Step Rate Monitor for Running Analysis

Christa Wille – Team Leader

Carmen Coddington – Communicator

Bryan Jepson – BWIG

Joel Schmocker – BSAC

Mitch Tyler – Advisor, Department of Biomedical Engineering

Client Information

Bryan Heiderscheit, PT, PhD

- Professor in the Physical Therapy department
- Director of UW Runners' Clinic
- Research focus is on running related injuries

UW Neuromuscular Biomechanics Lab

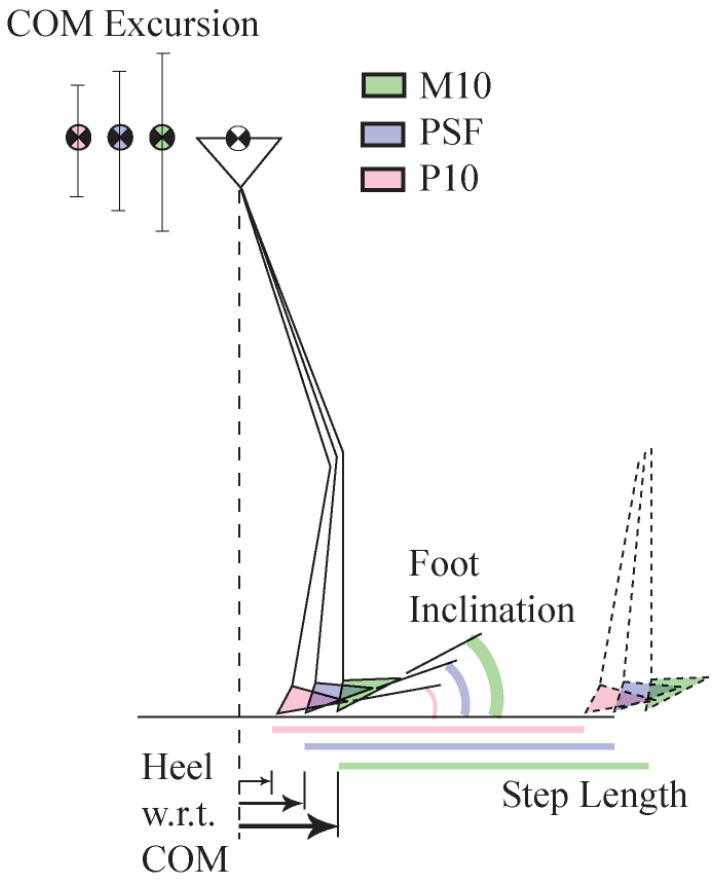
Problem Statement

- Create a device that will identify a runner's step rate while on a treadmill
- Identify step from the resulting vibrations carried through the treadmill
- Device is intended for use in the clinical setting

Running Related Injuries

- 56% of recreational runners will sustain a running related injury each year[6]
- Excessive joint loading is a common risk factor[1,4]
- Modifying applied load may be one injury prevention strategy

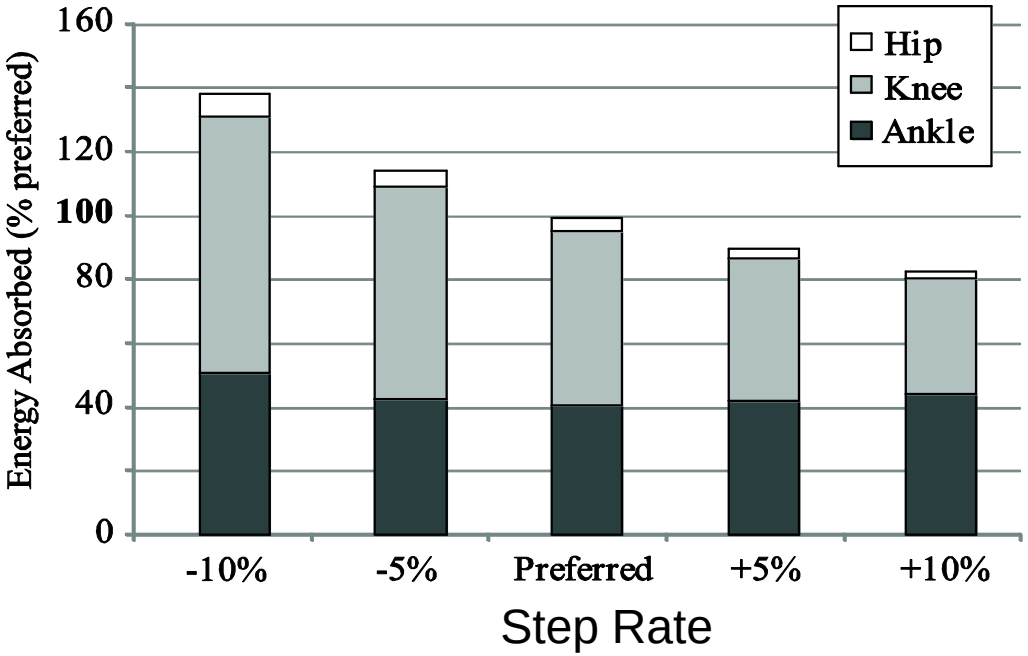
Step Rate Modification



- Kinematic changes resulting from an increase in step rate
  - Decrease step length
  - Decrease heel to center of mass (COM) distance at initial contact
  - Decrease foot inclination angle
  - Decrease COM vertical excursion

Heiderscheit et al. 2011

Energy Absorbed



- Increase in step rate reduces energy absorbed
- Reduction in joint loading may allow runners to continue running without aggravating symptoms during rehabilitation

Heiderscheit et al. 2011

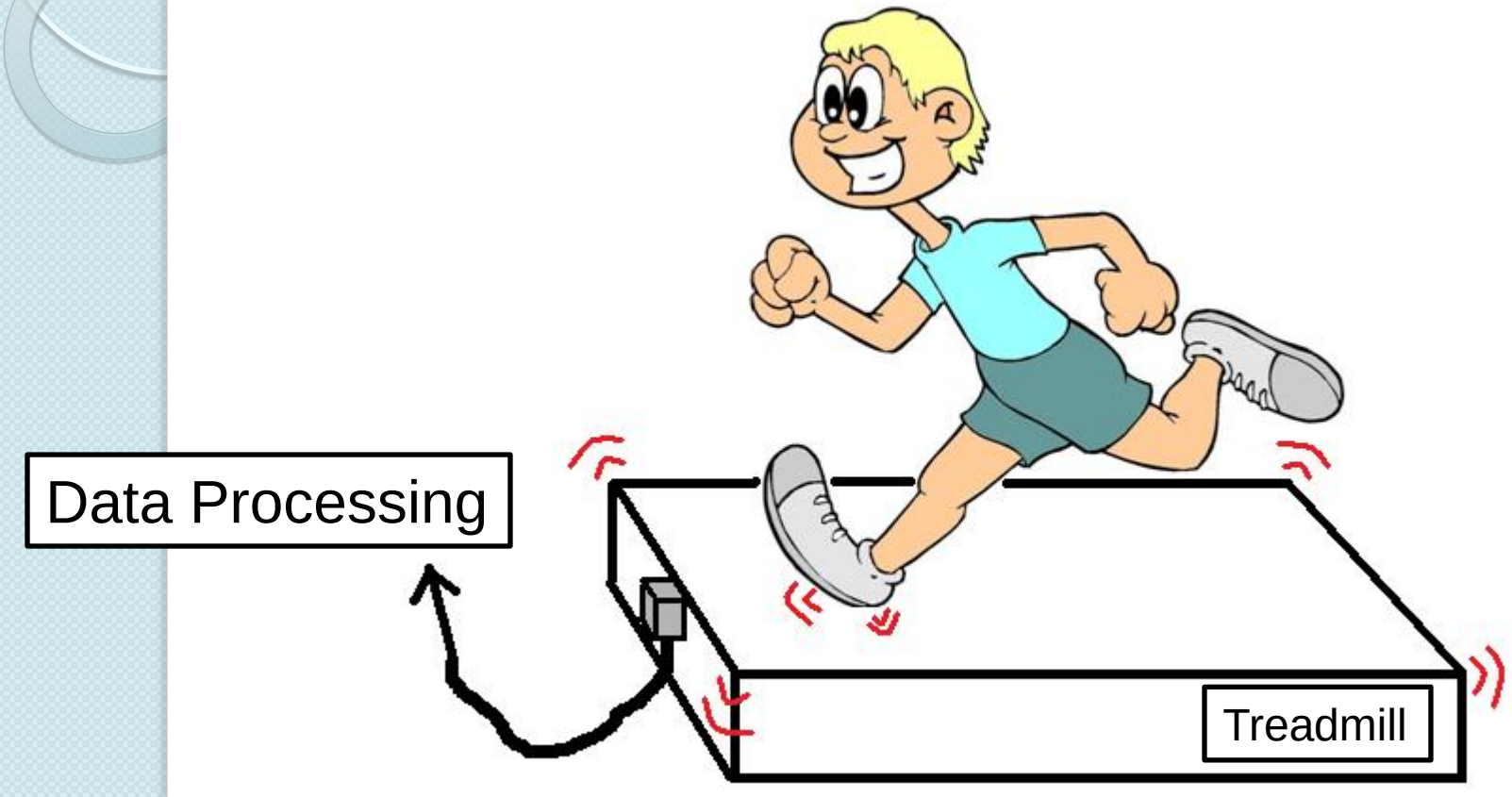
Competition

- Visual observation
  - Time consuming
  - Inaccurate
- Pedometer
  - Time consuming
- Instrumented treadmil
  - Costly

Figure 1. Garmin watch and footpod used to identify step rate.

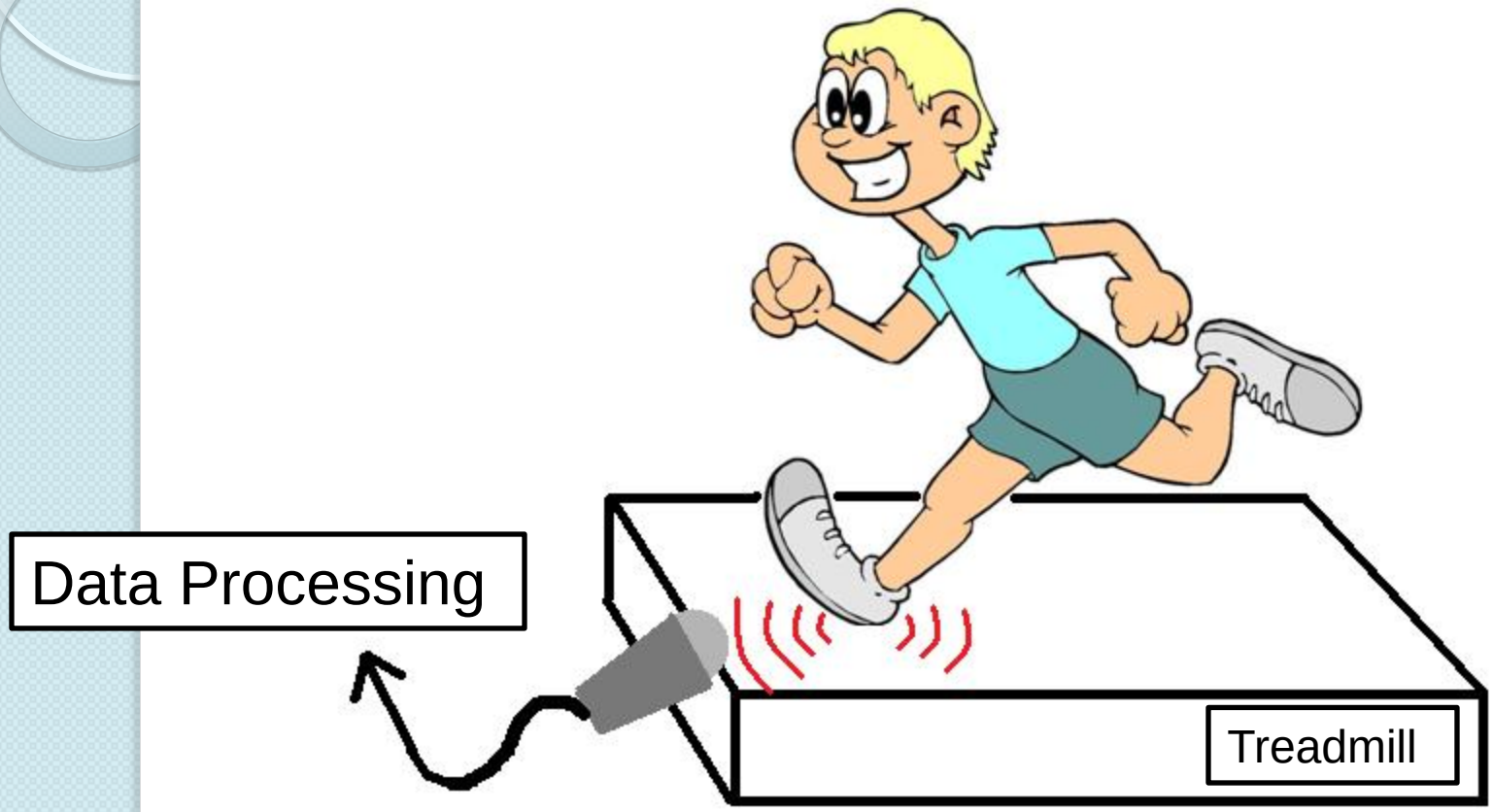
Figure 2. Treadmill instrumented with force plates.

Sensor Alternatives: **Accelerometer**



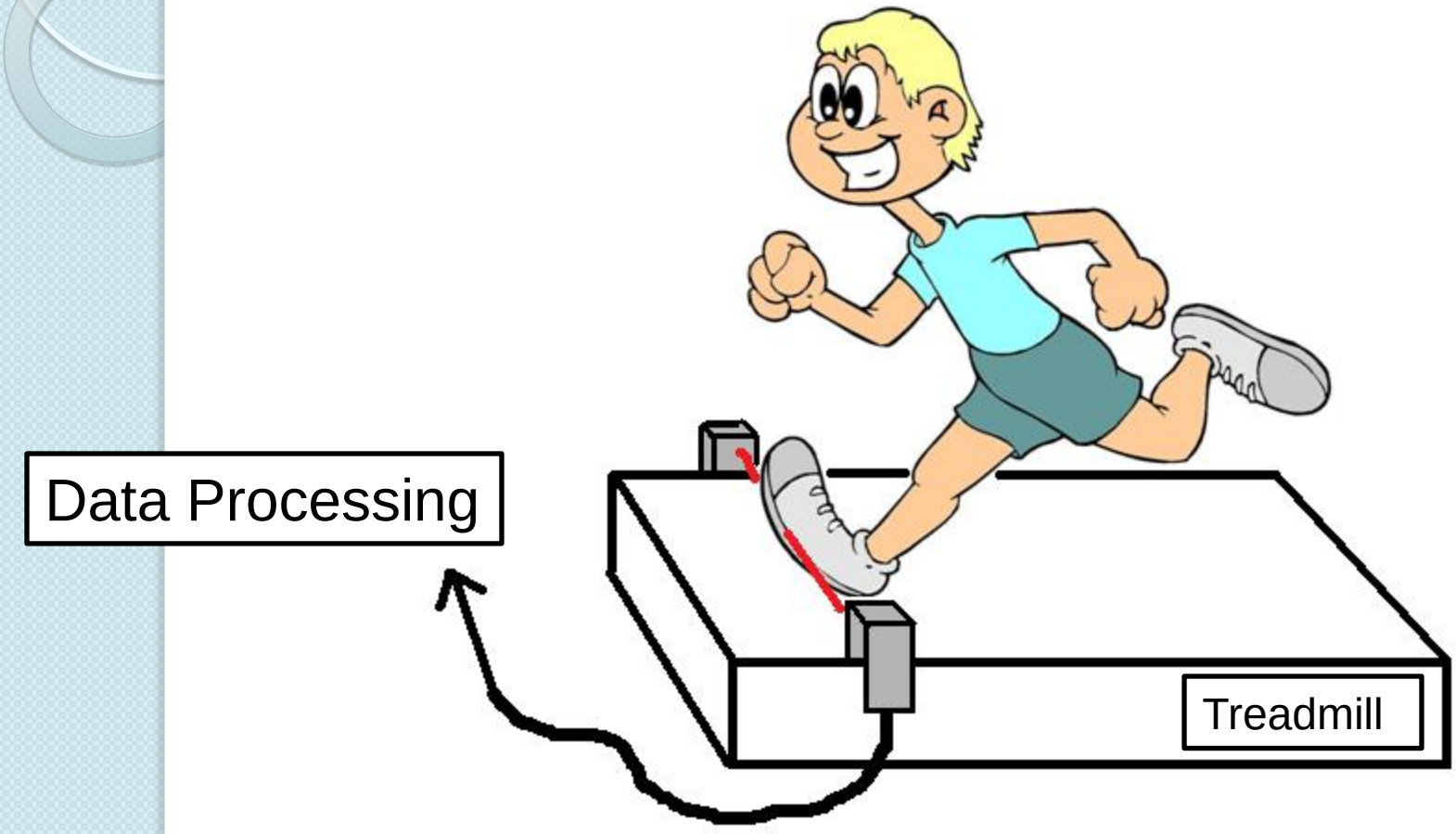
- Signal of interest: treadmill vibration or tibial acceleration

Sensor Alternatives: **Sound**



- Signal of interest: footfall “noise”
- Must separate signal from extraneous audio

Sensor Alternatives: **Optical**



- New variable: runner placement

Sensor Alternatives

	Weight	**Accelerometer**	Sound	Optical
Sensitivity	20	**16**	16	16
Signal:Noise	40	**34**	16	32
Feasibility	15	**13**	10	9
Cost	5	**4.5**	4.5	2
Reliability	20	**12**	5	15
Total	100	**79.5**	51.5	74

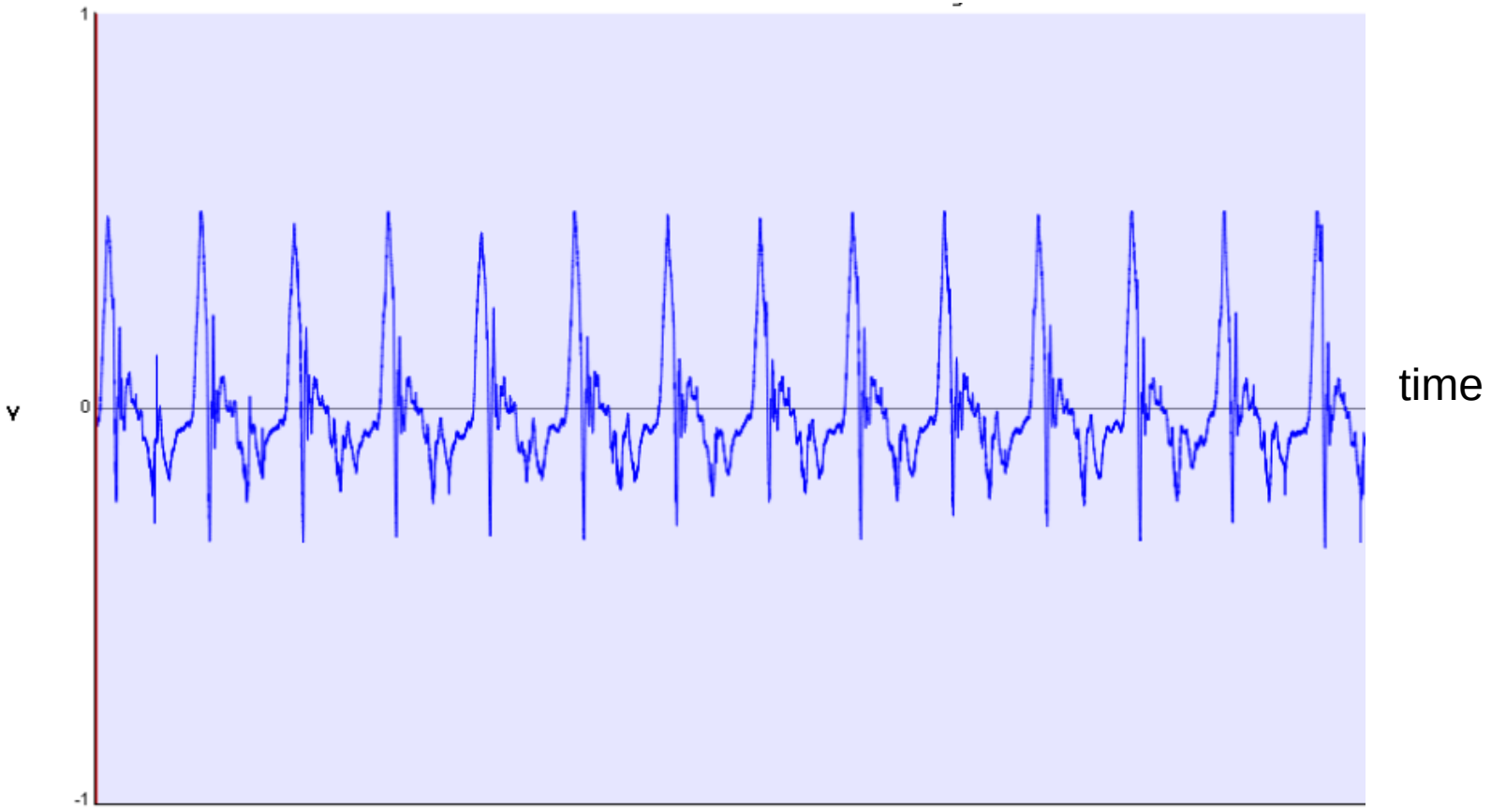
Sensor Placement Alternatives

	Weight	Tibia	**Under Treadmill**
Signal:Noise	25	20	**15**
Preparation Time	40	25	**40**
Biologically Relevant Signal	35	30	**25**
Total	100	75	**80**

Software Alternatives

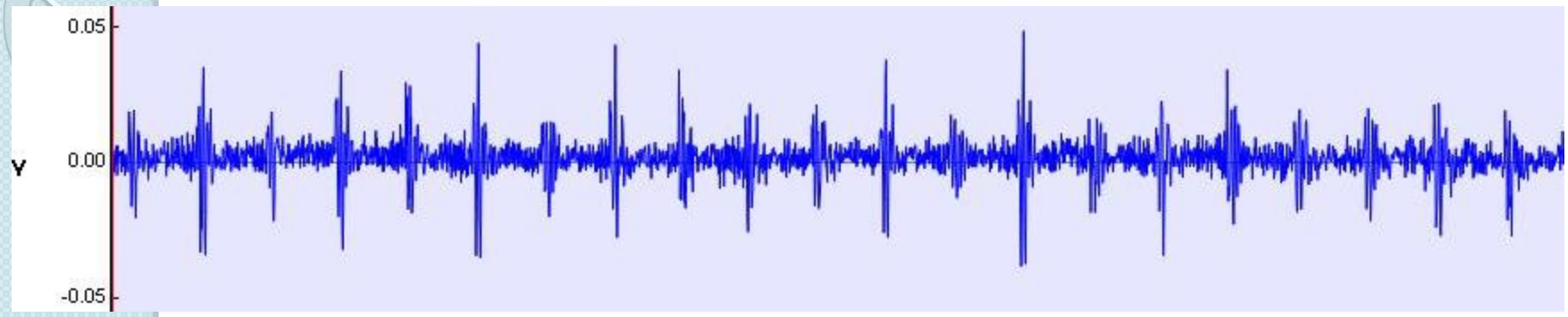
	Weight	**LabVIEW**	Java	Matlab
Real-time Processing	40	**35**	25	20
Data Presentation	30	**27**	25	10
Built-in Functionality	20	**15**	10	10
Flexibility	10	**8**	10	5
Total	100	**85**	70	45

Sensor Placement: Tibia

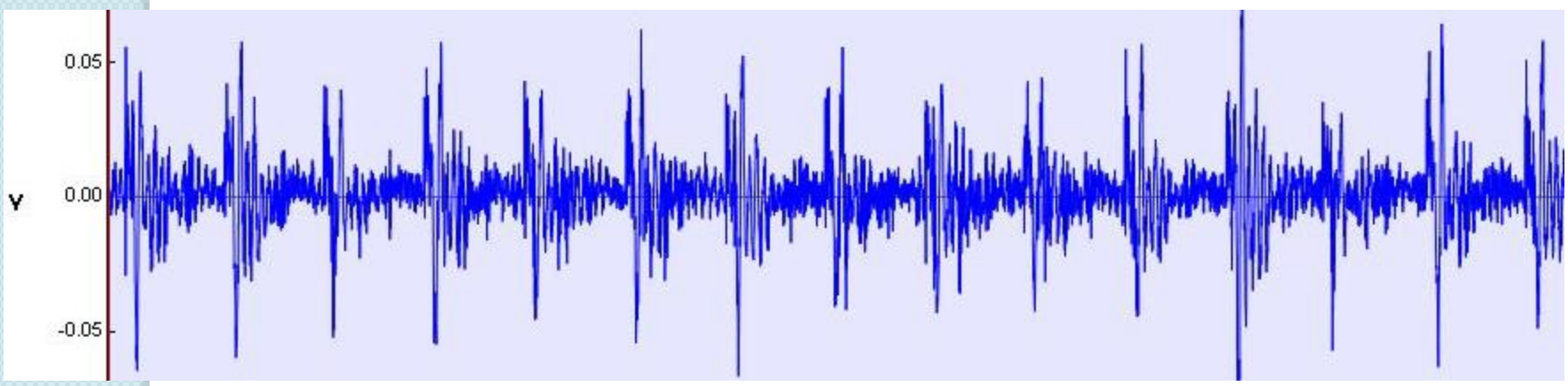


- Clear signal but requires sensor attachment for each subject

Sensor Placement: Under treadmill



Subject walking



Subject running

Final Design

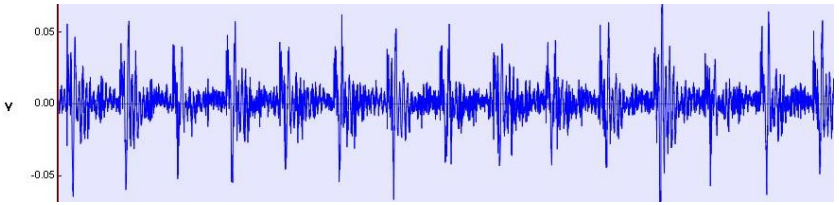
Accelerometer (U353B16 SN69619)

NI CA-1000 Configurable Connector Accessory Enclosure

LabVIEW

Real Time Feedback

Stored Data



Programming with LabVIEW

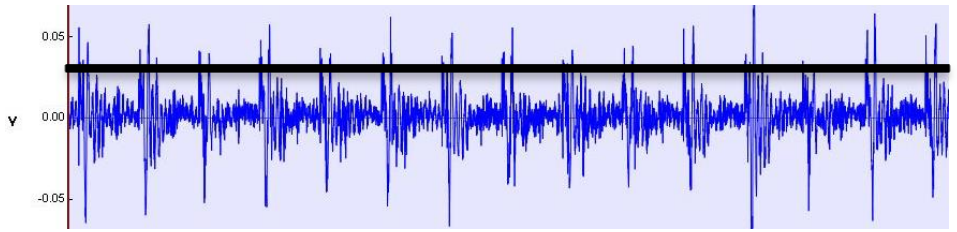
Import Data → Filter (Butterworth) → Set Threshold Voltage

↓

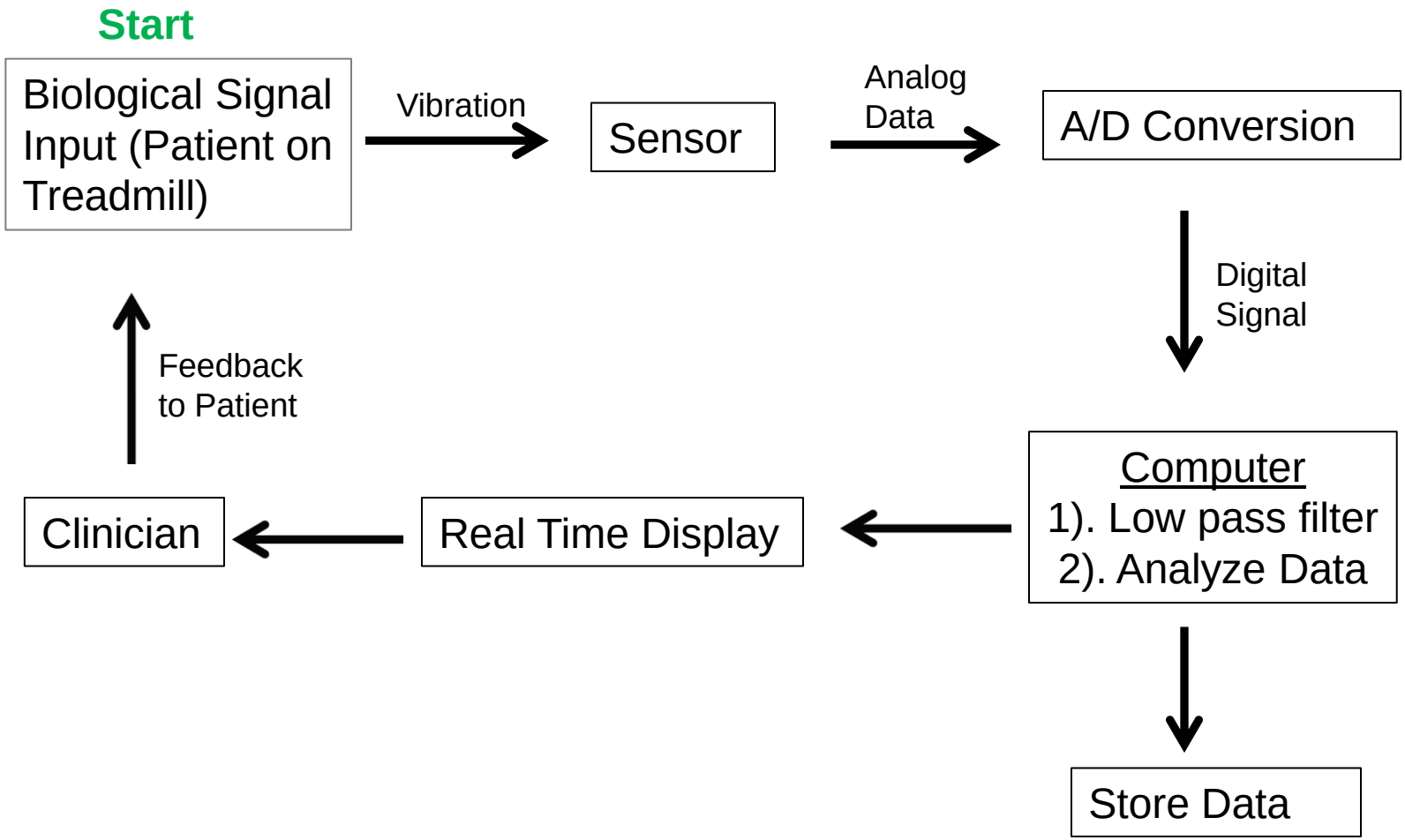
Step Counter/Time Delay

↓ Real Time User Interface

↓ Store Date for Later Use (TDMS Data File)



Final Design



Future Work

- Design & build hardware & software
  - Mount accelerometer
  - Capture and process data in real-time
  - Use LabVIEW for relevant display
- Test
  - Placement of accelerometer
  - Mounting options
  - Orientation of accelerometer
- Analyze
  - Threshold and filters for each individual

Future Work

- Identify Revisions
- Build
- Optimize
  - Device interface with runner
  - Identification of ground reaction forces
  - Feedback

Overall Objectives

- Improve clinical experience
  - Eliminate need to count step rate
  - Improve runner – clinician interaction
- Easy to use system
- Clear and simple results

http://reginanuzzo.com/?p=36

References

1. Ferber R, Noehren B, Hamill J, Davis I. *J Orthop Sports Phys Ther.* 2010; 40:52–8.
2. Fitzgerald J. Strength Running. 2011. http://strengthrunning.com/2011/07/how-to-get-hurt-running-injury/
3. Heiderscheit BC, Chumanov ES, Michalski MP, Wille CM, Ryan MR. *MSSE. 20011. 43:2:296-302.*
4. Noehren B, Davis I, Hamill J. ASB *Clin Biomech* (Bristol, Avon). 2007;22:951–6.
5. UW Health. Sports Medicine. 2011. http://www.uwhealth.org/sports-medicine/runners-clinic/11310
6. van Gent RN, Siem D, van Middelkoop M, van Os AG, Bierma-Zeinstra SM, Koes BW. *Br J Sports Med.* 2007;41:469–80; discussion 80.

Acknowledgements

- Bryan Heiderscheit, PT, PhD
- Mitch Tyler, BME Department
- Pete Klomberg, BME Department
- Deborah Yagow, National Instruments

Questions?