Experiment # 2

Vertical Jump Measurement Using Force Plates

Objectives

1. To apply Newton's second law.
2. To understand the forces involved during counter movement jump and squat jump.
3. To calculate the flight height of a jump from the time of flight.

Background: Vertical Jump

The vertical jump is an essential motor skill in many sports. The success or failure of a sportive action strongly depends on the ability of the athlete to jump high and fast .This is the reason why many studies have analyzed the vertical jump from a physical point of view, to establish the factors that have to be improved to increase jump height.

There are two types of standing vertical jump: "countermovement jump" and "Squat jump" .In a countermovement jump (which will be applied during the lab), the jumper starts from an upright standing position, makes a preliminary downward movement by flexing at the knees and hips, then immediately and vigorously extends the knees and hips again to jump vertically up off the ground (Figure 1). A countermovement jump is an example of a movement that benefits from the ‘‘stretch–shorten cycle.’’ Many human movements such as running, jumping, and throwing involve muscle actions in which the desired motion is preceded by a movement in the opposite direction. The muscles are said to be ‘‘prestretched’’ before shortening in the desired direction. Experiments have demonstrated that a pre-stretch enhances the force production and work output of the muscles in the

subsequent movement. In a squat jump, the jumper starts from a stationary semi squatted position then vigorously extends the knees and hips to jump vertically up off the ground.

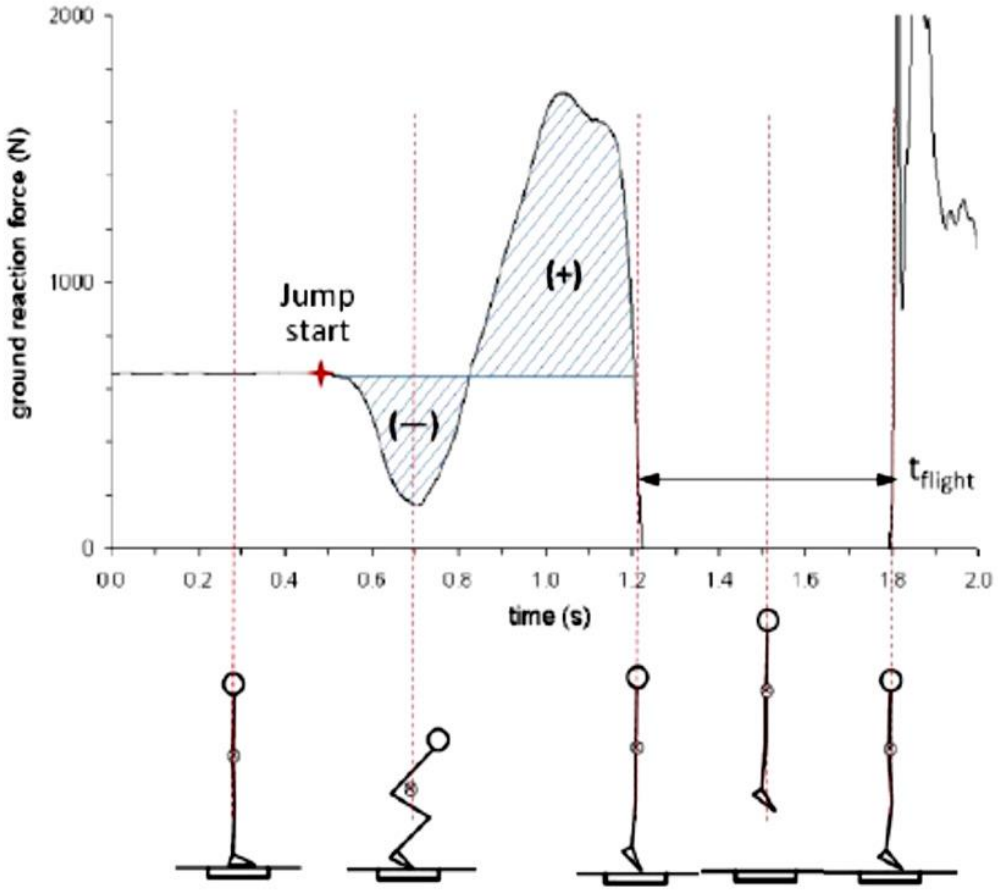

Figure 1: Vertical ground reaction force (Fz) measured by the force plate during a standing vertical jump

Remember:

$$\sum \vec{F} = m\vec{a} = m\frac{d\vec{v}}{dt} \quad \text{Eq. (1)}$$

Considering just the vertical component of this vector equation, the forces acting on the body in the z-direction are the ground reaction force Fz (t) and the force due to the mass of the body, mg. This can be related to the vertical acceleration dVz/dt.

$$\sum F_z = m\frac{dv_z}{dt} = F_z(t) - mg \quad \text{Eq. (2)}$$

Solving Eq. (2) for dVz/dt and integrating results in an expression for the velocity of the whole body center of mass as a function of time:

$$v_z(t) = \frac{1}{m}\int (F_z(t) - mg)\ dt \quad \text{Eq. (3)}$$

Time of flight:

Center of mass jump height is purely a function of take-off velocity after take-off. Hence during a vertical jump, the total impulse that is imparted to the body will determine the jump height that can be achieved.

$$h_{tof} = -\frac{gt_{flight}^2}{8}$$

$$v_o = -\frac{gt_{flight}}{2}$$

Equipment

1. PC Computer
2. Lab Quest 3.
3. Vernier Force Plate Platform

Procedure

1. Before starting to collect data, make sure that the cables from the force plate to the Lab quest 3 is properly connected.
2. Zero the force measurement in both channels.
3. Start the Digital Acquire
4. Avoiding the platform connector, have the test subject stand on the force platform and position his/her feet to form a square on the middle of the platform.
5. For vertical jump measurements, there is no need for paper but another subject should stand next to the test subject to recording his/her jump.
6. Press the Start button to start data collection and instruct the subject to start countermovement jump: **start out standing straight up, then bend his/her knees, then push off and jump up as high as he/she could, and land back on the force plate.**
7. Data will be saved to the file that you specified while collecting data. Therefore, no additional action is required.
8. Repeat the above procedure for squat jump.

Data Analysis (Calculations and Results)

1. Plot the ground reaction force Fz (N) as a function of Time (sec) for countermovement jump.
2. Plot the ground reaction force Fz (N) as a function of Time (sec) for squat jump.
3. Calculate the flight time for the counter movement jump and squat jump.
4. From the force graph, calculate the time of flight (how long you were in the air) for the counter movement jump and squat jump.
5. From the flight time, calculate the height of the subject's jumps.
6. Describe the benefits of knees bending before start jumping and while landing.

7. Compare between the countermovement jump and squat jump.
8. Compare and discuss the results for the three subjects.
9. What are the possible errors in your calculations or measurements?