# Johnson Health Tech: EMG Sensor Holder


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UW BME Design


## Abstract


Delsys Trigno sensors are used by Johnson Health Tech (JHT) to collect center of mass and step force data of a runner, by converting acceleration into force using the subject's mass. The purpose of this device is to create sensor holders for the shoes and chest that ensure accurate gait data is obtained. The shoe sensor holder consists of a stainless steel wire that runs beneath the insole and a latex band that wraps under the arch and over the laces of the shoe. The chest sensor holder is made of an elastic band with silicone strips for increased adhesion. JHT currently uses athletic tape to secure the sensor to the shoe creating a tripping hazard. Both designs were tested in comparison to the JHT control over multiple 30 second trials at speeds of 3.5 mph, 6 mph, and 8.5 mph. The design performed significantly better in the z-direction for each of the tested speeds. Additionally, surveys indicated that the design was comfortable, and easily applied and removed. These results indicate that the design is easy to use, provides more accurate data collection, and does not sacrifice user comfort.


## Motivation

- Accelerometers can be used to determine forces and velocities of body segments [1].
- Ground reaction forces and step rate data can be used to assess injury risk [1].
- JHT has no reusable method for attaching the sensors.
- JHT needs sensor holders that are easily applied, stable, reusable, and will not impede on the runners natural gait.
- JHT would benefit from a sensor holder that provides more accurate gait data.

## Background Research

- An electromyography and accelerometry device [2].
- Outputs data wirelessly and processed externally [2].
- Acceleration data can be converted to step rate and force per step.
- Addition of center of mass data can yield more accurate data for total body movement.
- Forces can be combined with loading rate to characterize running technique [3].
- JHT can characterize a runner's gait and determine injury risk.

**Figure 1**: The current method of taping that Johnson Health Tech uses.

## Design Specifications

- Weigh < 0.5 lbs.
- Cost less than $500.
- Reusable and easily sterilized.
- Does not interfere with the runner or cause injury.

**Shoe Sensor Holder:**

- Held on the heel.
- Fit shoes sizes 21.6 cm to 28.6 cm [4].
- Withstand up to 4 kN of force [5][7].
- Displacement less than 0.5 cm

**Chest Sensor Holder:**

- Fit chest circumference 80-150 cm [6][7].
- Sensor displacement less than 2.0 cm

## Acknowledgements


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## Final Design

**The Chest Strap**

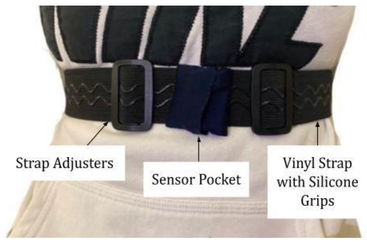


**Figure 2**: The final chest strap design with silicon waves on strap to reduce slippage.

**Chest Strap-**

- Circumference
  - Min: 32 cm
  - Max:
    - Unstretched: 55.5 cm
    - Stretched: 100+ cm

**Shoe Holder**

- Clip Constrains Motion in X- and Y-direction
- Strap Constrains Motion in Z-direction

**The Shoe Holder**


**Figure 3**: The complete shoe holder design with a latex strap and clip design to reduce movement in all directions.

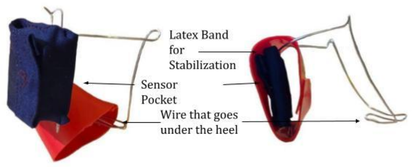


**Figure 4**: The clip part of the holder design with a pocket and latex holder to stabilize the sensor.

## Testing - Chest Strap

**Treadmill Testing:**

- Six rounds of 30 sec testing at 6mph, 8.5mph, and 3.5 mph tested simultaneously with the shoe sensors
- Filtered data with a bandpass filter using frequencies corresponding to twice the step rate of one foot

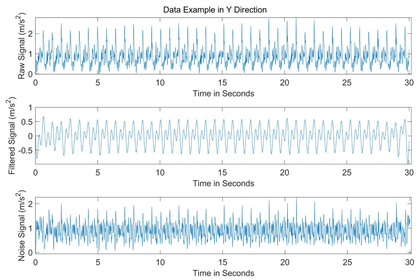


**Figure 5**: Sample data from one of the trials showing the raw data, filtered data, and noise.

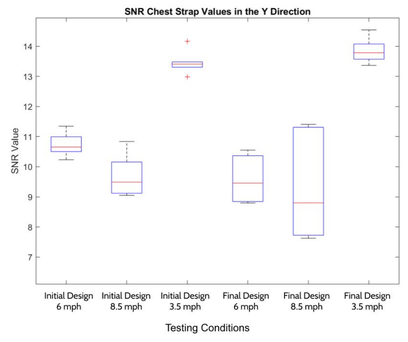


**Figure 6**: Boxplots showing the signal to noise ratio in the Y direction during both phases of the chest band testing

## References


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## Testing - Shoe Holder

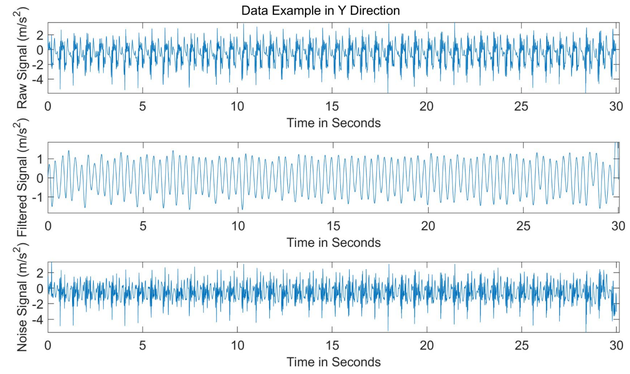


**Figure 7**: Example data showing the raw, filtered, and noise signals for the shoe sensor holder. The Y-direction is show which represents the direction going up the leg.

**Treadmill Testing:**

- Six rounds of 30 sec testing at 6mph, 8.5mph, and 3.5 mph
- Filtered data with a bandpass filter using frequencies corresponding to stride rate
- P values of 0.0136, 0.0077, and 0.0136 respectively when compared to the current method

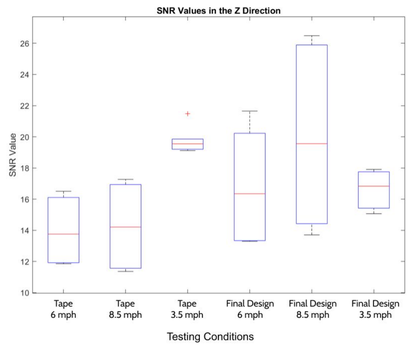


**Figure 8**: Boxplots showing the signal to noise ratio in the Z direction for the current method and new sensor holder

**Comfort Testing:**

- Comfort
  - (1 = painful, 10 = design not noticeable)
- Ease of Use
  - (1 = complicated, 10 = easy)

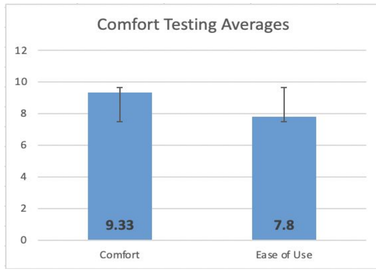


**Figure 9**: Users rated the shoe holder design on "comfort" and "ease of use" out of a max score of 10 (n=15).

## Discussion and Future Work

**Sources of Error**

- Different running styles
- Straps not tied tight

**Future Design Modifications**

- More stable connection between wire and sensor pouch.
- 3D printed sensor compartment

**Future Testing**

- More trials with an updated design
- Trials designed for specific movements
- Test the chest band over different types of clothing