DOCUMENTATION

for

GAIT DATA

in

MIDUS 3
BIOMARKER PROJECT
(P4)

University of Wisconsin ♦ Institute on Aging
March 2023

INTRODUCTION

This document provides an overview of the gait data collected in the MIDUS 3 (M3) Biomarker Project (P4). This document describes the gait protocol and measures. Administrative and computed variables are also identified and information about the construction and usage of these variables is included.

Data users are also encouraged to review the MIDUS 3 Biomarker (P4) Readme Data File Notes. This document provides information about naming conventions, as well as administrative and filter variables included in the data file. It also includes information about how we handled missing values and other issues that arose over the course of the study. For example, there are instances when variables were added or sections of an instrument were expanded for data entry purposes to accommodate additional information provided by the respondent.

This document will be periodically revised and updated as more information is gathered and as researchers continue to work with the MIDUS 3 Biomarker data. If there are suggestions or comments, please submit a message through the MIDUS HelpDesk (http://midus.wisc.edu/helpdesk.php).

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Section A: OVERVIEW OF DATA FILE AND COLLECTION PROTOCOLS

The MIDUS Biomarker Project (P4) assesses Gait using the APDM Mobility Lab System via 3 accelerometers: one affixed to the top of each foot and one at the lumbar spine. Data is streamed from the accelerometers to a dedicated laptop computer while participants walk back and forth at their usual pace along a straight 25-meter course for 2 minutes.

The gait assessment was added to the MIDUS Refresher as a pilot project conducted at Site 2 (UW). At MIDUS 3, gait assessment was expanded to all three data collection sites (UW, UCLA, Georgetown).

The following describes changes to the APDM system between waves, the summary measures reported and the data collection protocol.

As described in the "MIDUS 3 Biomarker Project (P4) Readme Data File Notes" naming conventions organize variables according to data type or the method used for data collection. Following this convention, the first three characters of the gait data are "C4G".

Data Documentation

APDM implemented substantial changes to its software and hardware in April 2016 that affected both data collection methodology as well as data output. MIDUS Refresher data was collected and exported using Mobility Lab v1; MIDUS 3 data was collected and exported using Mobility Lab v2. The APDM software and hardware were both updated to improve the accuracy of gait output, primarily by changing the location of the lower extremity sensors (from ankle to foot) (Washabaugh et al, 2017). A summary and description of the differences between gait measures reported by these two versions of the software can be found here (https://support.apdm.com/hc/en-us/articles/115000521106-Differences-in-the-gait-measures-between-Mobility-Lab-v1-and-v2).

MIDUS data are affected by the following differences between the two software versions.

- *Mobility Lab v1 (Refresher, prior version) Data (per email from APDM staff in May 2019):*
    - Variables containing metrics for both legs combined were created for all gait characteristics. These metrics are created in two different ways:

        - The mean of the left and right values was computed for:
            - Stride Length
            - Stride Velocity
            - Swing
            - Stance

        - For a few gait characteristics the right and left metrics are essentially phase shifted versions of each other and are highly correlated. Thus, for the following gait characteristics, the value reported is the value generated from a gait cycle that was initiated with a right foot heel strike and ended with the next right heel strike.
            - Cadence
            - Gait Cycle Time

        - Double Support

    - Coefficients of Variation (CoV) are computed.

- *Mobility Lab v2 (MIDUS 3, current version) Data include*:
    - Separate left and right measures only, there are no combined variables.
        - Metrics for both legs combined for M3 Stride Length, Gait Speed, Swing, and Stance, can be computed by averaging the left and right values for that gait characteristic.
        - Per the above, the values for the right leg for M3 Cadence, Gait Cycle Time, and Double Support should be used when a metric representing both legs combined is needed.

    - Standard Deviations (computed using normative data) rather than CoV.
        - Per email communication with APDM staff this change was made to minimize confusion among users of the software who are more familiar with the standard deviation. Users can convert between the two as follows:
            - CoV=Std.Dev/Mean
            - Std.Dev=CoV x Mean

Gait Variables

Two flag variables were created to indicate availability of data and, if applicable, reason for data unavailability.

- C4GAVAIL indicates whether or not gait data is available for a given case. This variable has the following codes:
    - 1 = YES, data is available
    - 2 = NO – TECHNICAL FAULT. Data was not collected due to an issue with the software or the accelerometers.
    - 3 = NO – R WAS UNABLE TO DO. Data was not collected because the respondent either had mobility issues, or was experiencing some other health event that prevented the protocol from being completed.
    - 4 = No – OTHER REASON. Data was not collected for a reason not included in the other two categories.

The following defines each M3 gait characteristic measured, any changes to that characteristic as a result of the software update, and then the variables available for each characteristic. Changes for each characteristic at M3 are also summarized in a table at the end of this section.

Stride Length – The forward distance (in meters) travelled by the foot during a gait cycle. Measured at MR as a percent of stature. Includes the variables

- C4GSTRLLMM – Gait: Stride Length Left (meters) [Mean]
- C4GSTRLLMSD – Gait: Stride Length Left (meters) [Std]
- C4GSTRLRMM – Gait: Stride Length Right (meters) [Mean]
- C4GSTRLRMSD – Gait: Stride Length Right (meters) [Std]

Gait Speed (formerly Stride Velocity) – The forward speed of the subject (in meters per second), measured as the forward distance traveled during the gait cycle divided by the gait cycle duration. Measured at MR as the percent of the subject's stature per second. Includes the variables:

- C4GGSPLMSM – Gait: Gait Speed Left (meters/s) [Mean]
- C4GGSPLMSSD – Gait: Gait Speed Left (meters/s) [Std]
- C4GGSPRMSM – Gait: Gait Speed Right (meters/s) [Mean]
- C4GGSPRMSSD – Gait: Gait Speed Right (meters/s) [Std]

Swing – The percentage of the gait cycle in which the foot is not on the ground.

- C4GSWLM – Gait: Swing Left (%GCT) [Mean]
- C4GSWLSD – Gait: Swing Left (%GCT) [Std]
- C4GSWRM – Gait: Swing Right (%GCT) [Mean]
- C4GSWRSD – Gait: Swing Right (%GCT) [Std]

Stance – The percentage of the gait cycle in which the foot is on the ground.

- C4GSTALM – Gait: Stance Left (%GCT) [Mean]
- C4GSTALSD – Gait: Stance Left (%GCT) [Std]
- C4GSTARM – Gait: Stance Right (%GCT) [Mean]
- C4GSTARSD – Gait: Stance Right (%GCT) [Std]

Cadence – The number of steps per minute, counting a step from heel strike to heel strike.

- C4GCLSMM – Gait: Cadence Left (steps/min) [Mean]
- C4GCLSMSD – Gait: Cadence Left (steps/min) [Std]
- C4GCRSMM – Gait: Cadence Right (steps/min) [Mean]
- C4GCRSMSD – Gait: Cadence Right (steps/min) [Std]

Gait Cycle Duration (formerly Gait Cycle Time) – The duration of a full gait cycle (in seconds), measured from the foot's initial contact to the next initial contact of the foot.

- C4GGCDLSM – Gait: Gait Cycle Duration Left (seconds) [Mean]
- C4GGCDLSSD – Gait: Gait Cycle Duration Left (seconds) [Std]
- C4GGCDRSM – Gait: Gait Cycle Duration Right (seconds) [Mean]
- C4GGCDRSSD – Gait: Gait Cycle Duration Right (seconds) [Std]

*Double Suppor*t – The percentage of the gait cycle in which both feet are on the ground.

- C4GDSLM – Gait: Double Support Left (%GCT) [Mean]
- C4GDSLSD – Gait: Double Support Left (%GCT) [Std]
- C4GDSRM – Gait: Double Support Right (%GCT) [Mean]
- C4GDSRSD – Gait: Double Support Right (%GCT) [Std]

Measure	Changes at M3			
	Change in Measure Label	Unit Change	Averaged Measures Removed	New Left Foot Measures *
Gait: Stride Length		X	X	
Gait: Gait Speed	X	X	X	
Gait: Swing			X	
Gait: Stance			X	
Gait: Cadence				X
Gait: Gait Cycle Duration	X			X
Gait: Double Support				X

* As noted above the values reported at MR for these items were the right foot measures only.

REFERENCES:

Washabaugh EP, Kalyanaraman T, Adamczyk PG, Claflin ES, Krishnan C. Validity and repeatability of inertial measurement units for measuring gait parameters. Gait Posture. 2017; 55:87–93. DOI: 10.1016/j.gaitpost.2017.04.013

Section B: GAIT DATA COLLECTION PROTOCOL

Participants will be instrumented with ankle and lumbar spine accelerometers, each weighing 22 grams (Opal, manufactured by APDM, Portland OR). The devices simply strap on. Participants then receive instructions to walk at their usual pace back and forth along a 25 meter straight course for 2 min. The monitors stream data on gait to a dedicated laptop computer. At the end of the 2 min task, the monitors are removed and the participant is finished with this part of the protocol.

When to conduct the Gait Analysis?
Gait Analysis is generally conducted after the Psychophysiology protocol, mid-morning, on Day 2 of the respondent visit. Gait Analysis, however, can be conducted on Day 1 if time permits. The Gait Analysis should take no longer than twenty minutes.

Materials Needed
1. Laptop with APDM *Mobility Lab* software
2. Three Opal Monitors (2-foot, 1-back). *See example below of Opal Monitor docked*.

3. DOCKING STATION (shown) with USB (micro-USB connector) and power cables *or* USB dock with connection cables (not shown).
4. ACCESS POINT (wireless receiver) and USB (boxy type-B connector) cable
5. Power source
6. Cart for transporting the Mobility Lab System and conducting Gait Analysis
7. USB/Jump drive for saving data.

PREPARING FOR DATA COLLECTION

Pre-Visit: Charge Monitors/Batteries
At least 24 hours before the respondent visit, be sure that the following items are plugged into a power supply and are charging:

1. Opal Movement Monitors and DOCKING STATION (monitors should be set in the DOCKING STATION).

2. APC battery backup/surge protector.

Day of Visit: Hardware setup
Before setting up hardware, move the Mobility Lab System to the designated space allowing for a 25 meter walk.

1. Plug the laptop containing the APDM software into the power source and turn on the laptop.

2. Make sure that the three Opal Monitors are set in the DOCKING STATION.

3. Connect the DOCKING STATION to the power source using the power cable.

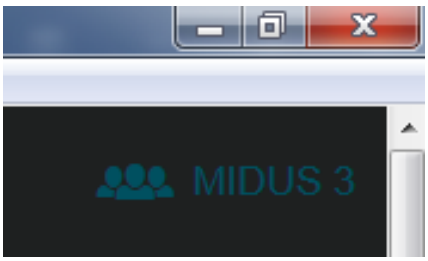
Note: *The DOCKING STATION must be connected to power in order to configure the Opal monitors.*

4. Connect the DOCKING STATION to the laptop using the USB (micro connector) cable/input.
5. Connect the ACCESS POINT to the laptop using the USB cable/input. The Access Point MUST be connected to the laptop to configure the sensors (see below).

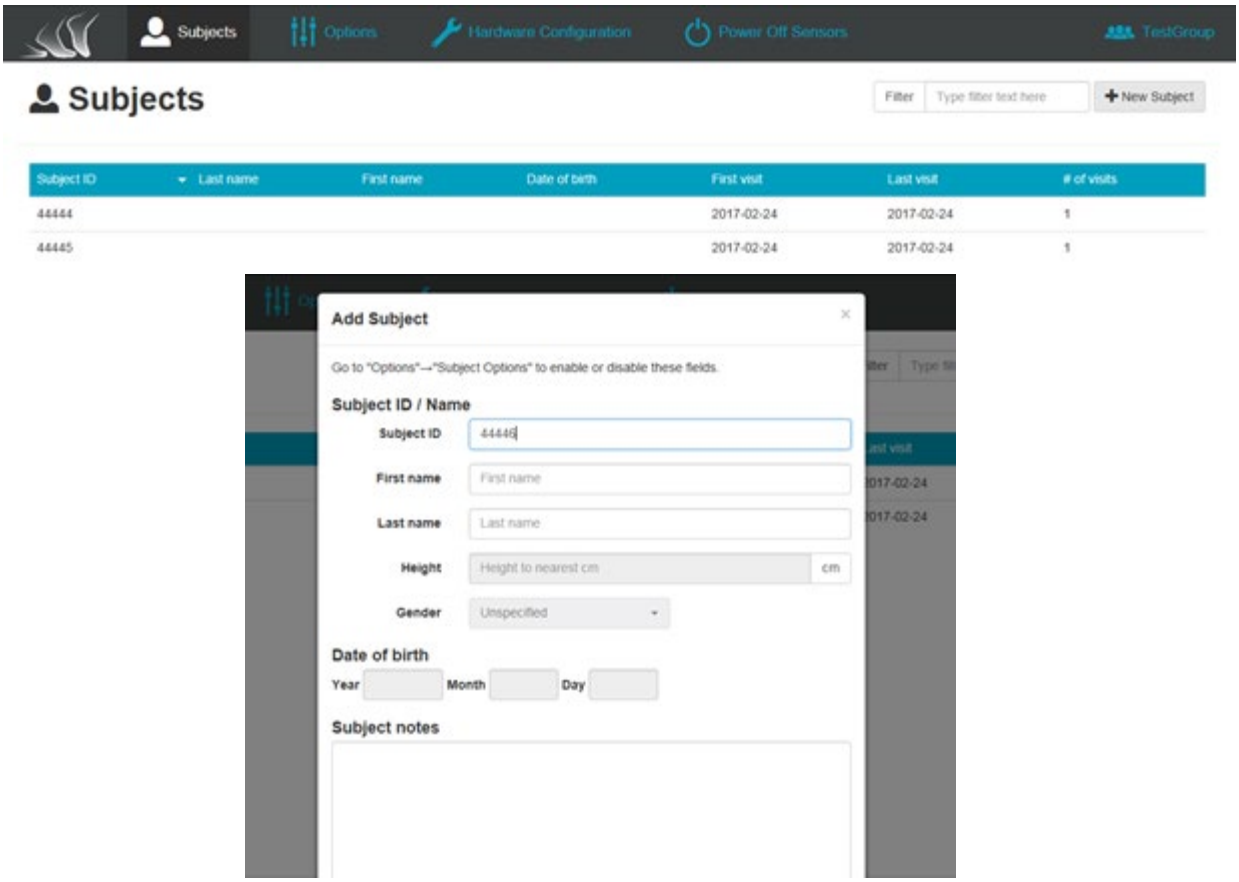
Session Setup

1. Open the *Mobility Lab* software by clicking on the ***Mobility Lab*** icon on the laptop taskbar.

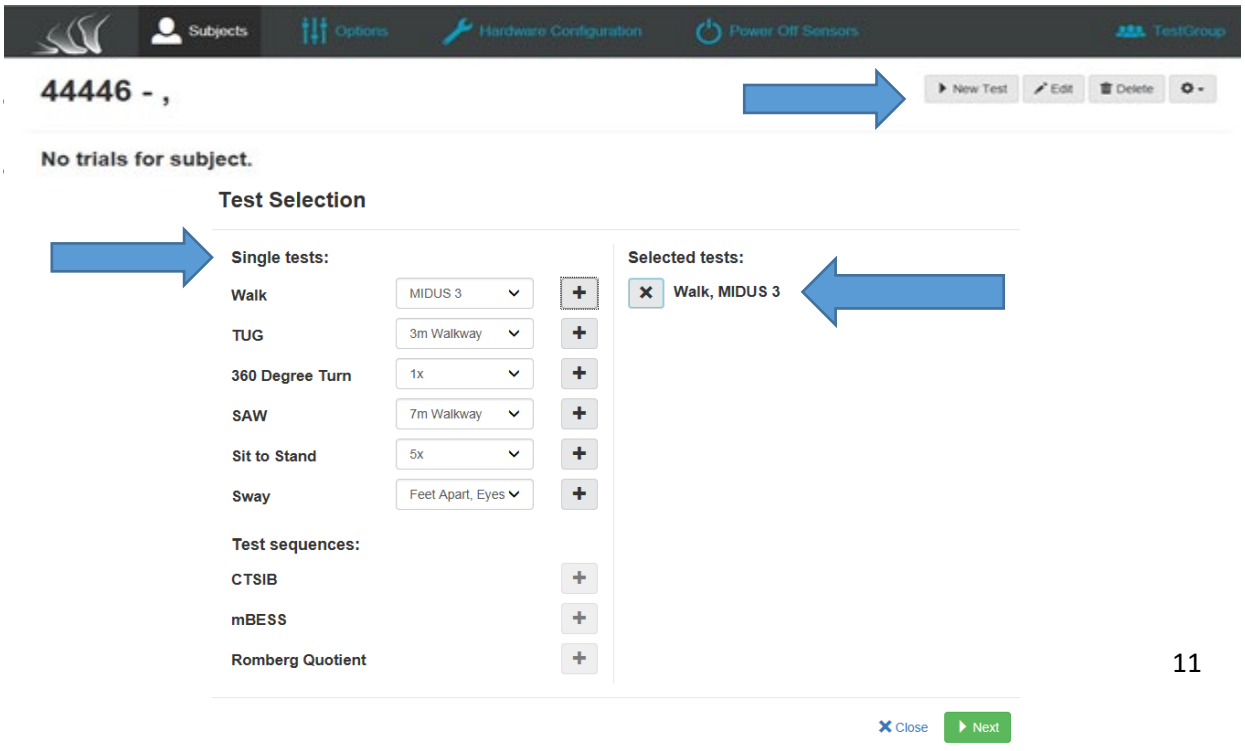
2. Studies Tab - ensure that **MIDUS 3** is the active tab (far right on the uppermost toolbar, see sample image below).



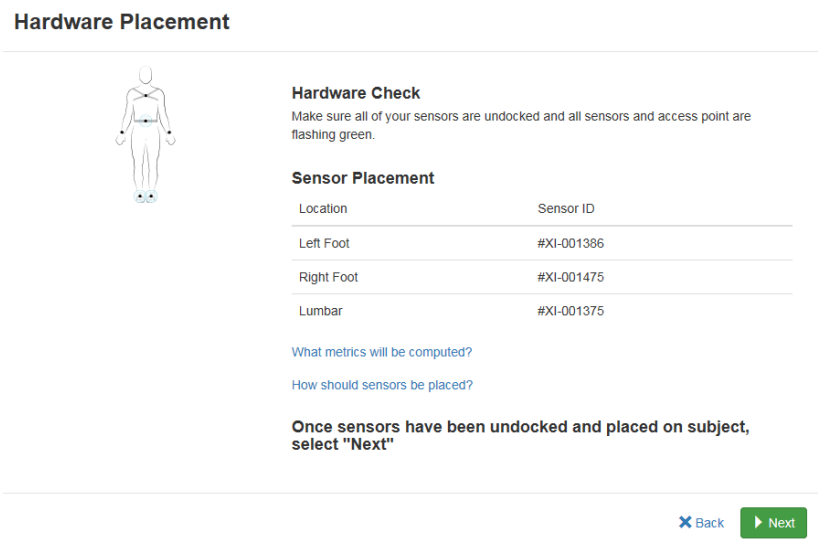
3. Subjects Tab - select **+ New Subject**. Enter the respondent's ID in the **Subject ID** box and click **Save**.



4. With the Subject's page open, click **New Test** then select **MIDUS 3** from the **Single Tests: Walk** dropdown menu. Click **+ (Add)**. The **MIDUS 3** walk test will appear in the right column under "**selected tests**." MIDUS 3 should be the only test in the "selected tests" column. Click **Next**.



5. Follow the instructions in the dialogue box that appears on the screen. Undock the sensors and hold them together until each sensor and the access point are flashing green simultaneously. Once the sensors and access point are flashing green, an adequate signal has been established. Ensure that sensors are placed properly on the participant (see detailed placement instructions below) and that each sensor ID corresponds with the sensor ID on the screen. Click **Next**:



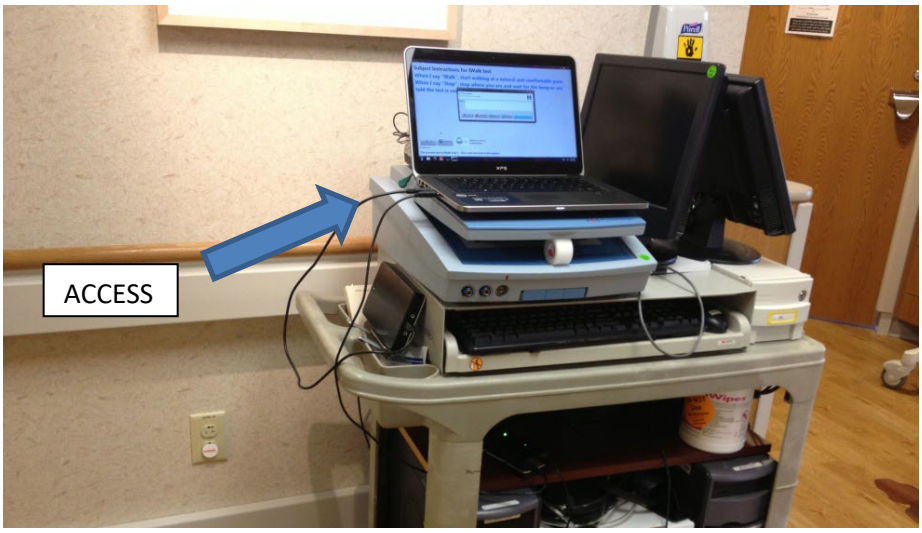
Hardware Setup and Conducting a Trial

1. **Sensor Placement:**

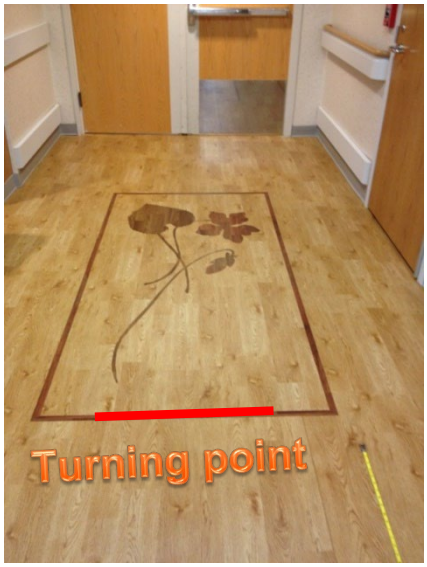
- Place the left foot monitor around the respondent's left foot so that the sensor is on top of their shoe (make sure that the green light is exposed and the USB port is pointing down towards the toe).
- Place the right foot monitor around the respondent's right foot so that the sensor is on top of their shoe (make sure that the green light is exposed and the USB port is pointing down towards the toe).
- Place the lumbar monitor on the respondent's lower lumbar/back (make sure that the green light is exposed and the USB port is pointing down towards the floor).

Note: *The order of monitor placement does not matter.*

2. **Positioning the computer** - The computer should be located near the starting position for the walk with the ACCESS POINT aimed down the hallway toward the turnaround position. This helps to maintain the computer's link with the Opal Monitors and minimizes downloading after data has been collected. Note the positioning of the laptop and ACCESS POINT on the psychophysiology cart.

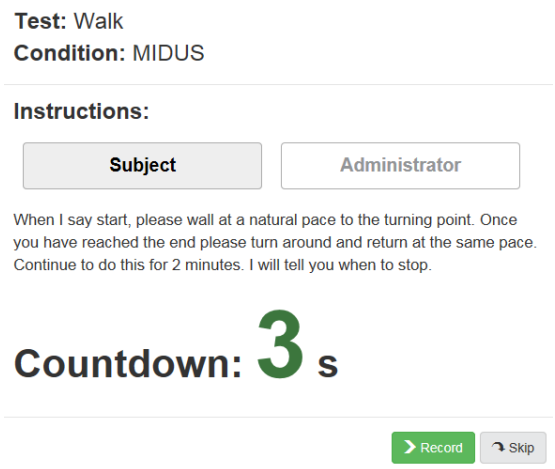


3.**Beginning a trial** - Show the participant the starting point and turning point of the 25 meter long course and then have them stand at the designated starting point. Remind the participant that it is important to stand completely still until you tell them it is time to start.

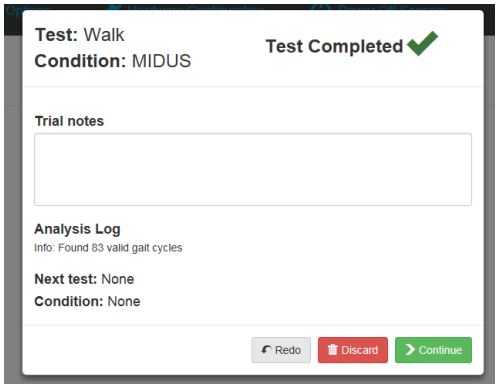


When the participant is ready and standing at the starting point read the following instructions aloud. *"When I say start, please walk at a natural and comfortable pace to the turning point. Once you have reached the end, please turn around and return at the same pace. Continue to do this for 2 minutes. I will tell you when to stop."*

Click on the **Record** button to begin the walking task. There will be a **3** second countdown. When the timer hits 0, say **Start**. The computer will beep at the start and end of a recording - this is an added feature. Feel free to tell the respondent they will hear a beep. However, they should wait to hear "start" from the research staff before beginning the task.



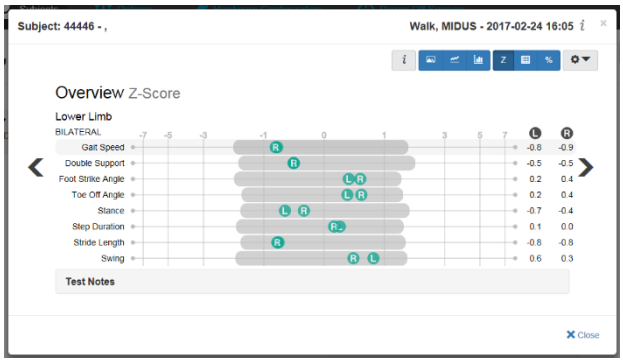
4. Once the test is completed, the following screen will appear:



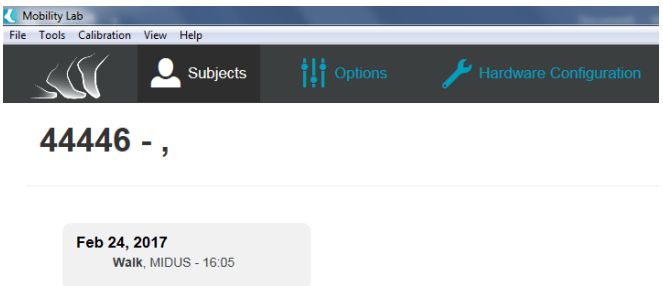
Note: It is important that 60-120 valid gait cycles are recorded. The top right corner of the image above indicates that the test was completed successfully. The number of gait cycles recorded is listed in the Analysis Log section. **If an error occurs, it is necessary to redo the trial.**

If the test was completed successfully, click **Continue.**

5. A results analysis overview will appear on the screen. These results have no clinical significance to the subject and can be closed by clicking the **x** in the bottom right corner.



6. The subject's ID number will appear on the screen along with an summary icon of task they completed.



7. Remove the monitors and allow the respondent to return to his/her room.