Johnson Health Tech EMG Sensor Holder Product Design Specification

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Function: The current methods used by Johnson Health Tech do not do a sufficient job in holding the center of mass and force sensors steady and in place. They use electromyography sensors that also function as accelerometers to collect data. The shoe holders are currently taped to the user with athletic tape that often slips and rolls up. The slippage causes less accurate data while the rolling can cause the user to trip. This project's goal is to create a safer and more stable sensor holder in order to collect more accurate data.

Client requirements (itemize what you have learned from the client about his / her needs):

- Two sets of sensor holders
- Each set contains two shoe holders and one chest strap
- The holders should hold the sensors vertically on the back of the shoe
- The chest holder should hold the sensor towards the bottom of the sternum
- The sensor holders should fit the delsys trigno EMG and accelerometer sensor
- The shoe holders should hold the sensors with minimal alteration to the gait of the runner
- The sensor holders should be reusable or inexpensive enough to discard them after each use.

Design requirements:

- Total cost should be less than $500

1. Physical and Operational Characteristics

a. *Performance requirements*: The device should be able to be used once a week and withstand being used by multiple runners or be built for a single use. It should be able to take the force of someone stepping. According to a Harvard study, the impact during running can be as much as three times the body weight which would translate on average to 2.28 kN for women and 2.64 kN for men [1] [2]. To allow most people to utilize the device, the sensor holder should be able to withstand 4 kN of force. The center of mass holder must be able to securely hold the sensor in place on the abdomen during running. There is no direct load on the device, but should be able to maintain position while undergoing vertical momentum. Both holders should be barely noticeable by the user as if they are running normally. They should be easily cleaned/sterilized so

they can be used by multiple users.

b. *Safety*: The shoe holders should not cause any slipping or tripping. If it wraps around the bottom of the shoe it should be able to grip the ground like a shoe, to avoid loss of traction and injury [3]. The device should not incorporate any hard materials that could rub against the users skin. There are no real liabilities when it comes to the safety of the chest holder.

c. *Accuracy and Reliability*: The shoe holder should limit movement of the sensor to +/- 0.5 cm in any direction. The chest band should limit movement to +/- 2 cm in any direction. The device should also minimally change the runner's gait.

d. *Life in Service*: The devices should last at least a year being used on average about once a week for several hours.

e. *Shelf Life*: It is not anticipated that there will be any particular storage conditions needed for this device.

f. *Operating Environment*: The devices will need to be able to be used in various environments both inside on a treadmill and outside on pavement during different weather/temperature conditions ranging from 0-32° Celsius during dry and rainy days. The shoe device will need to be compatible with up to 100 different users who have different shoe sizes (women's 5 through men's 13) and different running shoe brands/styles. Since the device will be attached to the user's shoe during physical activity it will experience a variety of different loads (1-4 kN). The chest holder must be able to fit around the abdomen of a large variety of subjects in different amounts of shape.

g. *Ergonomics*: These devices must be as light weight and minimally invasive as possible. Each component should not weigh more than 0.25 kg. The user should not experience much discomfort while wearing the device. This will be dependent on the material and the design. Additionally, the shoe device should not extend to the calf of the user.

h. *Size*: These devices should be adjustable to fit most users. One set of holders will be designed to fit women's shoes ranging from a women's size five to size eleven. This constitutes to shoes lengths between 21.6 and 26.7 centimeters [SOURCE]. The other size will be for men's shoes ranging from a men's size eight to a size twelve. Thus the sensor holder needs to be adjustable between 25.4 and 28.6 centimeters in length [SOURCE]. The part that secures the sensor should be able to fit the 26.85 mm x 37.00 mm x 14.75 mm sensor. The chest holder must have a circumference exceeding 100 cm, the average circumference of the abdomen of an American male [2]. To better fit a wide range of subjects, the design should be able to tightly fit an

abdomen in the range 80 centimeters to 150 centimeters.

i. *Weight*: The goal is to make this product as light as possible so the user does not feel that they are running with weights on their feet. The average running shoe weighs 9 oz or 270 grams [5]. To keep interference at a minimum we want to keep each sensor under 45 grams. The weight of the chest sensor should be restricted to a similar weight as to not apply additional stress on the body as a subject runs.

j. *Materials*: Important material properties for this design are that it is lightweight, durable, and adjustable for different shoe sizes. Hard materials such as metals and plastics should be avoided as they could cause discomfort or injury to the user. Depending on the design, it may be preferable to use multiple materials. The chest strap should be washable or able to be wiped down with disinfectant like the shoe holders.

k. *Aesthetics*, *Appearance, and Finish*: The holders should be designed with the least amount of material that can reliably secure the 26.85 mm x 37.00 mm x 14.75 mm sensor to the heel of a shoe or to the center of mass. Excess material may cause the user to modify their natural gait. The color should be neutral so that it goes well with multiple different shoe types; although this is not an essential component of the design.

2. Production Characteristics

a. *Quantity*: Two sets of sensor holders. Each set includes a chest band and two shoe holders.

b. *Target Product Cost*: The total budget for this project is $500, but the product should be less than $50.

3.Miscellaneus

a. *Standards and Specifications*: The additive of the device to running shoes does not follow the standards for competitive athletic shoes as it gives an unfair advantage and information the shoe itself cannot provide [6]. Taking this into consideration there are no specific standards that the design has to meet.

b. *Customer*: The sensor hold should be able to better stabilize the sensor than the current use of tape. It should be able to accurately measure the force and velocity of the lower limb and the center of mass. Although it is necessary for it to function properly during running trials, adaptability to other athletic endeavours is a welcomed bonus.

c. *Patient-related concerns*: The sensor holder should be able to be sterilized between use. They should be able to withstand being wiped down with a disinfecting wipe or spray.

d. *Competition*: There are similar designs for strapping different types of sensors to the user's shoe during different physical activities. One design that is similar is by PlayerMaker. Their product is a smart motion sensor with a strap system that is intended to be strapped to the user's cleat while playing soccer. It uses AI and machine learning algorithms to give insight on the player's performance and collects data such as stride length, acceleration/deceleration zones, cadence, and release velocity zones [7].The strap goes around the heel and both above and below the cleat, and the sensor is held on the inside of the heel. US Patent (US7912672B2) attaches a sensor to the back of the heel by rubber bands on the heel cap [8]. The design has a smaller sensor that obtains data on vertical acceleration and an ankle cuff to which the sensor is attached.

Sources

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