BMEDesign: Product Design Specification

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Team project: Preventing Weight Lifting Injuries by Barbell Modifications

Lab section: 305

Group members
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Function

Weight training is the second most common form of regular activity done by Americans outside of walking, with about 8.9% of the population engaging in some form of lifting [1]. Of those ~29 million people, an average of ~970,000 total emergency department visits each year are due to a weight training injury [2]. The goal of this project is to reduce this number starting with one of the most common & potentially hazardous lifts: The bench press. The cause of most weight training injuries is an imbalance in the lift, so our device will detect if the barbell is level and alert the user if it's not. Along with this feature, other data will be collected during the lift, including sets, reps, speed, etc. Instead of simply logging the data, however, it will be displayed in real time to the user during their lifting motion. Hopefully the end result is a product that is both convenient and reliable, that protects its user from potential harm, and that is in the house of every weight-lifter in the nation.

Client requirements

- Real-time feedback on reps during weight training
    - Display reps and sets
    - Inform user of uneven lifting
- Device must be something that hasn't been done before
    - New technology or ideas
    - No use of wristband devices for biometric monitoring
- Produce a measurable increase in the safety of weight training
- *Optional:* measurement of muscle force

Design requirements

1. **Physical and Operational Characteristics**

A. Performance Requirements:

The measuring device will be used often and must measure the balance of the lift and bar each time a lift is performed. There should be 100% accuracy for the balance measurement when lifts are performed and the usability should be easy to use, for the common adult.

B. Safety:

The FDA regulations apply, as a medical device. As a class II medical device, the product will need to follow general and premarket approval [3].

C. Accuracy and Reliability:

The device should be about 100% accurate in terms of showing balance in the bar. Over time the wear of the calibration is due to grow, but during the time of the device's shelf life it should remain 100% accurate in measurements regarding balance.

D. Life in Service:

The device should last roughly a year before calibration is required. Annual calibration is the safest way to make sure the sensors remain up to date and accurate [4]. Outside of calibration this device should last around 3-5 years before updates are made or new versions would be better than a worn out device.

E. Shelf Life*

The device should be stored at normal conditions of around 20-22 degrees celsius. It is an electronic device so it should not be placed on the floor for long term storage to avoid any water risk.

F. Operating Environment

The device will operate in weight room settings, which will fluctuate around 21 degrees celsius. The device may also be exposed to various liquids such as sweat, energy drinks, water, etc. - Therefore water resistance is a must for the device. It may also endure forces due to the bar being placed or rested on the user. The device must be able to function under all of these conditions.

G. Ergonomics

The device must be able to withstand strong human grip strength (~800N) and torque (17.39Nm) [5]. Depending on the form factor, it should also be able to easily be attached/detached and adjusted with relative ease of the user.

H. Size

The device must be able to be integrated onto or into a standard barbell, which has a diameter of 28 mm [6] and a holdable grip length of 1.37 m. It is essential that the device is symmetrical along the

sagittal plane - plane perpendicular to the bar and parallel to the face of the ends of the bar, so that the device does not cause imbalance during the lift.

I. Weight

The mass of the device must not exceed 2 kilograms in order to be as minimally invasive to the lift as possible, and the mass must also be evenly distributed to not imbalance the bar during the lift, imbalance may lead to injuries and render the device useless.

J. Materials

The materials used for the device should be safe for the body to have contact with. Since the sensors will be wearable the patient should not have to worry about injuries to themselves or those around them. Also, the material if something is attached to the barbell should not be harmful to the longevity of the barbell.

K. Aesthetics, Appearance, and Finish

The product should have a good appearance that if it is brought to a public gym it would not make the user self-conscious. It should also be good to the touch and be wearable and or usable comfortably while not inhibiting the movement of the lift.

Production Characteristics

a. **Quantity**

The goal of this project is to create an idea and a working proof of concept for the semester. The goal is to be able to get to a successful marketable product in the future. The final goal would be to sell as much of the product as possible.

b. **Target Product Cost**

The target product cost will be within the $100-$200 range which would place it below the average cost of the competition of around $300 [7]. This would ensure that there would be profitable margins for the product.

Miscellaneous

c. **Standards and Specifications**

The device will be considered a Class II medical device according to the FDA [X], and it will require FDA clearance. In order to market the device, a premarket notification 510(k) or De Novo will be required to be submitted [8]

d. **Customer**

The customer of the product needs a device that is able to both improve the safety of their lifts and improve the overall experience of their lifts. They would like it to be something that can be easily used and be visually appealing.

e. **Patient-related concerns**

The device must be designed as a modification or addition to the bar, not the individual to make the lifting process safer. The design of the device must also not impede on the ability of the user to lift the barbell in any manner, or else this may cause an increased amount of user error, which will lead to increased chance of injuries and adverse effects.

f. **Competition**

There are several related patents to this project that are necessary to avoid. The “Barbell level indicator” [9] is a patent that uses a housing shaped to fit adjacent to the barbell, with magnetic attachment, that utilizes an accelerometer, an alarm, and a microprocessor to analyze data from the accelerometer. This utilizes a phone app to output the workout data to the user. Another patent is the "Multi-functional weight rack and exercise monitoring system for tracking exercise movements” [xy]. It utilizes an array of cameras around an arch to detect the motion of the exercise equipment and matrices of distance values. This is also accompanied by a mobile app in order to receive information on the lift.

References

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