

Hips, Knees, Heels, and Toes

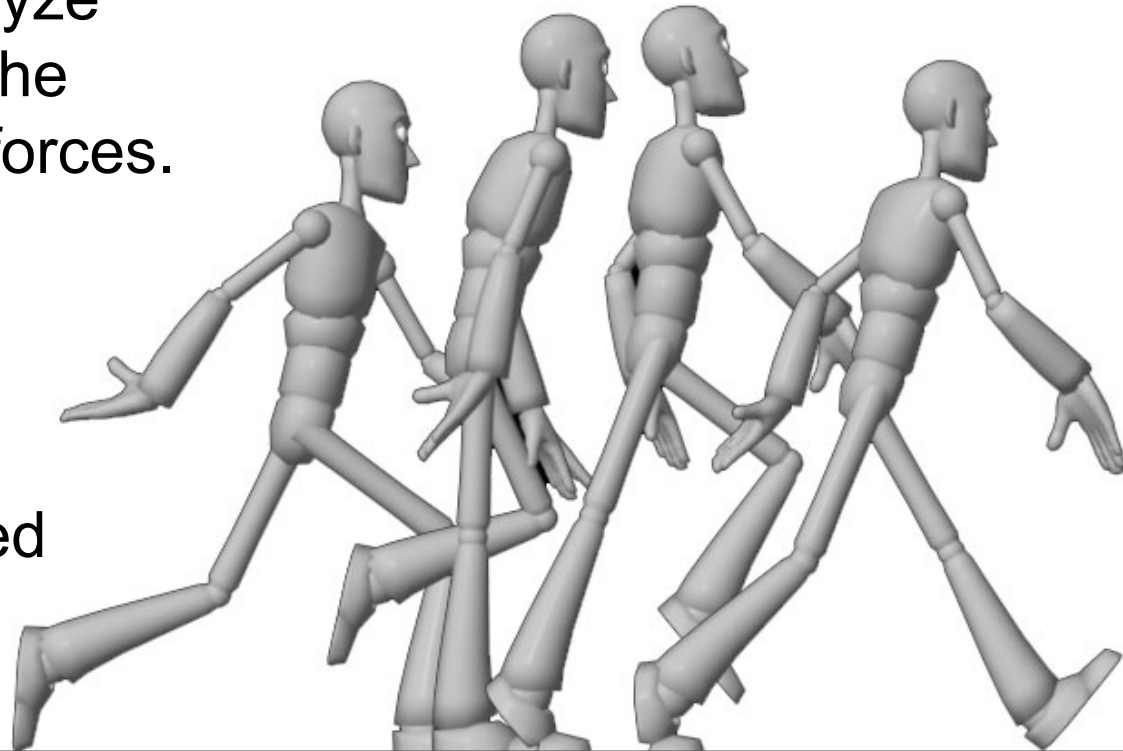


National Science Foundation
WHERE DISCOVERIES BEGIN

Energy and Walking

One way to analyze walking is from the point of view of forces.

An alternative approach is to consider the **energy** expended in walking.



We're inherently lazy so many actions that we perform unconsciously while walking reduce energy expenditure.

Silly Walks

Try walking around as John Cleese, who is the Minister of Silly Walks.

You will find that you use much more energy than normal walking.



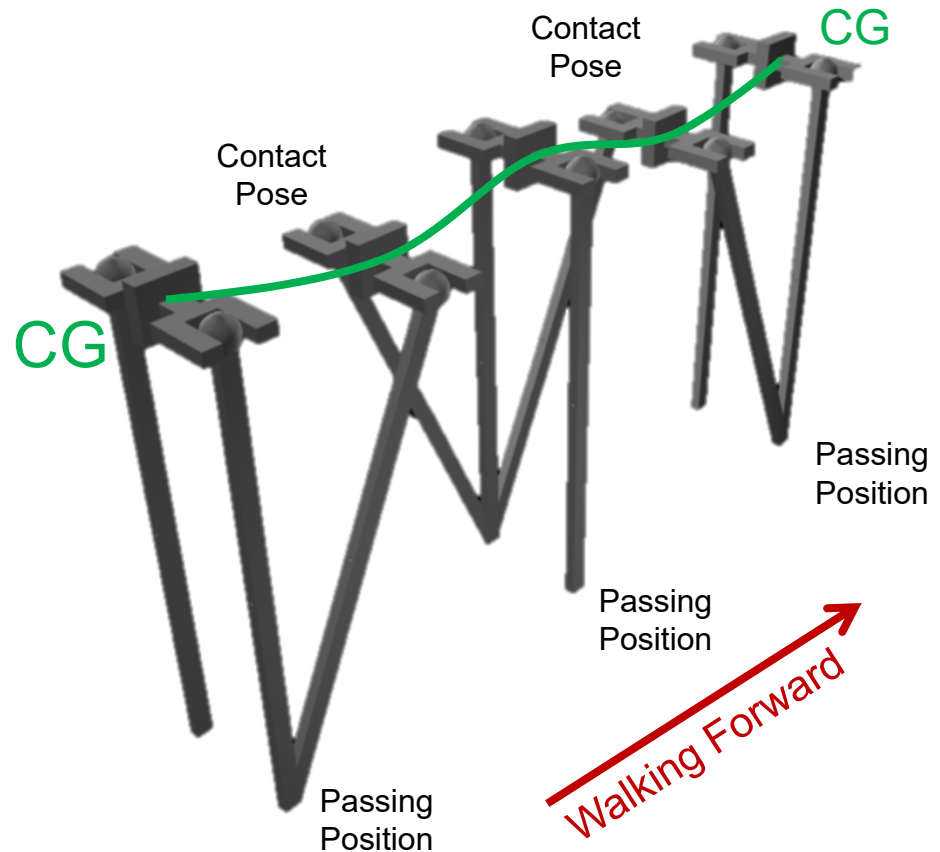
Silly Walks



Simplified Walking Model

Pelvis is a double-forked bar with spherical hip joints. Legs are straight bars without knees, ankles, or feet.

Center of gravity (CG) rises and falls as an inverted pendulum.

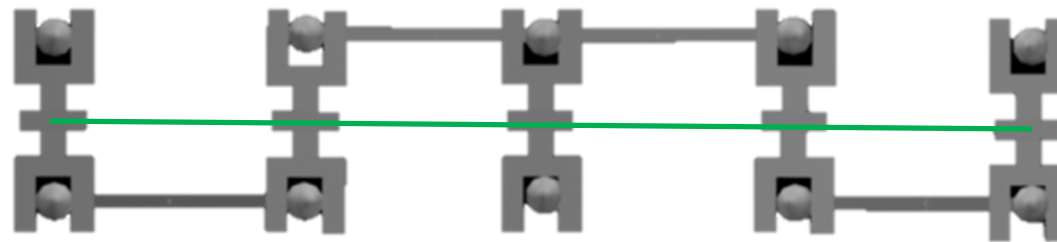
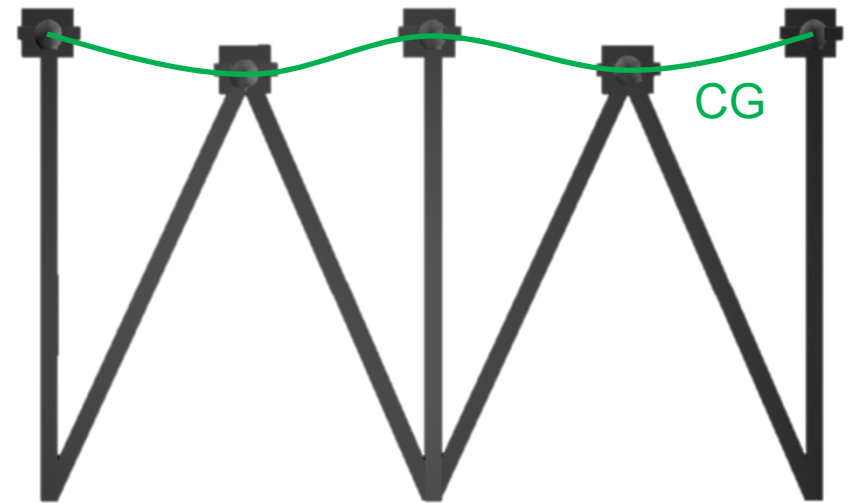
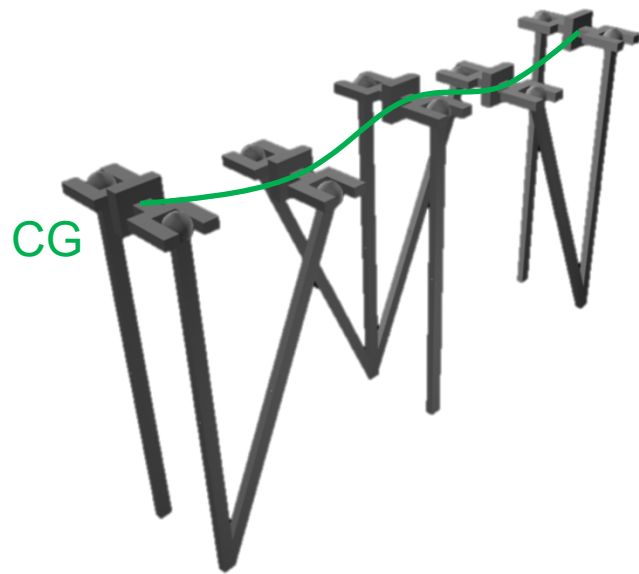


Our body has to do work to raise the CG and much of that energy (30-40%) is lost to friction.

Simplified Walking Model



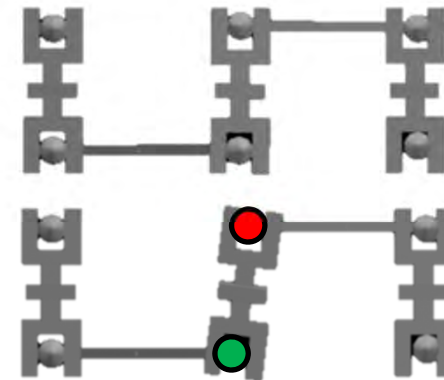
Simplified Walking Model



Pelvic Rotation

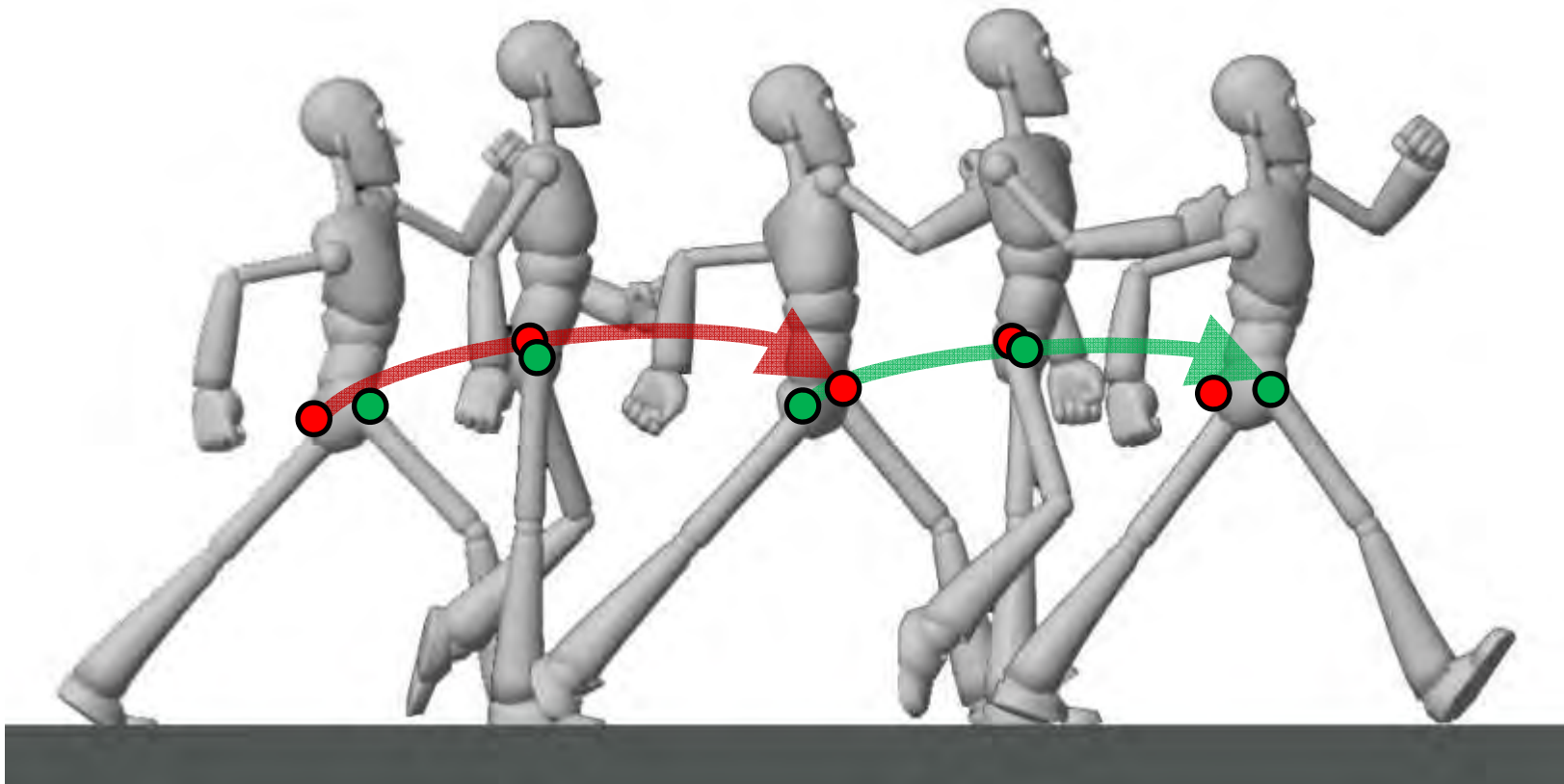
As the passing leg swings forward, the hips swing around, rotating about the planted leg.

Top View



Without
Rotation

With
Rotation

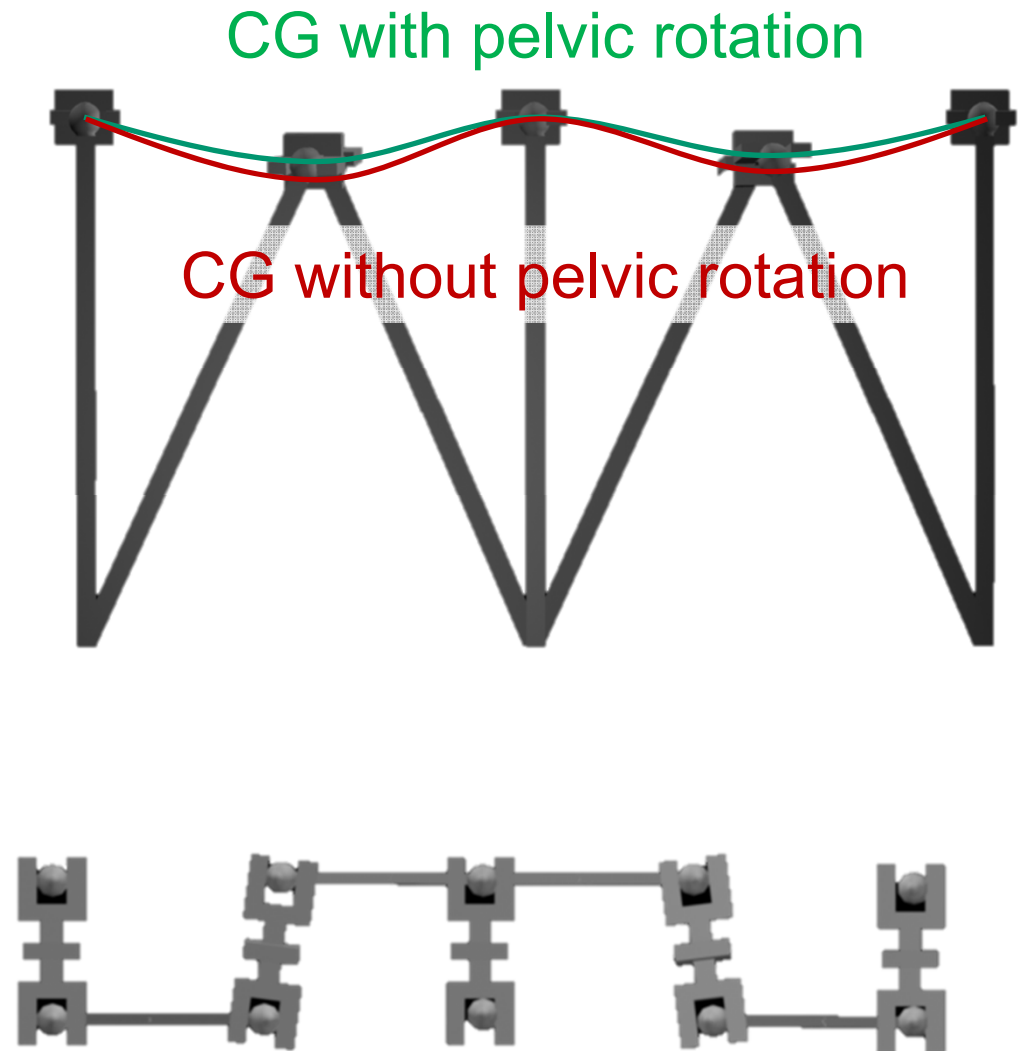


Pelvic Rotation



Pelvic Rotation & Center of Gravity

Pelvic rotation keeps the center of gravity higher in the contact pose, saving energy.



Pelvic List for the Passing Leg

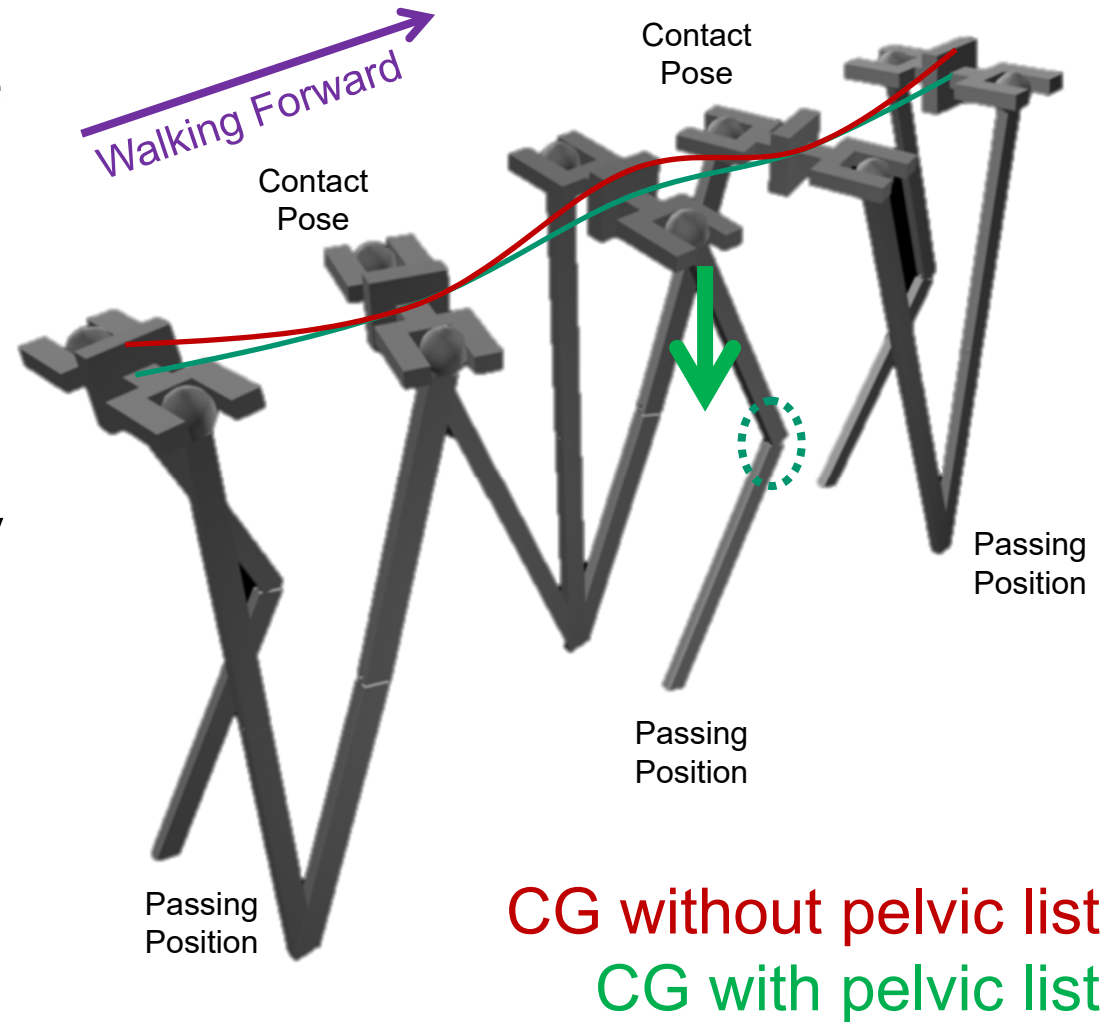
In the passing position the pelvis drops slightly on the non-weight bearing side. This motion is called “pelvic list.”



Note that the knee has to bend to lift the foot, otherwise it would drag the ground.

Pelvic List for the Passing Leg

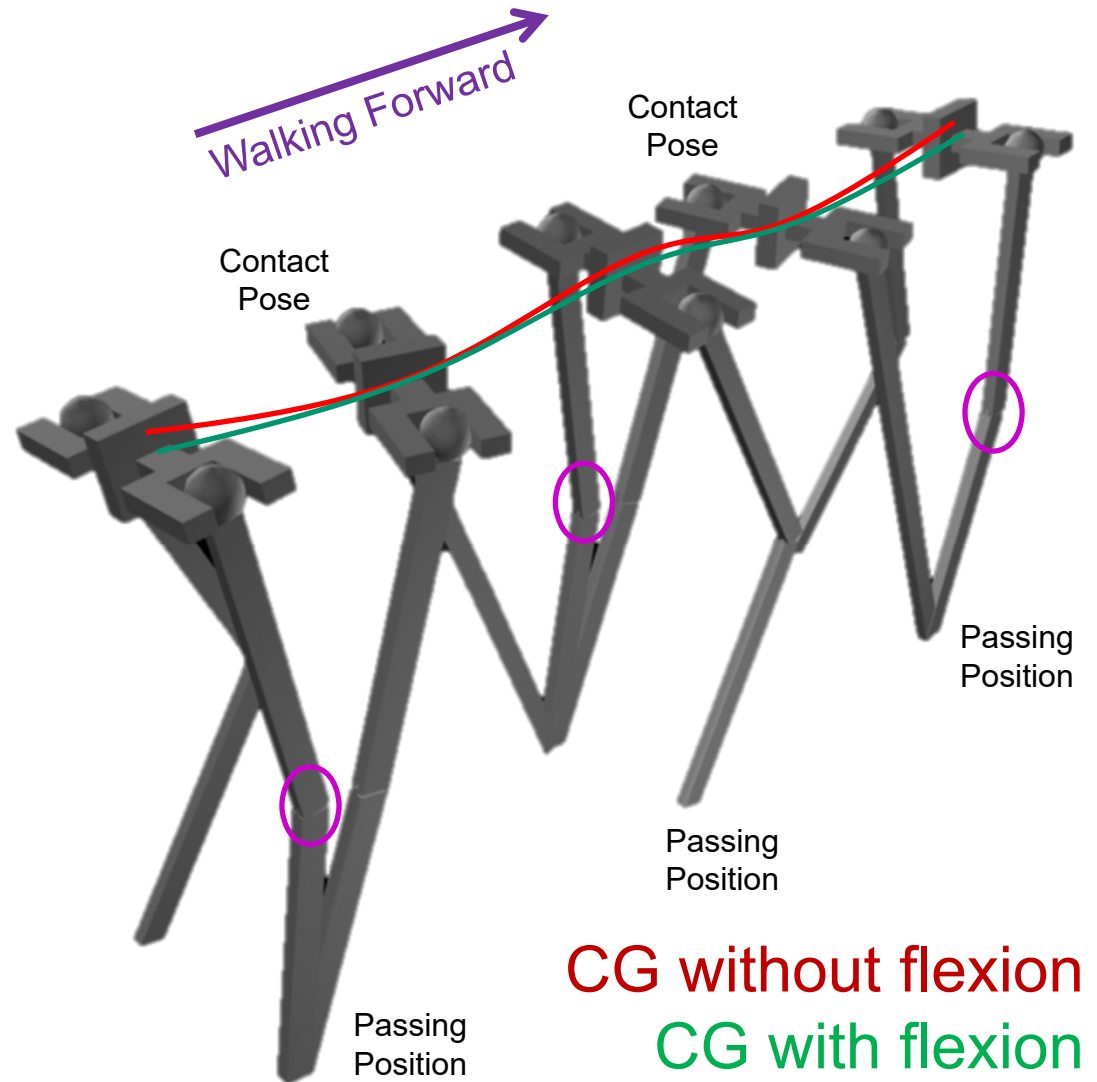
Pelvic list keeps the center of gravity from rising as much in the passing position, keeping the center of gravity on a flatter path of action.



Knee Flexion for the Weighted Leg

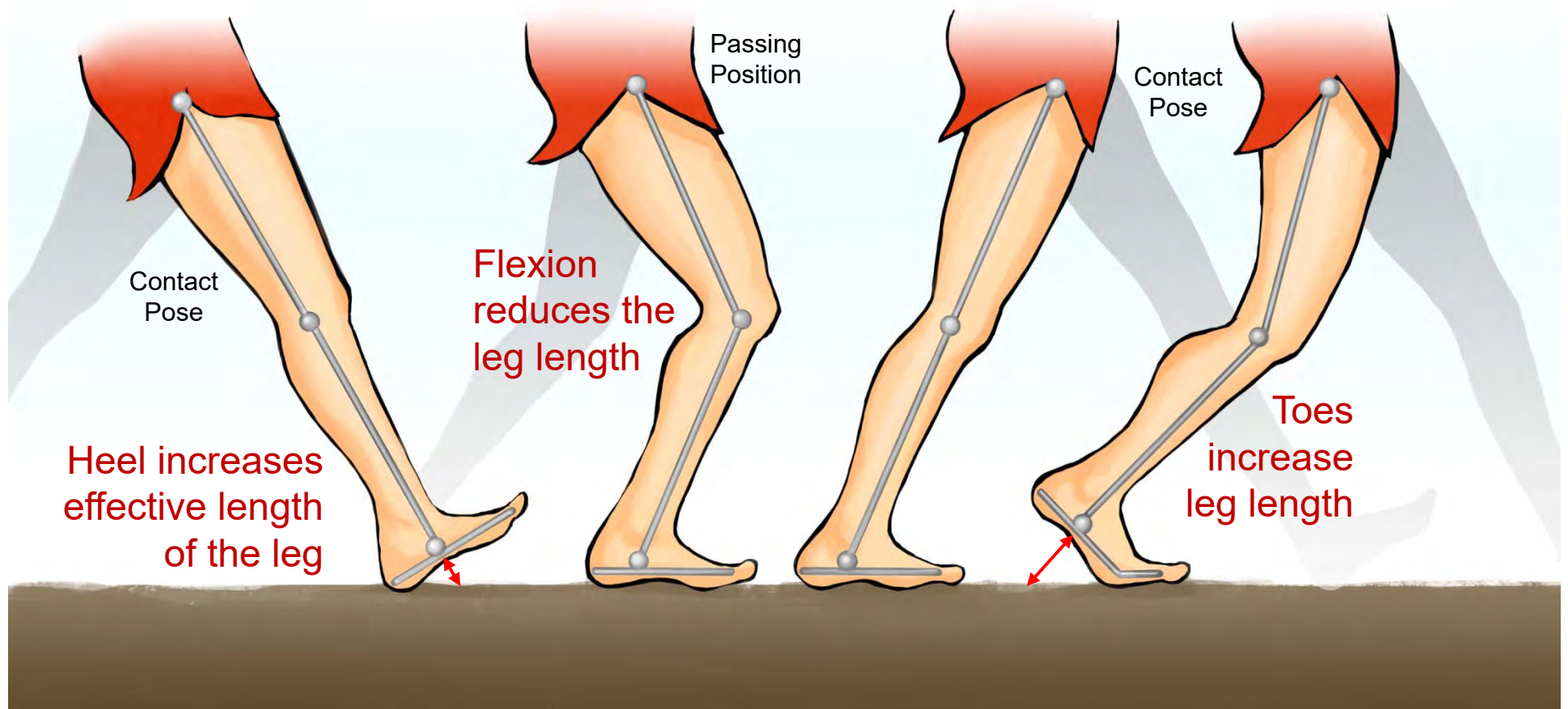
Knee flexes about 15 degrees just after the heel strike and remains flexed until the center of gravity passes over the weight bearing leg.

Knee flexion keeps the center of gravity from rising as much during the passing position.



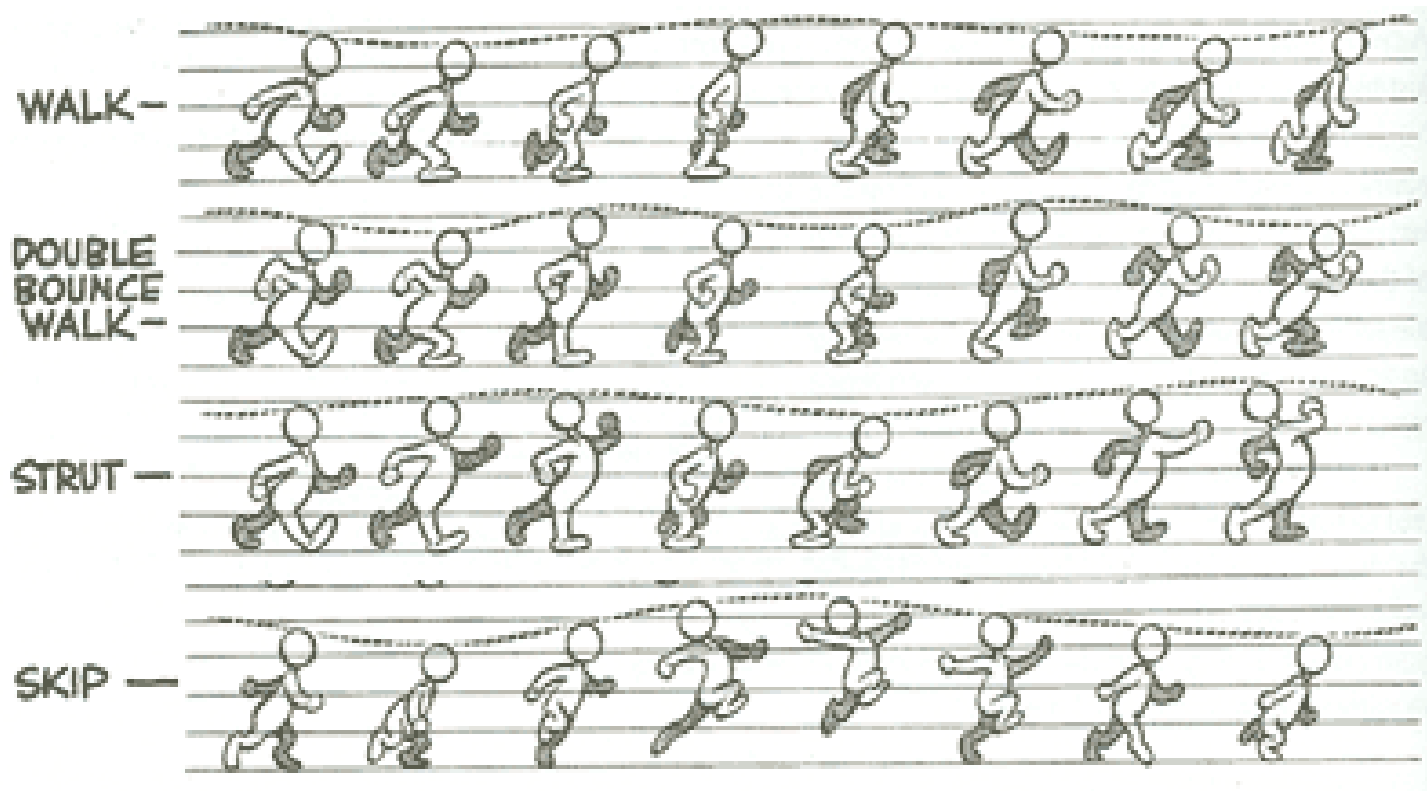
Heel and Toes

Heel and toes, combined with knee flexion, increase & decrease the effective leg length.

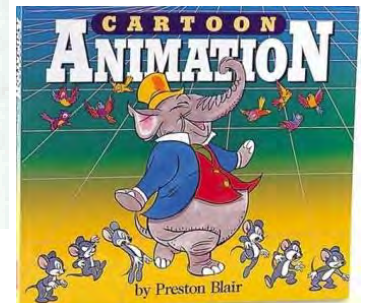


Energetic Walks

A character with lots of energy will have a walk that doesn't try to minimize the up/down motion.



Various walks by Preston Blair



Energetic Walks

Austin Powers: International Man of Mystery (1997)



Summary

- The hips, knees, heels and toes help us to walk more efficiently (use less energy).
- Pelvic rotation reduces the downward motion of the CG through the contact pose.
- Pelvic list reduces the upward motion of the CG through the passing position.
- Knee flexion of the weight-bearing leg also keeps CG lower in the passing position.
- Heel and toes increase and decrease the effective length of the leg.