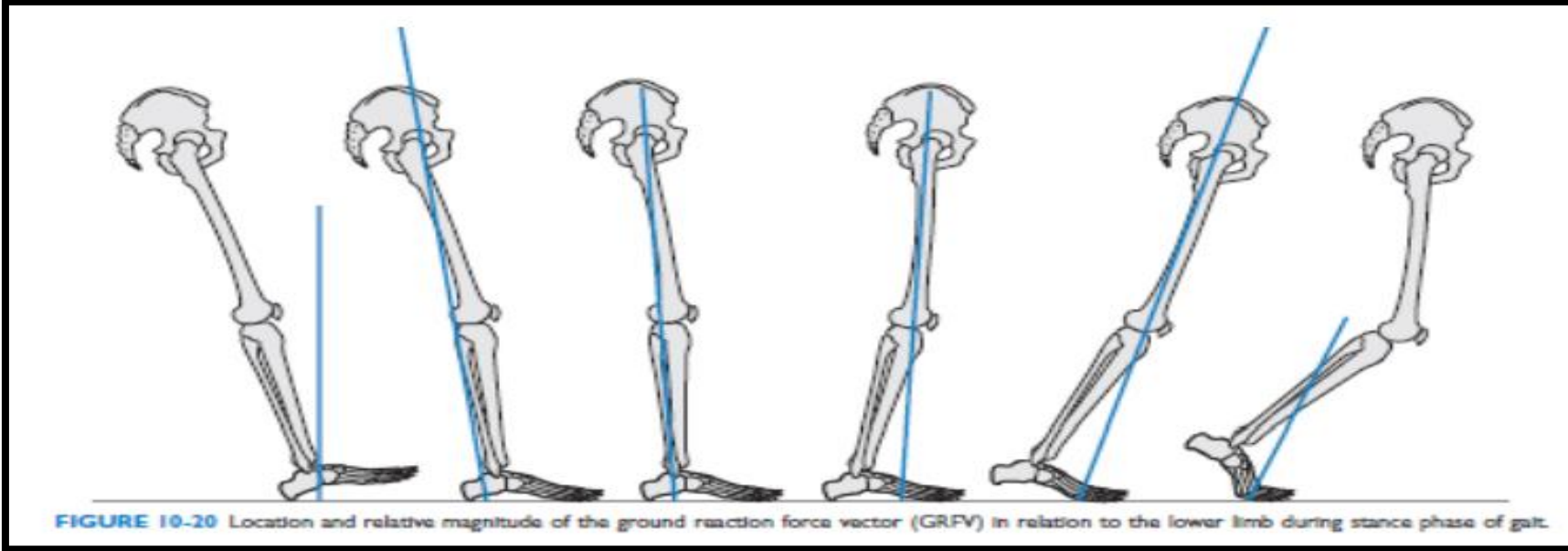
# Kinetics of Foot and Ankle at Gait (single-link model)



Three-Dimensional Lower Extremity Joint Kinetics in Normal Pediatric Gait, Journal of Pediatric Orthopaedics, 11:341-349, 1991

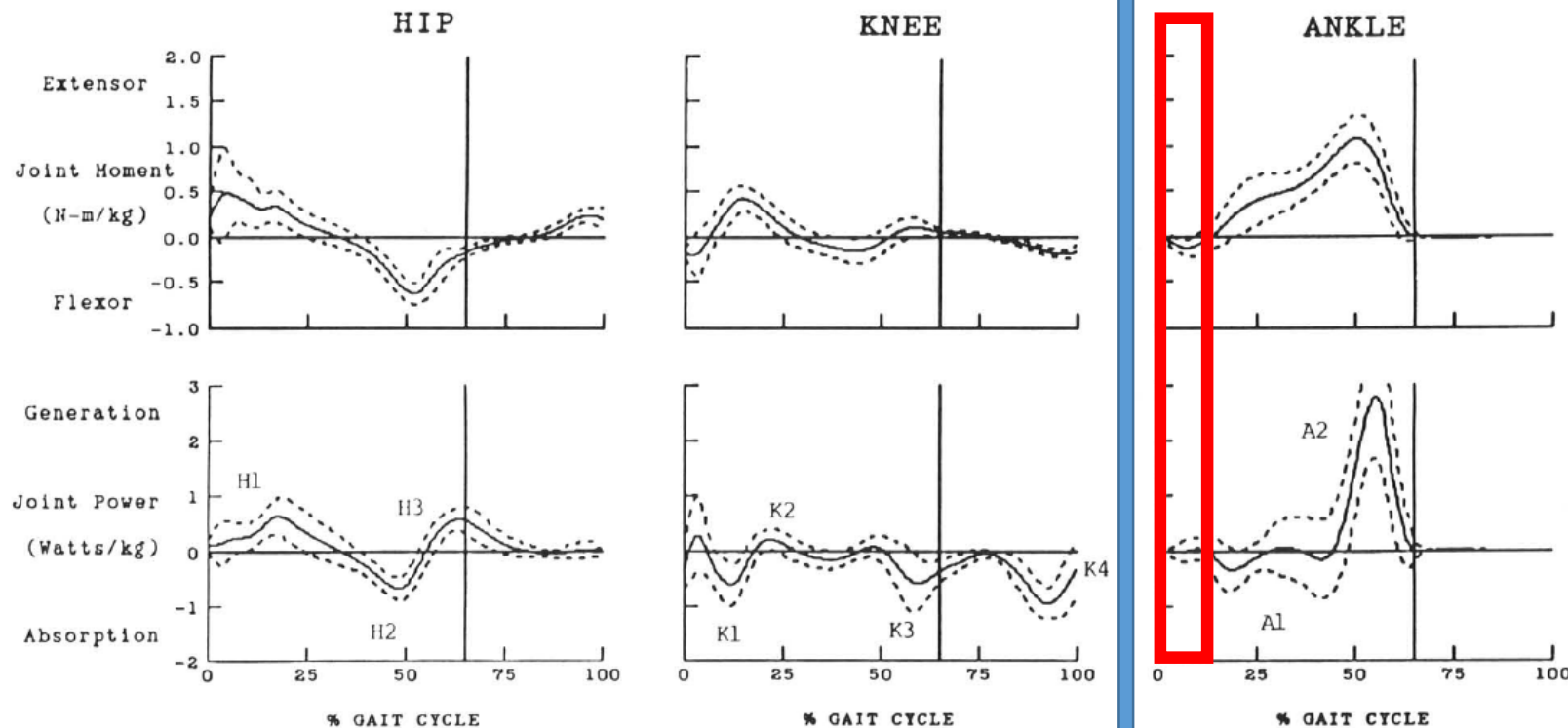
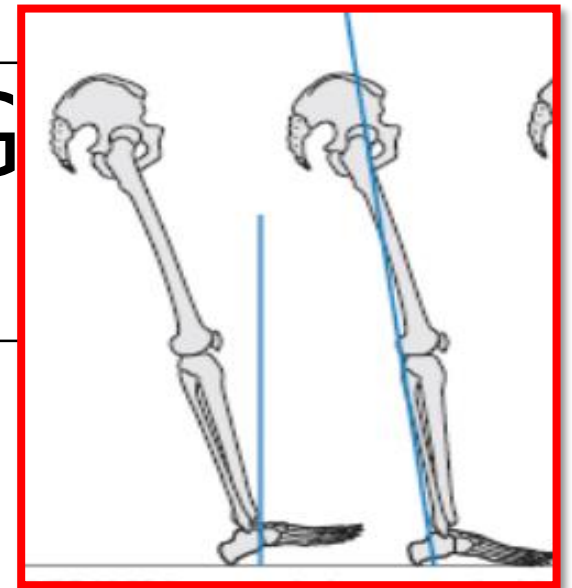
- 1A: initial contact:  
GRF-post. to ankle J. center  
Tend to PF  
To control ankle DF,  
net DF moment is produced by  
ankle DF m.
- 1B: push-off:  
GRF-ant. to ankle J. center  
Tend to DF  
To produce active PF,  
net PF moment is produced by  
ankle PF m.





	Initial contact	Loading response	Mid-stance	Mid-stance	Terminal stance	Pre-swing
	Heel strike ~ foot ground contact	Flat foot ~ contralat. foot off	Contralat. foot off ~ ipsilat. heel off		Ipsilat heel-off ~ contralat. IC	Ipsilat. Toe-off, contralat. IC
Rocker	1st (Heel)		2nd (Ankle)		3rd (Forefoot)	
GRF	Center -> Post.	Post.	Center -> Ant.	Ant.	Ant	
Net moment	DF		PF		PF (peak)	PF
Action	DF m. eccentric contraction		PF m. eccentric contraction		PF m. concentric contraction	
Power	Absorption		Absorption		Generation	

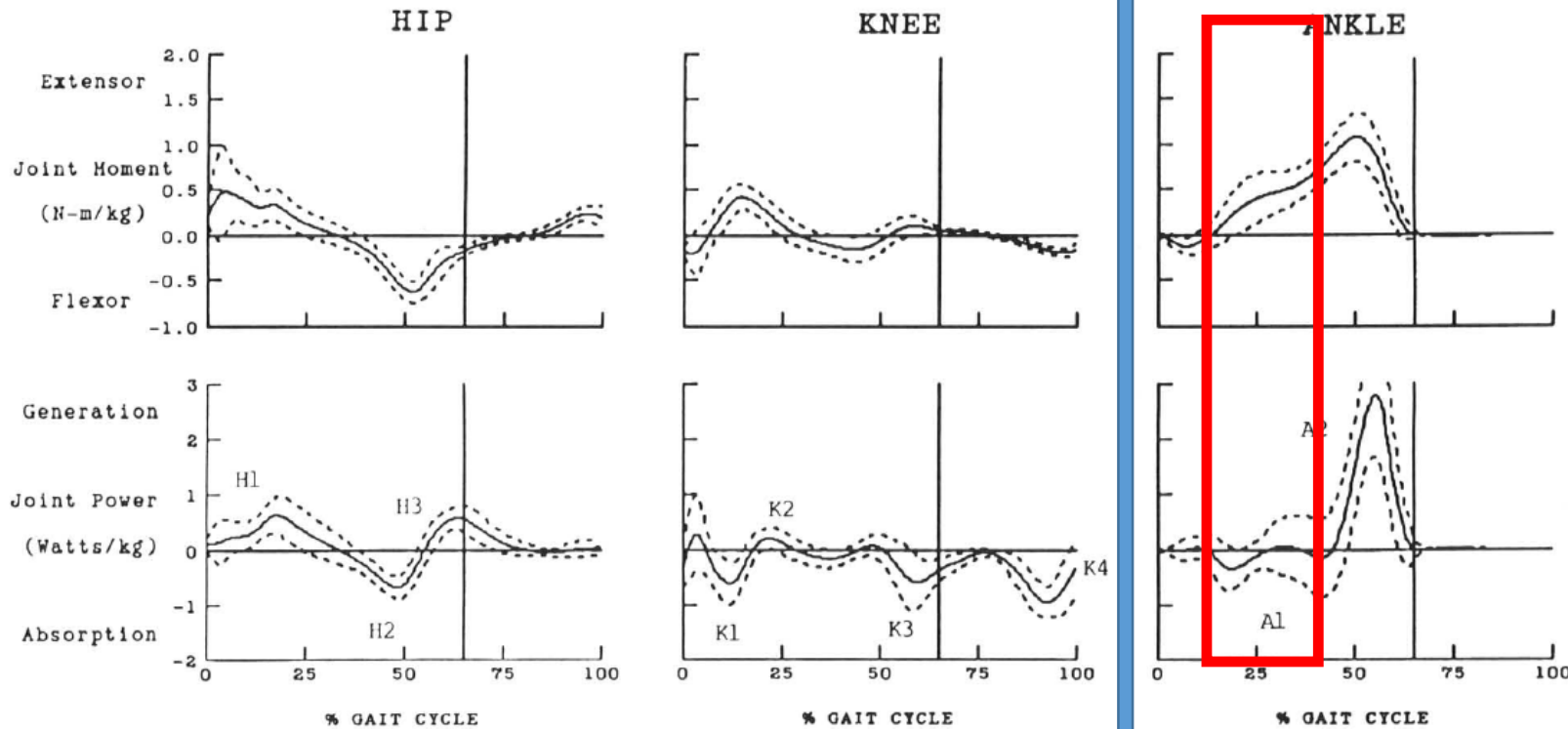
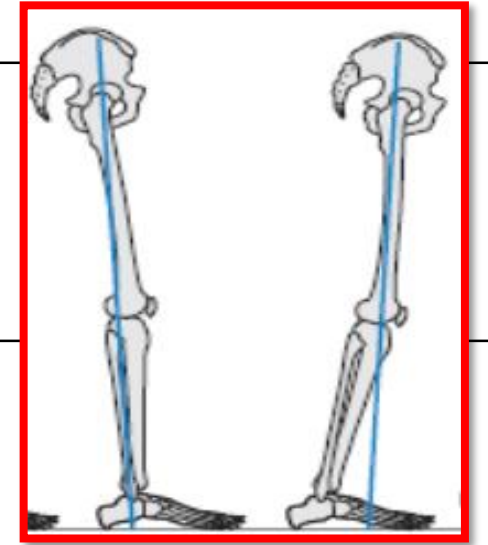
# Kinetics of Foot and Ankle at G (single-link model / sagittal)



**FIG. 7.** The average ( $\pm 1$  SD) sagittal plane joint kinetics are plotted. **Top:** Joint moments for the hip, knee, and ankle (the respective joint powers) are shown below. All data are normalized to 100% of the gait cycle, and toe-off is indicated by the vertical dotted line on each plot.

	Initial contact	Loading response
	Heel strike ~ foot ground contact	Flat foot ~ contlat. foot off
Rocker	1st (Heel)	
GRF	Center -> Post.	Post.
Net moment	DF	
Action	DF m. eccentric contraction	
Power	Absorption	

# Kinetics of Ankle Kinetics of Foot and Gait (single-link model / sagittal)



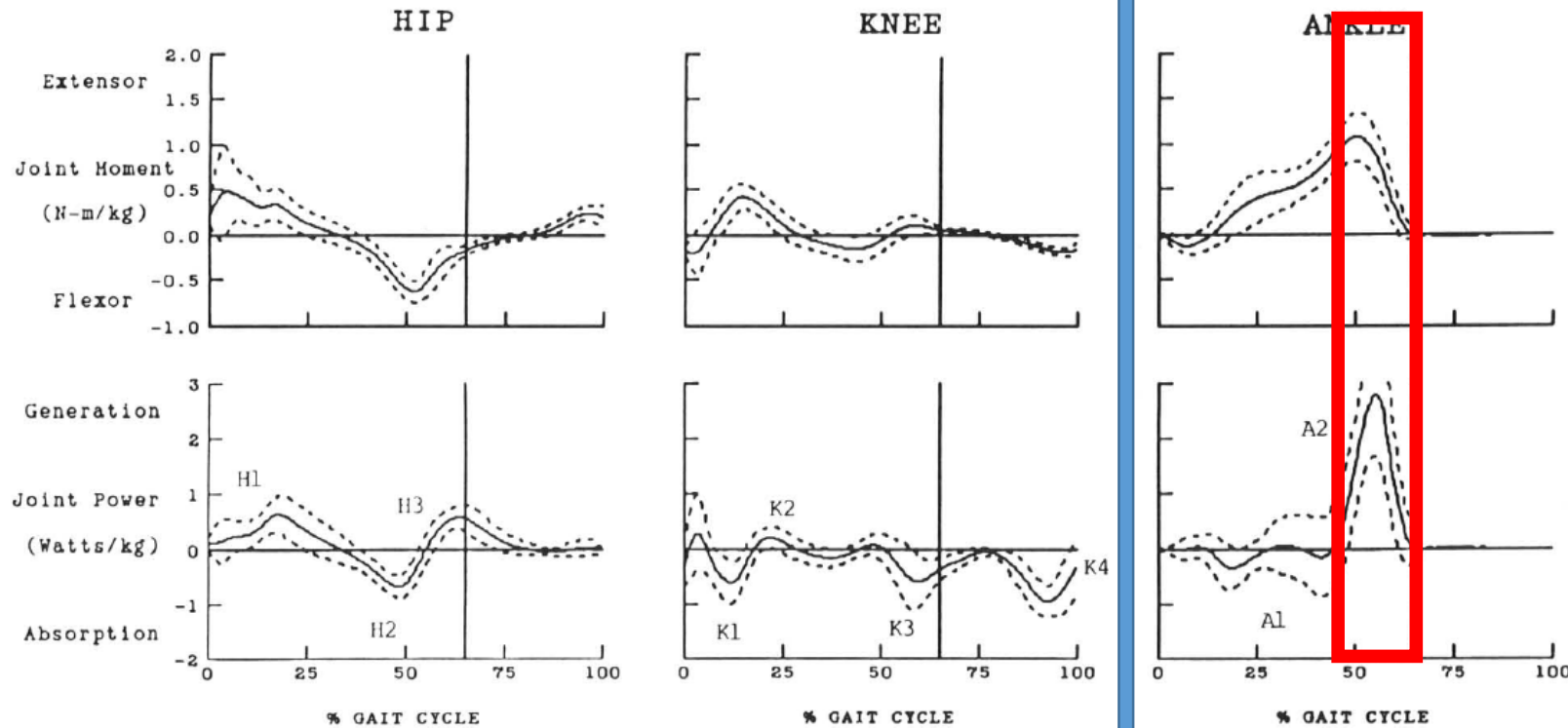
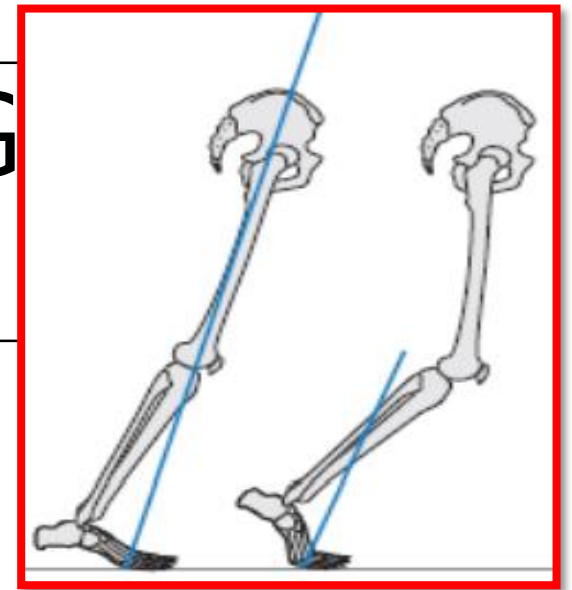
**FIG. 7.** The average ( $\pm 1$  SD) sagittal plane joint kinetics are plotted. **Top:** Joint moments for the hip, knee, and ankle (the respective joint powers) are shown below. All data are normalized to 100% of the gait cycle, and toe-off is indicated by the vertical dotted line on each plot.

	Mid-stance	Mid-stance
	Contlat. foot off ~ ipsilat. heel off	
Rocker	2 <sup>nd</sup> (Ankle)	
GRF	Center ->Ant.	Ant.
Net moment	PF	
Action	PF m. eccentric contraction	
Power	Absorption	



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# Kinetics of Foot and Ankle at G (single-link model / sagittal)



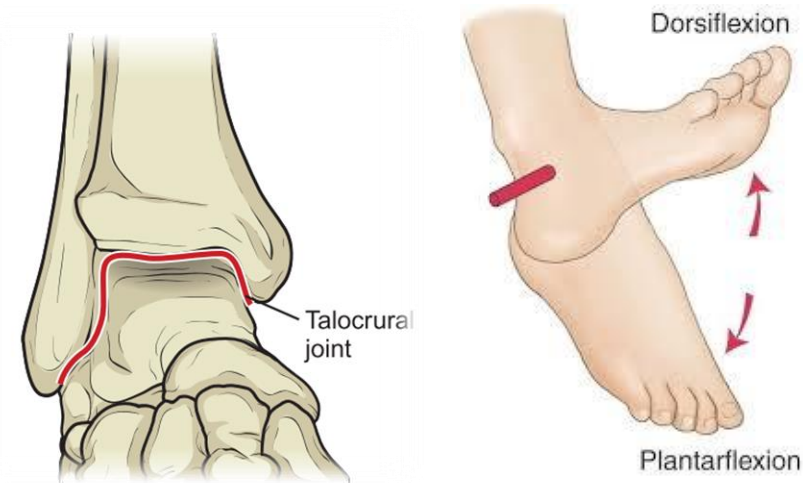
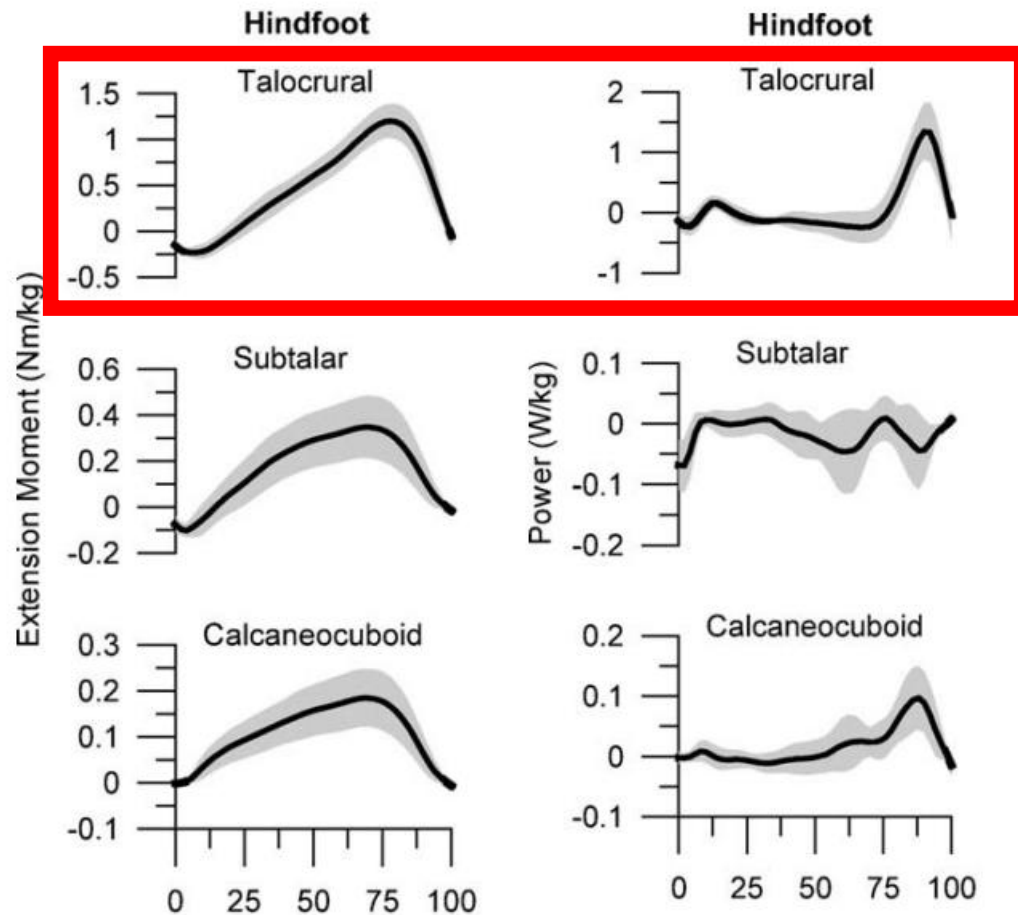
**FIG. 7.** The average ( $\pm 1$  SD) sagittal plane joint kinetics are plotted. **Top:** Joint moments for the hip, knee, and ankle (the respective joint powers) are shown below. All data are normalized to 100% of the gait cycle, and toe-off is indicated by the vertical dotted line on each plot.

	Terminal stance	Pre-swing
	Ipsilat heel-off ~ contrlat. IC	Ipsilat. Toe-off, contralat. IC
Rocker	3 <sup>rd</sup> (Forefoot)	
GRF	Ant	
Net moment	PF (peak)	PF
Action	PF m. concentric contraction	
Power	Generation	



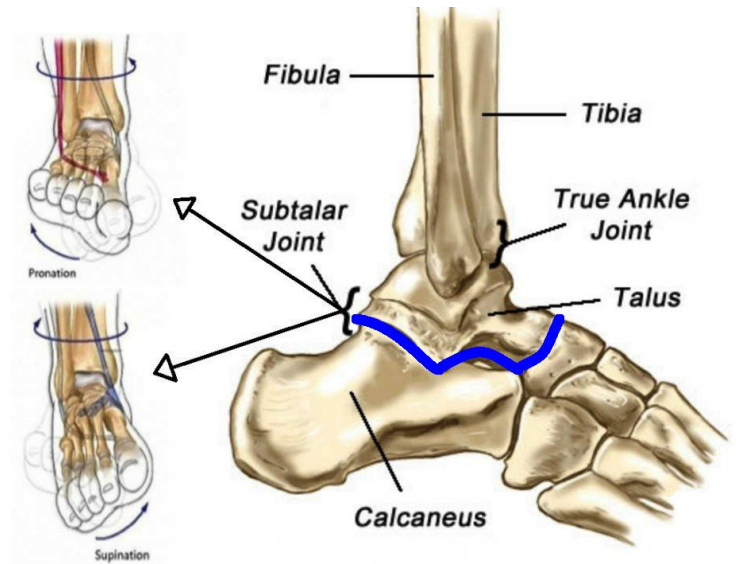
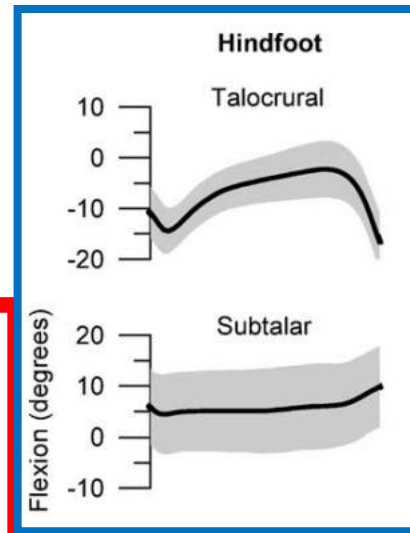
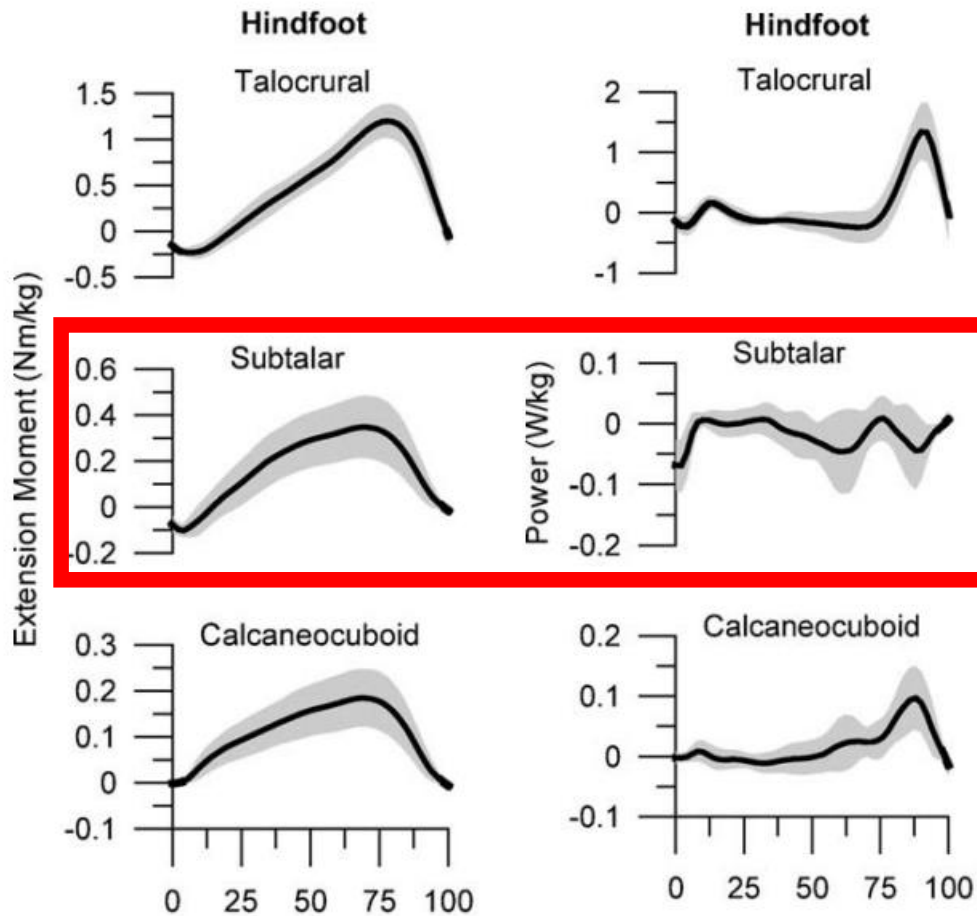
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# Kinetics of Foot and Ankle at Gait (multi-segment foot model / sagittal)



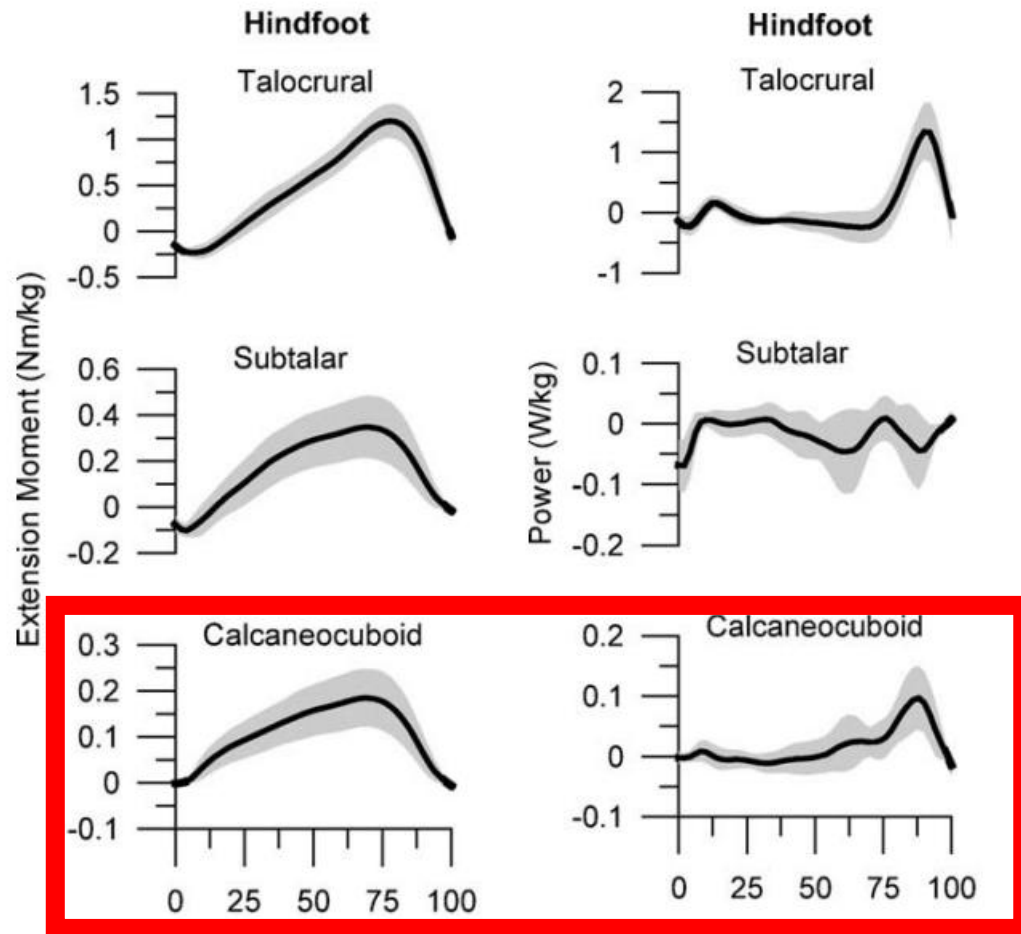
Talocrural joint		
Type	Uniaxial hinge joint	
Movement	DF	PF

# Kinetics of Foot and Ankle at Gait (multi-segment foot model / sagittal)



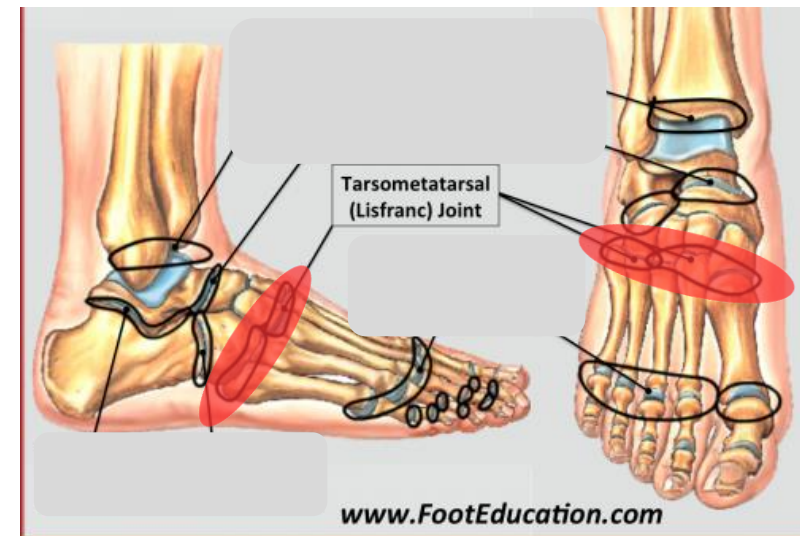
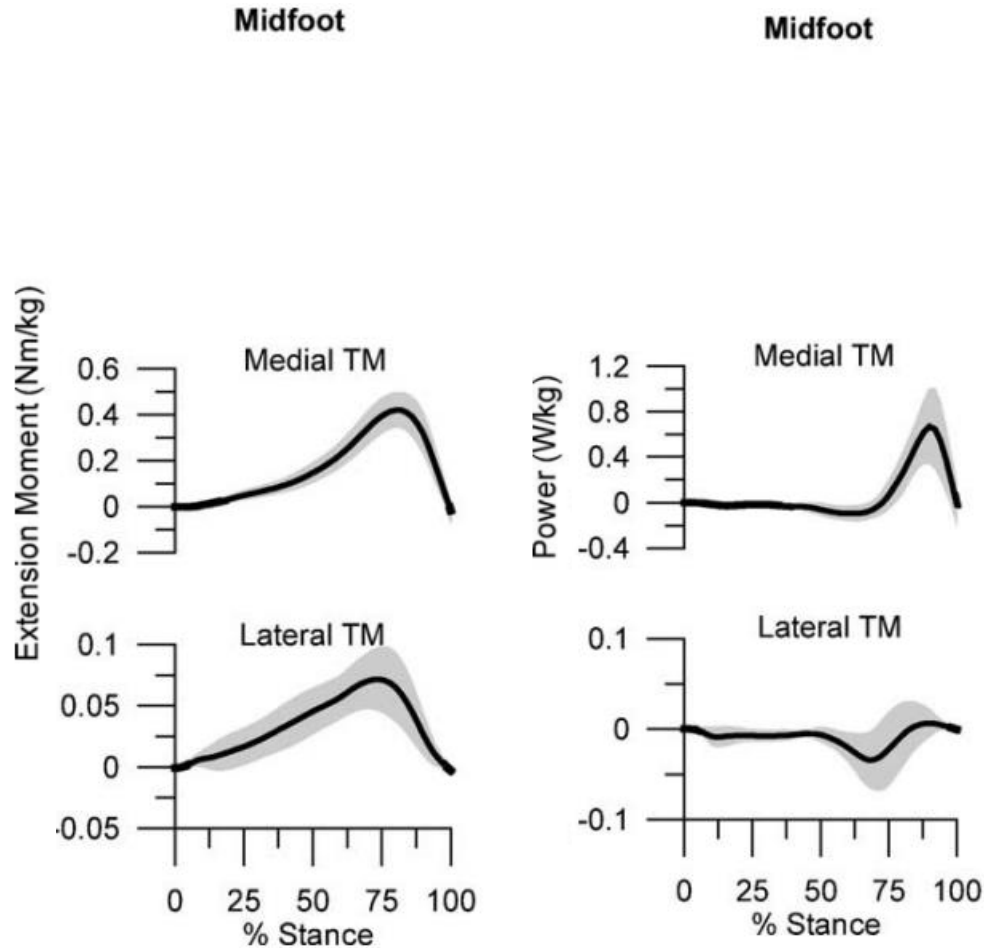
Subtalar joint		
Type	Multi-articular joint (gliding + rotation)	
Movement	Pronation (DF+AB+EV)	Supination (PF+AD+InV)

# Kinetics of Foot and Ankle at Gait (multi-segment foot model / sagittal)



Calcaneocuboid joint		
Type	Multiaxial, synovial saddle joint	
Movement	Pronation (DF+AB+EV)	Supination (PF+AD+InV)

# Kinetics of Foot and Ankle at Gait (multi-segment foot model / sagittal)

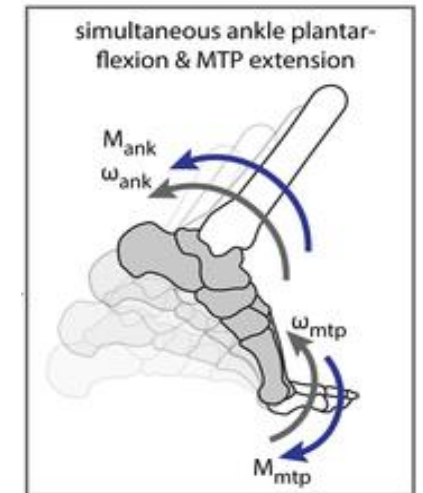
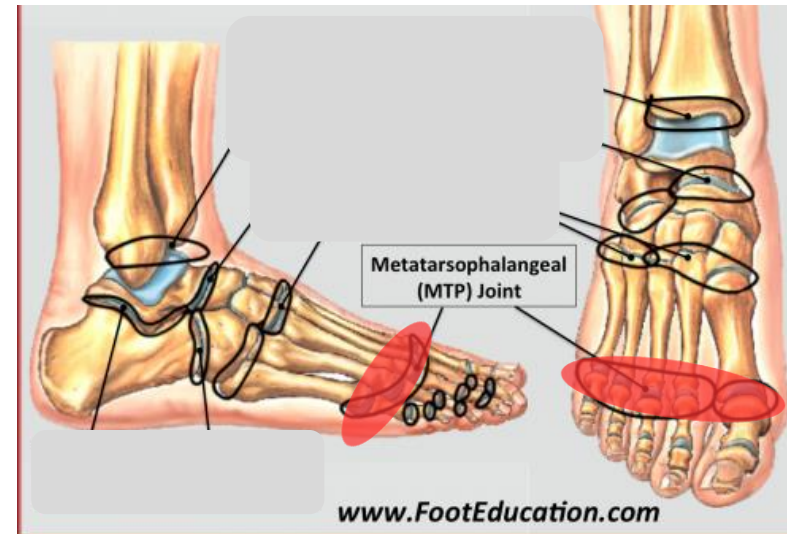
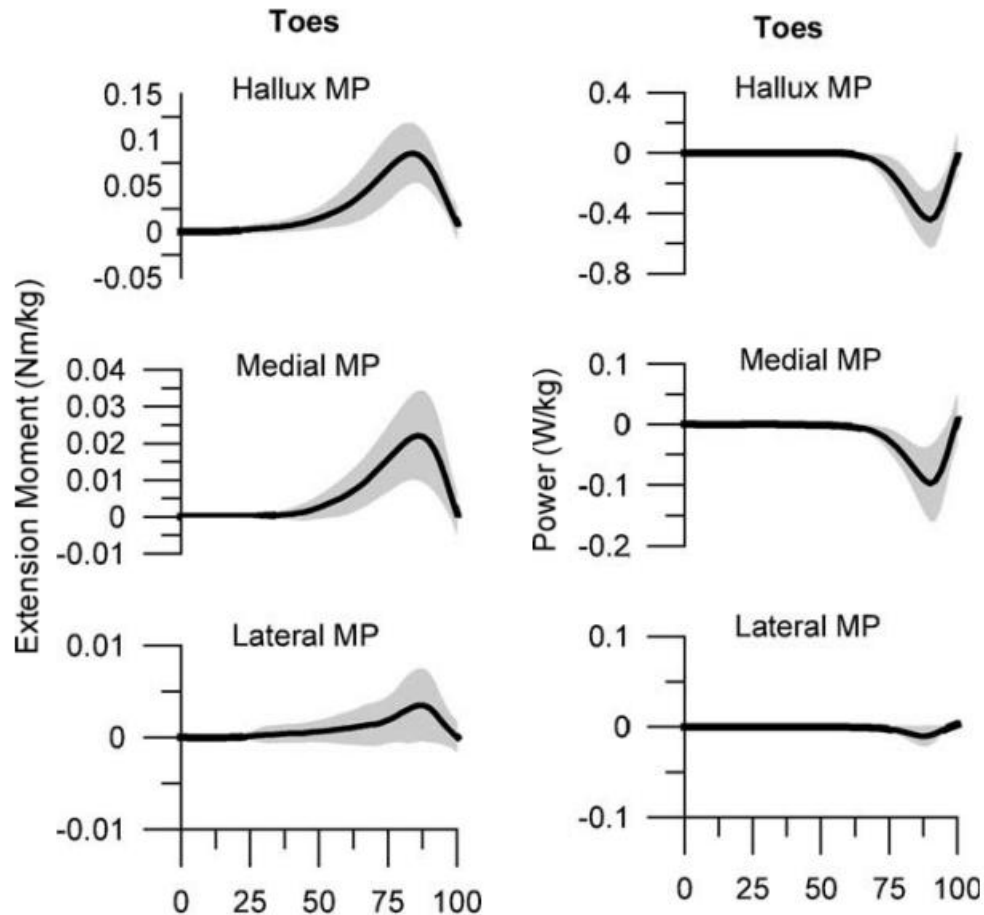


## Tarsometatarsal joint

Type	Synovial plane joint
Movement	DF/PF

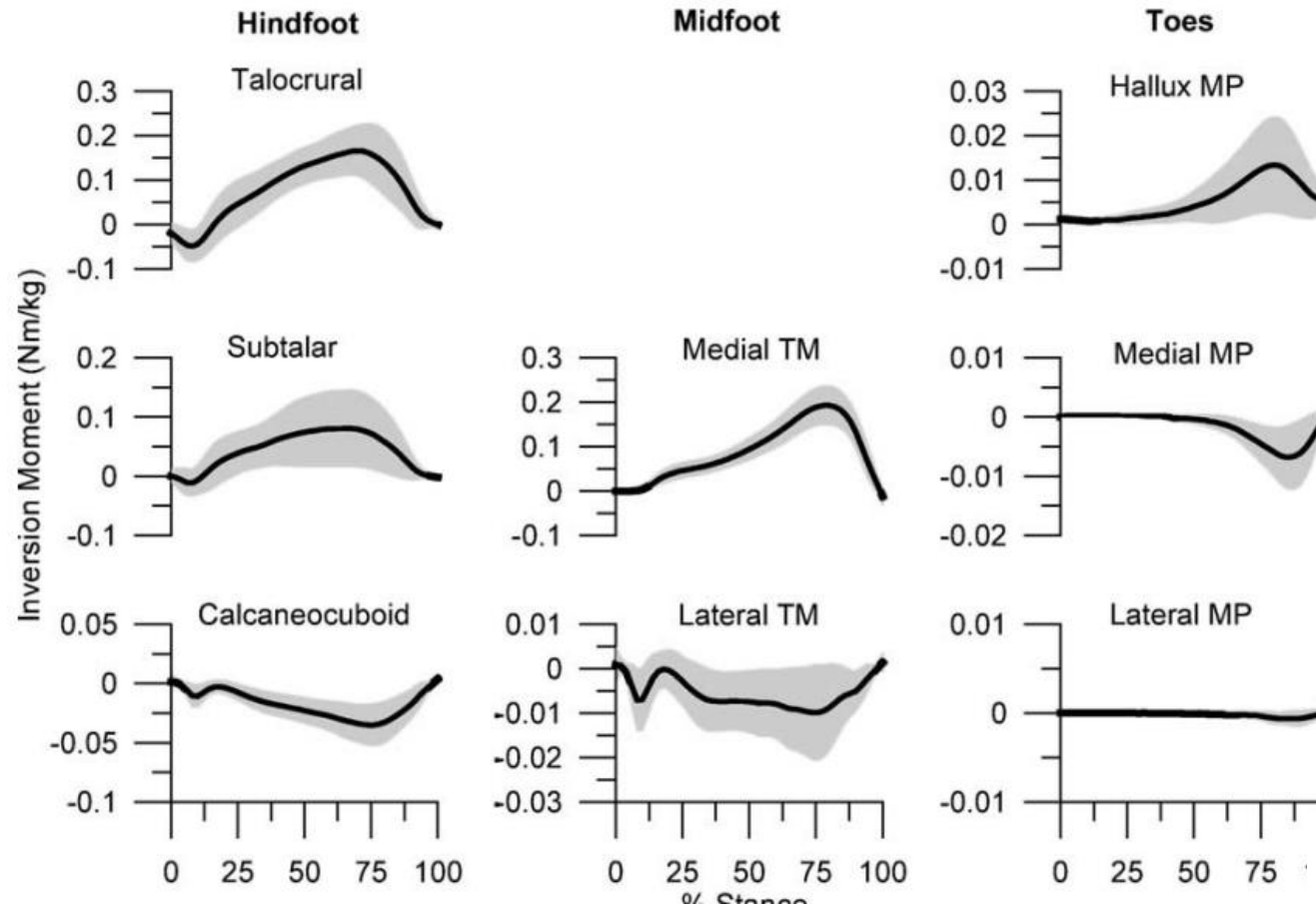


# Kinetics of Foot and Ankle at Gait (multi-segment foot model / sagittal)

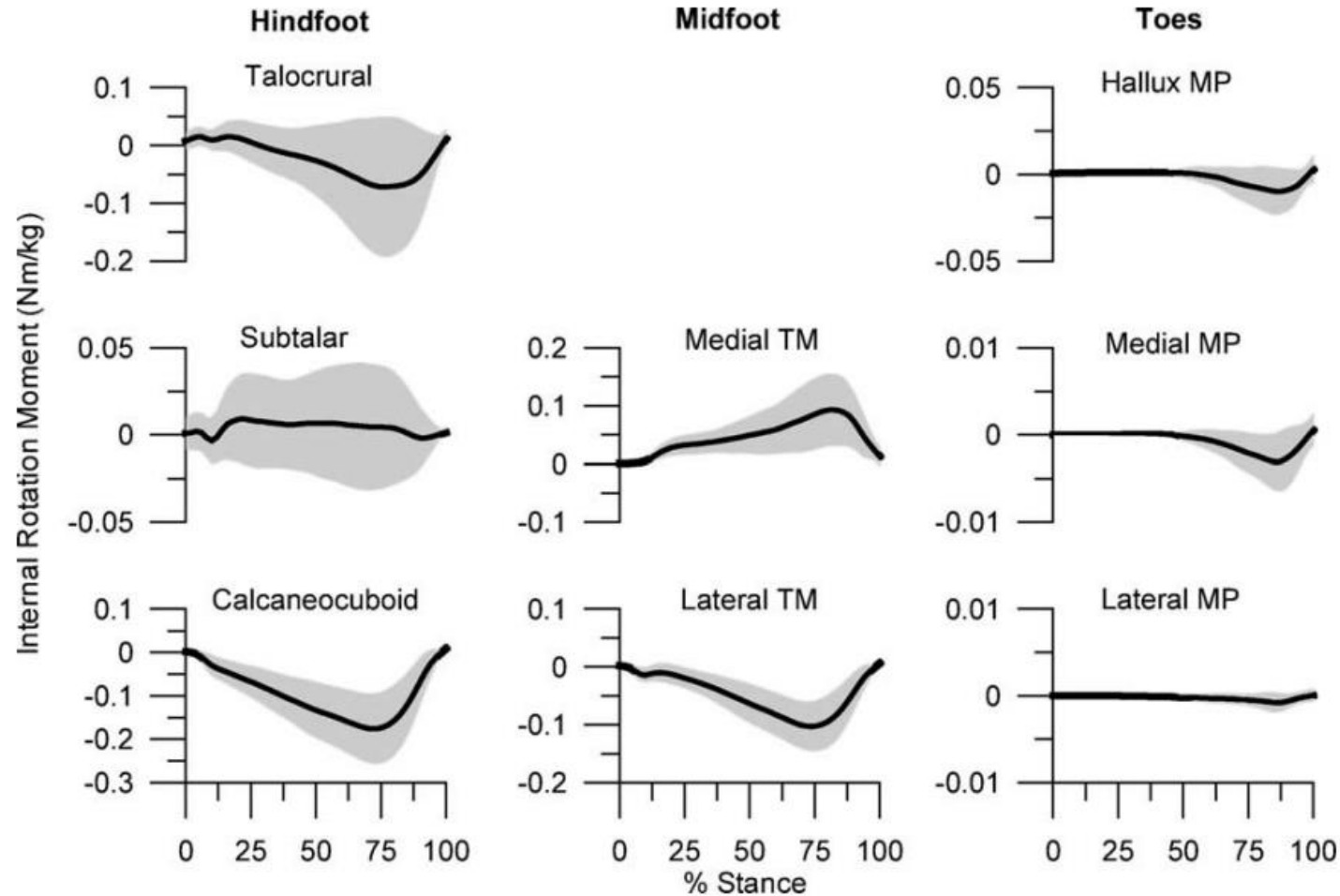


Metatarsophalangeal joint	
Type	Synovial biaxial joint
Movement	Fl/Ex
	Ab/Ad
	circumduction

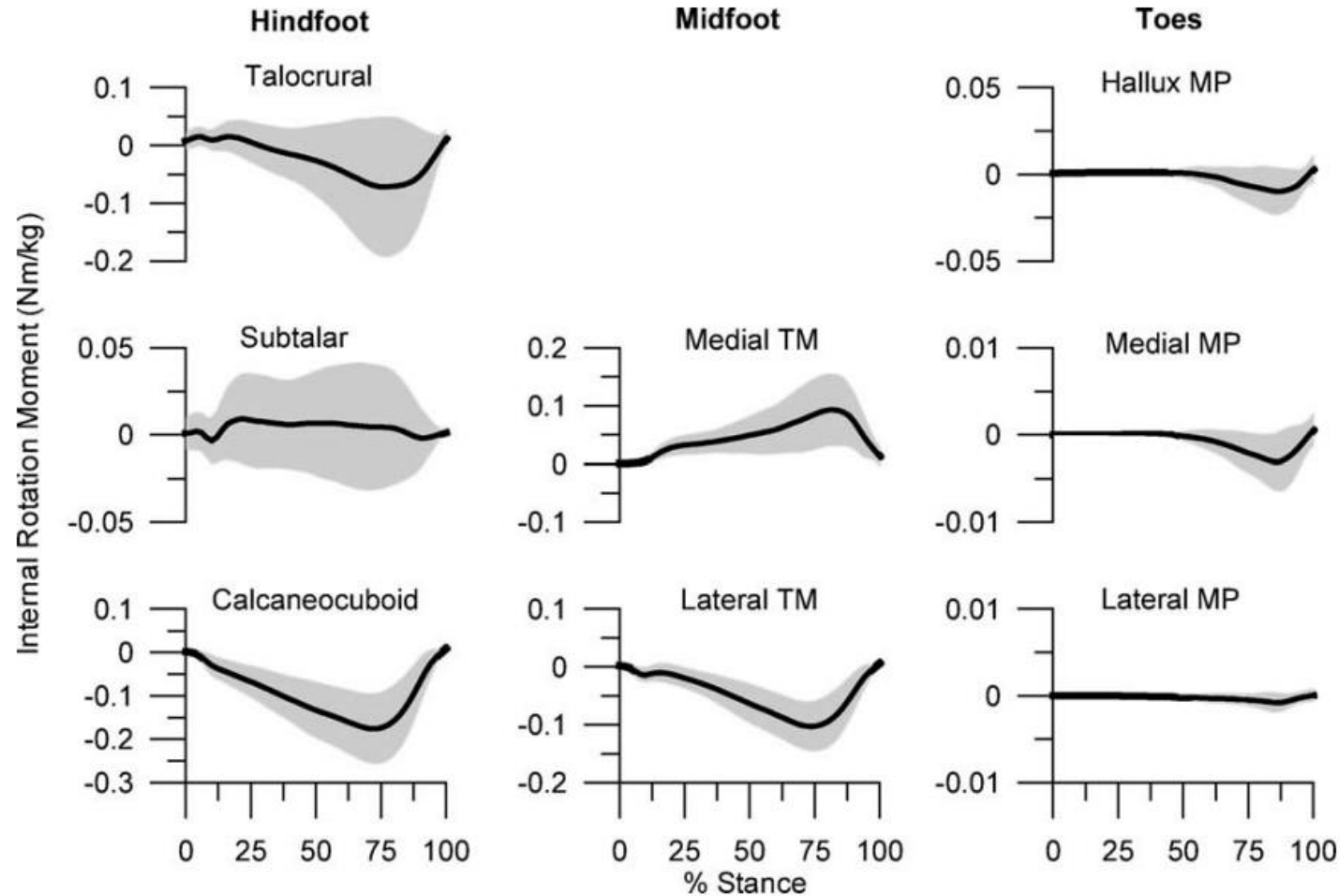
# Kinetics of Foot and Ankle at Gait (multi-segment foot model / frontal)



# Kinetics of Foot and Ankle at Gait (multi-segment foot model / transverse)



# Kinetics of Foot and Ankle at Gait (multi-segment foot model / transverse)



*thank you*