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A. Overview

Gait Analyzer allows for a cost-effective and valid means for assessing gait in a clinical, laboratory, or free-living environments. While most tools available for the biomechanical assessment of gait require closed environments, with expensive, time-consuming methodologies such as Motion Capture, this app provides a valid, easy-to-use, inexpensive, and time efficient means of analyzing a person's gait and cognitive performance in either single- or dual-task situations.

B. Installation

Gait Analyzer is an Android app which can be installed via the Google Play Store:
<https://play.google.com/store/apps/details?id=com.matlabgeeks.gaitanalysis>

In order to fully utilize the app, a tri-axial accelerometer sensor is required. For a free test of all sensors on your smartphone, take a look at another Android app here:
<https://play.google.com/store/apps/details?id=com.matlabgeeks.gaitanalyzer>

While Android 4.4 and newer (API 18+) are supported, it is recommended that you utilize a more recent version of Android such as Android 6.0.1 or newer (API 23+).

Currently, Gait Analyzer can only be found for Android, with support for Apple iOS coming soon.

i. Permissions

The application requires four permissions in order to work to its full extent. On installation, you will be asked to approve and confirm the following:

Write External Storage – This permission permits saving of gait and cognitive results locally to a tab-delimited file.

Get Accounts – This permission allows for the saving of gait and cognitive results to your Google Drive account.

Record Audio – Permit usage of the microphone to record user responses to verbal response tasks.

Access Coarse Location – Allow the app to estimate the phone's general location. In order to conform to Protected Health Information (PHI) standards, only the state that you are located in will be recorded. For more information about your PHI, take a look at the following:
<https://www.hipaajournal.com/what-is-considered-protected-health-information-under-hipaa/>



C. User Information

The Gait Analyzer app requests some user information, but ensures privacy is retained for all users, as no PHI is collected or stored. Protected information such as your birthdate is not stored, but rather used to compute the user’s age. Furthermore, gender, ethnicity, and anthropometric information will be utilized to allow for age-, gender-, anthropometric- and other group-based comparisons for evaluating gait and cognitive performance. No identifiable information will be requested, with users asked to provide non-identifiable usernames. For more information about your PHI, take a look at the following:

<https://www.hipaajournal.com/what-is-considered-protected-health-information-under-hipaa/>

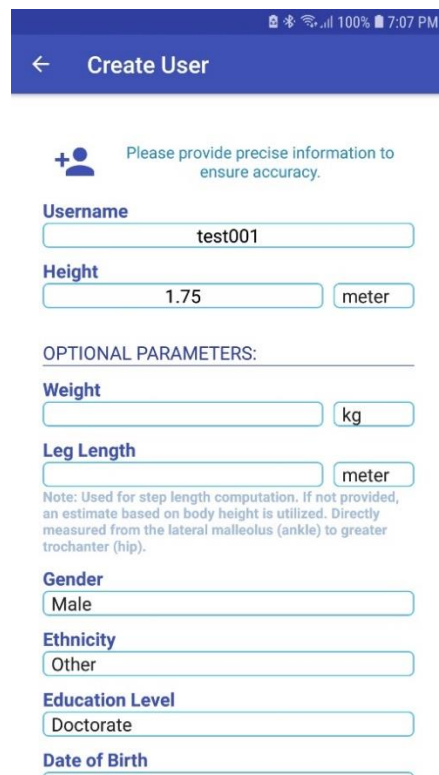
For additional information please don’t hesitate to contact us or browse our privacy policy:
<https://www.gaitanalyzer.com/privacy-policy>

i. Creating a user

Select the “create user” icon at the bottom right of the app:



Enter as much information as is available in the create user screen. Though some items are optional, additional information will allow for a more robust experience:



Click “Create” when complete:



User creation can be cancelled by clicking the back button.



In order to properly assess gait, accurate anthropometrics measures are required, specifically the person’s leg length (or height). This value can be measured as the distance from the ASIS (Anterior Superior Iliac Spine – located by palpating the hip and finding the most anterior point) to the medial malleolous (the inside portion of the ankle). If direct measurement is not possible, provide the body height, with estimations of the leg length performed by the app.

ii. Editing a user

Select the user of interest and click the “Edit User” option:



Edit fields of interest and click the “Edit” button to finish:



Editing of the user can be cancelled by clicking the back button.

iii. Deleting a user

Currently unavailable. Coming soon.

D. Recording

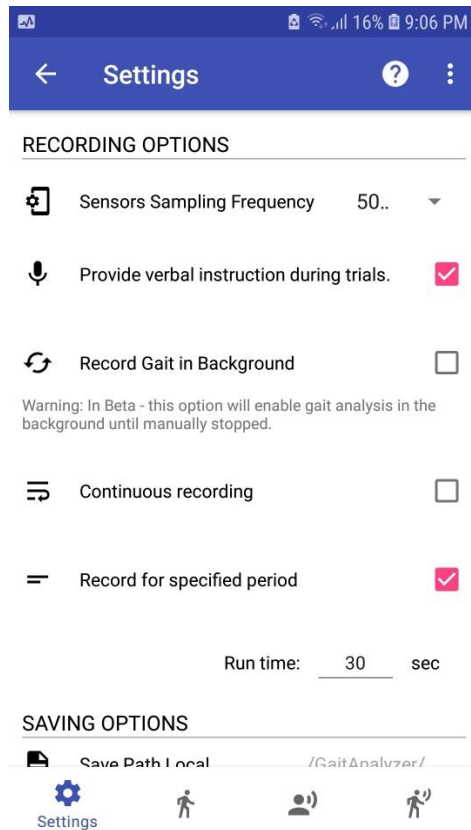
Select the user of interest and click the “Walk” icon:



At this point, you will have the option of configuring your recording settings, or selecting a recording option. Select your option by clicking on the appropriate icon at the bottom of the screen.

i. Recording and Saving Settings

Settings for gait and cognitive data collections can be configured here.



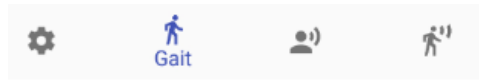
Recording options include the ability to record in the background, record until the stop button is clicked, or record until a specified period of time has passed. The “Record Gait in Background” option is only enabled for the “Single Task Gait” recording option. The sampling frequency for the sensors is set at 50Hz at default, but can be increased to the maximum value of your phone (~100Hz) or lower (5 or 15Hz – not recommended) as needed.


The “Provide verbal instructions during trials” is selected by default. When selected instructions will be announced prior to the start of each trial upon pressing the record button [see *section ii. Single Task Gait*]. A ‘trial complete’ instruction will also be played upon completion of the trial, either when the user manually presses stop (during “Continuous Recording”), or when the trial automatically stops (during “Record for specified period” option).

Saving options include the ability to save locally to a text file on your phone, to your Google Drive account, as well as the automatically saving and progressing to the next trial following completion of a recording.

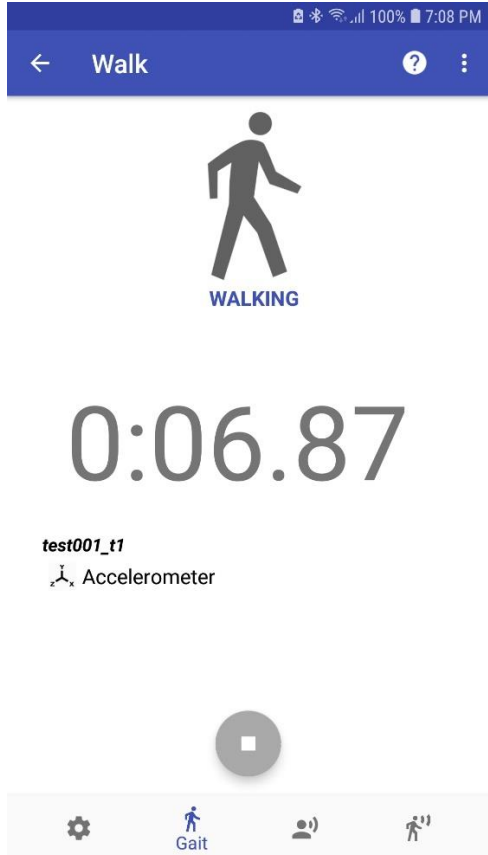


ii. Single Task Gait



Click the record button to begin: 

A timer will be displayed, with a stop button present:



If in “Continuous Recording” (or “Background Recording”) mode, click the stop button when the gait trial is complete (or when you want to stop detecting gait throughout the day). If in “Specified Period Recording” mode, the trial will stop automatically after the stated number of seconds (or click stop prior to the given seconds if wanted). Upon completion, a report will be provided with the option to save results and/or continue to the next trial.



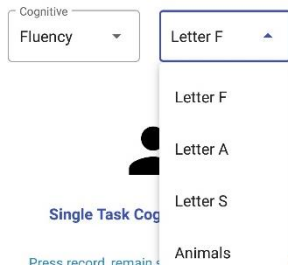
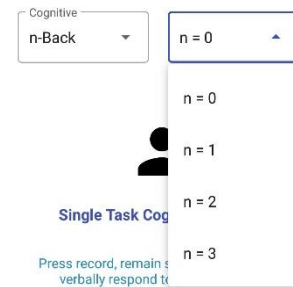
iii. Single Task Cognitive

There are currently three cognitive tasks that can be selected from the drop down window:

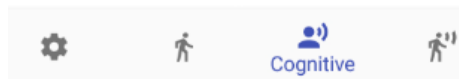


During the Stroop task you will be presented with one of four possible combinations: 1) the word “high” spoken in a *high* tone; 2) the word “high” spoken in a *low* tone; 3) the word “low” spoken in a *low* tone; and 4) the word “low” spoken in a *high* tone. The user is to verbally respond with the tone of the sound, not the word spoken.

During the n-back task, a second drop-down window will be displayed. For this task, the user needs to respond with a “yes” if the prompt they hear is identical to the prompt they heard “n” spaces back, as selected from this menu. If the value selected is “n=0”, the user needs to simply respond “yes” to every prompt.



During the fluency task, a second drop-down window will be displayed. For this task, the user needs to answer the question presented with as many responses as they can in the given trial period.



Click the record button to begin:

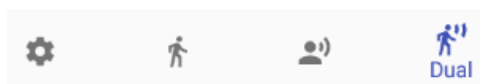


Click stop when the trial is complete:



Upon completion a report will be provided with the option to save results and/or continue to the next trial.

iv. Dual Task Gait and Cognitive





During this recording mode both the cognitive task (Stroop) and gait will be performed simultaneously.

Click the record button to begin:



Click stop when the trial is complete:



Upon completion a report will be provided with the option to save results and/or continue to the next trial.

E. Calibration

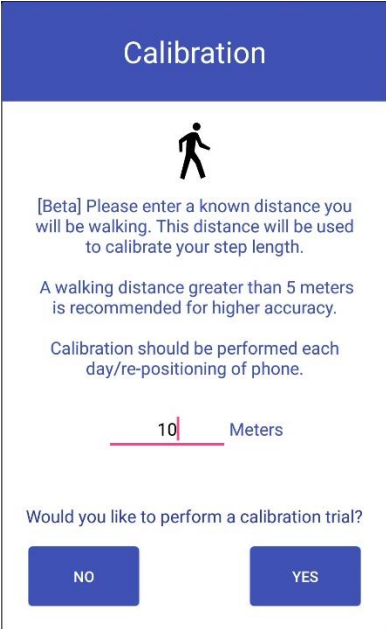
While currently in Beta testing, there is an option to perform calibration of the user's step length calculation during gait. To perform such calibration, click the "Calibration" button in the "Single Task Gait" tab:




CALIBRATION

A dialog window will be presented, with an option available for the known walking distance to be ambulated for a single trial. Upon completion of this trial, the user's "calibration constant" for step length will be used for all subsequent trials. These trials will not have to be of the same walking distance.

Note: If the phone is moved between trials, a new calibration might be necessary.



Calibration



[Beta] Please enter a known distance you will be walking. This distance will be used to calibrate your step length.

A walking distance greater than 5 meters is recommended for higher accuracy.

Calibration should be performed each day/re-positioning of phone.

10 Meters

Would you like to perform a calibration trial?

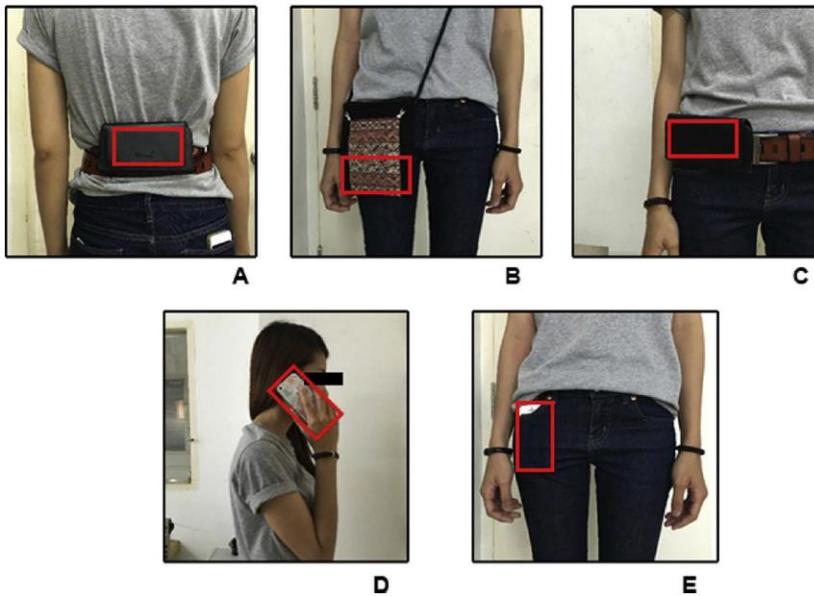
NO YES



F. Phone placement

During gait analysis trials, the location of the phone can play a vital role in the quality of data obtained. Validity tests have been performed when the phone is placed at five locations: 1) on the body at the location of lumbar L3-L5; 2) on a belt clip at the hip; 3) in a shoulder bag; 4) in a pants pocket; and 5) in the hand. While the orientation of the phone is not a factor, the body, belt, and bag locations have demonstrated greater validity and reliability than the hand and pocket locations, especially for the spatial measures including step length and gait velocity. Step time and cadence have shown high validity across all locations. For more information refer to the following peer-reviewed publication:

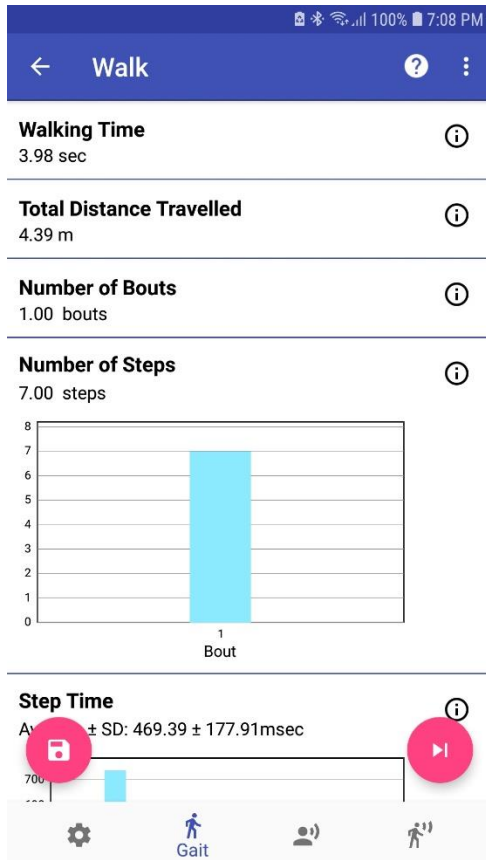
<https://www.ncbi.nlm.nih.gov/pubmed/28961548/>





G. Saving

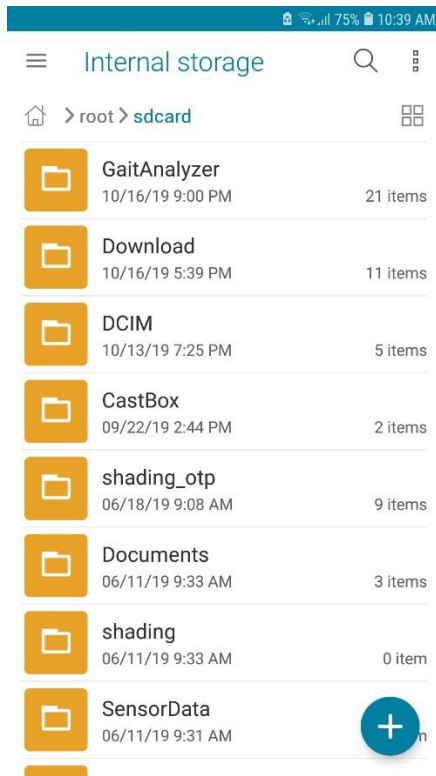
Upon completion (after the recording is stopped), you will be presented with computed gait and/or cognitive performance for the given trial:



Currently, you are able to save computed gait and cognitive data to the phone locally as a tab-delimited txt file or to Google Drive (requires internet connectivity), by clicking on the save icon at the bottom left. Additionally, data is saved to the app’s local database, to be browsed and analyzed further as required

i. Saving locally

Ensure the “Save Data Locally” option is selected in the settings tab. Data will be saved to your /GaitAnalyzer/ folder on the phone. To find your outcome file(s) consider installing a file manager app on your phone if you do not already have one:



ii. Saving to Google Drive

Ensure “Save to Google Drive” is selected on your phone. The first time clicking save, you will be prompted to choose your Google account to use. All data will be saved into a Google Drive titled “GaitAnalyzer”.

iii. Saving to Personal Pre-defined Database

Currently unavailable. Coming soon.

iv. Don't save

If you would like to continue to the next trial, click the next trial button:



H. Reviewing Data

In the user select screen, select the user of interest and click the “View Data” button:



Data recorded and saved across each visit or date is viewable:



test_vlugade
 Gender: Null
 Race: Null
 Education level: Null
 DOB: null
 Study:
 Diagnoses: null

GAIT DATA

| | Date | Condition | Cognitive Task | Num Bouts |
|---|-------------|-----------|----------------|-----------|
| 1 | 05-Mar-2020 | 🚶 | | 27 |
| 2 | 01-Dec-2020 | 🚶 | | 1 |
| 3 | 17-Dec-2020 | 🚶 | | 1 |

COGNITIVE DATA

| | Date | Condition | Cognitive Task | Num Bouts |
|---|-------------|-----------|----------------|-----------|
| 1 | 10-Feb-2020 | 👤 | Stroop | 1 |
| 2 | 12-Nov-2020 | 👤 | Stroop | 1 |
| 3 | 11-Dec-2020 | 👤 | Fluency | 1 |
| 4 | 14-Dec-2020 | 👤 | Fluency | |
| 5 | 17-Dec-2020 | 👤 | Fluency | |

TABULAR GRAPHICAL

Single Task Dual Task

Gait Variable
 Num Steps

Cognitive Task
 Stroop

Cognitive Variable
 Reaction Time

TABULAR GRAPHICAL

Switch between “Table – Tabular” and “Graph – Graphical” modes using the tabs at the bottom of the screen.

In the “Graphical” mode, you can update graphs depending on whether you select “single task” and/or “dual task” conditions.

Graphs of gait outcome variables and cognitive outcome variables can be generated by selecting the appropriate options from the drop down menus provided.

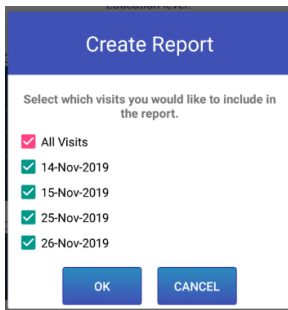
More variables and comparison options will be added in the future.

I. Generate User Reports

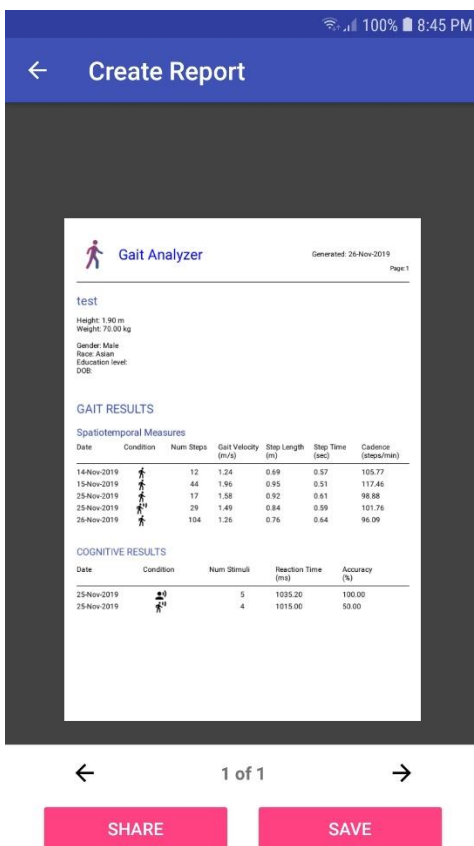
A .pdf file can be generated describing all gait spatiotemporal and cognitive data recorded and computed in prior visits. In order to generate such a file click on the “create report” button:



Select the visits you would like to include in the report from the dialog box:



At least one visit needs to be selected for this function to work. Click “OK” to proceed. A pdf file will be generated as shown here:



This pdf file can be saved locally by clicking “save”, or shared via email or social media by clicking the “share” button.

J. Coming Soon

- Deleting users/visits/trials.
- Additional cognitive tasks.
- Saving data to a custom user-defined database.



- Comparing user data versus age-, gender-, anthropometric-, other- matched users.
- Graphical visualization of outcome data.
- Other options? Contact us and we will be happy to accommodate interesting suggestions.

K. Validation

Parameters validated include: Gait spatiotemporal measures, the vertical displacement of the center of mass, and step symmetry.

Phone locations include the body, belt, bag, pocket, and hand.

Environments include the laboratory setting, in the home, and in the free-living environment.

Surfaces include level walkways, uneven walkways, and obstacles.

Walking conditions include gait speed modulation (slow to fast, fast to slow, usual to fast, usual to slow), 90-degree turns, and level walking. While slow conditions < 0.5 m/s demonstrate reduced validity, other conditions were both reliable and valid.

Continued testing is being performed. For additional information, please refer to the following publications:

<https://www.ncbi.nlm.nih.gov/pubmed/28961548/>

<https://www.ncbi.nlm.nih.gov/pubmed/30445278/>

<https://www.ncbi.nlm.nih.gov/pubmed/31198074/>

<https://www.ncbi.nlm.nih.gov/pubmed/31329138/>

<https://www.ncbi.nlm.nih.gov/pubmed/31342939/>

L. Troubleshooting

While all attempts to remove errors/bugs have been made, some might have slipped our notice. If you happen to see an error, please let us know, and we will attempt a hotfix ASAP. A pop-up window with the option to email us should be presented on any application error.

In case of error, please close other applications, and restart the Gait Analyzer app.

M. Current Research Projects

- A joint project with UC-Denver to evaluate gait and cognitive performance in adolescent youth having a mild traumatic brain injury.



Gait Analyzer – User Guide

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<https://www.gaitanalyzer.com>

GaitAnalyzerHelp@gmail.com

- A joint project with UN-Reno to evaluate gait performance in participants with facioscapulohumeral dystrophy (FSHD).
- To evaluate gait in the home-based environment over a 4-day period among elderly fallers.
- Evaluation of gait strategies in healthy young and older adults in the free-living and laboratory-based environments.