Gait Analysis of Wittenberg's Women's Basketball Team: The Relationship between Shoulder Movement and Injuries

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Senior Presentation
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Research Question

- Among basketball players, lower body injuries are highly common. Can these injuries be observed in the motion of the shoulder when walking?

Outline

- Background
  - Gait Analysis
  - Experimental Set-Up
- Calculations
  - Simple Pendulum/ Shoulder movement
- Analysis
  - Normal vs. Injured
- Future Work

Background

Models of Gait Analysis

Gait Analysis

- Walking
  - Both feet touch the ground
- Gait
  - The pattern of movement of the limbs of humans
- Gait Analysis
  - Study of how human's walk
  - Medical research and sports performance

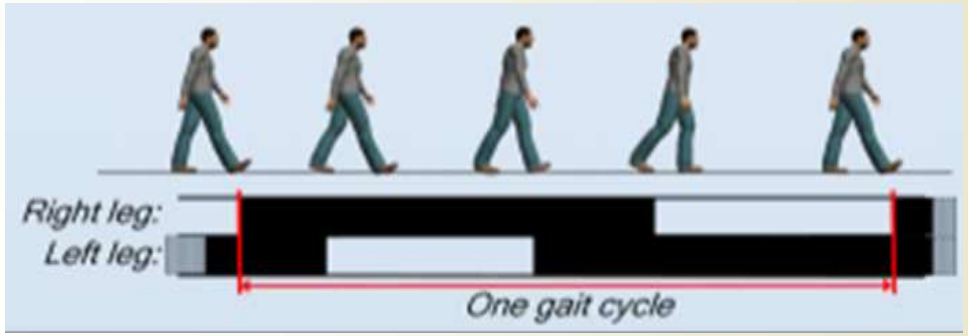
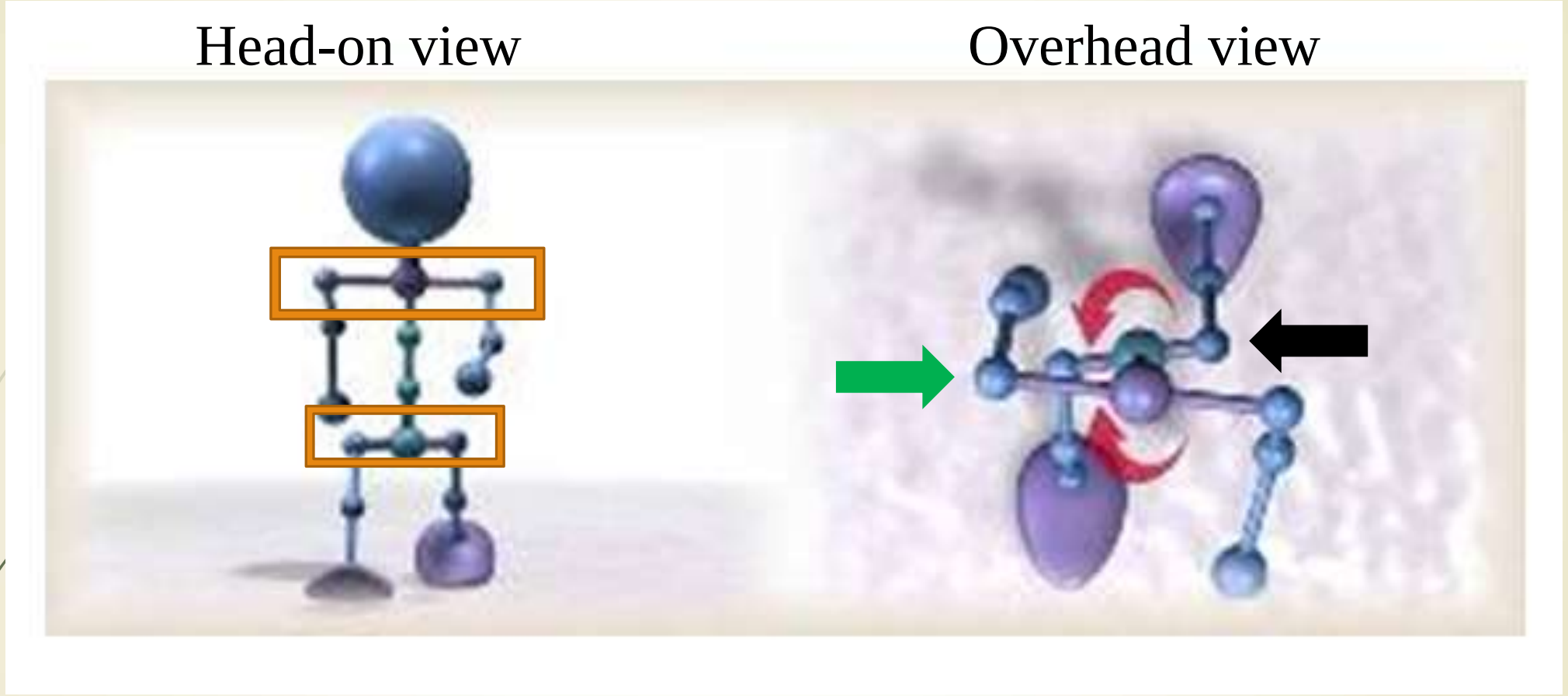


Figure 1: Model of one full gait cycle.

Model of Walking Gait: Full body movement



Relationship with Hip Movement in Walking

Figure 2: Top view of hip movement showing how shoulder movement relates to hip rotation. As the back leg (black arrow) is back, the opposite shoulder (green arrow) is swinging forward.

Model of Walking Gait: Shoulder Movement

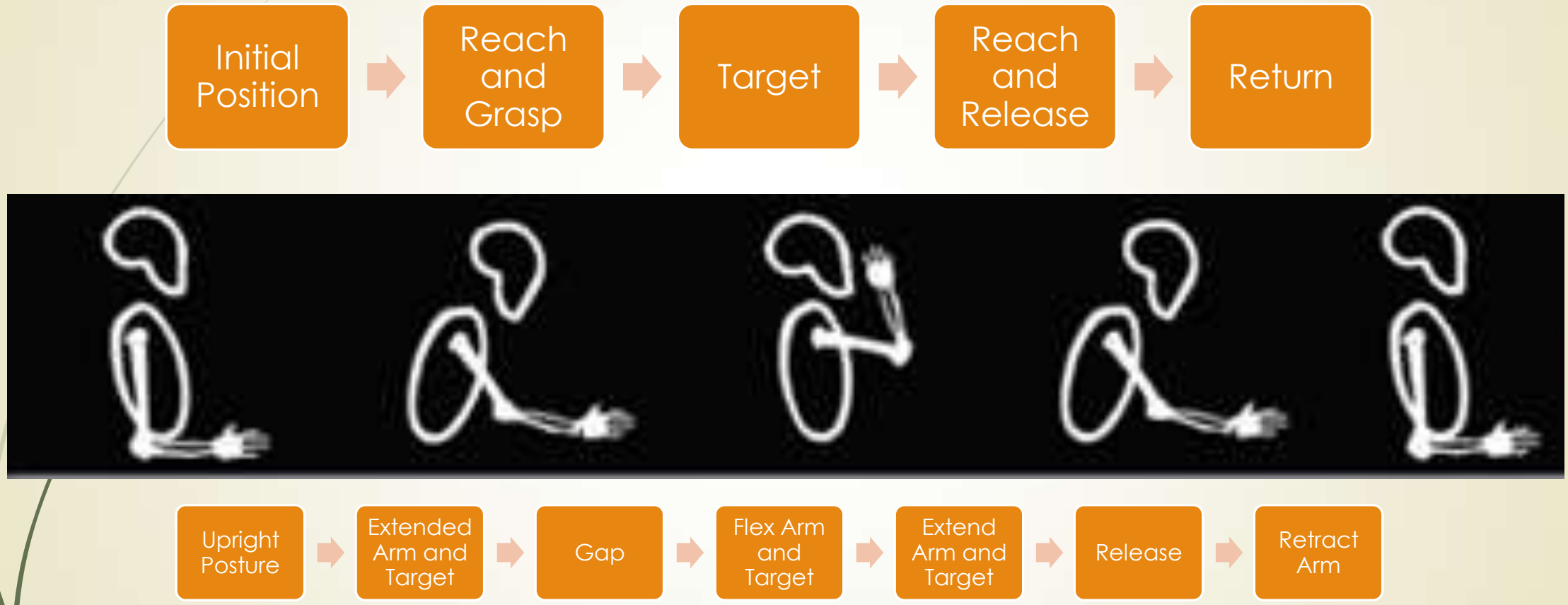


Figure 3: Shoulder movement in walking. The pattern of the movement forms a sinusoidal wave.

Experimental Design

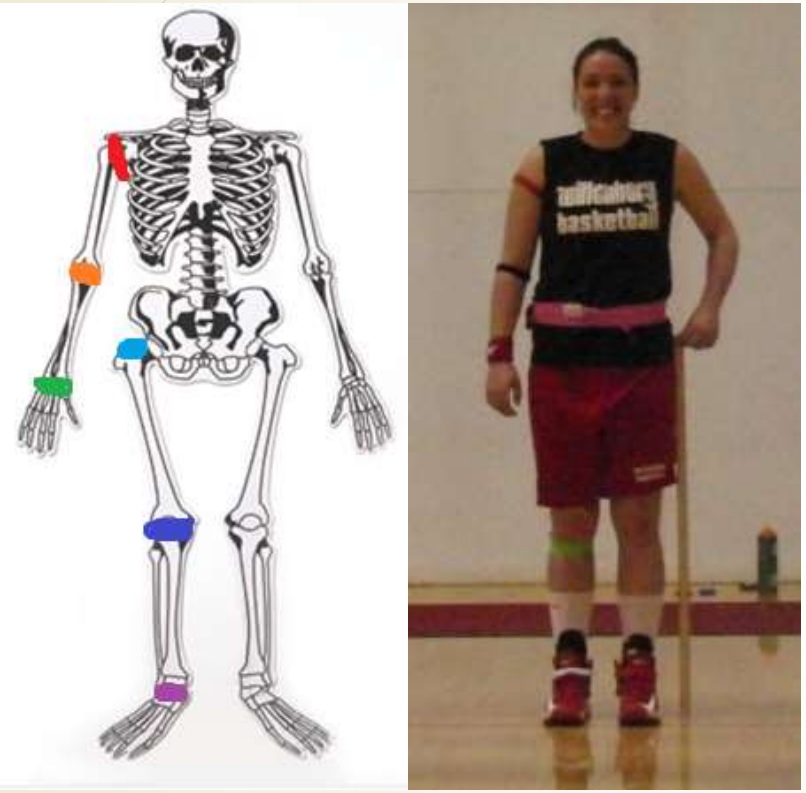


Figure 4: Model of Data Collection

Bands were located on the shoulder, elbow, hand, hip, knee, and ankle. The length of shoulder to hand and shoulder to elbow was also measured.

Table 1: Out of the 12 girls tested, only 7 girls stated injuries in the lower body.

Control	2
Right	2
Left	2
Both	3
Outliers	3

Common Injuries Seen

Upper Body

- Back injuries
  - Spina Bifida
  - Broken back
- Broken wrist
- Concussions

Lower Body

- Knee
  - MCL and ACL
- Ankle
  - Sprain
- Hip
  - Tear

Calculations

Simple Pendulums

Ball and Socket Joint to Pendulum

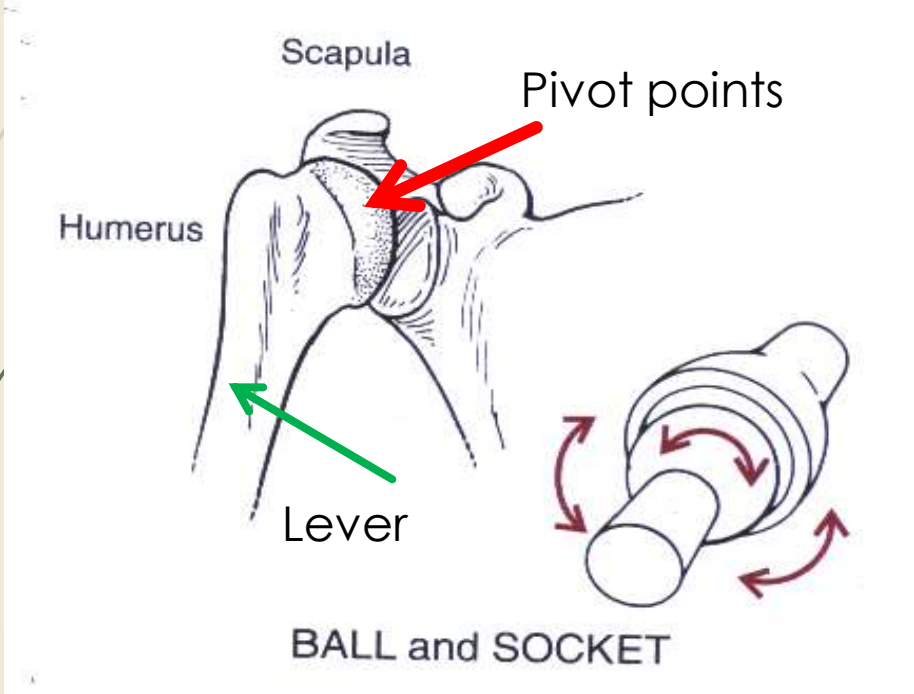


Figure 5: Model of a ball and socket joint.

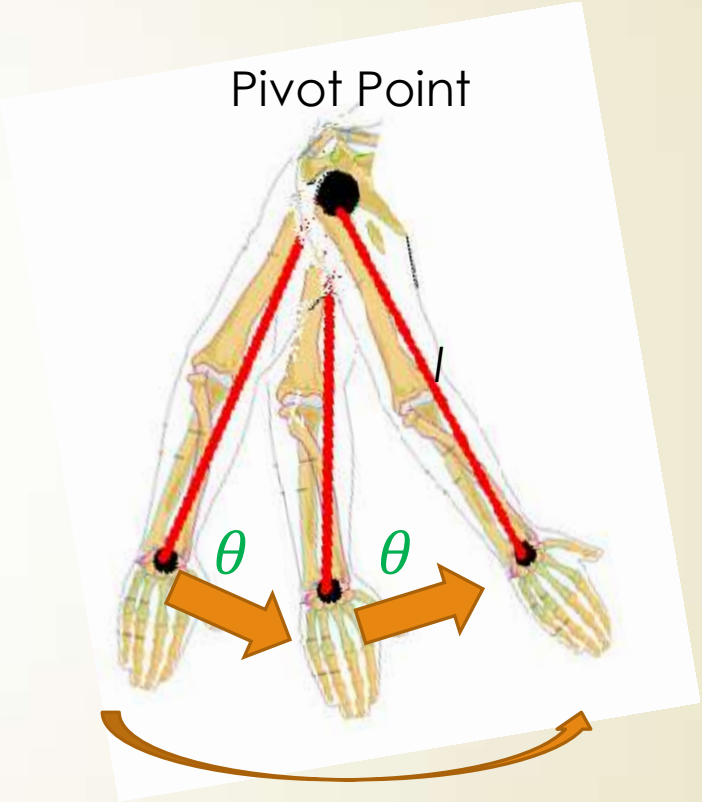


Figure 6: Model of right arm movement with length l, and arm angle θ.

Geometry of Shoulder Movement

- Motion of various body parts was tracked using Tracker
- Angle of the elbow relative to the shoulder
- Angular displacement
  - $\theta = \theta_{max} sin\left(\sqrt{\frac{g}{l}}t\right)$

$$\theta = \tan^{-1}\left(\frac{x_{\text{interest}} - x_{\text{pivot}}}{y_{\text{interest}} - y_{\text{pivot}}}\right)$$

Equation 1: Arm angle analysis

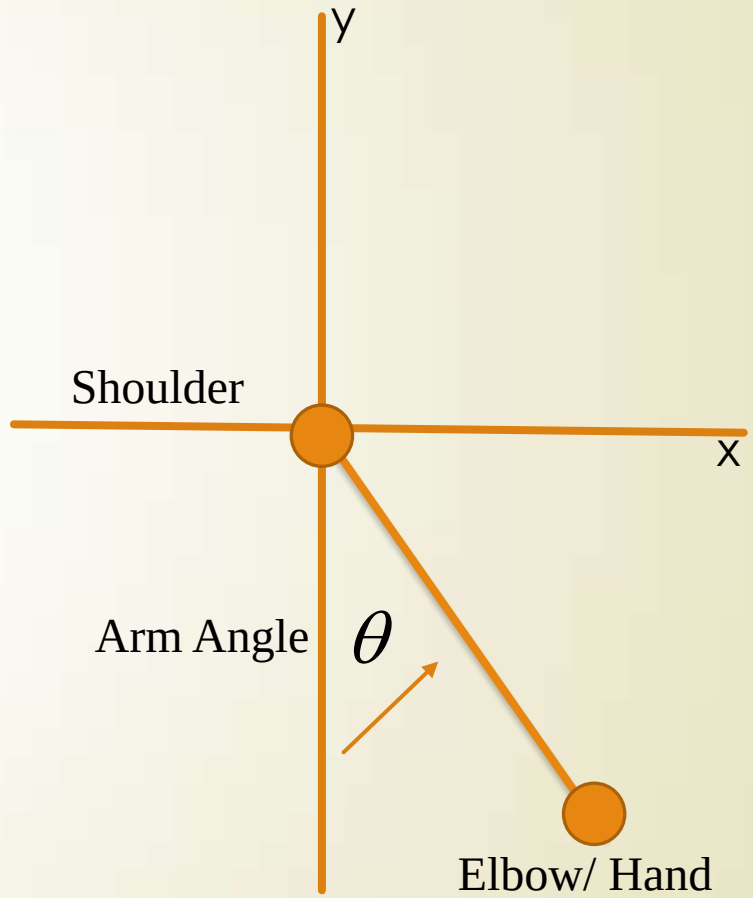


Figure 7: Geometry of upper body movement.

Analysis With Tracker Program

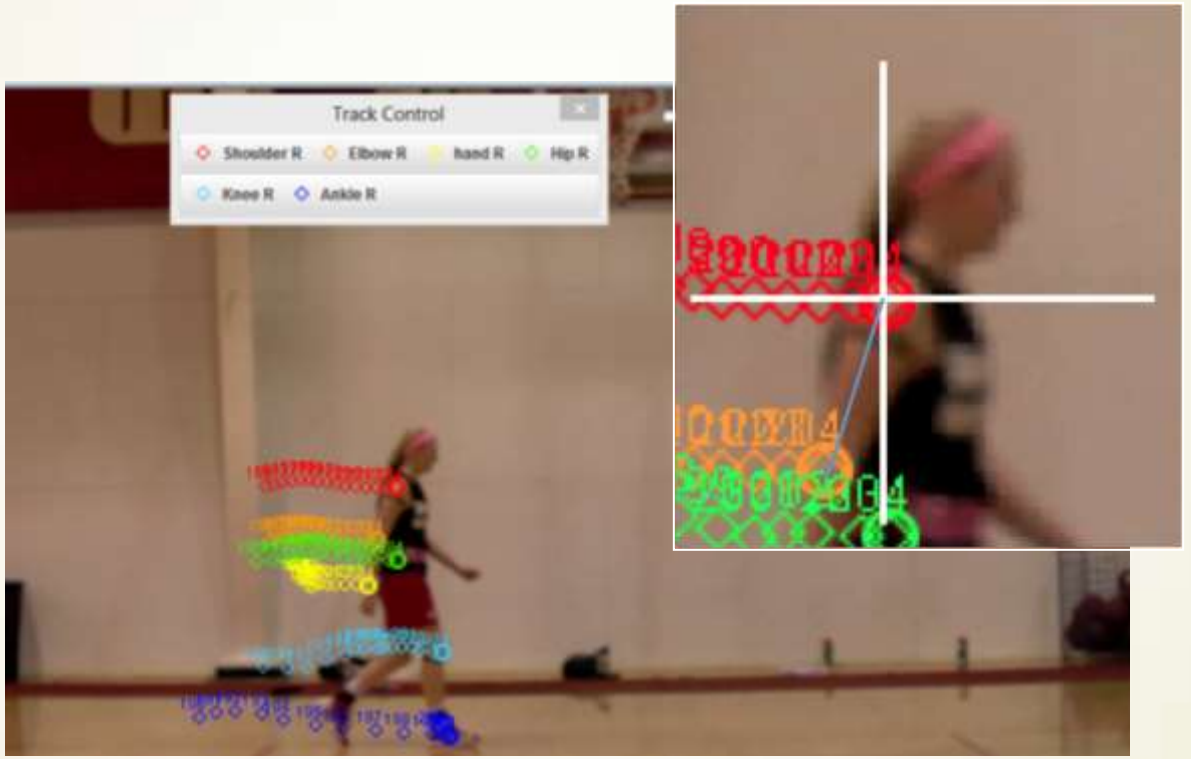
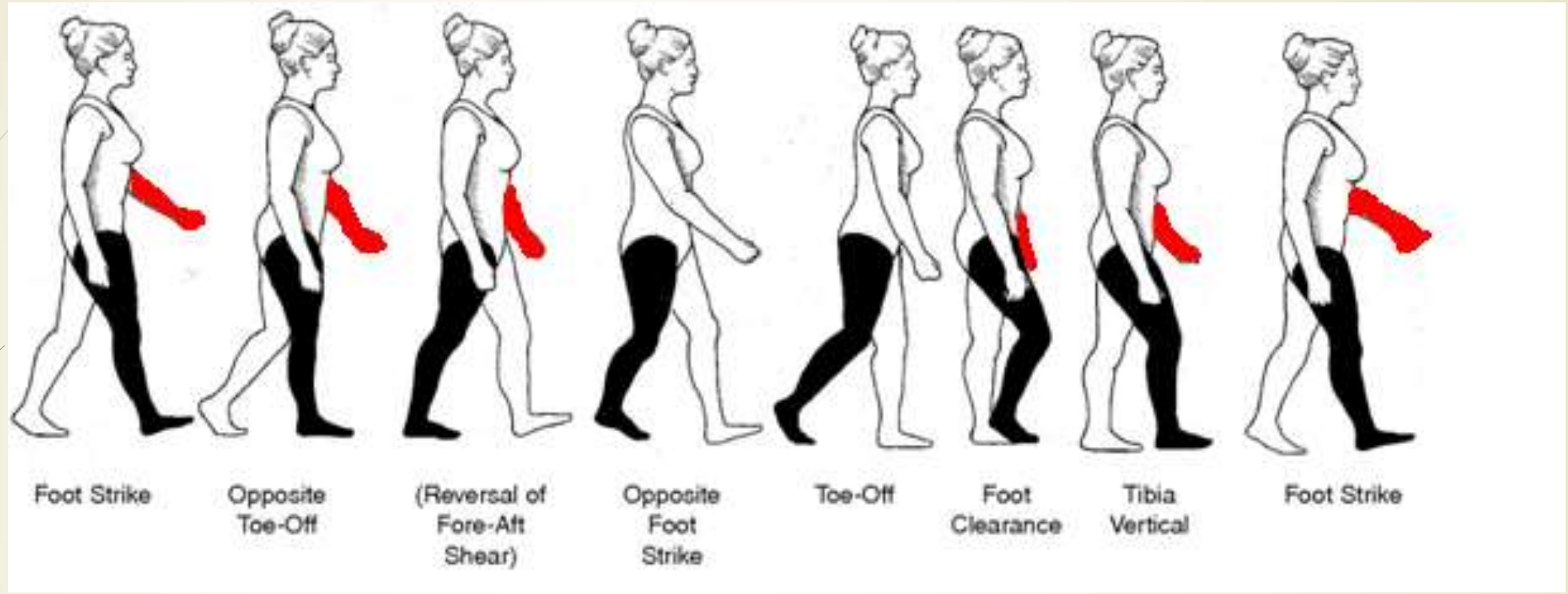


Figure 8: Showing the motion of the shoulder (red), elbow (yellow) etc. during walking. The insert shows the geometry that is used for examining the motion of the elbow relative to the shoulder.

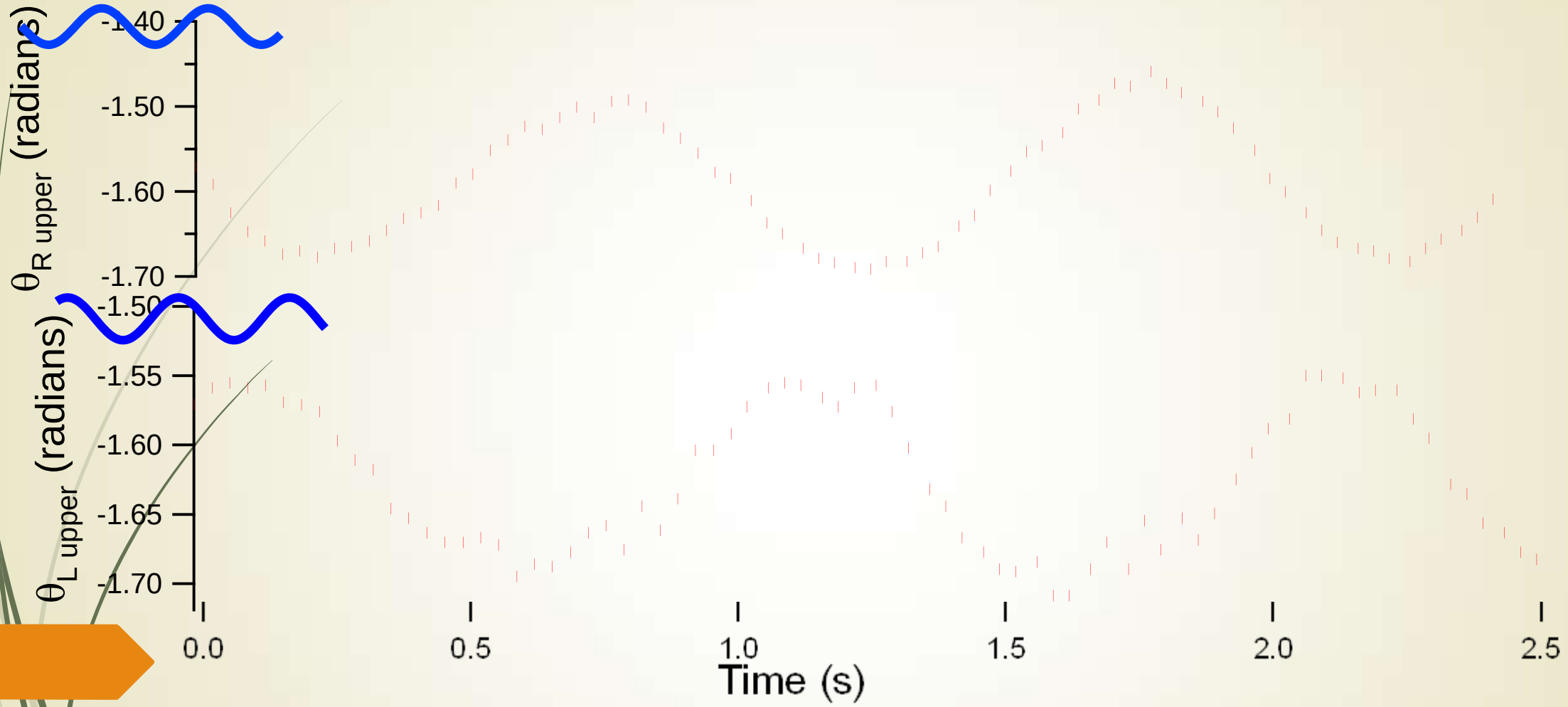
Analysis

Normal to Injured Gaits



Control Group

Figure 9: Diagram of a normal walking gait. The right leg (black) and the left arm (red) show the counterbalance between steps.



Control Group

Figure 10: Comparison between the upper half of the arm movement: shoulder as the reference point to the elbow.

Results of the Control

Table 2: Comparison between arm location and their corresponding arm frequency in an non-injured athlete.

Arm Location	Frequency
Right Elbow	6.13 ± 0.04
Left Elbow	6.07 ± 0.05
Right Hand	$6.14 \pm .0.04$
Left Hand	6.13 ± 0.03

- No injuries are present: the frequencies are within standard deviation
- Model of simple pendulum is accurate

Results of Right Side Injury

Table 3: Comparison between arm location and their corresponding arm frequency in right knee injury.

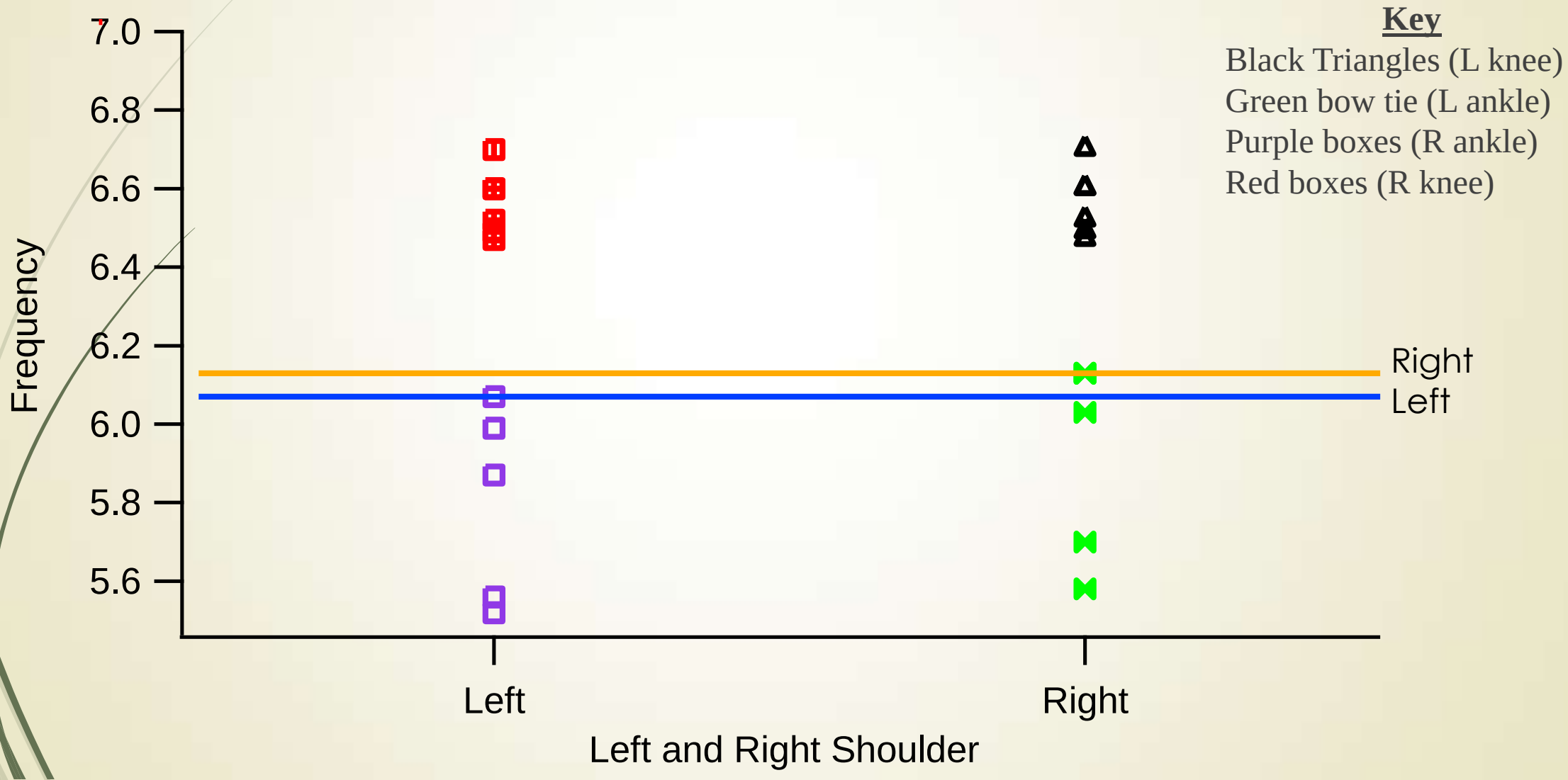
Arm Location	Frequency
Right Elbow	6.49 ± 0.02
Left Elbow	7.04 ± 0.05
Right Hand	6.48 ± 0.01
Left Hand	6.99 ± 0.02

Results of Left Knee Side Injury

Table 4: Comparison between arm location and their corresponding arm frequency in left knee injury.

Arm Location	Frequency
Right Elbow	5.71± 0.05
Left Elbow	5.52 ±0.03
Right Hand	5.83 ± 0.02
Left Hand	5.50 ± 0.02

Major Results: Comparison with Data sets to Control



Conclusion

- Simple harmonic motion
  - Sinusoidal movement
- Body size plays a key role in arm movement
- Frequencies should be equal in a normal gaits
- Lower body injuries
  - implies overcompensation
- Medical uses to help increase sport performance

Acknowledgements

- Dr. Jeremiah Williams
- Wittenberg's Women's Basketball team
- Coach Jurewicz

Future Work

- Study the relationship between lower body movement and lower body injuries
- The relationship between upper body injuries and arm movement
- Relationship between walking and running with Tracker program
  - When and where is the injury most commonly found

References

- Brown, D. 2009.Computer Program TRACKER VIDEO ANALYSIS AND MODELING TOOL, Version 4.80 WWW Document, (http://www.Cabrillo.edu/-dbrown/tracker/).
- Heck, A. 2002. Mathematics and Physics of Walking. COACH. AMSTEL Institute
- Srinivasan, M. and Ruina, A. 2005. Computer optimization of a minimal biped model discovers walking and running. Nature 439, 72-75.

Questions

Simple Pendulum Equations

- Period (Equation 1)
- $T = 2\pi\sqrt{\frac{L}{g}}$
  - T = period
    - F = $\frac{1}{T}$
  - L is length
  - G is gravity 9.8 $\frac{m}{s^2}$

- Angular displacement (Equation 2)
  - $\theta = \theta_{max} sin\left(\sqrt{\frac{g}{l}}t\right)$

Shoulder movement with a Left Knee Injury

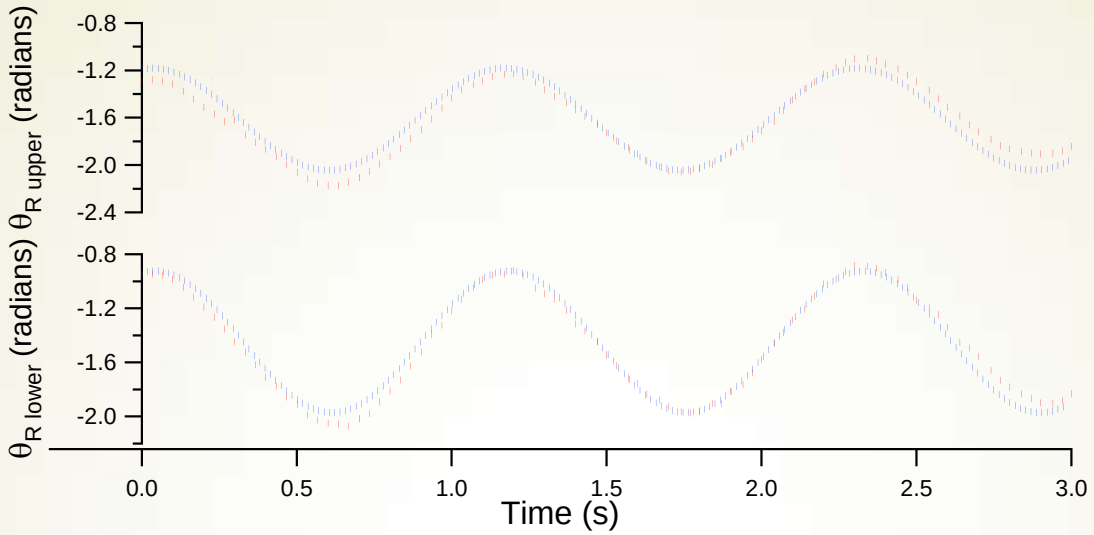


Figure : Showing a sinusoidal relationship, the right arm movement has a larger amplitude between the shoulder to elbow than the elbow to hand.

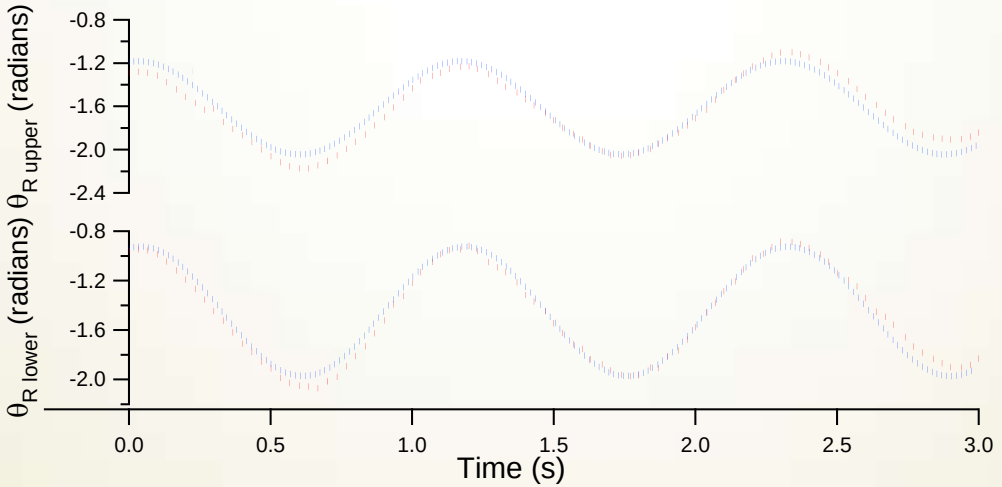
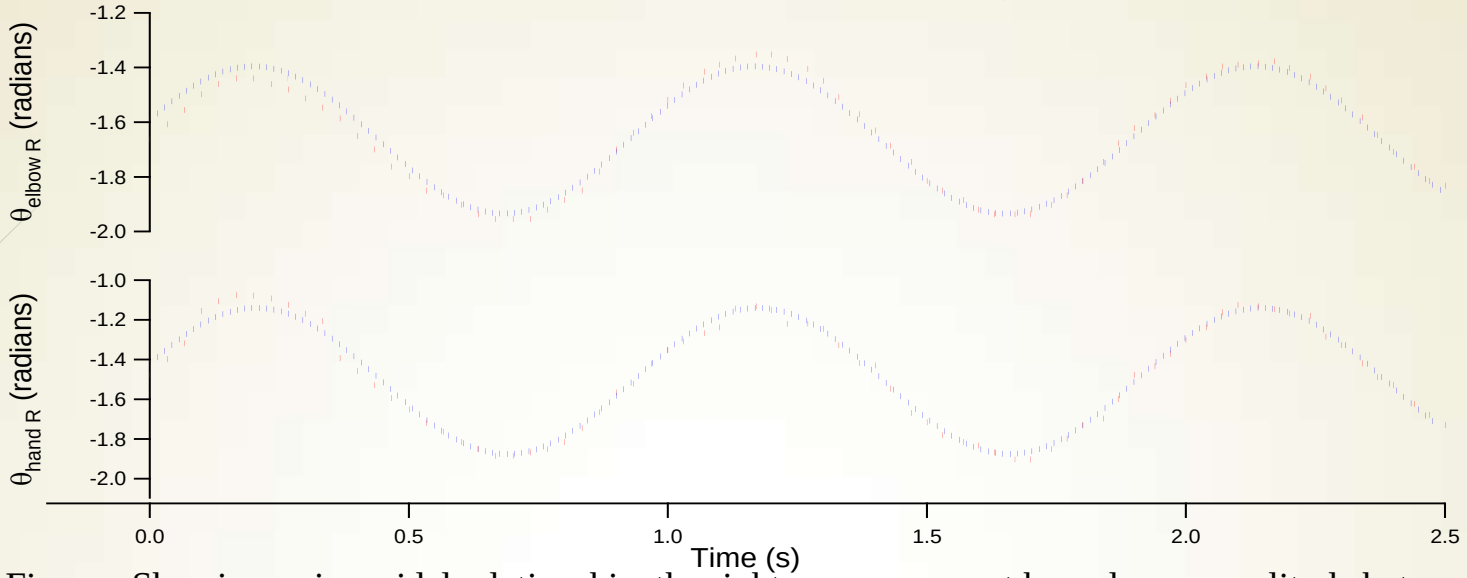


Figure : The movement in the left arm displays a sinusoidal pattern. The upper graph is the relationship between the shoulder and elbow and the lower graph displays the elbow to hand relationship.

Shoulder movement with a Right Knee Injury



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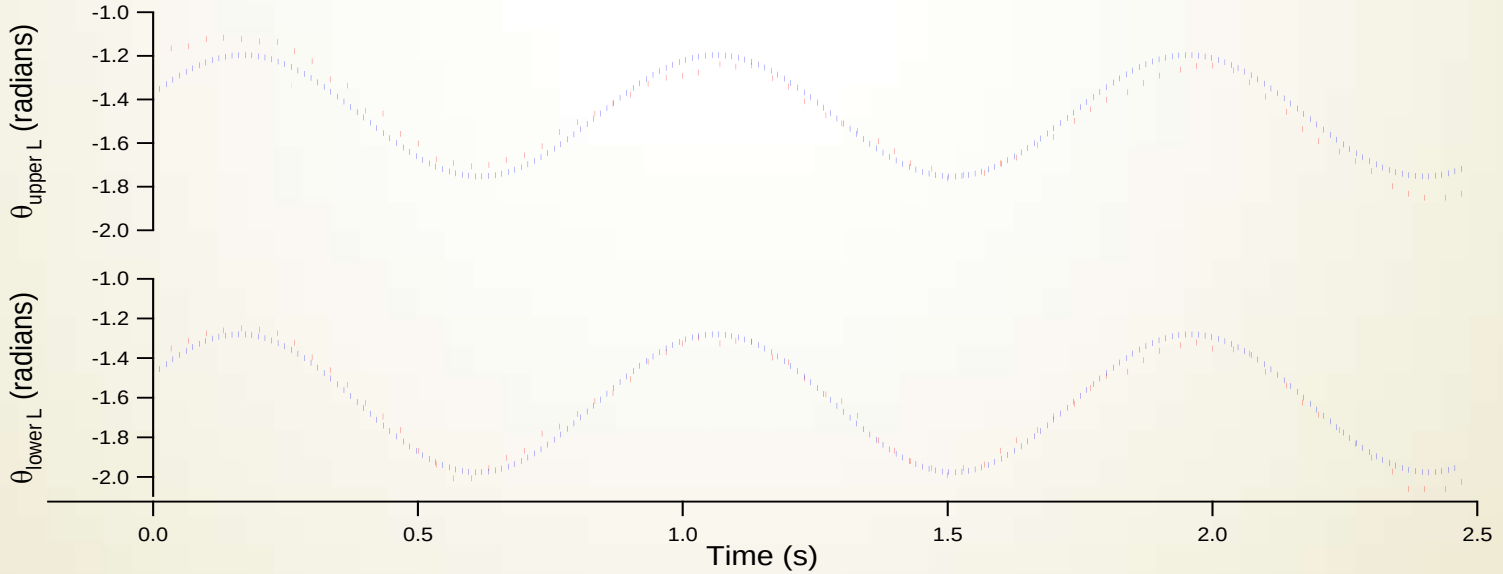

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