Mobility Lab provides sensitive, valid and reliable outcome measures.

Using APDM’s advanced wearable sensors, Opals, Mobility Lab makes it easy to collect, analyze, and store outcome measures. Attach sensors to your subject and instruct them to perform a standardized test. A report is then automatically generated to compare against normative values. This process takes less than five minutes.

### What Can You Measure?

**GAIT**

<table>
<thead>
<tr>
<th>Lower Limb</th>
<th>Upper Limb</th>
</tr>
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<tbody>
<tr>
<td>Cadence</td>
<td>Arm Swing Velocity</td>
</tr>
<tr>
<td>Foot Clearance</td>
<td>Arm Range of Motion</td>
</tr>
<tr>
<td>Gait Cycle Duration</td>
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<tr>
<td>Gait Speed</td>
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<tr>
<td>Double Support</td>
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<tr>
<td>Terminal Double Support</td>
<td>Anticipatory Postural Adjustment</td>
</tr>
<tr>
<td>Lateral Step Variability</td>
<td>APA Duration</td>
</tr>
<tr>
<td>Circumduction</td>
<td>First Step Duration</td>
</tr>
<tr>
<td>Dorsiflexion</td>
<td>First Step Range of Motion</td>
</tr>
<tr>
<td>Plantarflexion</td>
<td>Sagittal APA Peak</td>
</tr>
<tr>
<td>Stance</td>
<td>Coronal APA Peak</td>
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<tr>
<td>Step Duration</td>
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<tr>
<td>Stride Length</td>
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<tr>
<td>Swing</td>
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<tr>
<td>Toe Out Angle</td>
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<tr>
<td>Stride Length Variability</td>
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**BALANCE**

<table>
<thead>
<tr>
<th>Trunk</th>
<th>Sit to Stand</th>
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<tbody>
<tr>
<td>Coronal Range of Motion</td>
<td>Lean Angle</td>
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<tr>
<td>Sagittal Range of Motion</td>
<td>Duration</td>
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<tr>
<td>Transverse Range of Motion</td>
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</table>

<table>
<thead>
<tr>
<th>Lumbar</th>
<th>Stand to Sit</th>
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<tbody>
<tr>
<td>Coronal Range of Motion</td>
<td>Lean Angle</td>
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<tr>
<td>Sagittal Range of Motion</td>
<td>Duration</td>
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<tr>
<td>Transverse Range of Motion</td>
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</tbody>
</table>

<table>
<thead>
<tr>
<th>Postural Sway</th>
<th>Turning</th>
</tr>
</thead>
<tbody>
<tr>
<td>95% Ellipse Sway Area</td>
<td>Angle</td>
</tr>
<tr>
<td>RMS Sway</td>
<td>Duration</td>
</tr>
<tr>
<td>Centroidal Frequency</td>
<td>Turn Velocity</td>
</tr>
<tr>
<td>Frequency Dispersion</td>
<td>Steps in Turn</td>
</tr>
<tr>
<td>Jerk</td>
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<tr>
<td>Mean Velocity</td>
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<tr>
<td>Path Length</td>
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<tr>
<td>Range</td>
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</table>
With hundreds of universities and hospitals using this system worldwide, Mobility Lab is the most trusted wearable gait and balance system on the market.
PORTABLE
Set up in any location with our lightweight, wireless system

RELIABLE
Numerous clinical studies have proven high test-retest reliability

SENSITIVE
Accurately measure minimally detectable changes

VALID
Algorithms validated against gold standard motion capture systems
MEASURE OBJECTIVELY
Easily interpret data compared to normative values

JUSTIFY TREATMENT
Precisely see asymmetries and improvement over time

INCREASE REFERRALS
Provide cutting-edge analysis for visible results

REDUCE COSTS
Save time with automatic data interpretation and reports
## Lower Limb

<table>
<thead>
<tr>
<th>Term</th>
<th>Definition</th>
</tr>
</thead>
<tbody>
<tr>
<td>Cadence</td>
<td>The number of steps per minute, counting steps made by both feet</td>
</tr>
<tr>
<td>Gait Cycle Duration</td>
<td>The duration of a full gait cycle, measured from the left foot's initial contact to the next initial contact of the left foot</td>
</tr>
<tr>
<td>Gait Speed</td>
<td>The forward speed of the subject, measured as the forward distance traveled during the gait cycle divided by the gait cycle duration</td>
</tr>
<tr>
<td>Foot Clearance</td>
<td>The height of the foot sensor measured at midswing, relative to its start position while standing</td>
</tr>
<tr>
<td>Double Support</td>
<td>The percentage of the gait cycle in which both feet are on the ground</td>
</tr>
<tr>
<td>Lateral Step Variability</td>
<td>In a series of 3 consecutive foot placements of the same foot, the variability of perpendicular deviations of the middle foot placement from the line connecting the first and third</td>
</tr>
<tr>
<td>Circumduction</td>
<td>The amount that the foot travels perpendicular to forward movement while swinging forward during an individual stride</td>
</tr>
<tr>
<td>Foot Strike Angle</td>
<td>The angle of the foot at the point of initial contact. The pitch of the foot when flat is zero and positive when the heel contacts first.</td>
</tr>
<tr>
<td>Toe Off Angle</td>
<td>The angle of the foot as it leaves the floor at push-off. The pitch of the foot when flat is zero.</td>
</tr>
<tr>
<td>Stance</td>
<td>The percentage of the gait cycle in which the foot is on the ground</td>
</tr>
<tr>
<td>Step Duration</td>
<td>The duration of a step, measured as the period from initial contact of one foot to the next initial contact of the opposite foot</td>
</tr>
<tr>
<td>Stride Length</td>
<td>The forward distance travelled by a foot during a gait cycle</td>
</tr>
<tr>
<td>Swing</td>
<td>The percentage of the gait cycle in which the foot is not on the ground</td>
</tr>
<tr>
<td>Toe Out Angle</td>
<td>The lateral angle of the foot during the stance phase, relative to the forward motion of the gait cycle. Positive angle is outward rotation.</td>
</tr>
</tbody>
</table>

## Upper Limb

<table>
<thead>
<tr>
<th>Term</th>
<th>Definition</th>
</tr>
</thead>
<tbody>
<tr>
<td>Arm Swing Velocity</td>
<td>The maximum rotational velocity of the arm swing</td>
</tr>
<tr>
<td>Arm Swing Range of Motion</td>
<td>The angular range of the arm swing</td>
</tr>
</tbody>
</table>

## Trunk Range of Motion

<table>
<thead>
<tr>
<th>Plane</th>
<th>Definition</th>
</tr>
</thead>
<tbody>
<tr>
<td>Coronal</td>
<td>The angular range of the thoracic spine in the coronal plane (roll)</td>
</tr>
<tr>
<td>Sagittal</td>
<td>The angular range of the thoracic spine in the sagittal plane (pitch)</td>
</tr>
<tr>
<td>Transverse</td>
<td>The angular range of the thoracic spine in the transverse plane (yaw)</td>
</tr>
</tbody>
</table>

## Lumbar Range of Motion

<table>
<thead>
<tr>
<th>Plane</th>
<th>Definition</th>
</tr>
</thead>
<tbody>
<tr>
<td>Coronal</td>
<td>The angular range of the lumbar spine in the coronal plane (roll)</td>
</tr>
<tr>
<td>Sagittal</td>
<td>The angular range of the lumbar spine in the sagittal plane (pitch)</td>
</tr>
<tr>
<td>Transverse</td>
<td>The angular range of the lumbar spine in the transverse plane (yaw)</td>
</tr>
</tbody>
</table>

## Sit To Stand

<table>
<thead>
<tr>
<th>Term</th>
<th>Definition</th>
</tr>
</thead>
<tbody>
<tr>
<td>Duration</td>
<td>The duration of the sit to stand transition</td>
</tr>
<tr>
<td>Lean Angle</td>
<td>The angular range of motion of the trunk during the sit to stand transition</td>
</tr>
</tbody>
</table>

## Stand To Sit

<table>
<thead>
<tr>
<th>Term</th>
<th>Definition</th>
</tr>
</thead>
<tbody>
<tr>
<td>Duration</td>
<td>The duration of the stand to sit transition</td>
</tr>
<tr>
<td>Lean Angle</td>
<td>The angular range of motion of the trunk during the stand to sit transition</td>
</tr>
</tbody>
</table>

## Turning

<table>
<thead>
<tr>
<th>Term</th>
<th>Definition</th>
</tr>
</thead>
<tbody>
<tr>
<td>Angle</td>
<td>The rotational angle of the turn</td>
</tr>
<tr>
<td>Duration</td>
<td>The duration of the turn</td>
</tr>
<tr>
<td>Velocity</td>
<td>The peak angular velocity of the turn</td>
</tr>
</tbody>
</table>

## Postural Sway

<table>
<thead>
<tr>
<th>Term</th>
<th>Definition</th>
</tr>
</thead>
<tbody>
<tr>
<td>Sway Area</td>
<td>The area of an ellipse covering 95% of the sway angle in both the coronal and sagittal planes</td>
</tr>
<tr>
<td>RMS Sway</td>
<td>The root mean square (RMS) of the sway angle in both the coronal and sagittal planes</td>
</tr>
<tr>
<td>Coronal RMS Sway</td>
<td>The root mean square (RMS) of the sway angle in the coronal plane</td>
</tr>
<tr>
<td>Sagittal RMS Sway</td>
<td>The root mean square (RMS) of the sway angle in the sagittal plane</td>
</tr>
</tbody>
</table>

## Anticipatory Postural Adjustment

<table>
<thead>
<tr>
<th>Term</th>
<th>Definition</th>
</tr>
</thead>
<tbody>
<tr>
<td>Duration</td>
<td>The duration of the period starting from the first measurable change of the lateral lumbar acceleration from baseline, to the return to baseline</td>
</tr>
<tr>
<td>First Step Duration</td>
<td>The duration of the period spanning from the end of the APA to the initial contact of the first step</td>
</tr>
<tr>
<td>First Step Range of Motion</td>
<td>The integrated angular velocity of the stepping foot from the end of the APA to the initial contact of the step</td>
</tr>
<tr>
<td>Forward APA Peak</td>
<td>The peak forward lumbar acceleration during the APA</td>
</tr>
<tr>
<td>Lateral APA Peak</td>
<td>The peak lateral lumbar acceleration during the APA</td>
</tr>
</tbody>
</table>
• McConnell & Silverman. “Comparing Usability and Variance of Low and High Technology Approaches to Gait Analysis in Healthy Adults.” University of Nevada. 2015
• Mancini, et al. “Continuous Monitoring of Turning in Parkinson’s Disease: Rehabilitation Potential.” NeuroRehabilitation. 2015
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• Martori. “A Wearable Motion Analysis System to Evaluate Gait Deviations.” University of South Florida. 2013


• Beach. “Effect of Compliant Flooring on Postural Stability in an Older Adult Population and in Individuals with Parkinson’s Disease.” University of Dayton. 2013.


• Simoes. “Feasibility of Wearable Sensors to Determine Gait Parameters.” University of South Florida. 2011
## GAIT CYCLE ANALYSIS

1. **GAIT CYCLE ANALYSIS**
   - Stance
   - Swing
   - Gait Cycle Duration
   - Gait Speed
   - Double Support
   - Spatial Analysis
     - Cadence
     - Step Duration
     - Stride Velocity
     - Stride Length
     - Toe Out Angle
   - Lateral Step Variability
   - Circumduction
     - Lateral Swing Max
   - Clearance
   - Heel Pitch
   - Toe Pitch
   - Arm Range Of Motion
     - Arm Swing Velocity

## MOBILITY LAB TEST MEASURES

4. **MOBILITY LAB TEST MEASURES**
   - Walk Test
   - Stand and Walk Test (SAW)
   - Timed Up and Go Test (TUG)
   - Postural Sway Test
   - mCTSIB Test
   - BESS Test
   - mBESS Test
   - 360º Turn Test
   - 5x Sit To Stand

## POSTURAL MEASURES

8. **POSTURAL MEASURES**
   - Turning Analysis
     - Turn Angle
     - Turn Duration
     - Turn Velocity
   - Sit To Stand Analysis
     - Lean Angle
     - Duration
   - Turn To Sit Analysis
     - Turn duration
     - Turn Velocity
   - Trunk Range Of Motion

## POSTURAL SWAY MEASURES

10. **POSTURAL SWAY MEASURES**
   - Postural Sway
     - 95% Ellipse Sway Area
     - 95% Ellipse Rotation
     - RMS Sway
     - Mean Velocity

## MOBILITY LAB FOOTPLATE TESTS

11. **MOBILITY LAB FOOTPLATE TESTS**

12. **TESTS**
GAIT CYCLE ANALYSIS

- 0%: Right Initial Contact
- 10%: Left Toe Off
- 20%: Left Initial Contact
- 30%: Right Toe Off
- 40%: Right Initial Contact
- 50%: Left Initial Contact
- 60%: Right Toe Off
- 70%: Left Initial Contact
- 80%: Right Initial Contact
- 90%: Left Initial Contact
- 100%: Right Initial Contact

- Stance (R)
- Swing (R)
- Swing (L)
- Stance (L)
- Double Support
- Single Limb Support (R)
- Double Support
- Single Limb Support (L)
- Step Duration (L)
- Step Duration (R)
- Stride Length (R)
SENSOR CONFIGURATIONS AND MEASURES

BALANCE
1 OPAL

BALANCE, LOWER LIMB GAIT, TURNING
3 OPALS

BALANCE, LOWER LIMB GAIT, UPPER LIMB GAIT, TURNING, SIT TO STAND
6 OPALS
## MOBILITY LAB TEST MEASURES

<table>
<thead>
<tr>
<th>TESTS</th>
<th>Lower Limb</th>
<th>Upper Limb</th>
<th>Trunk Range of Motion</th>
<th>Lumbar Range of Motion</th>
<th>Sit To Stand</th>
<th>Stand To Sit</th>
<th>Turning</th>
<th>Postural Sway</th>
<th>Anticipatory Postural Adjustment</th>
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</table>

### Lower Limb

- Cadence
- Gait Cycle Duration
- Gait Speed
- Elevation at Midswing
- Double Support
- Lateral Step Variability
- Circumduction
- Foot Strike Angle
- Toe Off Angle
- Stance
- Step Duration
- Stride Length
- Swing
- Toe Out Angle

### Upper Limb

- Maximum Velocity
- Range of Motion

### Trunk Range of Motion

- Coronal
- Sagittal
- Transverse

### Lumbar Range of Motion

- Coronal
- Sagittal
- Transverse

### Sit To Stand

- Duration
- Lean Angle

### Stand To Sit

- Duration
- Lean Angle

### Turning

- Angle
- Duration
- Velocity
- Steps in Turn

### Postural Sway

- 95% Ellipse Sway Area
- RMS Sway
- Coronal RMS Sway
- Sagittal RMS Sway

### Anticipatory Postural Adjustment

- Duration
- First Step Duration
- First Step Range of Motion
- Sagittal Max Acceleration
- Coronal Max Acceleration

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APDM, Inc. • 2828 SW Corbett Avenue • Portland, OR 97201
Phone: 888-988-APDM (2736) • Fax: 888-371-8370 • www.apdm.com • support@apdm.com
Gait measures are detected, analyzed, and averaged over the extent of the walking duration of the subject. All measures are assessed for asymmetry and variability.
Postural measures are detected, analyzed, and averaged over the extent of the walking duration of the subject.

**TURNING ANALYSIS**

- **Turn Angle**
- **Turn Duration**
- **Turn Velocity**

**SIT TO STAND ANALYSIS**

- **Lean Angle**
- **Duration**
TURN TO SIT ANALYSIS

Turn Duration
seconds

Turn Velocity
deg/s

Sagittal Range of Motion
degrees

Transverse Range of Motion
degrees

Coronal Range of Motion
degrees

TRUNK RANGE OF MOTION
POSTURAL SWAY MEASURES

All postural sway measures are assessed using the Opal movement sensor placed on a subject’s lumbar. All metrics are reported in Coronal, Sagittal and Transverse planes.
The Mobility Lab Footplate is designed to standardize stance width for each Mobility Lab test. All norms are derived from subjects using the standardized stance width measured by the Footplate unless otherwise noted in the test instructions. Standard instructions for some tests instruct the subject stand with their feet together to induce instability, but research has shown that using Mobility Lab with a wider stance is equally as sensitive and puts the subject at less of a risk of falling during the tests.
The Walk test is the most comprehensive test to measure a subject’s gait. We recommend that your subject walks for at least 2 minutes in order to collect a sufficient amount of gait cycles to accurately measure variability and asymmetry.

**TEST MEASURES:**
Full body gait (legs, arms, and trunk), asymmetry, variability, turning, and anticipatory postural adjustments

**NUMBER OF SENSORS:** 3 or 6

**SETUP:**
1. Walking corridor must be at least 7 meters in length

**PROTOCOL:**
1. Select Walk and press start trial.
2. Subject should stand comfortably and wait for instruction to begin walking.
3. When the subject is ready, press record and instruct the subject to walk.
4. The subject can walk freely in a straight path and perform 180 degree turns when necessary.
5. Terminate the trial at any point.

**NORMATIVE VALUES:**
Normative values were collected using a 2 minute walk in a corridor 7 meters or longer with 180 degree turns at both ends.
The Stand and Walk (SAW) test allows clinicians and nonexperts to quickly obtain objective measures of standing balance, step-initiation, gait, and turning.

TEST MEASURES:
Full body gait (legs, arms, and trunk), asymmetry, variability, turning, postural stability, and anticipatory postural adjustments

NUMBER OF SENSORS: 3 or 6

SETUP:
1. Walking corridor must be 7 meters in length

PROTOCOL:
1. Select SAW and press start trial.
2. When the subject is ready, press record and instruct the subject to stand quietly for 30 seconds.
3. Instruct the subject to walk 7 meters, turn around, and return to the starting point.

NORMATIVE VALUES:
Normative values were collected using the protocol listed above.
Timed Up and Go (TUG) is a common test to assess a subject’s mobility. APDM has made it more valuable by giving you the ability to precisely measure all of the components of mobility, rather than just duration.

**TEST MEASURES:**
Postural transitions (sit, stand, and turning)

**NUMBER OF SENSORS:** 3 or 6

**SETUP:**
1. Measure 3 meters, placing tape at the two ends.
2. Place an armless chair at the start before the tape.

**PROTOCOL:**
1. Select TUG and press start test.
2. Subject should sit comfortably in the chair with their arms on their legs, and back against the seat.
3. When the subject is ready, press record and the test will begin to count down from 3 seconds.
4. The subject should rise from the chair without using their arms and begin walking.
   If the subject is unable to rise from the chair with arms, reset the test and allow them to use their arms to stand.
5. After the subject walks passed the 3m end tape, they should turn 180 degrees and walk back.
6. Once they arrive at the chair they should turn 180 degrees, and sit down.
7. Terminate the trial when the subject rests their back against the back of the seat.

**NORMATIVE VALUES:**
Normative values were collected using the protocol listed above.
POSTURAL SWAY

The instrumented Postural Sway (Sway) test is a common test of quiet stance balance. It is a very simple test comprising of only one sensor on the lumbar. The test takes only 30 seconds to administer.

TEST MEASURES:
Postural sway

NUMBER OF SENSORS: 1 or 3 or 6

SETUP:
1. Have the subject fit their feet around the foot template provided with the Mobility Lab system (to normalize foot placement).

PROTOCOL:
1. Select Sway and press start test.
2. Subject should stand comfortably with their hands at their side or across their chest.
3. Press start and wait for the test to count down from 30 seconds.

NORMATIVE VALUES:
Normative values were collected with eyes open on a hard surface with arms crossed.
mCTSIB

The modified Clinical Test of Sensory Interaction and Balance (mCTSIB) is a composite test to assess a subject’s balance under different test conditions.

TEST MEASURES:
Postural sway, visual dependence, proprioceptive dependence, and vestibular loss

NUMBER OF SENSORS: 1 or 3 or 6

PROTOCOL:
1. Select CTSIB and press start test.
2. Subject should stand comfortably with their feet together and hands at their side.
3. Follow the conditions outlined in the test description.
4. Press start and wait for the test to count down from 30 seconds. Move on to the next test condition.

TEST CONDITIONS:
1. Eyes Open, Firm Surface
2. Eyes Closed, Firm Surface
3. Eyes Open, Foam Surface
4. Eyes Closed, Foam Surface

NORMATIVE VALUES:
Normative values were collected following the protocol listed above.
The modified Balance Error Scoring System (mBESS) test is a shortened version of the BESS test. It is a measure of assessing static postural stability, designed for the mild head injury population, and to assist in return to sports play decisions.

**TEST MEASURES:**
Postural stability in varying conditions

**NUMBER OF SENSORS:** 1 or 3 or 6

**SETUP:**
1. Have the subject fit their feet around the foot template provided with the Mobility Lab system (to normalize foot placement).

**PROTOCOL:**
1. Select mBESS and press start test.
2. Subject should stand according to the test condition with their hands on their hips, and their eyes closed.
3. Follow the conditions outlined in the test description.
4. Press start and wait for the test to count down from 30 seconds. Move on to the next test condition.

**TEST CONDITIONS:**
1. Eyes Closed, Double Support, Hard Surface
2. Eyes Closed, One Leg, Hard Surface
3. Eyes Closed, Tandem Stance, Hard Surface

**NORMATIVE VALUES:**
Normative values were collected following the protocol listed above.
360° TURN

The 360 degree Turn Test is a measure of dynamic balance. The subject turns in a complete circle (360 degrees) while time to complete and/or number of steps to complete the turn are recorded.

TEST MEASURES:
Turn velocity, time, number of steps

NUMBER OF SENSORS: 1 or 3 or 6

SETUP:
1. Place a piece of masking tape on the floor to mark the start/stop position. Have the subject fit their feet around the foot template provided with the Mobility Lab system (to normalize foot placement).

PROTOCOL:
1. Select 360° Turn and press start test.
2. Subject should stand with their toes aligned with the tape.
3. Press start and wait for the subject to complete a full turn. Press stop when the subject’s shoulders are back in the start position.

NORMATIVE VALUES:
Normative values were collected following the protocol listed above.
The 5 Times Sit to Stand (5xSTS) test is a measure of functional lower limb muscle strength. It is useful in quantifying functional change of transitional movements.

TEST MEASURES:
Lean angle, duration

NUMBER OF SENSORS: 1 or 3 or 6

SETUP:
1. It is preferable to use a chair with no armrests, to ensure that subjects stand without assistance.

PROTOCOL:
1. Select 5x Sit to Stand and press start test.
2. Subject should sit with their back against the back of the chair.
3. Press start and wait for the subject to stand up completely, then return to the sitting position. Press stop when the subject has returned to the sitting position the 5th time.

NORMATIVE VALUES:
Normative values were collected following the protocol listed above.