

Feasibility Testing Report – Foot Lift Phase 3

Team: P15001: Active Ankle Foot Orthotic

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Test Date: 03/03/2015 & 03/12/2015 & 03/17/15

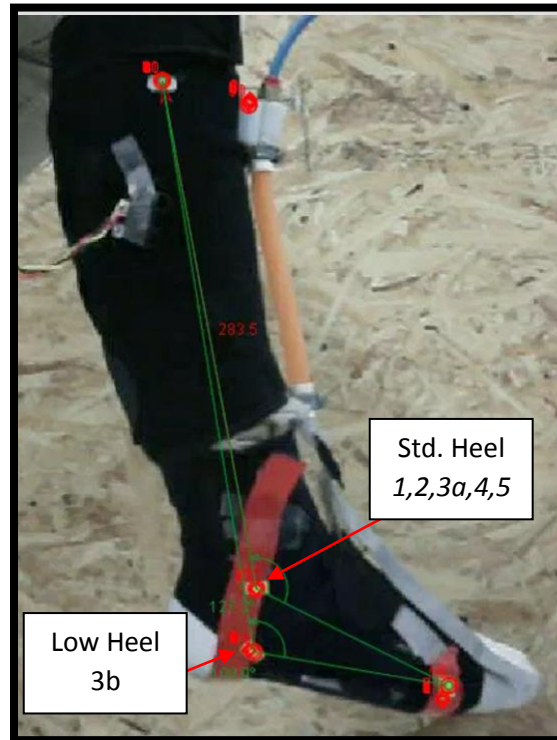
Related System: ABBBB: Raise Foot, AAA: Secure Foot

The test is being completed to determine the angle range at which the foot is lifted by the actuation of the McKibben Muscle as well as determine the amount of deflection experienced by the upper muscle attachment piece during muscle actuation.

Supplies:

- 1.) AFO Base with McKibben Muscle and Muscle Attachment Pieces
- 2.) Solenoid Control
- 3.) Pressurized Air from Lab Hose
- 4.) Video Camera
- 5.) Wooden Backboard
- 6.) Tracking Software

Setup:



Procedure(s):

Test:

1. Have volunteer sit on table top with their right foot hanging freely
2. Place the AFO brace on volunteer's foot
3. Attach the McKibben muscle to the brace
4. Place yellow indicators near user's heel, arch, and on brace near upper strap
5. Set up and start the video recording
6. Actuate the muscle using the Solenoid- complete this step 5 times
7. Stop the video recording
8. Remove the device from the volunteer's leg

Data Analysis:

1. Import the recorded video in Tracker (video tracking software)
2. Create tracking points using the yellow indicators on the brace
3. Use the protractor measure function to find the ankle angle (foot relative to leg)

- Copy ankle angle data from Tracking Software and put into Excel document

Results:

Test #1

Conditions:

Buckle sewn in front of brace with tension strap under the lower brace and over pant leg

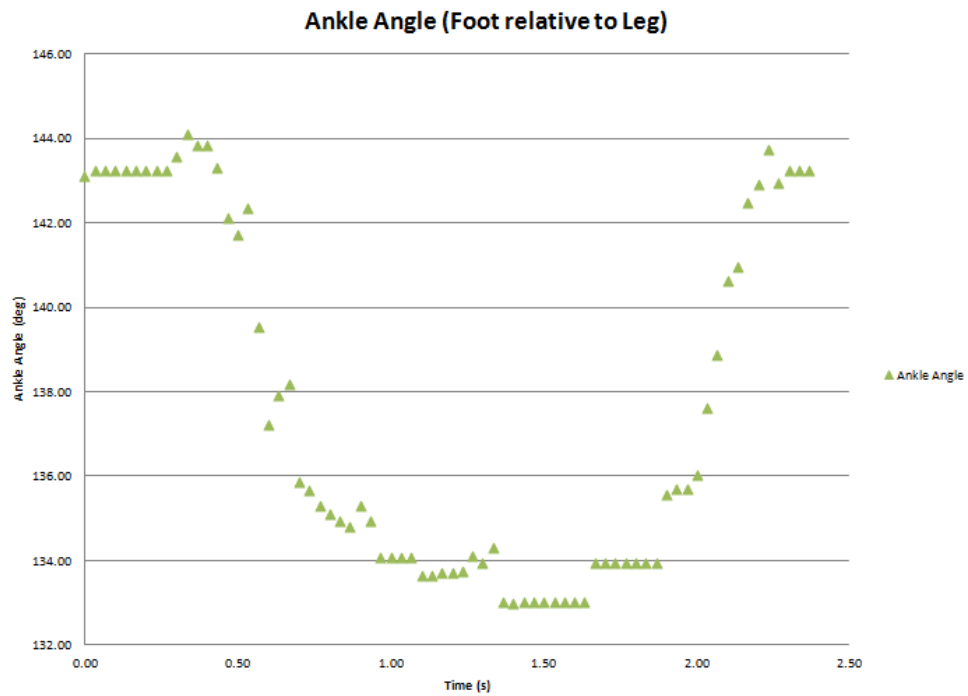


Figure 1.1: This plot displays the angle at which the foot is, relative to the leg, throughout the duration the lift in the 1st test conducted in phase 2

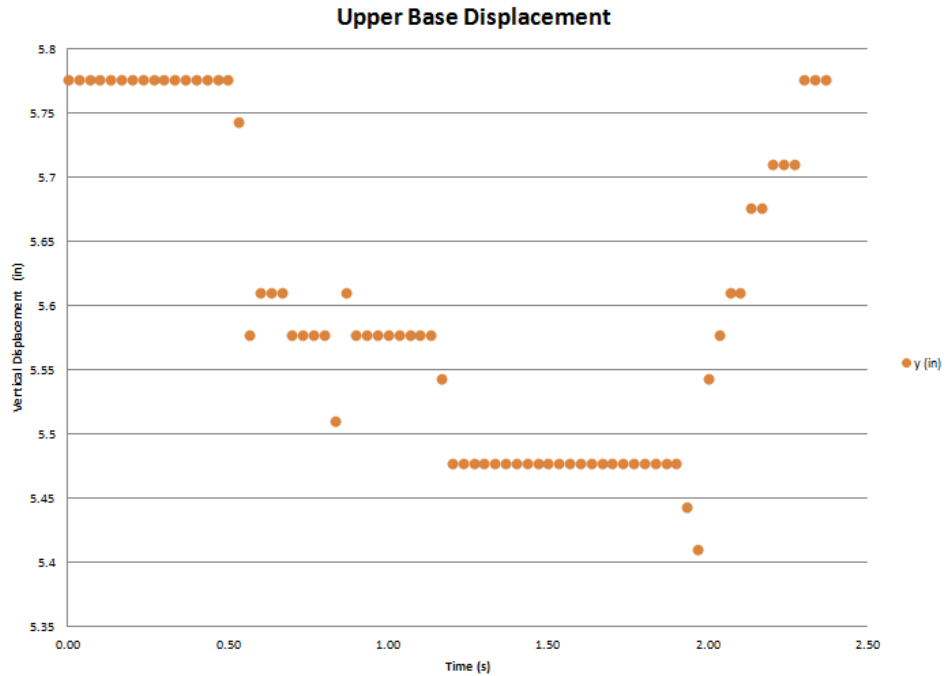


Figure 1.2: This plot displays the raw data of vertical displacement (in) of the upper muscle attachment piece, collected by Video Tracking Software, in the 2nd test conducted in phase 2

Summary:

- a.) The foot lift angle range is between -20.89 and -34.45 degrees
- b.) The foot lift angle range during a natural gait cycle is between -8.2 and -38.6 degrees
- c.) Difference_{natural Gait}: 30.4 degrees
- d.) Difference_{device}: 11.10 degrees
- e.) Vertical Displacement: 0.37 inches

Test #2

Conditions:

Same conditions as test 1 but with inelastic material added to the back of the upper brace from the leg strap to the bottom of the muscle base. The buckle was also more tightly secured plus the general upper brace strap sewing was redone.

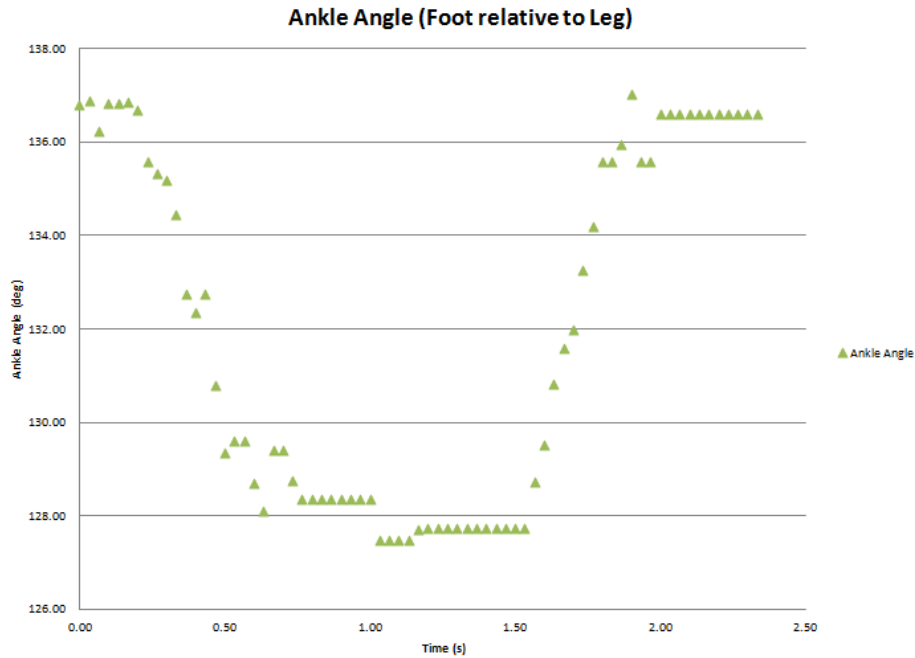


Figure 2.1: This plot displays the angle at which the foot is, relative to the leg, throughout the duration the lift in the 2nd test conducted in phase 3

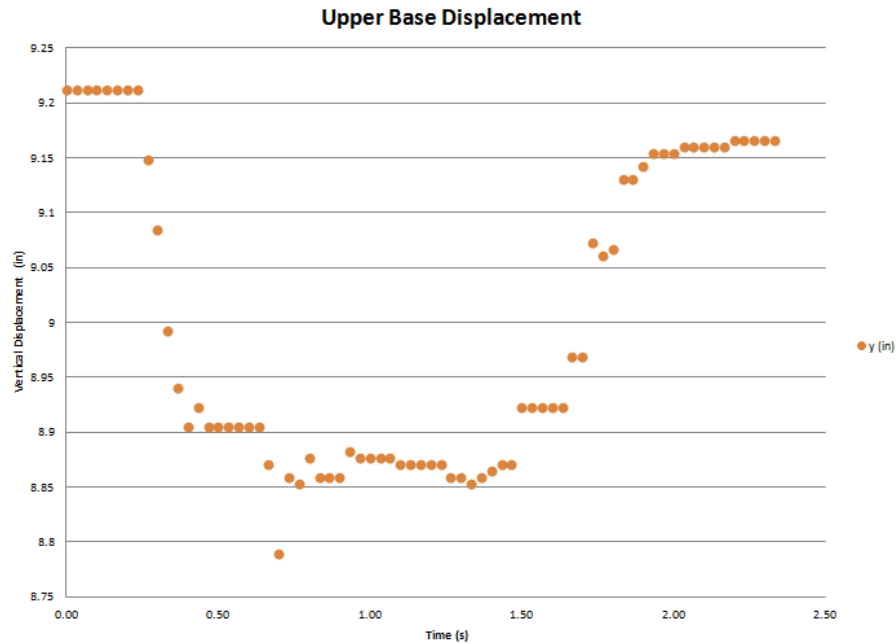


Figure 2.2: This plot displays the raw data of vertical displacement (in) of the upper muscle attachment piece, collected by Video Tracking Software, in the 2nd test conducted in phase 3

Summary:

- a.) The foot lift angle range is between -37.47 and -47.03 degrees
- b.) The foot lift angle range during a natural gait cycle is between -8.2 and -38.6 degrees
- c.) Difference_{natural Gait}: 30.4 degrees
- d.) Difference_{device}: 9.56 degrees
- e.) Vertical Displacement: 0.42 inches

Test #3

Conditions:

- a) Same conditions as test 2
- b) Same conditions as test 2 but with tracker heel measurement located at a lower position on the foot.

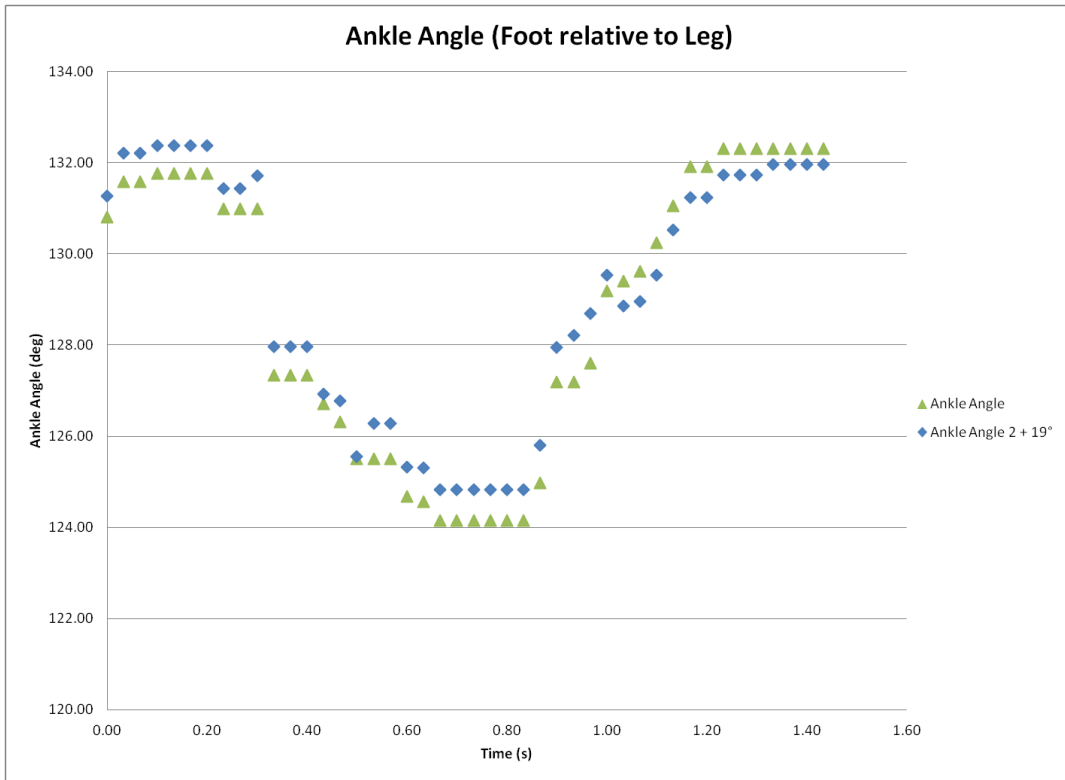


Figure 3.1: The plot displays the angle at which the foot is, relative to the leg, throughout the duration the lift in the 3rd test conducted in phase 3. Two heel locations were tested and the 2nd heel position was given an additional 19° for ease of comparisons.

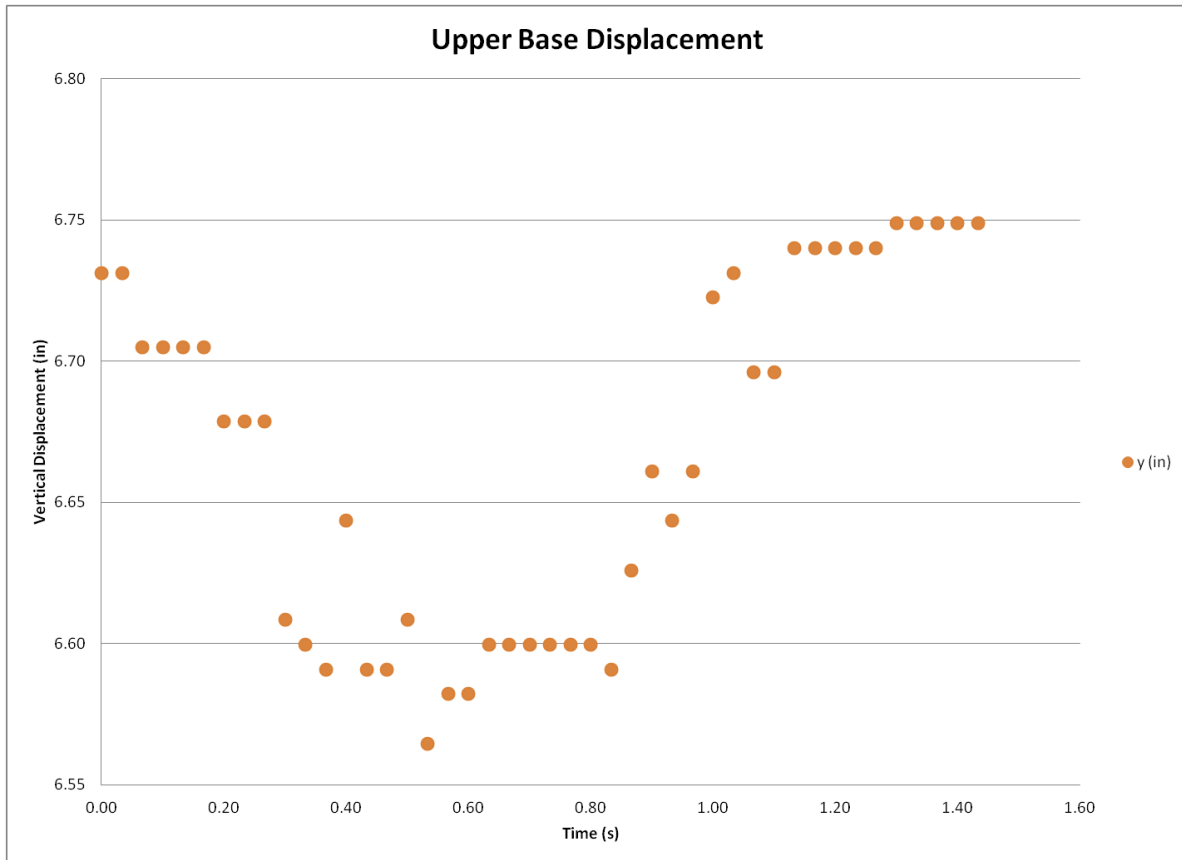


Figure 3.2: The following plot displays the raw data of vertical displacement (in) of the upper muscle attachment piece, collected by Video Tracking Software, in the 3rd test conducted in phase 3

Summary:

- f.) The foot lift angle range for a.) is between -34.15 and -42.31 degrees
- g.) The foot lift angle range for b.) Heel-2 is between -15.83 and -23.37 degrees
- h.) The foot lift angle range during a natural gait cycle is between -8.2 and -38.6 degrees
- i.) Difference_{natural Gait}: 30.4 degrees
- j.) a.) Difference_{device}: 8.16 degrees
- k.) b.) Difference_{device}: 7.54 degrees
- l.) Vertical Displacement: 0.18 inches

Test #4

Conditions:

- a) Same conditions as test 3a. but with the tension strap placed over the lower brace

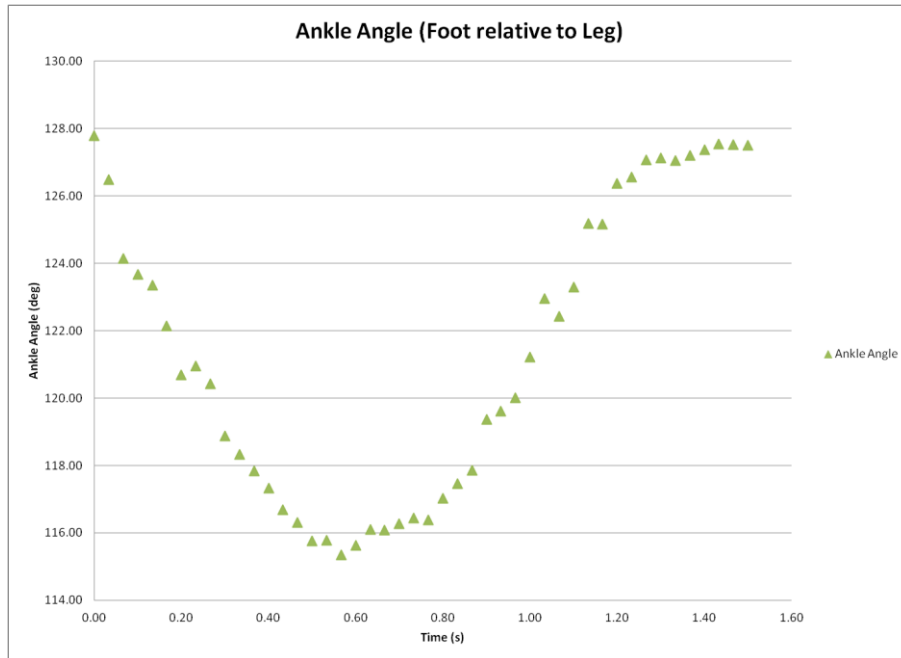


Figure 4.1: The plot displays the angle at which the foot is, relative to the leg, throughout the duration the lift in the 4th test conducted in phase 3

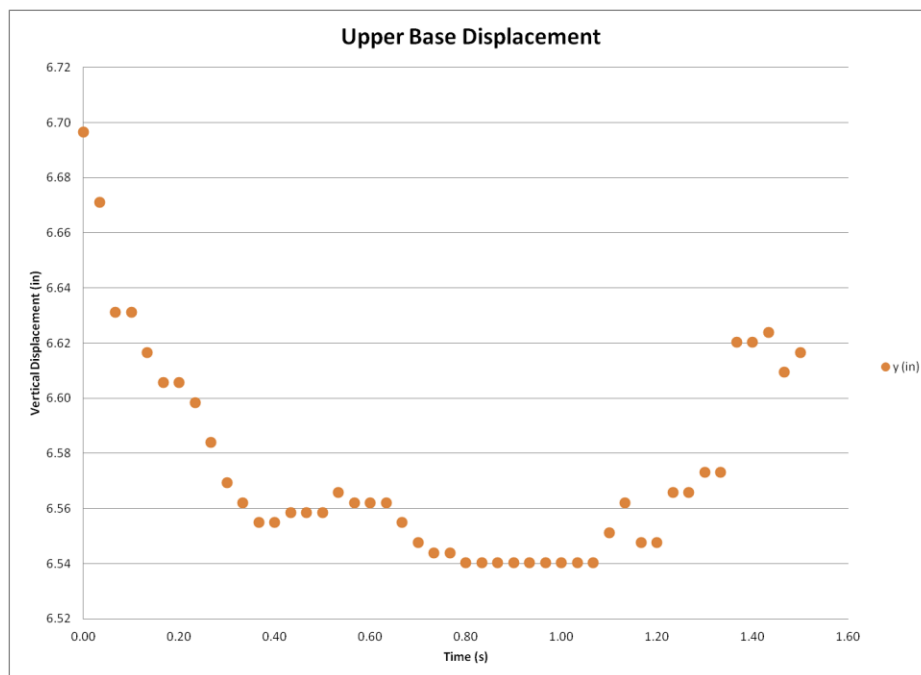


Figure 4.2: The following plot displays the raw data of vertical displacement (in) of the upper muscle attachment piece, collected by Video Tracking Software, in the 4th test conducted in phase 3

Summary:

- m.) The foot lift angle range is between -25.35 and -37.79 degrees
- n.) The foot lift angle range during a natural gait cycle is between -8.2 and -38.6 degrees
- o.) Difference_{natural Gait}: 30.4 degrees
- p.) Difference_{device}: 12.44 degrees
- q.) Vertical Displacement: 0.16 inches

Test #5

Conditions:

- a) Same conditions as test 3a
- b) Same conditions as test 3a but with the user pointing the toe and relaxing the foot before air muscle flexion.

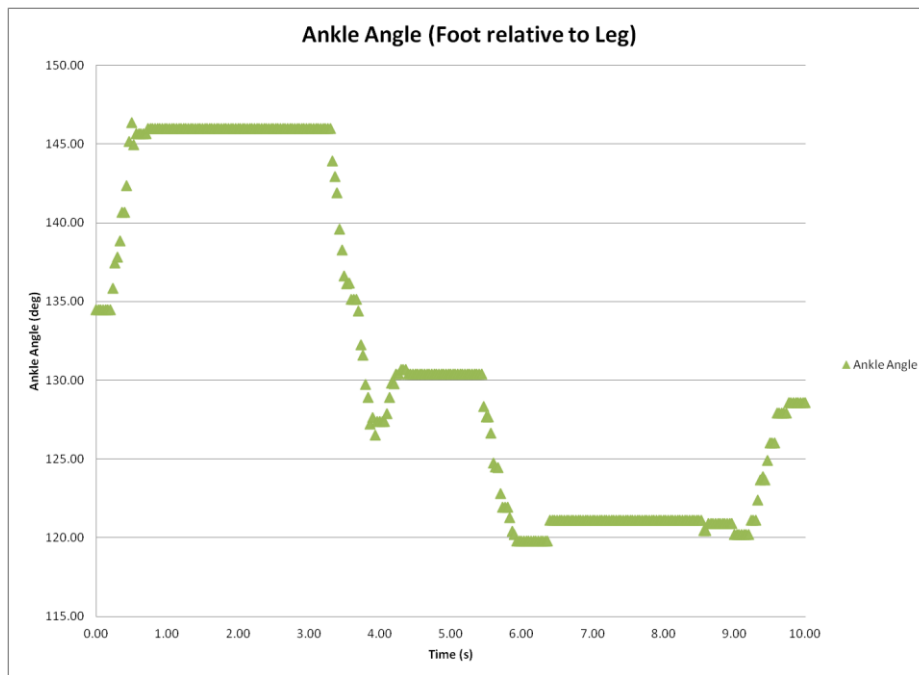


Figure 5.1: The plot displays the angle at which the foot is, relative to the leg, throughout the duration the lift in the 5th test conducted in phase 3

Summary:

Lift (#)	Deflection (in)	Δ Ankle Angle (°)	Conditions:
Phase2	0.35	13.60	Buckle sewn on far side of brace
1	0.30	11.10	Buckle sewn in front of brace
2	0.42	9.56	Inelastic material from brace to strap (below pant leg)
3a	0.18	8.16	Standard heel tracking (brace worn over pant leg)
3b	0.18	7.54	Lower heel tracking (brace worn over pant leg)
4	0.16	12.44	Strap over lower brace [standard heel (over pant leg)]
5a	0.34	10.63	Strap under lower brace [standard heel (over pant leg)]
5b	0.34	26.56	Toe-point & muscle lift {strap under, std. heel, over pants}

Figure 6: Summary Table

Conclusion:

- a.) The difference between $\Delta\theta_{\text{natural Gait}}$ and $\Delta\theta_{\text{device}}$ decreased since the phase 2 test from 13.6° to 10.63° (it should be noted that the difference may actually be largely accounted for when tolerance on tracker data is considered)
- b.) Average vertical displacement experienced by the Upper Muscle Attachment piece decreased since the phase 2 test from 0.35" to 0.18", 0.16", and 0.34" after the addition of the inelastic material. (note: the last data point is affected by an outlier and is closer to 0.28")
- c.) Using tracker based on a lower heel location resulted in a slightly lower Δ ankle angle of 7.54° vs. 8.16°
- d.) When no shoe is necessary, more ankle lift [12.44° vs. 8.16° and 10.63°] can be achieved if the tension strap is worn over the lower brace.
- e.) The total ankle angle range increased to 26.56° when the user pointed the down and then relaxed foot prior to air muscle articulation

Next Steps:

- 1) Discuss ways to minimize the upper muscle attachment deflection during muscle actuation and increase the difference between $\Delta\theta_{\text{natural Gait}}$ and $\Delta\theta_{\text{device}}$.
- 2) Implement chosen solution and repeat test.