The Chair Challenge

Primary Audience: 7th – 12th grade

Adapted from teachersource.com, Center of Mass Challenge by Jeremy Johnson

Video: Watch the video *The Science Behind the Chair Challenge, Part 1* and *Part 2*

Introduction: Have you seen the chair challenge? It turns out that this challenge is a fun way to discuss scientific concepts. Complete the series of challenges below and discuss them in terms of gravity and center of gravity.

Key Words:
- **Center of Gravity** – If you were to concentrate ALL of the mass of an object at one point, that point would be the center of mass. This term is often used interchangeably with center of gravity – the point at which gravity acts on a body or system. Finding the center of mass is easy for a symmetrical object, like a sphere, where the mass is evenly dispersed. In that case, the center of mass would be in the center of that sphere.
- **Gravity** – This is the force that keeps us on earth. The force of gravitation pulls on ALL mass. The larger the mass, the larger the gravitational force. The gravity you feel that holds you on Earth is the gravitational force between your body and the planet Earth. You can think of gravity as pulling from your center of gravity.

Materials:
- A chair
- A wall
- A small object like a coin

**Challenge 1 Instructions:**
1. Place a chair against the wall so that it cannot slide backward.
2. Have one person sit in the chair with their feet on the floor in front of them. Feet should not be angled or slanted to the side.
3. A second person should gently place a thumb in the middle of the first person’s forehead.
4. The first person should try to stand up without forcing the other person’s thumb back.

**Challenge 2 Instructions:**
1. Have one person stand with their back to the wall, feet together against the wall, and legs straight.
2. A second person should place a small object (like a coin) directly in front of the first person’s shoes, between their feet.
3. The first person should attempt to—while keeping their legs straight—bend over and pick up the small object without falling over.
Challenge 3 Instructions:
1. Have one person stand sideways against the wall, with their right shoulder and right leg pressed against the wall.
2. While keeping their right shoulder and leg against the wall, this person should now try to raise their left leg so that they are only standing on their right leg.

Challenge 4 Instructions:
1. Stand directly against the wall, facing the wall, then carefully step backwards, heel-to-toe, twice so that you are standing two of your own foot-lengths away from the wall.
2. A second person can place a chair or stool in front of/underneath the first person (sideways if it has a back).
3. The first person should now bend over the chair, gently placing their head against the wall. Then they should grasp the chair and try to stand up WITHOUT bracing their hands or the chair against the wall.
4. Now have the first person raise one leg out behind them – a little like a Velociraptor tail – and try again.

What’s Going On?
The center of gravity may be different for everyone, but generally it sits somewhere in or near your abdomen. Your body probably normally does a great job of balancing out your weight as you move around. But these challenges restrict your ability to balance things out.

In Challenge 1, the seated person’s center of gravity is near the back of the chair, not over their feet. Do you ever notice that when you stand up from a chair normally you lean forward first? That moves your center of gravity over your feet and allows you to stand up.

In Challenge 2, when person 1 is standing up their center of gravity is located directly above their feet. But if they move their center of gravity forward without moving their feet, they will be off balance and will have a hard time not falling over without moving their feet. Normally, when you lean forward to pick something up, part of your mass moves backwards - without you even thinking about it! The part of your mass that moves backwards balances your weight over your feet. Standing up against the wall, this is impossible.

In Challenge 3, when person 1 is standing against the wall their center of gravity is located directly above their feet. When they try to raise their left leg, this shifts the center of gravity to the left, making them off-balance. Try doing this without the wall being there – do you notice how your body adjusts sideways so that your weight is evenly dispersed over your right leg?
In Challenge 4, you might see mixed results. People with lower centers of gravity may be able to stand up unaided, while those with higher centers of gravity may have more trouble. Lifting one leg up will allow them to shift their center of gravity further back, enough that some will then be able to stand up. Another factor at play here is foot size – larger foot size means a person is standing further from the wall, and that too shifts their center of gravity backwards!

**Additional Resources:** Reach out to the [COSI Department of Science Content](https://cosi.org) if you have any questions or comments.