Biomechanics of Human Movement

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Abstract

Human motion analysis is used in clinical assessment, sports performance, and research fields. This project utilizes two different approaches to analyze the human motion. First, the project develops a method of calculating standing vertical jump height using kinetic data measured with a force plate, and then confirming the results using flight time method and motion capture data. Close agreement (11% mean) was found between jump height calculated with impulse-momentum and height calculated using time of flight. The average percentage difference between Kinovea and impulse momentum was found to be 23%.
The second half of the project includes designing and building an artificial upper arm that measures the forces of the biceps for different forearm positions. The system includes a force transducer to measure forces produced at biceps. Close agreement (within +/- 2N) was found between predicted and measured bicep forces at horizontal arm position.

Objective

- Understand and analyze the human motion
- Provide accessible solution to study applied biomechanics of human movement

Approaches

- Measurement of Vertical Jump Height
  - Force Plate and Impulse Momentum Technique
  - Time of Flight Method
  - Motion Capture Method, Kinovea
- Design and build a prototype of an arm
  - Measure the forces of the biceps in different forearm positions.

1. A. Impulse-Momentum Technique

- Force plate measures ground reaction force.
- Integrate generated graph with respect to time and subtract the body weight.
- $p = mv \ \ (impulse) \leftrightarrow \Delta p = F\Delta t$ (momentum) $\rightarrow F\Delta t = mv_{to}$

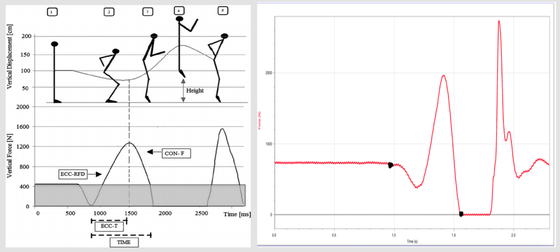
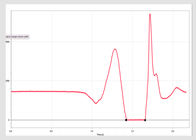


Figure 1: Force-time graph obtained from the force plate on the right. Position of the person on the force plate along with the graph, on the left. Left figure by Guillaume Laffaye .

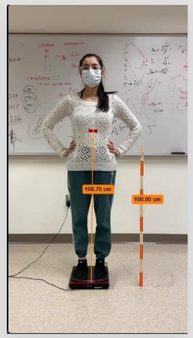
1. B. Flight Time Method

- $v_f - v_{to} = -g(t_f - t_{to})$
- $v_{to} = \frac{gt_{flight}}{2}$



1. C. Motion Capture Method, Kinovea

- Capture the jump video and annotate it to measure the height.
- The meter scale of the figure on the right acts as a reference length for the video.



Results

- Impulse Momentum Technique and Flight Time Method

Mean Difference (cm)	Mean Percent Difference
0.70	11%

- Kinovea and Impulse Momentum Technique

Mean Difference (K & I) (cm)	Mean Percent Difference (K & F)
3.23	23%

- The closer agreement between Impulse Momentum Technique and Flight Time Method proofs the concept of Impulse Momentum technique.

2. Design and Build a prototype of an arm

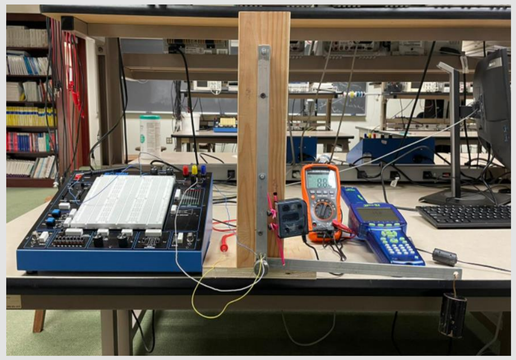


Figure 2: A prototype of an arm.. Force transducer was used to measure the bicep forces.

- Bicep forces were measured at different arm position with different loads.

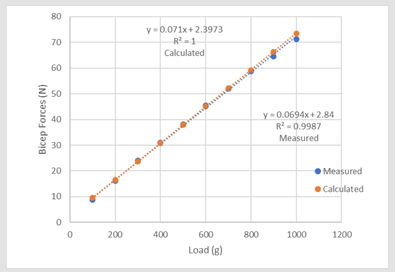


Figure 3: A graph showing calculated vs measured value of bicep forces at horizontal arm position. Both graphs are linear and aligns with each other.

- The linear relationship found for both measured and predicted value at horizontal arm position verifies the successful replication of our arm system.

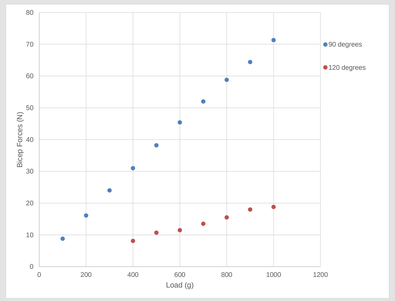


Figure 4: A graph showing bicep forces at horizontal arm position (90 degrees) and at 30 degrees of angle increment (120 degrees).

Discussion

- 23% of mean difference between Kinovea and Impulse momentum technique shows that Kinovea can be used in sport performance, where people just eyeball the height jumped. It can also be used by students for various biomechanics projects to enhance their performance and understanding of applied biomechanics in a real-world application.
- On increasing the angle of arm from horizontal position, the measured bicep forces decreases unlike the predicted value. The force transducer we used only measured the forces in the 75-degrees’ direction rather than net force. Using inline force transducer should solve this problem.

References:

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