



# Preventing Weight Lifting Injuries with Barbell Modifications

## Advisor

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## Client

Robert Gold

## The Team

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# Client Description and Problem Statement

Robert Gold

- Pharmacist
- Inventor

Our team's task is to create a marketable system that increases safety for lifting, specifically bench pressing.



# Background

- Around one million people a year obtain a weightlifting injuries that result in an emergency room visit [1].
- Roughly 20-40% of these injuries are due to the bench press [2].
- Majority of these bench press injuries are shoulder related.



Figure 1: Benching Exercise

# Competing Solutions

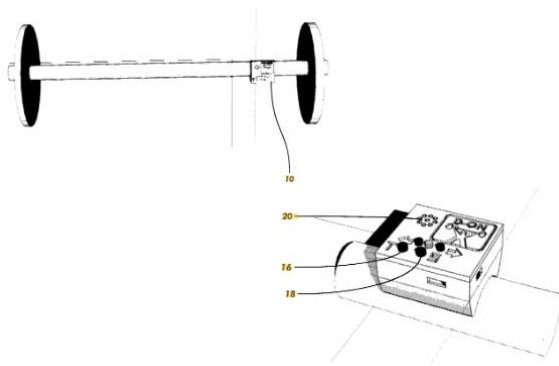


Figure 2: Barbell level indicator (US9623285B1) [3]

- Barbell attachment
- Accelerometer
- Sends to phone

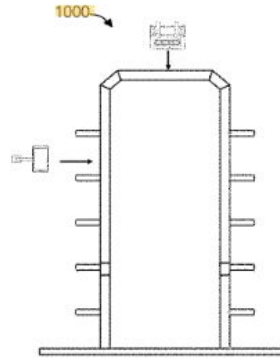


Figure 3: "Multi-functional weight rack and exercise monitoring system for tracking exercise movements (US10737140B2)" [4]

- Camera assembly
- Tracks Barbell
- Output to external device



Figure 4: Bar Sensei [5]

- Measures speed
- \$400
- Sends to phone by bluetooth

# Design Specifications

- Create a device that measures and displays the balance of the barbell during the bench press.
- Device must use technology in a way that is unique to other systems that have been designed previously.
- Device should not cause an imbalance during the lift.



# Barbell Design 1: Full Barbell

- Lift tracking and display circuitry implemented into the barbell
- Maintain physical properties and dimensions of existing barbells

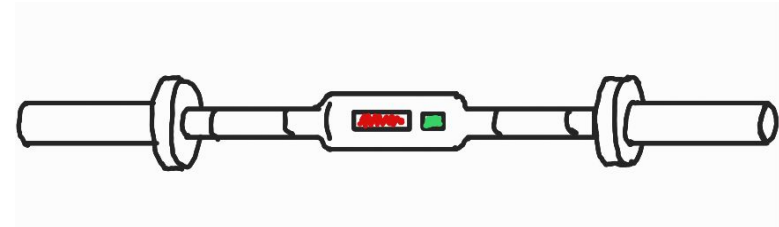


Figure 5: Drawing of Full barbell modification design.

# Barbell Design 2: Barbell Attachment

- Attachable clip or sleeve to standard barbell
- Display and tracking integrated into attachment

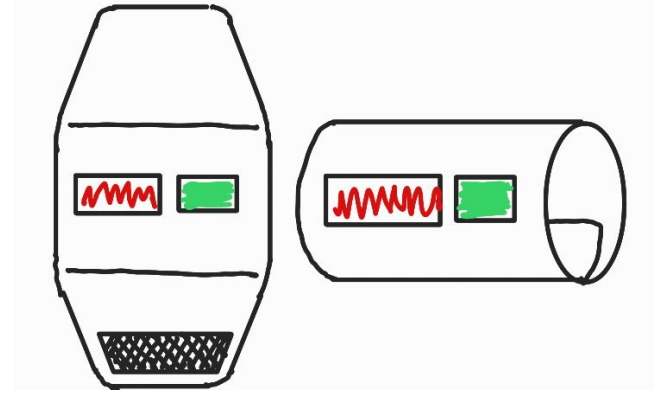


Figure 6: Drawing of potential barbell attachment designs.

# Barbell Design 3: Full Suit + VR

- Visually track the body and the barbell
- Use VR/headset to display lifting results and tracked data

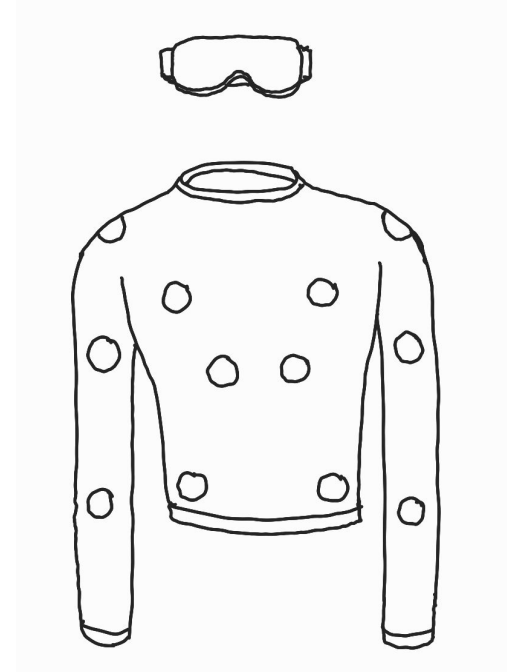


Figure 7: Drawing of Full Suit and VR design idea.



# Barbell Design Matrix


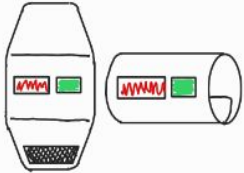

Design	Full barbell		Barbell attachment		Full suit + VR	
						
Safety (25)	4/5	20	5/5	25	5/5	25
Ease of Use (20)	4/5	16	5/5	20	2/5	8
Uniqueness (20)	3/5	12	2/5	8	5/5	20
Marketability (20)	3/5	12	4/5	16	5/5	20
Cost (10)	3/5	6	5/5	10	1/5	2
Ease of Fabrication (5)	2/5	2	4/5	4	1/5	1
Overall Score:	68		83		76	

Table 1: The Design Matrix Ranking each Barbell Design

# Technology Design 1: Radar / Lidar

Idea: calculate distance by bouncing signal off of the ground and measuring time.

- Very unique
- Possible issues with angle of bar



Figure 8: Image of a Radar Sensor

# Technology Design 2: Accelerometers

Idea: use acceleration data to calculate distance traveled

- No significant drawbacks
- Already been used in a lot of similar patents

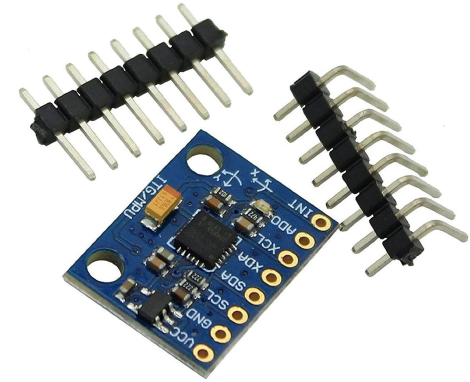


Figure 9: Image of Accelerometer

# Technology Design 3: IMUs

Idea: Similar to accelerometer, calculate distance with sensor output

- More specific data than accelerometer
- Potentially requires calibration before use

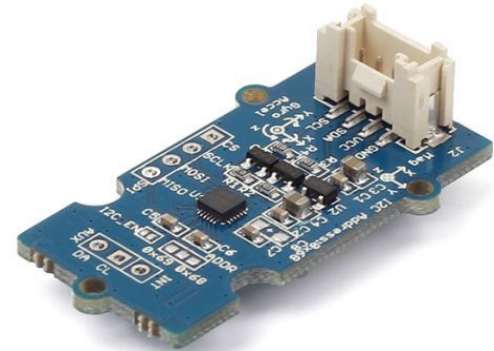


Figure 10: Image of an IMU

# Technology Design Matrix




Technology	Radar/Lidar		Accelerometer		IMU	
						
Accuracy (25)	5/5	25	4/5	20	3/5	15
Reliability (25)	3/5	15	4/5	20	4/5	20
Marketability (20)	5/5	20	2/5	8	3/5	12
Cost (15)	2/5	6	4/5	12	3/5	9
Ease of Fabrication (10)	2/5	4	4/5	8	3/5	6
Safety (5)	5/5	5	5/5	5	5/5	5
Overall Score:	75		72		67	

Table 2: The Design Matrix Ranking each Technology Design

# Preliminary Design

- Attach an ultrasonic array around both sides of the barbell
- Place a center screen around the center of the barbell



Figure 11: Preliminary Design

# Preliminary Design (Continued)

- Utilize position to track these data points:
  - Position, velocity, acceleration
  - Force
  - Angle
- Utilizing code to calculate this data

```
10.07in1, 10.07in2, 0.00ve11, 1.12ve12, 1.17acc.  
10.38in1, 10.20in2, -0.35ve11, 0.32ve12, 0.65acc.  
10.70in1, 10.70in2, 0.00ve11, -0.69ve12, -0.68acc.  
10.18in1, 10.54in2, 0.71ve11, -0.01ve12, -0.71acc.  
10.53in1, 10.20in2, -0.65ve11, 0.67ve12, 1.30acc.  
10.66in1, 10.47in2, -0.37ve11, 1.13ve12, 1.48acc.
```

Figure 14: Code output of the first draft of this design

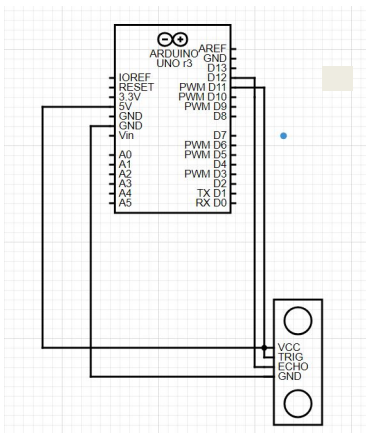


Figure 12: Circuit diagram of prototype

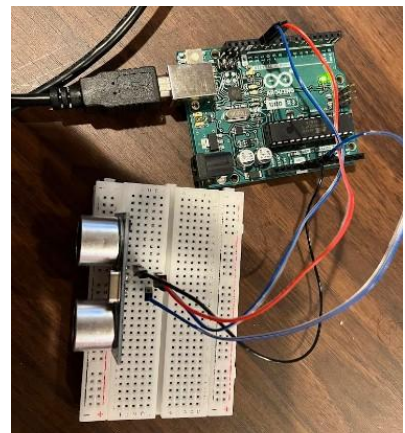
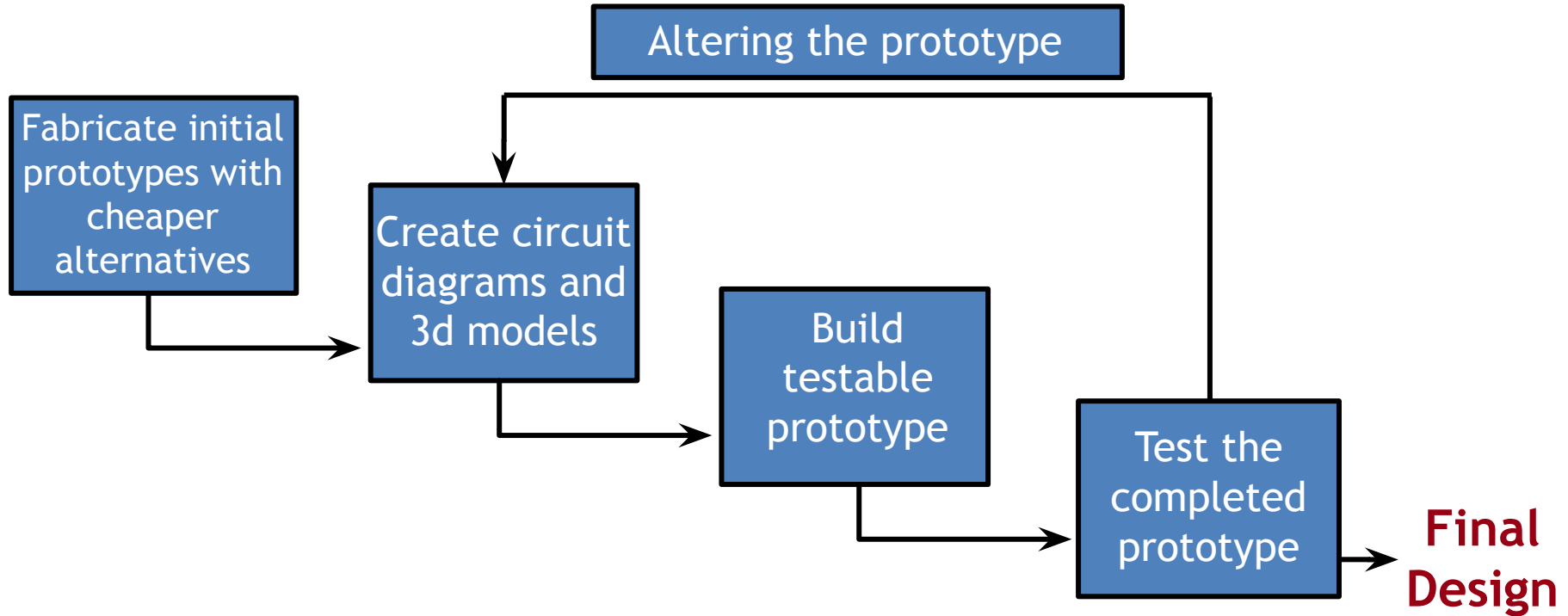


Figure 13: Initial prototype utilizing an ultrasonic sensor

# Future Plans





# Acknowledgments

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# References

- [1] K. Golshani, M. E. Cinque, P. O'Halloran, K. Softness, L. Keeling, and J. R. Macdonell, "Upper extremity weightlifting injuries: Diagnosis and management," *J Orthop*, vol. 15, no. 1, pp. 24–27, Mar. 2018, doi: 10.1016/j.jor.2017.11.005.
- [2] V. Bengtsson, L. Berglund, and U. Aasa, "Narrative review of injuries in powerlifting with special reference to their association to the squat, bench press and deadlift," *BMJ Open Sport & Exercise Medicine*, vol. 4, no. 1, p. e000382, Jul. 2018, doi: <https://doi.org/10.1136/bmjsem-2018-000382>.
- [3] Bar sensei, <http://files.assess2perform.com/barsensei.html> (accessed Feb. 28, 2024).
- [4] M. M. Ruiz, "Barbell Level Indicator," Apr. 18, 2017
- [5] J. Rothman and N. Rodman, "Multi-functional weight rack and exercise monitoring system for tracking exercise movements ," Aug. 11, 2020

# Questions and Comments?

