# Preventing Weightlifting Injuries by Barbell Modifications

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## Problem Statement

- 27,000 injuries/yr, often caused by an uneven distribution of load, causing more strain in muscles [1]
- The most common injuries in barbell bench pressing are impingements and tears [2]
- Benching with optimal form and using the best barbell path reduce the risk of injury by reducing strain on the shoulders [4]

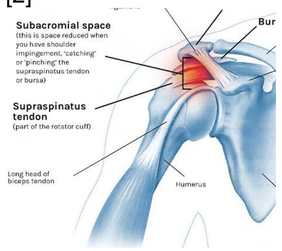


**Figure 1.** Diagram of Shoulder Anatomy [3]

- Goal: Create a device that can prevent injuries by targeting, identifying, and correcting improper form.
  - Detect when the barbell is not level to the ground or parallel with the users shoulders.
  - Track the barbell path and compare it to the ideal path.
  - Alert user when the barbell path isn't ideal and how to adjust.

## Background

- Benching injuries most often occur in the subacromial space, which is where your tendons are in your shoulder. [3]
- When benching with improper form the bones in your shoulder can rub on or get caught on the tendons causing the tendons to become inflamed, this can lead to chronic pain or cause a tear or impingement [3]
- Competing Designs
  - WL Analysis is a free app that tracks one side of the barbell using a phone camera. [5]
  - Bar Sensei is a $499 barbell sleeve with an accelerometer that tracks the barbell path from the center. [6]
- Both designs don't take into account any unevenness in the barbell and are not designed to prevent injuries. The Bar Sensei is very expensive for most weight lifters.

## Design Specifications

✅Modified weightlifting clip houses movement technology
✅Modified Weightlifting Clip retains functionality
✅Battery Life functions 3-5 hours
✅Electronic Components will be water protected
✅Acceleration data is collected and derived into displacement in centimeters along the X, Y, and Z axis.
🚫Instantaneous Data Collection shown on an Application
🚫Quantifiable Strain on specific muscles during a repetition

## Final Design

### External View

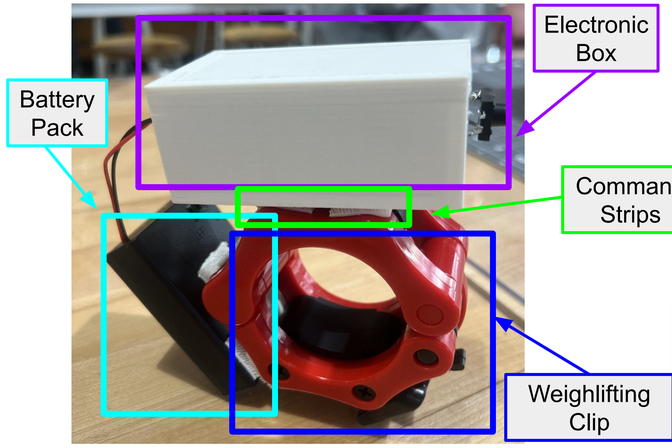


**Figure 2.1.** External View of Modified Weightlifting Clip

### Internal View

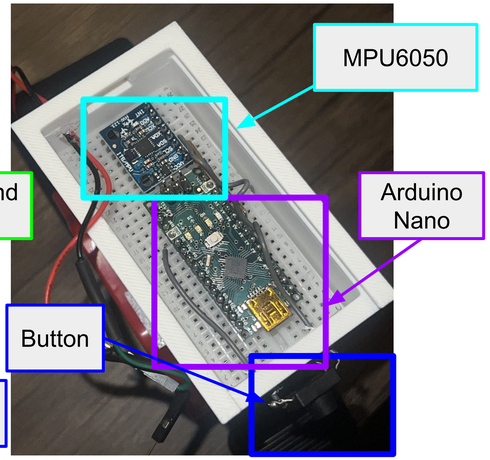


**Figure 2.2** Internal View of Modified Weightlifting Clip

## Testing Methods/Procedures

1. **Accuracy Testing**
   - Stationary: Collect Acceleration data when the device is not moving
   - Kinetic: Collect Acceleration data when the device is moving, such as in the path of a barbell
2. **Battery Life:** The amount of time that 3 AA batteries could power 5V was tested and compared to the average time of completion for a workout
3. **Water Protection:** The design team looked to ensure that exposure to small amounts of liquid, simulating the effects of sweat, would not affect the device. We applied 50 mL of water to device in order to test this.

## Testing


**Figure 3.1.** Final Design Clipped to Barbell for Testing


**Figure 3.2.** Active Testing of Device for Accuracy of Bench Press R.O.M.

## References

[1] R. Gupta, J. O. Quintana, N. Reddy, S. Ayotte, and J. T. R. Lawrence, "A National 20-year Analysis of Weight Lifting-related Injuries and Fractures Among Adolescents," J Pediatr Orthop, vol. 44, no. 6, pp. 373–378, Jul. 2024, doi: 10.1097/BPO.0000000000002685
[2] N. L. B. I. H. Mim, S. A. V. Haj, and V. D. H. Fit, "Effects of bench press technique variations on musculoskeletal shoulder loads and potential injury risk," Front. Physiol., vol. 15, Jun. 2024, doi: 10.3389/fphys.2024.1393235.
[3] "Shoulder Impingement & Resistance Training: What Powerlifters, Weightlifters and Barbell Strength Athletes Need to Know to Understand Shoulder Injuries." Accessed: Oct. 09, 2024. [Online]. Available: https://www.progressiverehabandstrength.com/articles/shoulder-impingement-resistance-training
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## Testing Results

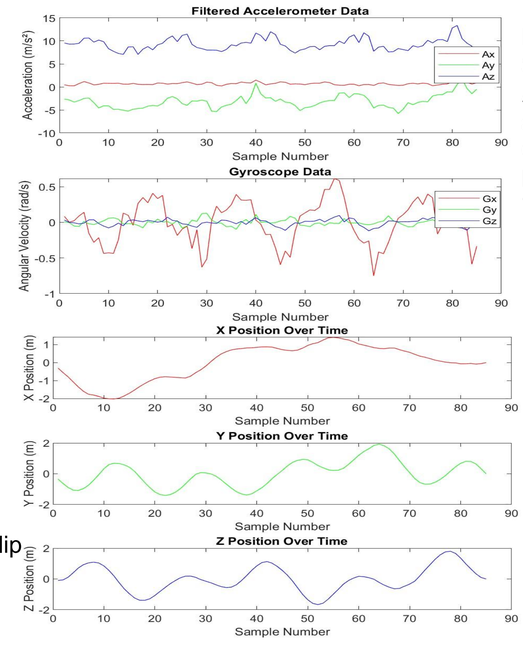


**Figure 4.1.** Subplot of Acceleration and Gyroscope Data during Testing Trial

**Figure 4.2.** Subplot of Position by double Integration of Accel. Data

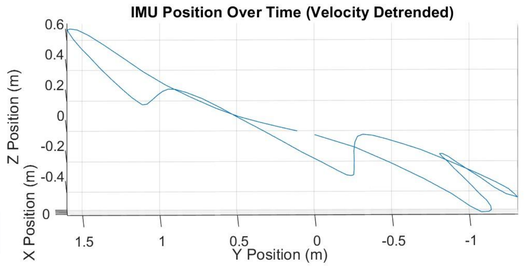


**Figure 4.3.** 3D Plot of Position Over Time for Testing Trial

**Results:** Accel. And Gyro. data support testing of no movement in X dir. (horizontal) but angular motion via wrist flexion. Position yields similar changes in Y and Z supporting that the barbell only moved in the sagittal and coronal plane of the user and at identical times (humps represent repetitions).

## Future Project Development

- Instantaneous Data Collection
- 3D visualization
- Application to compare data to previous and other collected data
- Decrease breadboard size to < 2 inches
- Application to start rather than button
- Improved accessibility to all users

## Acknowledgements

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