Biomechanics of Karate:
Measuring Impact Force in Shotokan Karate Strikes

Yasaman Shirazi

January 26, 2007

OVERVIEW

- Purpose
- Shotokan Technique
- Hypotheses
- Apparatus
- Experiment Protocol
- Data
- Results
- Future Plans and Studies

PURPOSE

- Studying Martial Arts from an Engineering Perspective
- Quantifying Strength of Various Techniques
- Finding Scientific Proof behind the Traditional Arts and their Applications
- Assisting Proper Teaching of Shotokan Karate Strikes

REVERSE PUNCH

- One of the Most Basic and Common Strikes
- Delivered in 3 Orientations:
  - Horizontal – Kihon (Basics)
  - Vertical (Jab) – Kumite (Sparring)
  - 45 Deg – Bunkai (Real Life Application)

REVERSE PUNCH

REVERSE PUNCH

HYPOTHESES

- Strike Effectiveness will be influenced by:
  - Experience
  - Angle of Delivery
    - Horizontal – Strongest
    - Vertical – Fastest
    - 45 Deg – Most Practical
  - Gender
  - Size

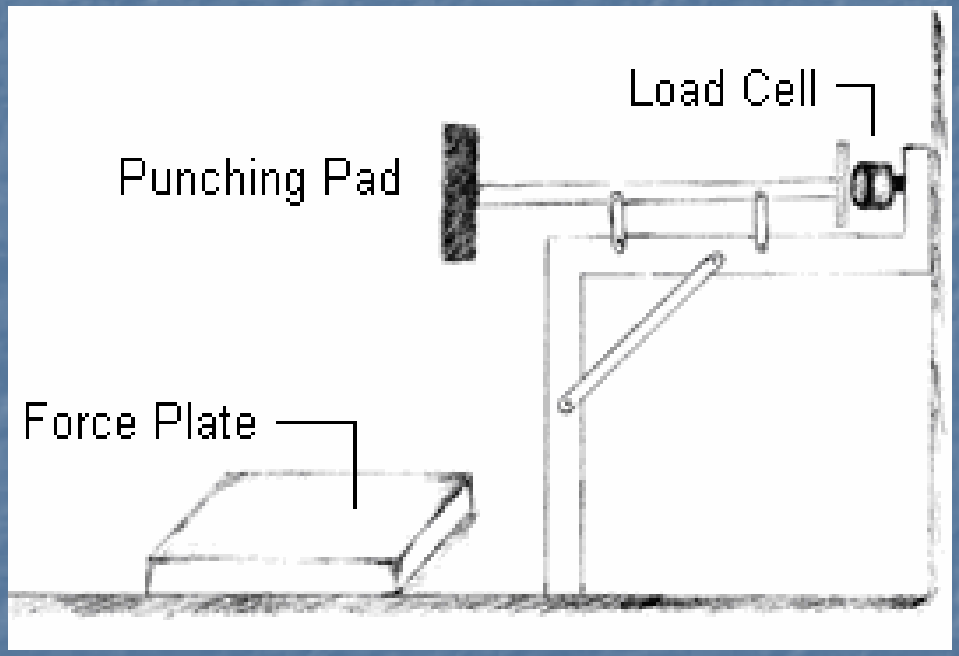
APPARATUS DESIGN

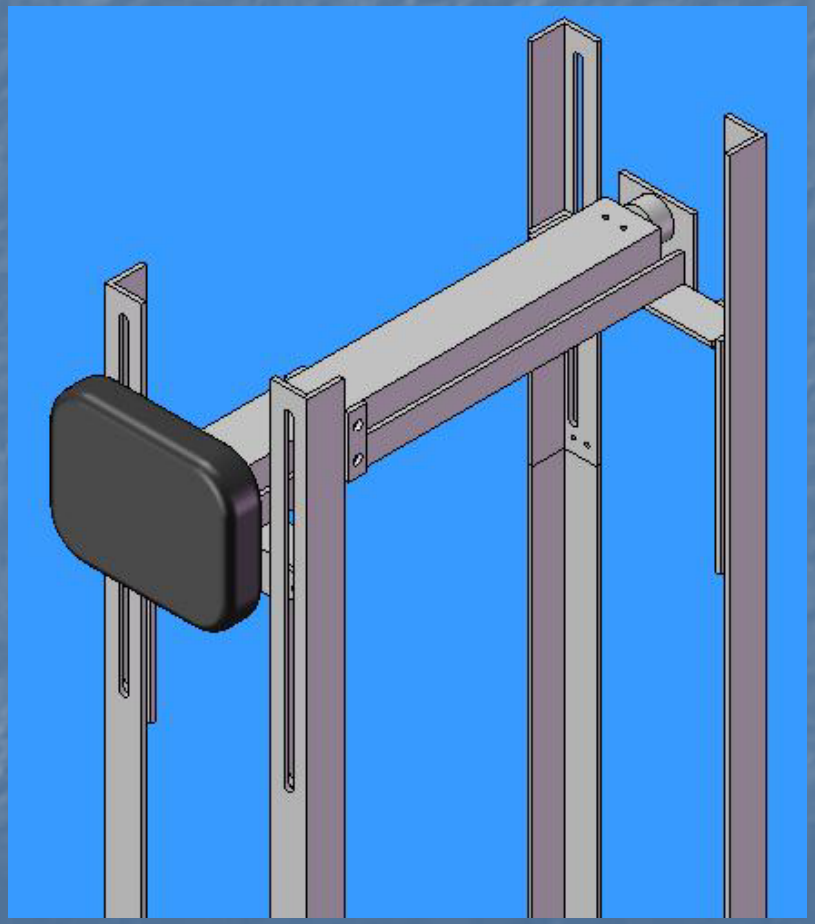
- Criteria:
  - Deliver Direct Linear Impact to a Force Sensor
  - Produce No Moment if Hit Off-centered
  - Be Adjustable According to Different Heights
  - Be Robust and Stable
  - Can Be Built Within Our Time Limit and Available Materials

DATA COLLECTION

- 2000lb Load Cell
  - Located Directly Behind the Target
- Motion Capture System
  - 3 High Speed Cameras to Record the Motion
  - 6 Reflective Markers on Joints of Interest on the Subjects

APPARATUS DESIGN





APPARATUS CONSTRUCTION

EXPERIMENTS

- Set Up
  - Calibrating the Cameras
  - Pilot Testing

EXPERIMENTS

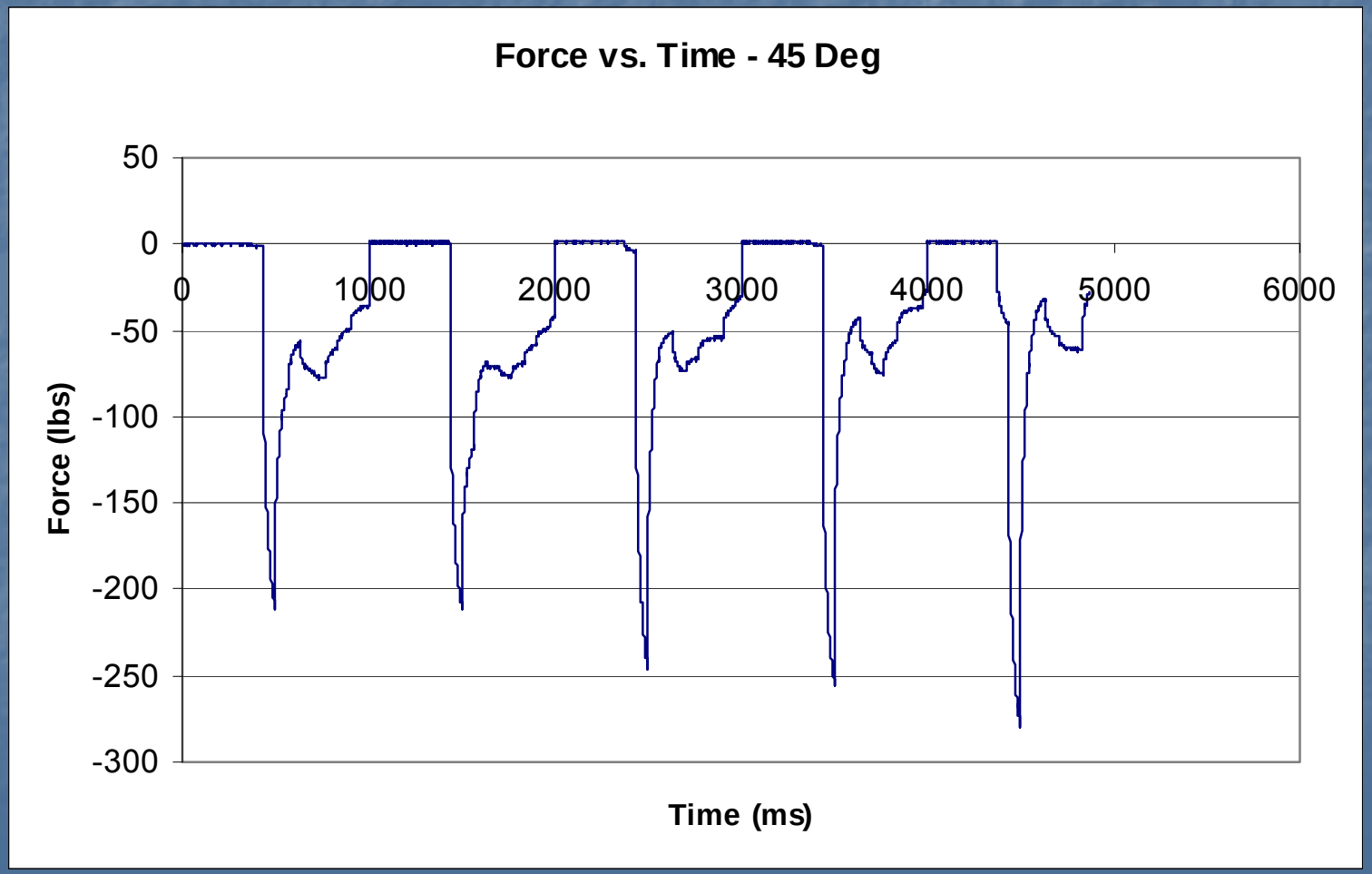
- Subjects:
  - Beginner (1F, 2M)
  - Intermediate (3F, 3M)
  - Advanced (3F, 3M)
  - Read & Sign the Consent Form
  - Warm up
  - Free Trials
  - Wear 6 Reflective Markers
- Testing Protocol
  - 3 Sets (Horiz, 45 Deg, Vert)
  - 5 Punches Each

DATA PROCESSING

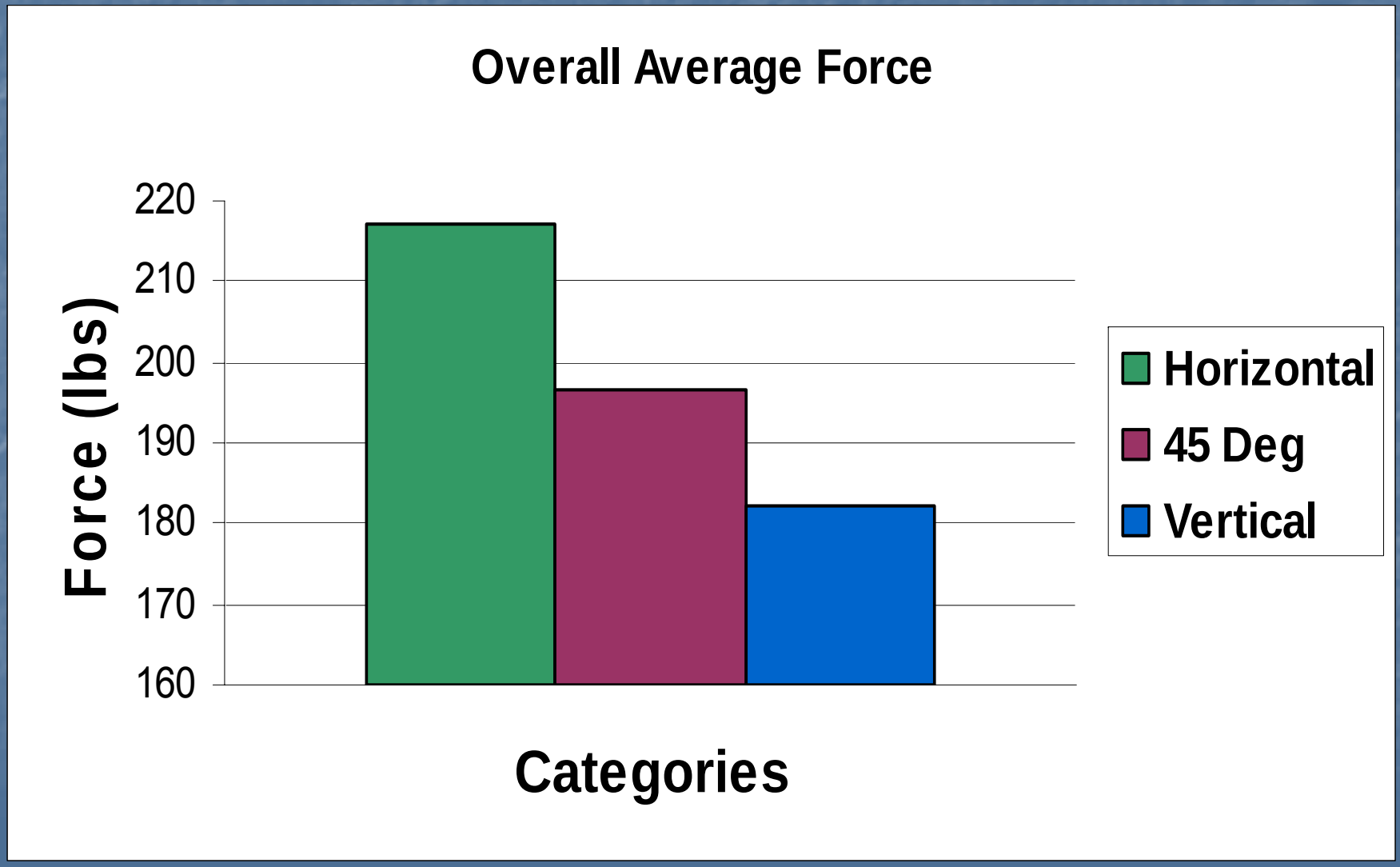
- SIMI
  - Recording the Force Data
  - Processing Video Files and Tracking Markers
- C++
  - Finding Peak Forces and Time of Impact
  - Adjusting the Off Set of the Force
  - Importing Data and Creating Excel Files
- Excel
  - Processing Numeric Results
  - Normalizing and Finding Correlations among Different Variables

RESULTS

- Processed Data

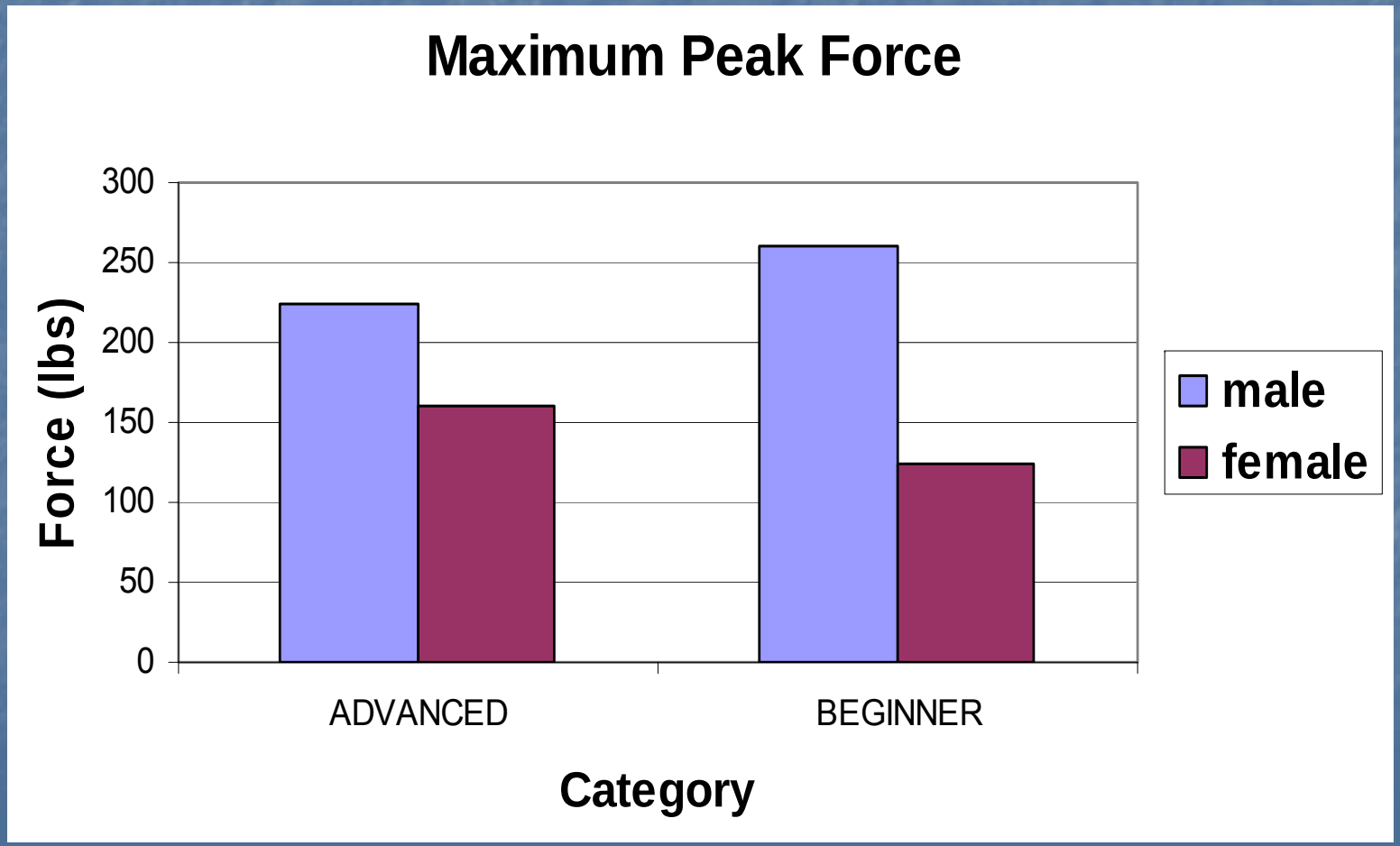


RESULTS


Overall Average Force
Force (lbs)
220
210
200
190
180
170
160
Categories
Horizontal
45 Deg
Vertical

RESULTS

- Comparing Force Based on Gender and Experience

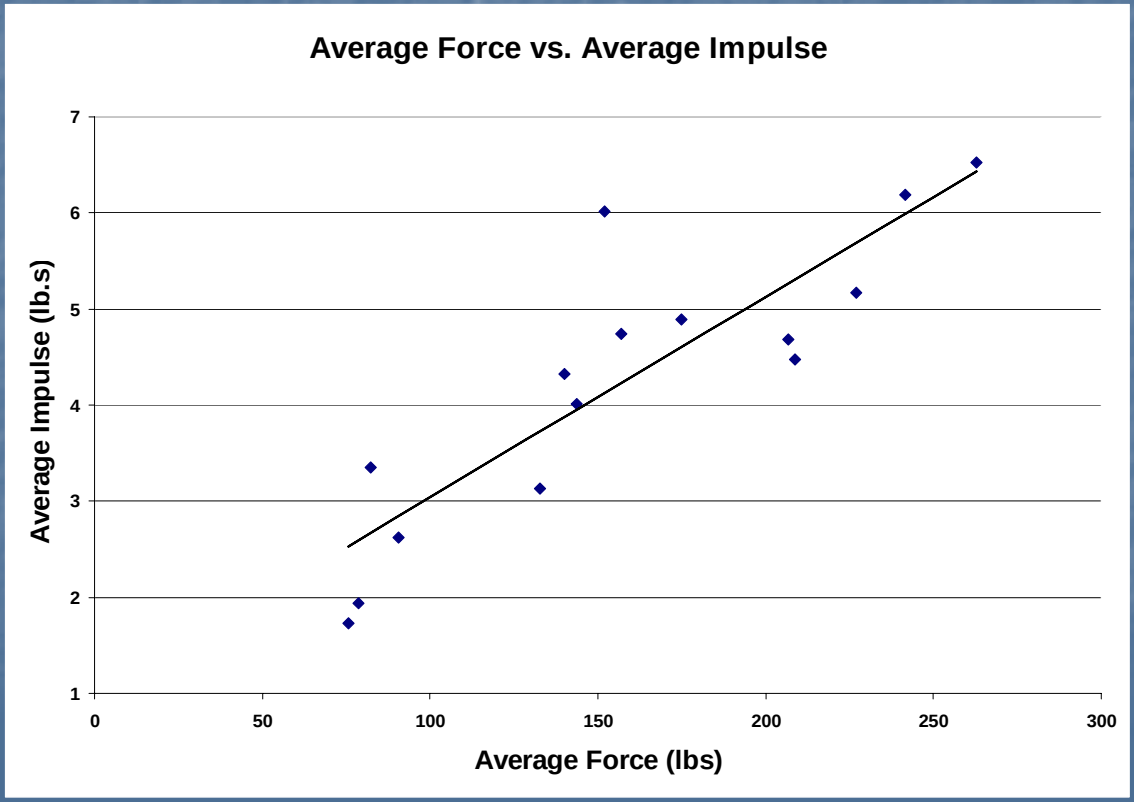


RESULTS

Pearson Correlation Coefficient	Max F (lbs)	Average F (lbs)	Force STD	Max Impulse (lb.s)	Ave. Impules (lb.s)
Grip Strength (lbs)	0.863	0.902	0.320	0.678	0.819
Weight (lbs)	0.741	0.686	0.523	0.705	0.607
Height (in)	0.587	0.628	0.168	0.191	0.509
BMI	0.436	0.318	0.562	0.392	0.332
Experience (Months)	-0.107	-0.054	-0.173	-0.082	-0.023

RESULTS

- Impulse = $\int F.\, dt$
- Ave. Impulse vs. Ave. Force
  - Pearson Correlation Coefficient = 0.8685



- Y = 0.0208 x + 0.955
- R^2 = 0.7543

CHALLENGES

- Not Having Enough Support to Keep the Apparatus in Place
  - Having Off-set Force Data
- Verifying if the Strike is Delivered Correctly
- Having to Recalibrate the Cameras
- Exporting Force Data from SIMI

FUTURE STUDIES

- Processing the Motion Capture Video Files
- Testing Larger Group of Subjects
- Using Random Combinations
- Experiment Different Padding or Gloves
- Modifying Apparatus Design
- Securing the Apparatus to the Wall
- Possibly Studying Other Strikes, i.e. Kicks
- ...