WALKING (& RUNNING)

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1. 4-legged locomotion

Gait:
Horses have 4 natural gaits: walk, trot, canter, and gallop
Have different speeds and beat patterns (a little like dancing)

The galloping question: Do all four hooves of a horse leave the ground when a horse is galloping? Posed by California Governor Leland Stanford in 1872.
What do you think?
(see "horse in motion" picture by Eadweard Muybridge)

2. 2-legged walking

What's the big deal? Dynamic balancing of an inverted pendulum!

2.1. **Exercise: Inverted Pendulum.** - Balance a pen or pencil vertically on the tip of your finger.
- Can you hold the pencil standing in one place?

- Can you make the pencil move in one constant direction?

- Can you make it move in a figure-8 pattern?

- Now, stand in place (leave some room in front of you)

- Lean forward slowly...keep going...

What happened? Why?

Notice that you are balanced when you are standing still, and when you lean forward, you maintain a balance by keeping your legs almost under you, but slightly behind your center of gravity.
Your body is very good at doing all of this automatically!
Quite a lot is actually going on when we walk!

Don't believe it? Try the above exercise again, VERY slowly.

Pay careful attention to how your center of mass moves. (Your center of mass is near your belly-button.) Does it move up and down? Does it move side-to-side?

Now try this:

2.2. **Exercise: unbalanced walking.** - Pair up with a neighbor (someone you haven't yet worked with)

- Find a straight line on the floor
- Walk down the line
- Go back to start

- Now, close your eyes and walk along the line
- Finally, return to start

- close your eyes
- Have your non-blindfolded partner spin you around 10 times, then stand you at the start of the line (keep your eyes closed)
- Try to walk along the line

What do you observe about these three trials of walking? What is going on?

3. Walking versus Running

In walking, one foot is always on the ground.

In running, both feet are actually off the ground at one point in the gait.

Interesting evolutionary trivia: Persistence Hunting (source: wikipedia)

"The persistence hunt may well have been the first form of hunting practised by hominids. It is likely that this method of hunting evolved before humans invented projectile weapons, such as darts, spears, or slings. Since they could not kill their prey from a distance and were not fast enough to catch the animal, the only reliable way to kill it would have been to run it down over a long distance.

In this regard one has to bear in mind that, as hominids adapted to bipedalism they would have lost some speed, becoming less able to catch prey with short, fast charges. They would, however, have gained endurance and become better adapted to persistence hunting.[1] The evolution of the distinctively human sweating apparatus and relative hairlessness would have given hunters an additional advantage

by keeping their bodies cool in the midday heat.

During the persistence hunt an antelope, such as a kudu, is not shot or speared from a distance, but simply run down in the midday heat. Depending on the specific conditions, hunters of the central Kalahari will chase a kudu for about two to five hours over 25 to 35 km (16 to 22 mi) in temperatures of about 40 to 42 C (104 to 108 F). The hunter chases the kudu, which then runs away out of sight. By tracking it down at a fast running pace the hunter catches up with it before it has had enough time to rest in the shade. The animal is repeatedly chased and tracked down until it is too exhausted to continue running. The hunter then kills it at close range with a spear."

So, bipedal running may have advantages to quadriped running, using less energy over a distance, and - combined with sweating - may be very central to why we survived and evolved as human beings!

4. Exercise: Walking race (outdoors)

- Pick a partner
- Hold a walking race!
- Try some other forms of locomotion (be creative and try funny ways of walking or moving)
- Which ones are fast, which are slow? Which are easy, which are hard? Which are more stable?
- Rank these in order of speed: 1-legged hopping, 2-legged hopping, skipping, wheel-barrow, crab-walk, stiff-legged walk, backwards walk, crawling, rolling (optional: if you don't mind getting dirty), and whatever else you think of
- Discuss how you would get a robot to do these.

5. Exercise: locomotion design (back inside)

- Pick one way of moving (not exclusively rolling on wheels or treads, but these can be combined with other forms)
- sketch a robot configuration (mostly the legs or whatever locomotion mechanism) label joints as necessary
- Write, in great detail, how you would get a robot to move in this way.