Product Design Specifications: Preventing Weightlifting Injuries by Barbell Modifications

September 19th, 2024

Biomedical Engineering 200/300: Biomedical Engineering Fundamentals & Design

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Function:

Over one million weightlifters experience serious injuries every year. These injuries are often caused by an uneven distribution of load on the barbell, leading to the weight lifter favoring one arm over the other. Incorrect loading while weight training can lead to sprains, strains, fractures and other painful injuries[1]. The team has been tasked with designing a biomedical device that can diagnose this strain on the body in coordination with specific muscles in use.

Client Requirements:

I. Quantify strain on specific muscles when used in complex weightlifting movements such as the barbell bench press
II. Create a sensor system to evaluate activated electronic signals in active muscle fibers
III. Utilize motion technology and camera tracking to develop a service that can track proper weightlifting form
IV. Explore emerging software opportunities while building upon previous years progression

Design Requirements:

1. Physical and Operational Characteristics:

a. Performance Requirements:

I. The sensor system will be attached to the barbell in the form of weight clips, with one sensor on each end. This will allow for use on every repetition of a compound weight lifting movement
II. Camera software will be implemented and set to track the user on every repetition of a compound weight lifting movement.
III. Motion tracking will be able to follow direct movements, and follow a designated track in order to ensure proper form when performing these complex movements.

b. Safety:

I. Any modifications to the barbell must abide by safety regulations put in place by the gym or institution in which the technology is being used
II. A sound system will be implemented with motion technology in order to alert the user of malpractice when performing a complex lift such as the barbell bench press

III. Electronic compartments will have no exposed electronic parts to prevent interaction with water or other fluids. Proper cover will ensure no malfunction to injury prevention technology

c. Accuracy and Reliability:

I. The muscle strain software will be able to quantify electronic signals released by active muscle fibers when performing complex lifts

II. The motion tracking system will follow direct movements by the user and follow a designated track in order to ensure proper form when performing complex lifts

III. All barbell modifications will be established on the basis of repeatability, in which actions can be performed upon every lift by the user

d. Life in Service

I. The barbell modifications will have ample power in order to be active for 45-60 minutes, the average time of complete workout [2].

II. The technology will be cased and able to travel via car, airplane, boat, etc.

e. Shelf Life:

I. This device should be stored inside in a climate-controlled environment, around 20-25℃. It should have minimal exposure to, and not be stored in outside conditions such as rain and snow.

II. The device should have a shelf life of at least 10 years while in storage and not being used.

III. If there are any batteries they should be replaced whenever they are dead or every 5 years.

f. Operating Environment:

I. This device will primarily be used inside at a weightlifting gym but can be used outside as long as there is no rain, snow, or extreme conditions (temperatures below 5℃ or above 30℃ or extreme winds)

II. The device should also be dust and dirt-resistant and be strong enough to withstand small impacts like being dropped from 1 meter.

g. Ergonomics:

I. This device should be usable by all people of all heights and weights given that they can use a barbell to do the weightlifting movement.

II. This device should be usable for squatting and benching with a 20kg barbell.

III. This device should be able to be transported by one person easily, and can be brought between different gyms and locations.

h. Size:

I. This product should be able to fit through standard doors and be moved by one person.

i. Weight:

I. This product should be able to be transported by one person so all total components should be less than 10kg.

II. Any barbell attachments should be less than 5 kg, and if the barbell attachment weighs more than 1 kg that weight should be recorded on the outside of the product so the user can accurately see how much weight they have on the bar with the added weight of the attachment.

k. Materials:

I. The materials should be durable enough so they can be dropped from 1 m and light enough to meet the requirements given above.

II. The materials should be safe to touch and should not react with common cleaning chemicals (bleach, alcohol, ammonia), sweat, or water.

l. Aesthetics, Appearance, and Finish:

I. This product shouldn't have any exposed electronics.

II. The product should not have any excessively sharp edges

2. Product Characteristics:

a. Quantity:

I. Only one of these devices should be needed per barbell.

II. Can be scaled to the amount of barbells that are in the gym .

b. Target Product Cost:

I. The cost of competitors products are in the range of $700-$900. We believe we can undercut this cost by triple and sell it for ideally $150-200. However with a budget of $300 the product will even at maximum cost be well under competition price range.

3. Miscellaneous:

a. Standards and Specifications:

I. *Under section 520(o)(1)(B) of the FD&C Act, software that is intended "for maintaining or encouraging a healthy lifestyle and is unrelated to the diagnosis, cure, mitigation, prevention, or treatment of a disease or condition" is not a device under section 201(h) of the FD&C Act. This also indicates that it is generally excluded form CPSC's authority over consumer products under the Consumer Product Safety Act.[3]*

II. *If we use EMG technology, the device is considered to be a diagnostic electromygraph (Definition: [A] device intended for medical purposes, such as to monitor and display the bioelectric signals produced by muscles, to stimulate peripheral nerves, and to monitor and display the electrical activity produced by nerves, for the diagnosis and prognosis of neuromuscular disease). This is classified as a Class II device and is exempt from the premarket notification procedures in subpart E of part 807 of this chapter subject to § 890.9. This device is considered noninvasive for testing and therefore does not need premarket approval and is exempt from Section 510(k).[4]*

III. *If the device does not use EMG technology, it is then classified as a "Low Risk Device" (Class I)and does not need premarket approval, clearance by the FDA, and is exempt from Section 510(k).[5]*

b. Customer:

I. There are not many competing designs on the market, but there are many systems that function in a similar fashion. Thus, the intended goal is to combine the technology used in other fields with the knowledge and devices in the fitness industry to make a one of one device that fine-tunes a user's form.

II. Cost effectiveness will be a major concern with this device, as current products with much less capabilities are ranged from $100 and up which is subpar given the population of people who could benefit from this technology.

III. It would be desired to have the device give a digital readout indicating their deviation from what will be considered their optimal range of motion. Other beneficial readouts

would be which muscles were under the most strain during the lift and recommendations to improve their performance.

c. Patient-Related Concerns:

I. *Since it is classified as a "Low Risk Device" there are minimal concerns for usage of it. There will be no need for sterilization since the device is noninvasive and strictly a biomechanical analysis tool.*

II. *Accuracy and precision will be crucial for the success of this type of device. The complexity and usability will have to be mitigated as much as possible as well.*

III. *The device will have a large amount of data to observe, analyze, and compute. This means that it will require robust software and computational resources.*

IV. *Integrating this technology with EMG tools may increase the complexity of its analysis and must be considered when designing.*

d. Competition:

I. "FLEX" , a barbell velocity tracker, provides real-time display, giving immediate feedback on every rep and set, watches velocity and power, and scrutinizes technique and refines movement patterns. Accuracy of these values is unknown.[6]

II. " Bar Sensei" is another barbell velocity tracker that measures your bar speed, displacement, and power output while performing a lift. It is a device that attaches directly to the barbell and takes measurements based on the displacement of the device itself.[7]

III. "InertiaCube® 4" , a 3 DOF sensor, uses MEMS technology to sense angular rate of rotation, gravity and earth magnetic field along three perpendicular axes. The angular rates are integrated to obtain the orientation (yaw, pitch, and roll) of the sensor. Gravitometer and compass measurements are used to prevent the accumulation of gyroscopic drift through advanced sensor fusion algorithms. This technology offers very low latency, unlimited range, precise factory calibration, smooth, jitter-free tracking, in situ static & dynamic magnetic compensation algorithms.[8]

References:

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