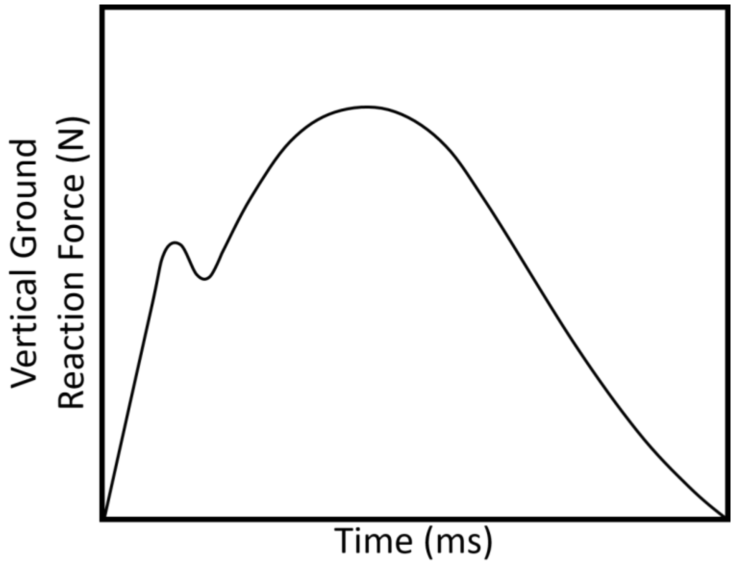
Ground Reaction Force Demo



Target Audience:

- Grade Level: 7
- Number of Participants: 1-8
- Duration: 5 min

Biomechanics Topic(s):

Ground reaction forces, running, walking

Background Information:

According to Newton's Third Law of Motion, "For every action, there is an equal and opposite reaction." When your foot strikes the ground during walking or running, it exerts a force on it. At the same time, the ground pushes back on your foot. This is called a ground reaction force (GRF). GRFs can tell us a lot about how a person walks or runs and are commonly measured as a part of gait analysis.

Gait analysis has both clinical and sports applications. The GRFs experienced by healthy individuals are different than those experienced by people with gait disorders that can result from a variety of medical conditions, such as multiple sclerosis, muscular dystrophy, and cerebral palsy. By measuring these forces, we can determine how different gait patterns affect loading on the body. We can also use GRF measurements to track progress of interventions such as gait retraining. Runners can benefit from gait analysis, as it can be used to identify biomechanical abnormalities and asymmetries during running. It can inform not only changes to running form but also changes to the type of running shoes worn by the athlete.

GRFs are commonly measured using either a force plate or an instrumented treadmill. Similar to a bathroom scale, a force plate can measure vertical GRFs. However, unlike a bathroom scale, it can also measure horizontal forces and center of pressure. Force plates are useful for measuring GRFs during overground walking, but they can only measure these forces for a single step. An instrumented treadmill, on the other hand, can measure GRFs for multiple gait cycles. For this activity, we will use a Wii Balance Board, which is an inexpensive alternative to a force plate.

Learning Objectives:

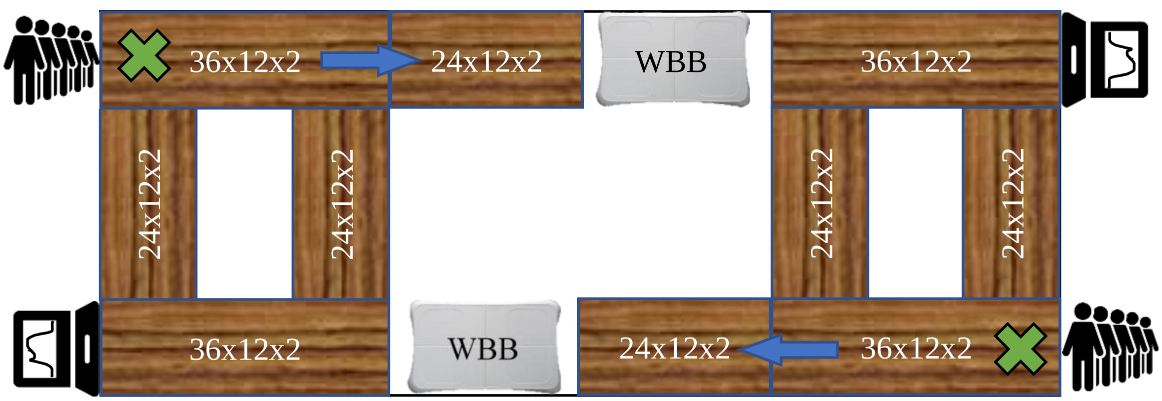
- To understand what ground reaction forces (GRFs) are.
- To learn how to measure GRFs in the laboratory.
- To observe how different foot strikes (heel vs. midfoot vs. forefoot) affect the shape of vertical GRF curves.

Equipment & Materials:

Item	Quantity
1. Wii Balance Boards (WBBs)	2
2. Wood boards (36x12x2)	4
3. Wood boards (24x12x2)	6
4. Colored tape	10 ft
5. Laptops with BrainBLoX installed	2
6. Tables	2

Setup:

Download and install to each laptop BrainBLoX software from here. Arrange wooden boards and WBBs as shown below. Tape arrows onto boards to indicate walking direction (blue arrows). Open BrainBLoX software on laptops and place them on tables positioned at the ends of each row such that they can be seen while walking across each WBB. Connect WBBs to laptops via USB cables. Walk over each WBB to ensure GRFs display properly.



Procedure:

Explain what GRFs are and how they are measured. Discuss applications of GRF measurement (e.g., gait analysis in clinical populations and athletes). Have participants stand behind the boards at the location of either of the green X's shown above. One-at-a-time have each participant step onto the board and walk in the direction of the blue arrows toward the computer at the other end of the course. As they pass over the WBB, GRFs should display on the computer screen in front of them. The vertical GRF during walking typically has two peaks. Challenge participants to change their gait such that 1) the first peak is greater, 2) the second peak is greater, or 3) there is only one peak. What did they do to cause these changes to occur?

Notes:

Printing examples of vertical GRF plots can help facilitate discussion of how GRFs can change with different patterns of gait. Consider plots of walking vs. running, healthy vs. crouch gait, etc.

Supplemental Resources:

Include links to videos, articles, and other resources relevant to the demo.

1. **BrainBLoX software download**: Developed at the University of Colorado, BrainBLoX is a user-friendly interface for viewing and recording center of pressure (CoP) data in real-time from a Wii Balance Board. It is a standalone executable that will work on Windows XP and later (They have tested up until Windows 10). All you need is a Nintendo Wii Balance Board, a Windows PC running Windows XP or later, and their CU BrainBLoX software.

   Reference: Cooper J, Siegfried K, Ahmed AA (2014) BrainBLoX: Brain and Biomechanics Lab in a Box Software (Version 1.0) [Software]. Available from: http://www.colorado.edu/neuromechanics/research/wii-balance-board-project