Testing Report – Slow Motion Deflection Video

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Related System: Articulate Muscle (ABBB)

The purpose of this test is to identify the strain requirements necessary to achieve foot-lift.

Testing Procedure

Supplies

1. Protractor
2. Packing tape
3. Shoe lace
4. Video camera
5. Treadmill
6. Tracker software
7. Velcro straps
8. Lower brace

Set-up

The test rig was set up according to Figure 1 with the protractor taped to the leg, an elastic cord attached from a Velcro strap around the calf to a knot near the protractor, and shoelace mimicking the lower strap placed around the arch of the foot, running under the brace and up to the knot.

Figure 1: Test Set-up

Procedure

A non restrictive shoe was worn on both feet during testing. A camera was placed near a treadmill and video footage (haha) was taken while walking slow on a treadmill with the foot rig. The rig is design to keep tension on the knot in order to take up the slack during the gait cycle to find the deflection required of the air muscle.

Tracker software is available as a free download and was used to mine data from the video footage. Key points were selected on the rig, namely:

- Top of the protractor
- Bottom of the protractor
- Knot
- Back of Heel
- Arch of foot (near toe)
- Back of calf

These points were tracked manually and visually frame by frame during a gait cycle.

Results

The data required some analysis in order to find useful results. The length and angle between the bottom of the protractor and the knot as well as the length and angle from the top of the protractor and the knot were measured in tracker. After trigonometric manipulation both sets of lengths and angles were resolved into the relative vertical distance between the bottom of the protractor and the knot. The

results can be seen in Figure 2. Due to poor resolution in the video, the latter portion of the gait cycle was unreliable.

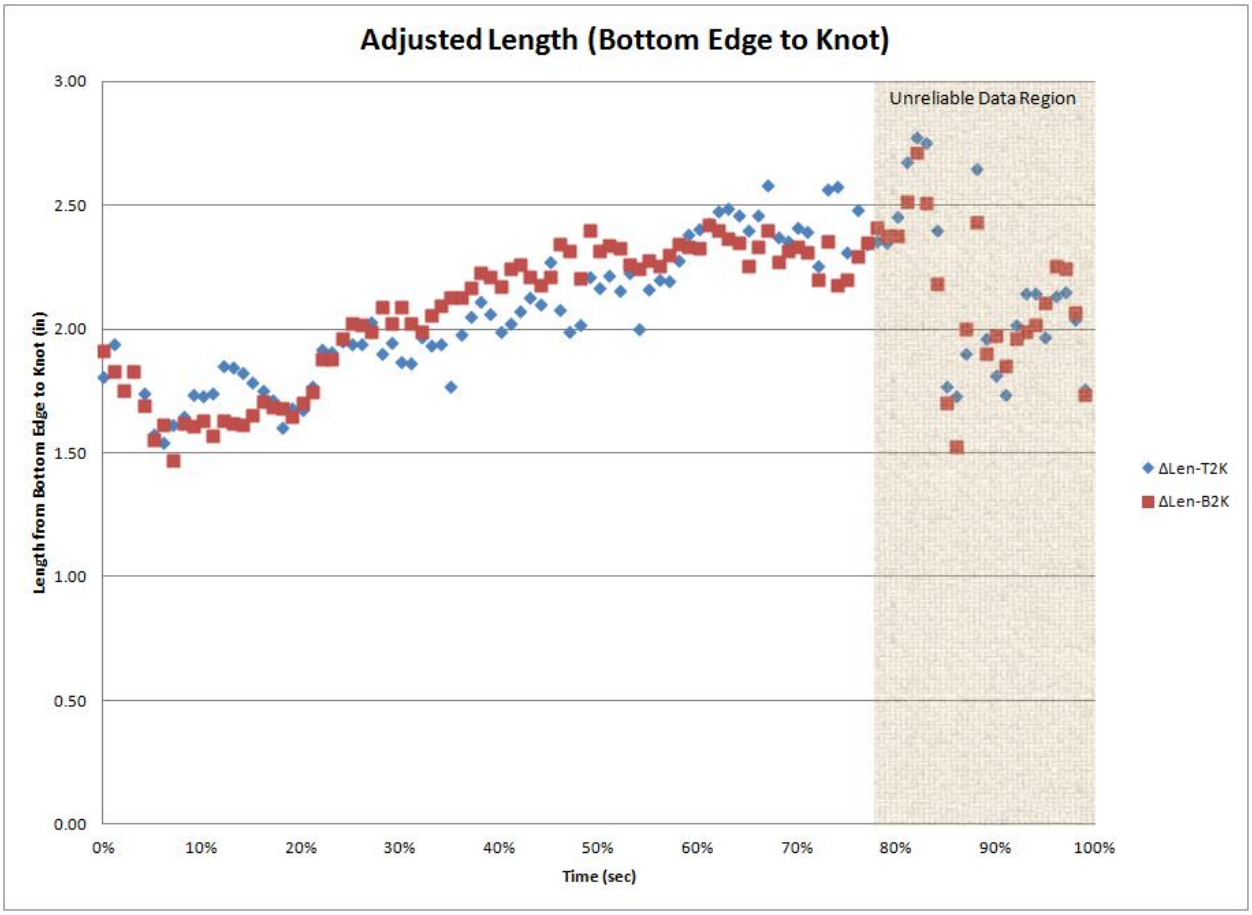

Figure 2: Resolved vertical relative distance from bottom of protractor to knot

If the outliers are neglected, the approximate change in deflection amounts to about 1.0 inch. This matches the values from previous findings fairly well and our muscle was designed to meet a 1 inch deflection requirement.

In order to compare this data with a wider sample, the foot angles were compared to what is believed to be similar data from a paper published about posture[1]. For this comparison, two specific angle measurements were studied: foot relative to horizontal, and foot relative to leg. It is believed that heel strike marks the beginning of the gait cycle and that the Posture data was measured based on the foot relative to the leg angle. By lining up heel-strike times, the image in Figure 3 represents the unadjusted ankle angle overlay.

[1] Bovi G., Rabuffetti M., Mazzoleni P., Ferrarin M, 2010, "A multiple-task gait analysis approach: Kinematic, kinetic and EMG reference data for healthy young and adult subjects", Gait & Posture

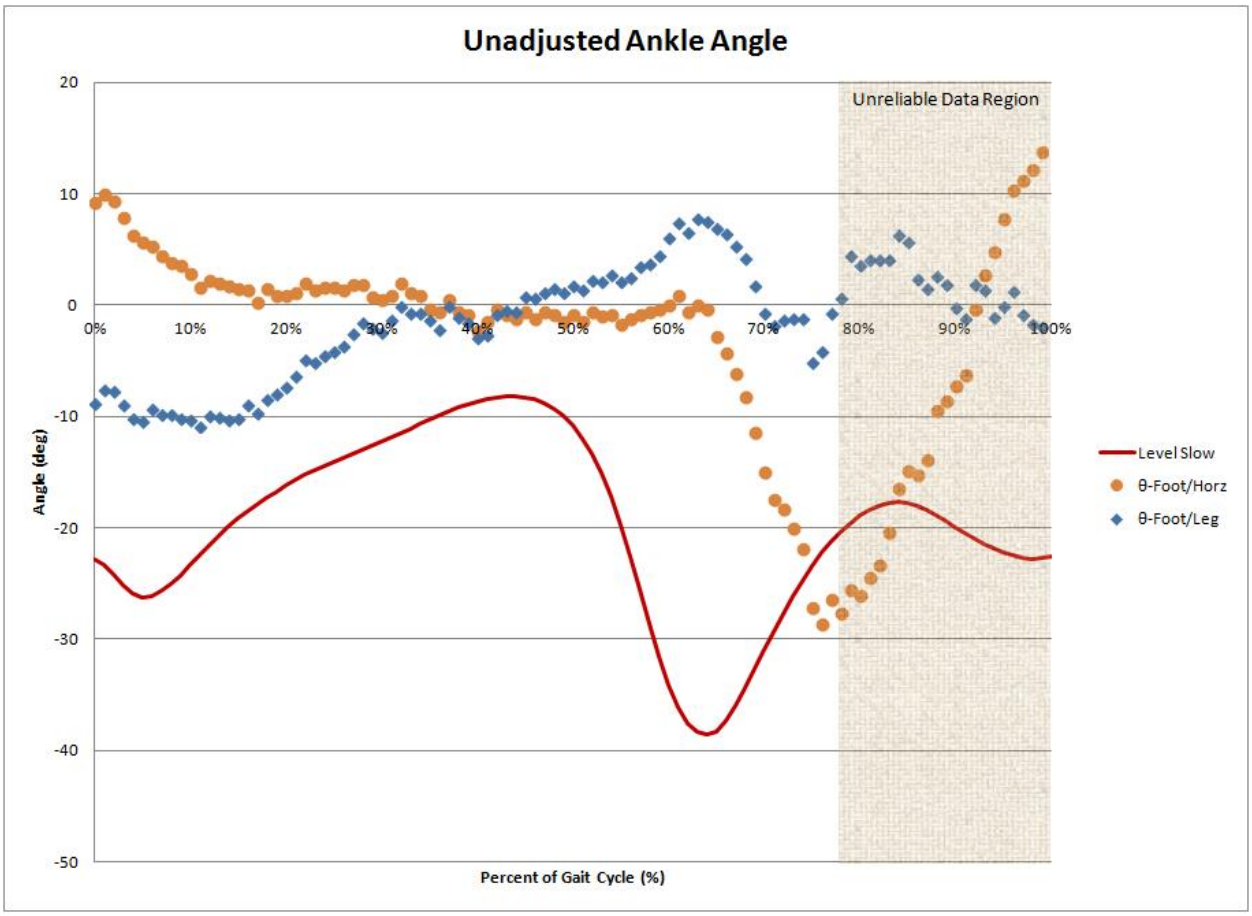

Figure 3: Unadjusted ankle angle overlay

Although the unadjusted plot may intuitively seem more appropriate, there can be several benefits from adjusting the data to match the Posture data better. For one, the time between heel-strike and heel-lift may not be the same for this experiment compared to the Posture tests. This video may have been taken with a slower walking speed than the posture data which may very well increase the time between heel-strike and heel-lift. To account for this, adjustments were made to the % gait cycle in order to line up the angle fall at heel-lift. Other adjustments were made to match the data points to the curve more closely which are fudge factors but may actually serve account for other various discrepancies between experiments. The adjusted ankle angle image can be seen in Figure 4.

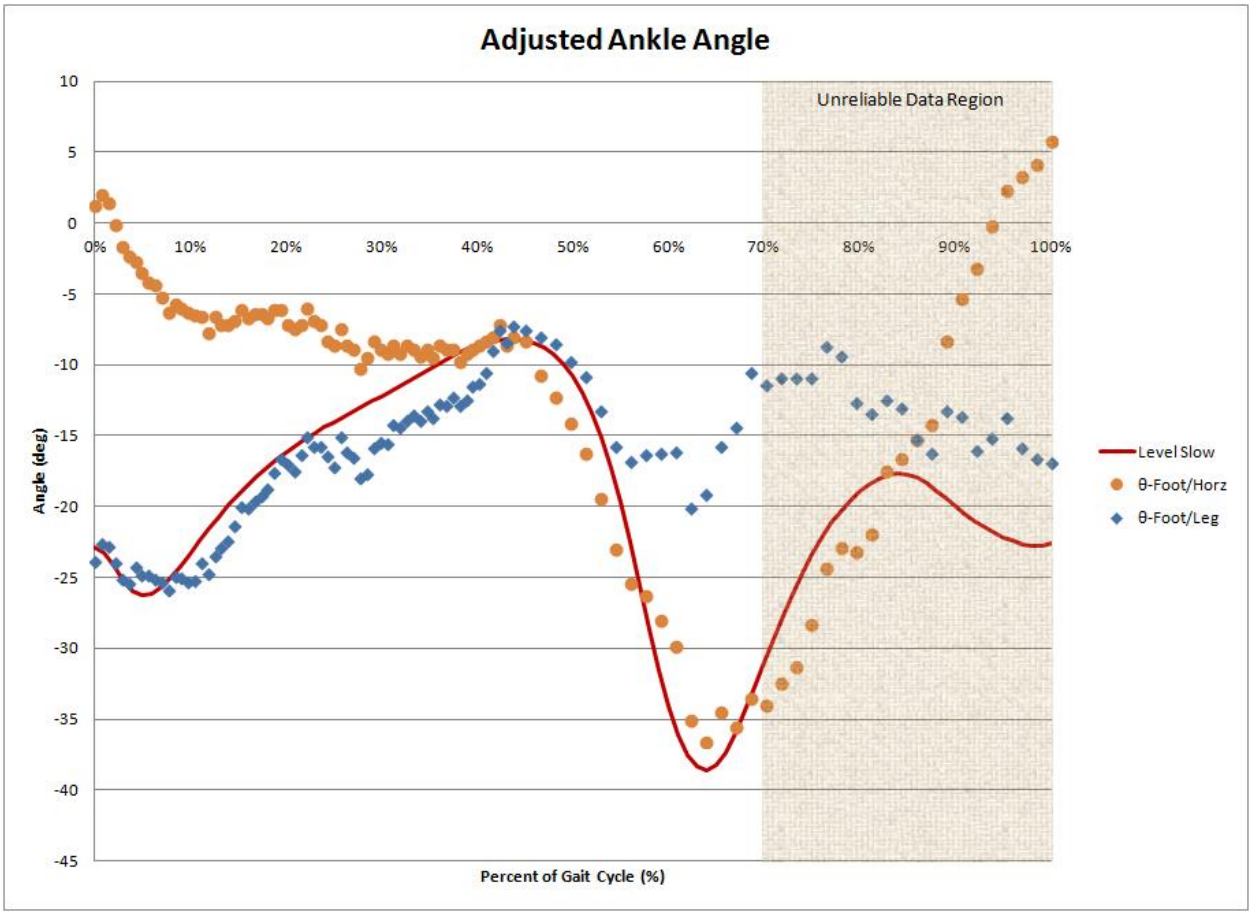

Figure 4: Adjusted ankle angle

Conclusions

From this test we have concluded that the strain requirement of 1.0 inche seems to be appropriate for our AFO. We also conclude that the ankle angle data from our tests are not very dissimilar from scientific data. It is important to keep in mind that this test was based on a level terrain - slow and that required strain may still possible be greater on stairs or other terrain.

Next Steps

1. Proceed with current muscle design
2. Perform integrated strain testing with real muscle on various terrains.