Illinois State University
School of Kinesiology and Recreation
KNR 352, Quantitative Analysis in Biomechanics

Project
Impulse During the Countermovement Vertical Jump

Data Collection Descriptors
Vertical Jump, 2 trials
Sample Rate: 1000 Hz, 6 second duration

Two spreadsheets are provided, CMJ1.csv and CMJ2.csv

Reference: Reiser et al, 2006: Basic principles through the VJ

The vertical jump is a common training technique and protocol used in research for the evaluation of lower extremity performance.

In this project, you will use Excel to analyze two trials of the countermovement jump. You will plot the vertical ground reaction force data from each trial together on a single graph, properly scaled and labeled. The analysis will consist of calculating the impulse on the jumper, by appropriate phases, and using these impulse values to then calculate the velocity changes and terminal velocities during the phases of the trials.

The impulse of interest is the *net* impulse, calculated as the area of the net force by time curve. When the vGRF is less, in magnitude, than the weight of the participant, the net force will be negative. Conversely, when the vGRF is greater, in magnitude, than the weight of the participant, the net force will be positive.

1) When we collect vertical jump data, our typical procedure is as follows:
    a. Have the participant stand beside the force platform (FP). Start the data collection from the Force Platform.
    b. Subject steps laterally onto force platform (this will trigger data collection), with both feet comfortably on the surface. The participant should stand motionless for 2 seconds.
    c. Have the participant perform the countermovement vertical jump with instructions to perform the jump according to the specific protocol of the study. The subject should always be instructed to land with both feet on the FP, or the trial needs to be repeated. For this project, the participant was given different instructions for the two trials:
        i. Jump as high as possible
        ii. Jump to half of that height
    d. Have subject step off force platform
2) The raw voltage from the force platform is converted to force in Newtons by the software.
3) Data are exported to an ASCII file (csv format) for later processing with Excel.

Procedures for each trial
1) Open the csv data file using Excel.
2) Find the section titled Imported Force Plate—Force. These data are the forces applied by the participant *on the force platform.*

a. Convert the Fz channel to the vertical GRF.
b. Eliminate all but 10 ms of the data before the subject steps onto the force plate. (Note: you can get rid of as much of the other data as you want, too).
c. Using the sampling rate listed above, create a column of time that corresponds to the vGRF data. Set time 0 as when the participant leaves the ground at the end of the counter movement jump.
d. Calculate the weight of the participant using an appropriate set of vGRF data.

3) Create a rough plot of the vGRF to facilitate the following steps, or just search through the data.
   a. Identify and record the point when the counter portion of the jump begins by looking for a change from the data representing the participant's weight. What criterion value of vGRF data are you using to identify when the jump begins?
   b. Identify and record the point when the vGRF returns to the participant's weight.
   c. Identify and record the point when the vGRF again returns to the participant's weight, just prior to the end of the jump.
   d. Identify and record the point when the participant leaves the FP.
   e. Identify and record the point when the participant first touches the FP after the flight phase.
4) Perform the following calculations for each trial:
   a. Calculate the net impulse during the counter motion.
      i. How did you identify the start and end of the counter motion from the vGRF?
      ii. What is the change in velocity from the net impulse?
      iii. What is the final velocity of the participant at the end of the counter motion?
   b. Use net impulse to identify when the downward speed of the participant comes to 0 (downward motion of the participant =0).
      i. Explain how you identified when $v_{downward} = 0$.
   c. Calculate the duration of the counter portion of the jump and the duration of the phase during which the $v_{downward}$ is reduced to 0.
   d. Calculate the net impulse from $v_{downward} = 0$ to when the vGRF again becomes equal to the weight of the participant.
      i. What is the change in velocity from the net impulse?
      ii. What is the final velocity of the participant at the end of this phase?
   e. Calculate the net impulse from when the vGRF becomes equal to the weight of the participant until the participant leaves the force platform.
      i. What is the change in velocity from the net impulse?
      ii. What is the final velocity of the participant as they leave the force platform?
   f. Using the take-off velocity, calculate the following relative to the flight of the participant:
      i. How high will the participant go?
      ii. How long will the participant be in the air?
   g. Using the duration of the vGRF while the participant is in the air, calculate
      i. How high did the participant go?
      ii. What was the participant's take-off velocity?

Your submitted work will consist of

1) A single graph, showing the vGRF of each trial plotted against time. The labels should be correctly labeled as Force and Time. Label/code the two vGRF curves as "High" and "low", according to the height of the performance.

2) Answers to the questions in part 4 above, of the procedures
    a. Respond to all of the questions on “how” in sentences
    b. Create a single table presenting the values of each of the variables calculated in part 3 above.
3) Describe the similarities/differences in the variables between the two trials, and an explanation of your observations.
    a. Also answer: Did your calculated weight differ between the two trials?

Bonus: since you are now very adept at using Excel, take a look at the force in the Anterior-Posterior direction. Calculate the positive and negative impulses during the take-off, and the positive and negative impulses during the landing. Compare the size of the impulses within and between the two phases.