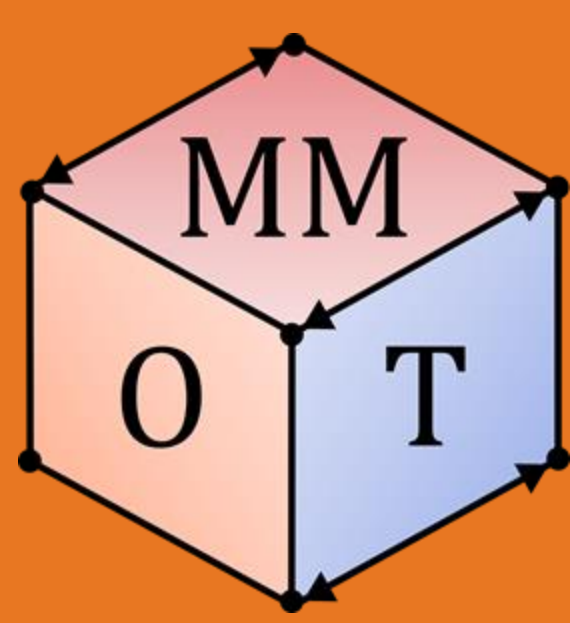




Mechanics and Modeling of
Orthopaedic Tissues Lab

Effects of Static Exercises on Hip Muscle Fatiguability as Assessed by Surface Electromyography

Olivia L. Dyer¹, Benjamin B. Wheatley², Mark A. Seeley¹

¹Geisinger Musculoskeletal Institute, Danville PA

²Department of Mechanical Engineering, Bucknell University, Lewisburg PA



Introduction

HipSIT and Vail Sports Test are commonly used to assess hip strength and fatiguability [1,2]

- Lack specific measurements and require subjective assessment from an individual

Surface electromyography (sEMG) has characterized fatigue, which is indicated by a decrease in mean and median frequency of the signal [3]

It is unclear if accelerometer data can be used as a quantitative substitute for sEMG to estimate muscle fatigue

- IMUs are easily accessible and low-cost

Project Goal:

Determine differences in hip muscle fatiguability as measured by sEMG and knee accelerometer data across 5 activities

Hypothesis:

Mean frequency will decrease across all muscles and knee acceleration will increase as the duration of the activities increased

Results

MNF regression slopes were consistently negative during all exercises (Fig. 3A)

- Within the responder group, gmed and gmax slopes were more negative than rec fem (Fig. 5A) and the wall sit and knee raise activities had more negative slopes than other activities (Fig. 5B)

AUC regression slopes were consistently positive, and the wall sit activity slopes were greater than other activities (Fig. 3B)

Knee wobble had a 90% positive predictive value (46/51) for fatigue of at least one muscle (Fig. 4)

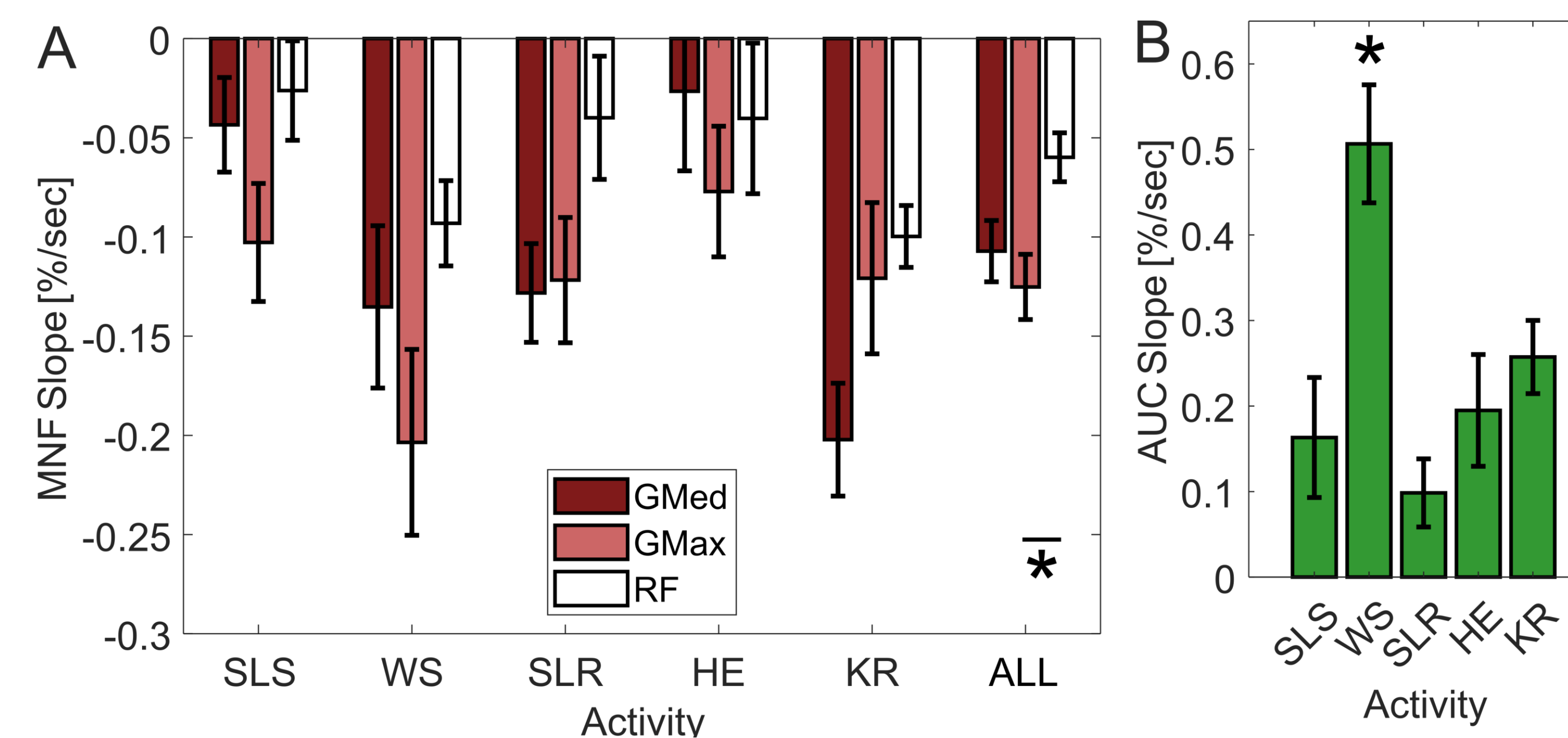


Figure 3. All univariate linear regression results, showing A) mean frequency (MNF) slopes and B) area under the resultant acceleration curve (AUC) slopes. Abbreviations denote the following: GMed – gluteus medius, GMax – gluteus maximus, and RF – rectus femoris, SLS – single leg squat, WS – wall sit, SLR – single leg raise, HE – hip extension, KR – knee raise, and ALL – all activities. All graphs show mean with standard error bars, with $p < 0.05$ denoted by *. Statistical tests not performed on R² data.

	Fatigue Responder	Fatigue Non-Responder	Predictive Value
Wobble Responder	46	5	Positive, 90%
Wobble Non-Responder	61	8	Negative, 11%

Figure 4. Knee wobble as a predictor of muscle fatigue.

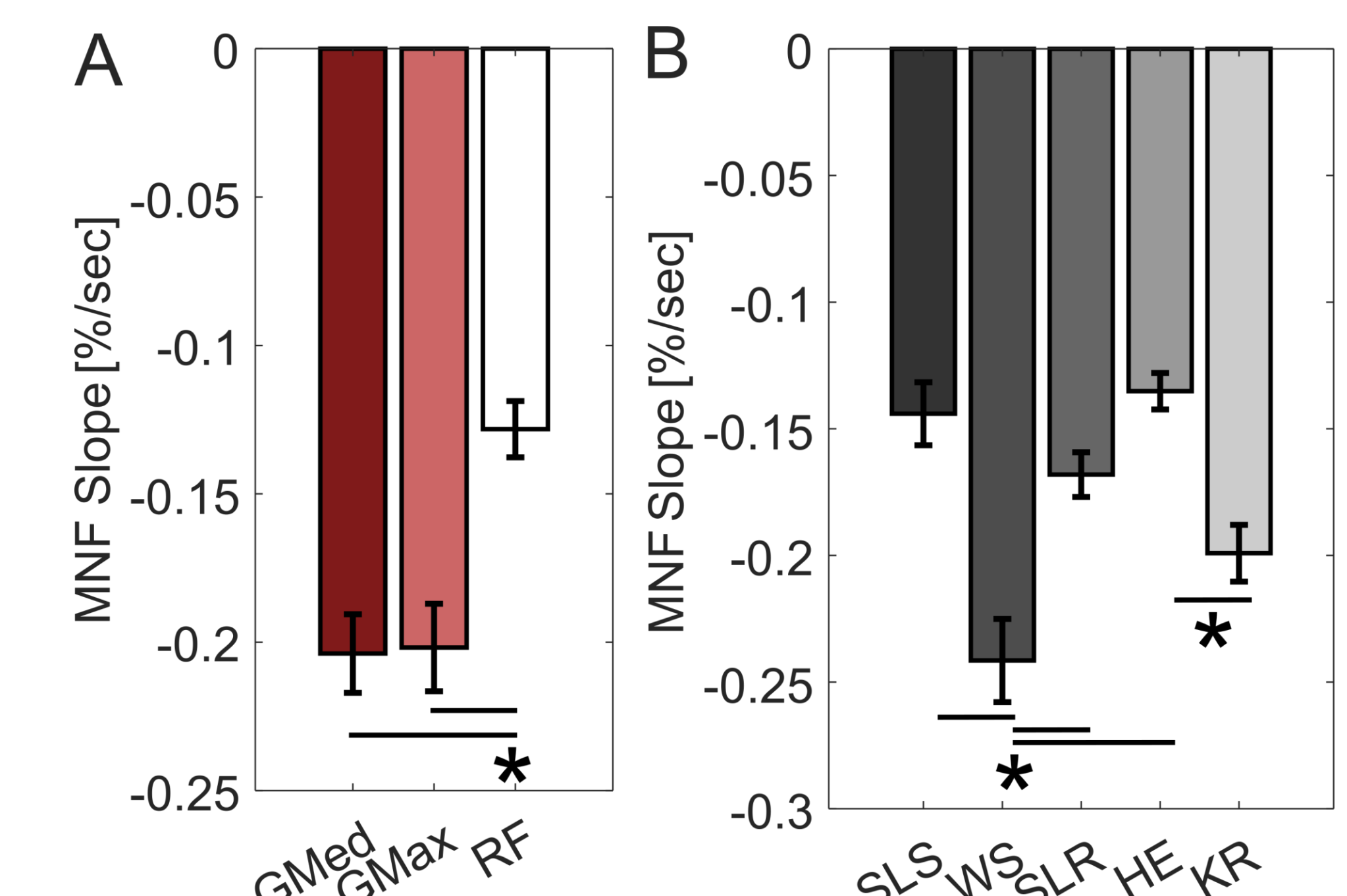


Figure 5. Grouped responder univariate linear regression results, showing A) mean frequency (MNF) slopes grouped by muscle, B) MNF slopes grouped by activity. Statistical significance ($p < 0.05$) denoted by *. Statistical tests not performed on R² data. All average data shown with standard error bars. Abbreviations are consistent with Figure 3.

Methods

Twenty-four participants (14F, 10M) recruited to participate in a fatigue analysis study

Three sEMG sensors and one 6-axis accelerometer (Fig. 1) were placed on the

- 1) gluteus medius (sEMG)
- 2) gluteus maximus (sEMG)
- 3) rectus femoris (sEMG)
- 4) lateral portion of the knee (IMU)

Two sets of activities were performed, the activities within each set were randomized (Fig. 2)

sEMG and accelerometer data segmented over 10s intervals to determine mean frequency and area under the acceleration curve (wobble) (Fig. 2)

Univariate and multivariate regressions performed on frequency and area under the curve against interval

Participants classified as responder from regression slope (negative – frequency and positive – area under curve) and p -value < 0.1

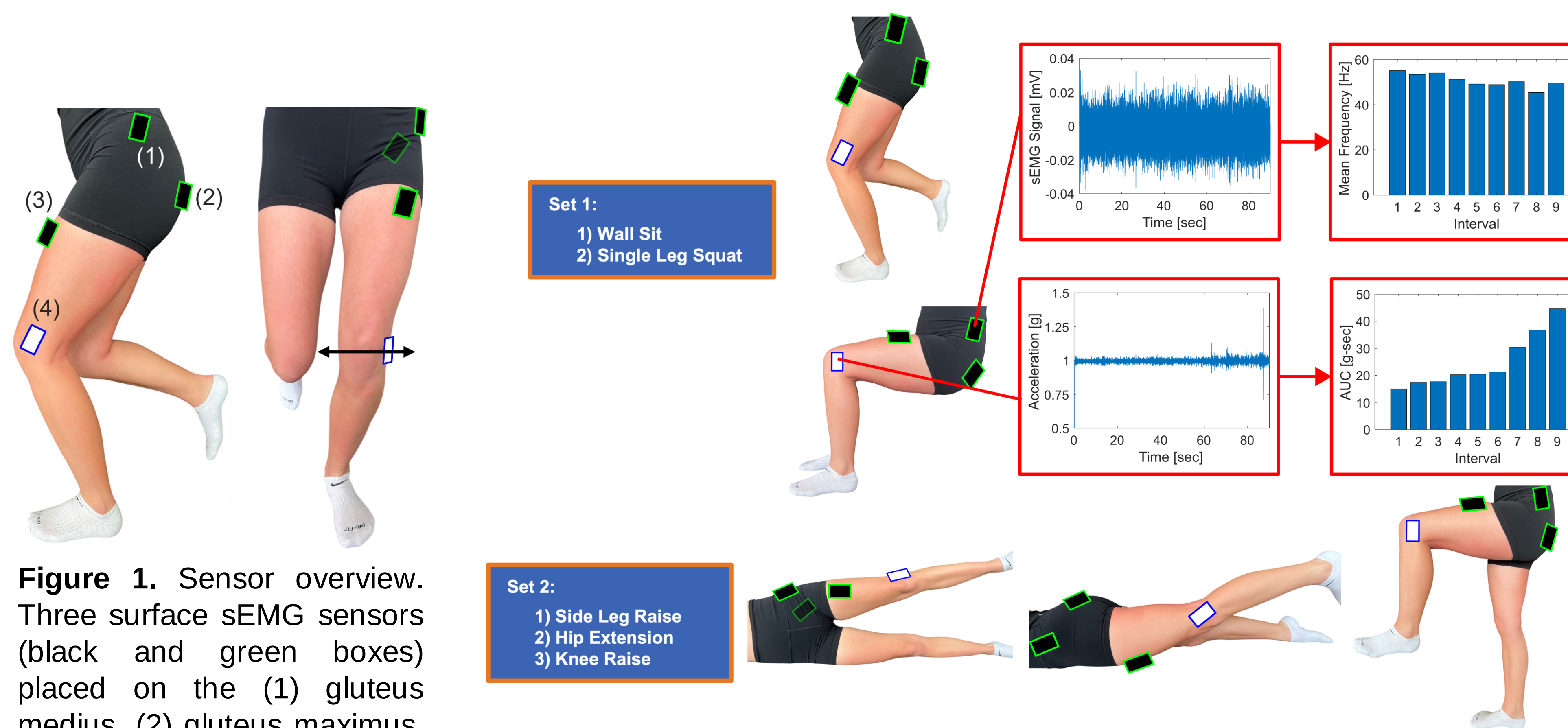


Figure 1. Sensor overview. Three surface sEMG sensors (black and green boxes) placed on the (1) gluteus medius, (2) gluteus maximus, and (3) rectus femoris muscles. A (4) six axis IMU sensor (white and blue boxes) was placed on the lateral portion of the knee. Knee wobble is represented in the black arrow.

Figure 2. Schematic overview of the experiment. The two sets of activities were performed, with the activities in each set being randomized. There were 3 sEMG sensors (black and green boxes) places on the gluteus medius, gluteus maximus, and rectus femoris as well as a 6-axis IMU sensor (white and blue boxes). Data was extracted an analyzed to determine mean frequencies and area under the acceleration curve for each activity.

Discussion

Muscle fatigue occurred in all exercises as indicated with the negative MNF frequency slopes

- The strongest correlations were in the wall sit and knee raise activities

This work suggest that the wall sit and knee raise activity fatigue the gluteus medius, gluteus maximus, and rectus femoris muscles the most reliably

A 90% positive predictive value for knee wobble against muscle fatigue suggests that simple IMU data could provide valuable clinical measurements for indications of muscle fatigue and weakness

Development of an accessible, low-cost, fast and standardized method to measure the fatiguability of hip muscles

- Allow for clinicians to determine the strength of these muscles and determine if a person can resume normal activity following a lower limb injury

Acknowledgements and References

The authors would like to acknowledge the Bucknell-Geisinger Research Initiative for funding.

- [1] Almeida GPL, et al. J Orthop Sports Phys Ther. 2017
- [2] Garrison JC, et al. Int J Sports Phys Ther. 2012
- [3] Cifrek M, et al. Clinical Biomechanics. 2009