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## Equidyn application tutorial

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**We use this protocol and it's working**

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**Keywords:** Dynamic balance , Evaluation protocol , Unipedal stance , leg motionless balance, same leg movement amplitude across participant, leg sway task, same leg movement amplitude, ap oscillation of the right leg, dynamic balance through smartphone, ml oscillation of the right leg, based trunk accelerometry, oscillation of the left leg, trunk accelerometry, standardized movement amplitude, movement amplitude, bipedal support, equidyn application, dynamic balance, supporting foot, right leg, left leg, movement, smartphone application, acceleration in the ap, standing phase, ap oscillation, acceleration, oscillation, smartphone, support base

## Abstract

The Equidyn application was developed to evaluate dynamic balance through smartphone-based trunk accelerometry. The evaluation protocol had as main characteristic a reduced support base while having standardized movement amplitude and rhythm. The evaluation protocol was composed of a series of seven tasks: 1. One-leg motionless balance supported on the right leg, 2. One-leg motionless balance supported on the left leg, 3. Anteroposterior (AP) oscillation of the left leg while supported on the right leg, 4. AP oscillation of the right leg while supported on the left leg, 5. Mediolateral (ML) oscillation of the left leg while supported on the right leg, 6. ML oscillation of the right leg while supported on the left leg, 7. Sit-to-stand with bipedal support. Markers were made through adhesive strips, attached 20-cm apart in parallel on the ground. Proximal markers were used as reference for positioning the supporting foot, while the distal AP marker was attached in front of the participant, and the distal ML marker was attached laterally regarding participant's spatial orientation. These markers were used to achieve the same leg movement amplitude across participants. The dynamic tasks were paced through beeps emitted by a digital metronome set at the frequency of 1-Hz. Each marker touching in the leg sway tasks, and either sitting or full standing phases of the sit-to-stand task were to be timed with metronome beeps. Tasks were assessed through three consecutive trials, lasting 15 s each. Intratest between-trial rest intervals were 30-s long, while 60-s intervals were provided between tests. The complete assessment lasted approximately 20 min. Participants' responses are administered through a smartphone application named Equidyn, designed and developed for the Android system. The root mean square (RMS) of acceleration in the AP and ML directions was analyzed in each task.

## Guidelines

To start the tests, participants must already have their personal data registered, and the smartphone must be firmly attached to their back, centered at the height of the thoracic spine (T10-T12), having as the anterior reference the xiphoid process. The application will provide voice instructions throughout the evaluation, indicating the test to be performed and the leg to be tested in the ensuing trial.

During performance of the dynamic tests, leg movements will be paced through beeps emitted by the application at a frequency of 1 per second (1 Hz). Trials endure 15 seconds each, with times for initiation and end indicated by the application. For each test, the participant will perform a series of three trials, with interatrial intervals of 30 seconds. Transitions between the tests have longer intervals of 1 minute.

**Test 1: One-leg motionless balance supported on the right leg.** Instruct the participant to keep as motionless as possible while supported exclusively on the right leg. The posture of the left leg should be knee flexed keep the left foot suspended over the ground by about 10-15 centimeters. Both arms should be kept hanging relaxed beside the trunk. Provide a spot 2-3 meters in front of the participant, about the eyes' height, to be gazed during this and the following tests.

**Test 2: One-leg motionless balance supported on the left leg.** Same procedures and instructions of the previous test, inverting the relationship between the legs.

**Test 3: Anteroposterior oscillation of the left leg while supported on the right leg.** To perform this test, use the first markers attached to the ground, in parallel with the participant frontal plane. The participant will support the right leg on the ground so that the big toe tip of the right foot is aligned with the right end of the proximal marker. As initial position, the participant supports the body on the right leg while maintaining a light touch on the proximal marker with the left leg. During the test, the participant is to maintain body stability on the right leg while making left-footed rhythmic sway movements in the anteroposterior direction, touching alternately the proximal and distal markers on the ground. Left leg movement rhythm will be paced by means of beeps emitted by the application, trying to touch each marker simultaneously with beep emission. Provide instruction that the markers should be touched gently with the big toe rather than supporting body weight on the moving left leg.

**Test 4: Anteroposterior oscillation of the right leg while supported on the left leg.** Same procedures and instructions of the previous test, inverting the relationship between the legs.

**Test 5: Mediolateral oscillation of the left leg while supported on the right leg.** To perform this test, use the second set of markers attached to the ground, in parallel with the participant sagittal plane. As initial position, the participant supports the body on the right leg positioning the right foot near and rightward to the right-sided marker. During the test, the participant is to maintain body stability on the right leg while making left-footed rhythmic sway movements in the mediolateral direction, touching alternately the left- and right-sided markers on the ground. Other details are the same as for the Test 3.

**Test 6: Mediolateral oscillation of the right leg while supported on the left leg.** Same procedures and instructions of the previous test, inverting the relationship between the legs.



**Test 7: Sit-to-stand with bipedal support.** This test starts with the participant sat on a regular height chair without armrests. It consists of standing up and sitting down cyclically. Each full standing and sitting movement is to be timed with a beep. To increase the demand for body balance by reducing the support area, this test should be done with both feet in parallel touching each other. The trunk should be held predominantly in the vertical orientation. Allow participants to make small arm movements during the test (observation: exaggerated arm movements could perturb balance). Instruct the participant to make the standing up and sitting down movements continuously.

## Materials

The whole evaluation protocol was administered through a smartphone application named Equidyn, designed and developed for the Android system.

## Troubleshooting

## Safety warnings

- ! We recommend that the professional be close to the evaluated person during all tests for the prevention of falls and, if it is not possible to anticipate the fall, that the professional be ready to provide the necessary assistance.



## Before start

**Preparation:** The participant should be barefoot on a firm support base without socks, preventing a malleable or slippery contact surface with the ground. Establish a point for visual fixation (it could be a marker on a wall), 2-3 meters away in front and at the height of the participant's eyes.

For two tests, markers on the ground (with adhesive tape) will be needed as references for leg movement amplitude. Then, prepare the place for data collection before starting the evaluation.

Make the spatial markers by attaching two strips of tape (approximately 15 cm long each) 20 centimeters apart in parallel on the ground. These markers will be used to evaluate either leg in the anteroposterior leg oscillation test. For mediolateral leg oscillation test, attach other markers on the ground with two strips of tape oriented perpendicular to the first ones. These markers must also be parallel 20 centimeters apart.

**Familiarization:** Before starting the effective assessment, simulates the tests with the participant so that he/she becomes acquainted with the specific procedures of each test.

Keep the smartphone sound volume aloud to allow the participant to hear clearly the beeps and instructions issued by the application.

## 1 The purpose

The Equidyn application was developed to evaluate dynamic balance through smartphone-based trunk accelerometry. The purpose of the Equidyn application is to guide the assessment of dynamic body balance in a series of probing tasks while measuring trunk accelerometry as an index of body balance stability.

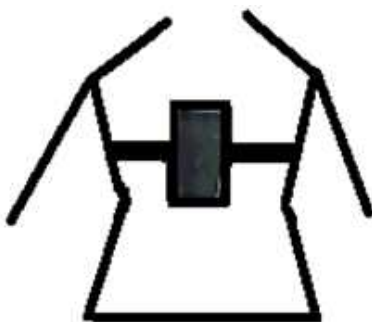
## 2 Preparation

The evaluation protocol is administered through a smartphone application named Equidyn, designed and developed for the Android system. The functions of this application are described below.

*Personal data.* Upon completing all fields personal data, the function of collection of balance data will be enabled. Fill in with "0" the fields that the participant is unable to inform.

*How to evaluate.* This function presents the tests of the balance evaluation protocol and how to use Equidyn to perform this evaluation. Smartphone devices have an embedded triaxial accelerometer, which will be used to assess trunk stability in tasks involving body balance. The evaluation will be done predominantly in unipodal support, alternating evaluation between the right and left legs to prevent fatigue.

*Device positioning.* The smartphone containing the application must be firmly attached by means of a belt on the medial portion of the participant's back in vertical orientation, over the backbone. The mobile device must be attached to the participant's trunk with its control display facing outside.



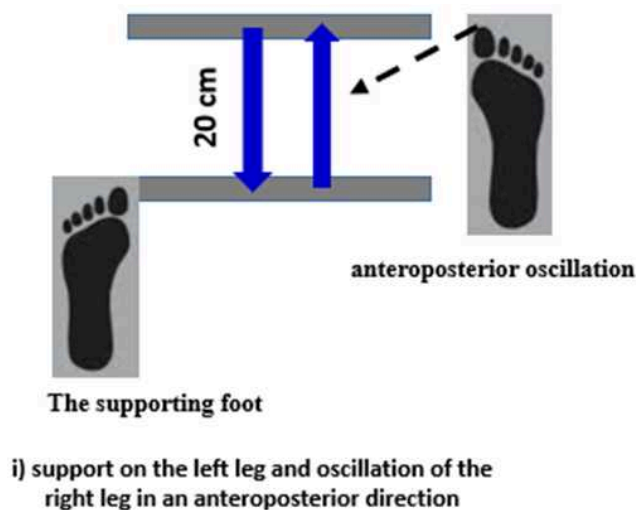
*Figure 1.* The smartphone positioning on the participant's back

*Preparation.* The participant should be barefoot on a firm support base without socks, preventing a malleable or slippery contact surface with the ground. Establish a point for

visual fixation (it could be a marker on a wall), 2-3 meters away in front and at the height of the participant's eyes.

For two tests, markers on the ground (with adhesive tape) will be needed as references for leg movement amplitude. Then, prepare the place for data collection before starting the evaluation.

Make the spatial markers by attaching two strips of tape (approximately 15 cm long each) 20 centimeters apart in parallel on the ground. These markers will be used to evaluate either leg in the anteroposterior leg oscillation test. For mediolateral leg oscillation test, attach other markers on the ground with two strips of tape oriented perpendicular to the first ones. These markers must also be parallel 20 centimeters apart.



*Familiarization.* Before starting the effective assessment, simulates the tests with the participant so that he/she becomes acquainted with the specific procedures of each test.

*Data collection.* To start the tests, participants must already have their personal data registered, and the smartphone must be firmly attached to their back. When you click on "New collection" in the Equidyn application, a screen will open for data collection. Once the "New collection" button is clicked, the complete evaluation protocol will be run automatically. The application will provide voice instructions throughout the evaluation, indicating the test to be performed and the leg to be tested in the ensuing trial. During performance of the dynamic tests, leg movements will be paced through beeps emitted by the application at a frequency of 1 per second (1 Hz). Trials endure 15 seconds each, with times for initiation and end indicated by the application. For each test, the participant will perform a series of three trials, with interatrial intervals of 30 seconds. Transitions between the tests have longer intervals of 1 minute. If you deem it necessary, allow fragile individuals to sit down in these longer intervals between tests. During the intervals, voice instructions will be given on the ensuing test. Near the start time of each trial, four beeps will be emitted by the application signaling when the trial is to be started; namely, simultaneously with the fourth beep. Keep the smartphone sound volume aloud

to allow the participant to hear clearly the beeps and instructions issued by the application.

### 3 Equidyn protocol

*Description of the protocol tests and important points during evaluation.*

*Test 1: One-leg motionless balance supported on the right leg.* Instruct the participant to keep as motionless as possible while supported exclusively on the right leg. The posture of the left leg should be knee flexed keep the left foot suspended over the ground by about 10-15 centimeters. Both arms should be kept hanging relaxed beside the trunk. Provide a spot 2-3 meters in front of the participant, about the eyes' height, to be gazed during this and the following tests.



*Test 2: One-leg motionless balance supported on the left leg.* Same procedures and instructions of the previous test, inverting the relationship between the legs.

*Test 3: Anteroposterioroscillation of the left leg while supported on the right leg.* To perform this test, use the first markers attached to the ground, in parallel with the participant frontal plane. The participant will support the right leg on the ground so that the big toe tip of the right foot is aligned with the right end of the proximal marker. As initial position, the participant supports the body on the right leg while maintaining a light touch on the proximal marker with the left leg. During the test, the participant is to maintain body stability on the right leg while making left-footed rhythmic sway movements in the anteroposterior direction, touching alternately the proximal and distal markers on the ground. Left leg movement rhythm will be paced by means of beeps emitted by the application, trying to touch each marker simultaneously with beep emission. Provide instruction that the markers should be touched gently with the big toe rather than supporting body weight on the moving left leg.





*Test 4: Anteroposterior oscillation of the right leg while supported on the left leg.* Same procedures and instructions of the previous test, inverting the relationship between the legs.

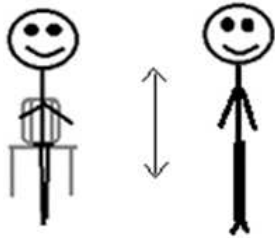
*Test 5: Mediolateral oscillation of the left leg while supported on the right leg.* To perform this test, use the second set of markers attached to the ground, in parallel with the participant sagittal plane. As initial position, the participant supports the body on the right leg positioning the right foot near and rightward to the right-sided marker. During the test, the participant is to maintain body stability on the right leg while making left-footed rhythmic sway movements in the mediolateral direction, touching alternately the left- and right-sided markers on the ground. Other details are the same as for the Test 3.



*Test 6: Mediolateral oscillation of the left leg while supported on the left leg.* Same procedures and instructions of the previous test, inverting the relationship between the legs.

*Test 7: Sit-to-stand with bipedal support.* This test starts with the participant sat on a regular height chair without armrests. It consists of standing up and sitting down cyclically. Each full standing and sitting movement is to be timed with a beep. To increase the demand for body balance by reducing the support area, this test should be done with both feet in parallel touching each other. The trunk should be held predominantly in the vertical orientation. Allow participants to make small arm

movements during the test (observation: exaggerated arm movements could perturb balance). Instruct the participant to make the standing up and sitting down movements continuously.



#### Observations:

1. Tests 3 to 7 correspond to dynamic tasks, while tests 1-2 are static tasks which can be used as reference for comparison. In tests 1 to 6 the right and left legs are evaluated for analysis of interlateral performance asymmetry.
2. Small imbalances are acceptable when performing the tests, and they will be reflected in the accelerometry. If there is a large imbalance of the participant, interrupt the test and restart it.
3. The complete assessment lasts approximately 20 minutes, including rest intervals between trials/tests.
4. Results are given in root mean square of the acceleration data recorded by the mobile device ( $\text{m/s}^2$ ), separately for each test. The values correspond to the average of the 3 trials for each test.

