MODULE: BODY SWAY

BRIEF DESCRIPTION:

Static balance of the human body is the ability to maintain a specific posture as still as possible. So called quiet stance tasks are most often used for the assessment of static balance. Because of the dynamic characteristics of the neuromuscular system and the inherently unstable mechanics of the human posture, the human body continuously sways. The specific characteristic of the body sway is influenced by several factors such as the size of the support area, the height of the centre of gravity, age, injury, etc. Body sway is traditionally evaluated through measurements of the sway of the centre-of-pressure (COP) below the subject`s feet. At a slow and moderate movement velocity the COP movement mirrors the transversal movement of the centre-of-gravity of the subject. During a long history of the body sway research, multiple analysis approaches and ways of parameterization have been developed by scientists.

The initial position of the subject depends on the difficulty level of the quiet stance task we would like to measure. The subject acquires an active upright stance posture, with the specific posture of the hands and feet as well as potential additional requirements (sensory manipulation or an additional mental task). After the subject has acquired the stance position the measurement starts and lasts for a pre-set period of time. Beware that the signal you measure is very sensitive to any manipulations and therefore avoid any unwanted small movements (head movements, coughing, etc.) that are not a part of your measurement set up.

When the Body Sway module opens, the existing measurements of the selected subject inside the current Visit are displayed and the user can review them (see section Analysis for details). If no measurements have yet been done for this subject, than only the option to start a new measurement is enabled. In order to begin a new measurement, click New Measurement button and select the Input Parameters to exactly define the measurement task.

When the New Measurement button is selected for the first time after entering the Body Sway module, the force plate is initialized. After the automatic initialization process is finished, the zero offset must be done (follow the instructions on the pop-up message). The plate must be unloaded during the entire initialization and zero offset procedure. This procedure is performed every time you enter the Body Sway measurement module. Zero offset can be repeated any time manually by pressing the Offset button, otherwise the automatic zero offset is done every 30 minutes.

BASIC FUNCTIONS:
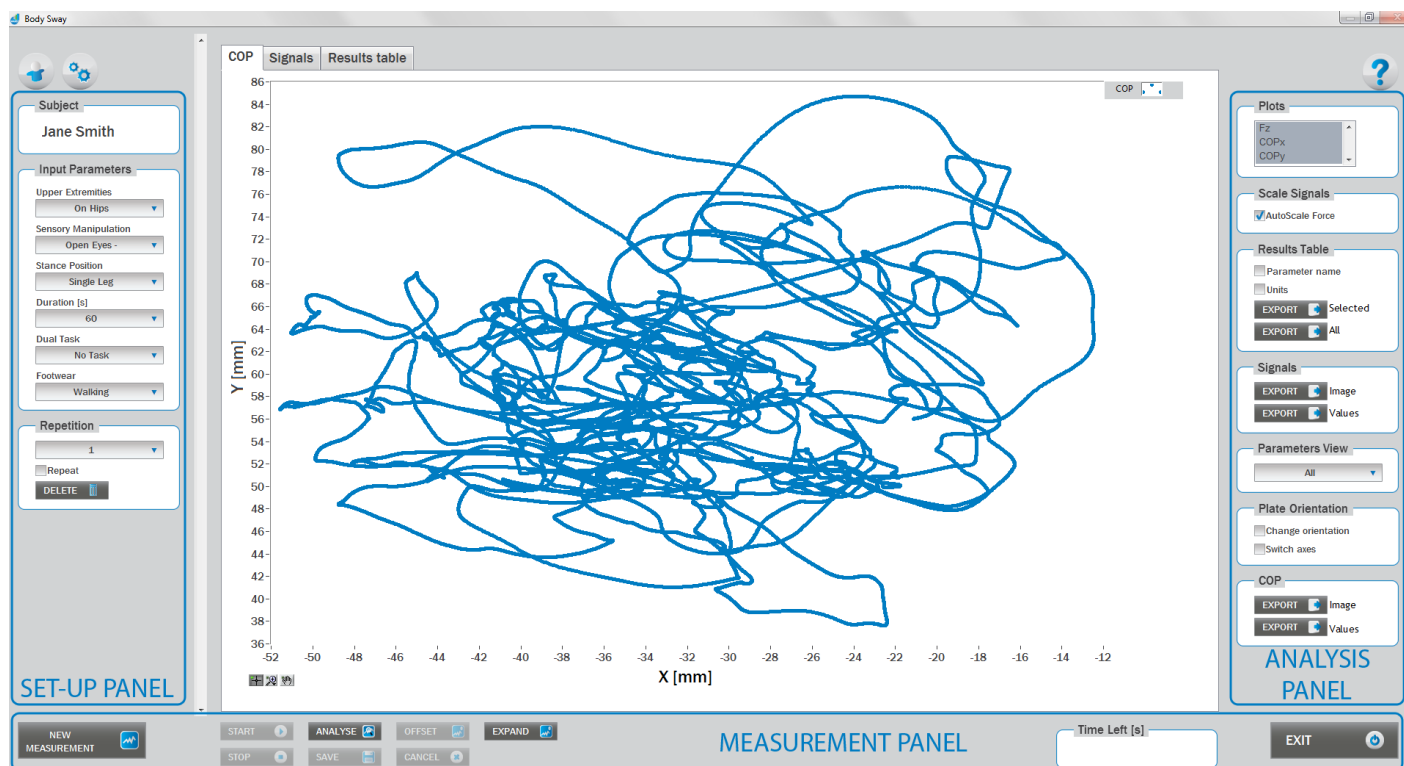
SET-UP PANEL:

SUBJECT

Name
The selected subject.

INPUT PARAMETERS

See Selecting Input Parameters section for details.

REPETITION

Repetition
Number of repetitions for the selected Input parameters.

Repeat
If checked, the selected repetition is replaced when the new measurement is performed.

Delete
Delete the selected repetition.

ANALYSIS PANEL:

PLOTS

Plots
The list of all channels. The selected channels are shown on the graph.

SCALE

AutoScale Force
If checked, the vertical scale of the graph is adapted to the maximum and minimum value of all force signals.

RESULTS TABLE

In the Result Table panel, result parameters from Result table tab can be exported into clipboard, CSV or TXT format. Format of the file can be set in settings window under export section. For details about setting the parameters refer to Settings Section.

Parameter Name
Parameter name will be included.

Units
Units of the parameters will be included.

Export Selected
By clicking on Export Selected button only the parameters that are selected in the table will be included.

Export All
By clicking on Export All button all parameters from the table will be included.

SIGNALS

In the Signals panel, image or values (row data) of acquired signal can be exported. Image and values can be exported with different parameters, which can be set in Settings window under export section. For details about setting the parameters refer to Settings Section.

Export Image
Export the image of signals (as visible on the graph on the Signals tab)into the clipboard. Image can be paste in any image editor.

Export Values
Export values (raw data) of signals (as visible on the graph on the Signals tab) into CSV or TXT format. Format of the file can be set in settings window under export section. For details about setting the parameters refer to Settings Section.

PARAMETERS VIEW

In the Parameters View panel, calculated parameters which are displayed in the result table can be set. By default, all and basic view are available. Basic view contains preset parameters and cannot be changed. Custom view can be defined, by clicking »Manage…« button.

To create a new view click on add button and enter the name of the view. Parameters included in the view are selected by checking the checkboxes next to them. To confirm the changes click save.

COP

In the COP panel, image or values (row data) of acquired signal can be exported. Image and values can be exported with different parameters, which can be set in Settings window under export section.

For details about setting the parameters refer to Settings Section.

Export Image

Export the image of signals (as visible on the graph on the Signals tab)into the clipboard. Image can be paste in any image editor.

Export Values

Export values (raw data) of signals (as visible on the graph on the Signals tab) into CSV or TXT format. Format of the file can be set in settings window under export section. For details about setting the parameters refer to Settings Section.

PLATE ORIENTATION

Change orientation
Plate orientation is changed for 180°.

Switch axes
Switches the X and Y axes without moving the force platform.

MEASUREMENT PANEL

New Measurement
Starts with a new measurement.

Start
Starts the measurement.

Stop
Stops the measurement.

Save
Saves the measurement.

Cancel
Cancel the last measurement.

Offset
Makes zero offset. Note that the force platform must be unloaded during the process.

Analyse
Performs the analysis.

Collapse
Collapses the graph and the side panels are shown.

Expand
Expands the graph and the side panels are hidden.

Time left [s]
Time left to the end of measurement.

Exit
Closes the measurement module.

SELECTING INPUT PARAMETERS:

Before the measurement can start, the user has to choose some input parameters with which the measured motor task (i.e. quiet stance task) is specifically defined. These parameters are important for further analysis, comparisons and reporting. The characteristics of the quiet stance task are defined by the following parameters:

STANCE POSITION:

Parallel Stance
The subject is standing in the centre of the force plate with the feet placed parallel at the shoulder width. The feet are oriented in anterior-posterior direction (along the Y-axis of the force plate) with the toes pointing anteriorly (+Y). Throughout the measurement the subject sustains his/her normal upright stance position.

Semi-Tandem Stance
The subject is standing in the centre of the force plate with the feet placed close together and shifted longitudinally against each other for one half of the length of the foot (i.e. semi-tandem foot position).

The feet are oriented in anterior-posterior direction (along the Y-axis of the force plate) with the toes pointing anteriorly (+Y). Throughout the measurement the subject sustains his/her normal upright stance position. Semi-tandem stance with the dominant leg in front is predominantly used; the opposite foot position is sometimes also referred as "contra semi-tandem".

Tandem Stance

The subject is standing in the centre of the force plate with the feet placed in-line one behind the other (i.e. heel-to-toe or tandem feet position). The feet are oriented in anterior-posterior direction (along the Y-axis of the force plate) with the toes pointing anteriorly (+Y). Throughout the measurement the subject sustains his/her normal upright stance position. Tandem stance with the dominant leg in front is predominantly used; the opposite foot position is sometimes also referred as "contra tandem".

Single Leg Stance – Left / Single Leg Stance - Right

The subject is standing on one leg in the centre of the force plate. The foot is oriented in anterior-posterior direction (along the Y-axis of the force plate) with the toes pointing anteriorly (+Y). Throughout the measurement the subject sustains his/her normal upright stance position.

Other user defined

In the Settings panel of the main window of the software the user can define any other type of stance (see Settings Section for details). After doing so, the newly defined input parameter will from then on appear as an optional choice under the Stance Position in the Body Sway measurement module.

UPPER EXTREMITIES:

On Hips

The subject places his/her hands on his/her hips.

Free

Subjects are free to use their arms as they want. In case of the easy quiet stance tasks the hands will normally remain passively hanging. However, in more demanding tasks the free use of the hands can be of great help.

Other user defined

In the Settings panel of the main window of the software the user can define any other position of the upper extremities (see Settings Section for details). After doing so, the newly defined input parameter will from then on appear as an optional choice under the Upper Extremities in the Body Sway measurement module.
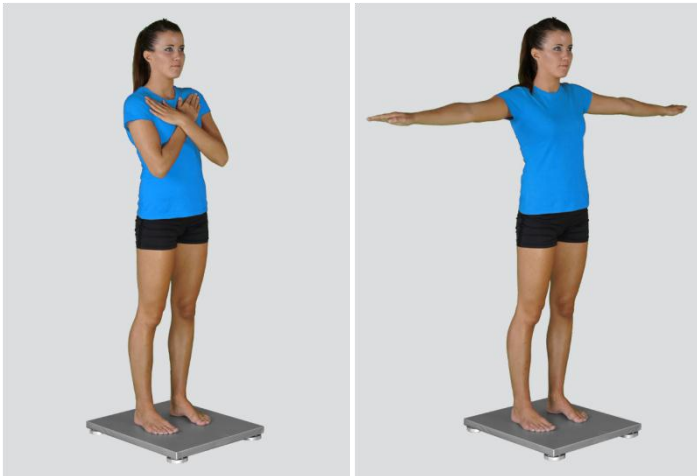
SENSORY MANIPULATION:

Eyes Closed

The subject is restricted to see. This might be done by simply closing the eyes but a better control over this sensory restriction can be by using a non-transparent band or goggles in order to best keep the subjects vision excluded.

Eyes Open – No Manipulation

The subject keeps his/her eyes open. The standard procedure is to ask the subject to keep a focus on a visual marker placed on a wall 1 to 3 meters in front of him/her.

Vestibular Perturbation

Perturbation of the vestibular sensory organ can be done in different ways: head rotation or head circumduction during or before the quiet stance; artificial stimulation of the vestibular system etc. The user should be aware of the potential direct mechanical effects of the vestibular manipulation task.

Other user defined

In the Settings panel of the main window of the software the user can define any other sensory manipulation used during the body sway test (see Settings Section for details). After doing so, the newly defined input parameter will from then on appear as an optional choice under the Sensory Manipulation in the Body Sway measurement module.

FOOTWEAR:

Barefoot/Running Shoes/Walking Shoes/High Heels
The user selects the type of the shoes that the subject is wearing.

Other user defined

In the Settings panel of the main window of the software the user can define any other type of footwear (see Settings Section for details). After doing so, the newly defined input parameter will from then on appear as an optional choice under the Footwear in the Body Sway measurement module.

DURATION:

10/20/30/40/50/60/70/80/90//100 s
The user selects the duration of the Body Sway test – either from the pre-set values or he/she can define other values (see Section Settings for details). After doing so, the newly defined duration of the quiet stance task will from then on appear as an optional choice under the Duration in the Body Sway measurement module.

DUAL TASK:

No Additional Task
The subject has no additional mental or motor task to do during the time of the measurement.

Additional Mental Task
Together with the quiet stance task the subject has to perform a required mental task. For this purpose different tasks have been used, the most commonly used are (1) counting up/down by three and (2) alternative finger tapping task.

Other user defined

In the Settings panel of the main window of the software the user can define any other type of the dual task (see Settings Section for details). After doing so, the newly defined input parameter will from then on appear as an optional choice under the Dual Task in the Body Sway measurement module.

MEASUREMENT:

After selecting the input parameters, the subject steps on the force plate and gets into the required position in a way that the orientation of the body is consistent with that of the plate (i.e. +Y direction of

the plate is the anterior direction). After you are satisfied with the quiet stance of the subject, click Start. After this the software begins with the signal acquisition and the time left until the end of the test is displayed in the top-left corner of the screen. For details about this automatic acquisition please see Settings Section.

If you want to start a new measurement, click the New Measurement button and repeat the procedure. Before doing so, you can change the Input Parameters; if not, the Input Parameters of the previous measurements will be used. If you want to repeat a certain measurement, click on the drop down menu, select the repetition you want to replace and check the box Repeat. Then click Start and a pop-up window will ask you if you really want to repeat the measurement. Click OK if you want to repeat.

ANALYSIS:

Analysis enables you to check the signal of the ground reaction force (GRF) and the calculated parameters. Under the COP tab you can see the X:Y signal. Individual components of the ground reaction forces and of the COP movement can be visualized under the Signal tab. Under the Results Table tab you can see all the calculated parameters numerically, while the visualisation of the results comparisons can be done under the Results Graphs tab. These two tabs enable you to make quick comparisons of the values of the parameters among different repetitions and/or among different sub-versions of the body sway test. If you want to confirm the measurement, click Save. If you would like to export the calculated parameters use Export function in Result Table panel.

Specific to the Body Sway measurement module is the extreme profoundness of the analysis which a user can carry out by the software. Altogether ninety-eight different COP-related parameters, which are well supported by the literature, are included. For more information regarding the parameters see the references below. These parameters can be divided into global and structural parameters, sample entropy and recurrence quantification analysis.

Additional analysis routines (e.g. Rambling-Trembling Analysis introduced by Duarte, Zatsiorsky and Latash) are available as separate products. See section About the Product for more information and contact us.

Medial-lateral displacement [mm]

Posterior-anterior displacement [mm]
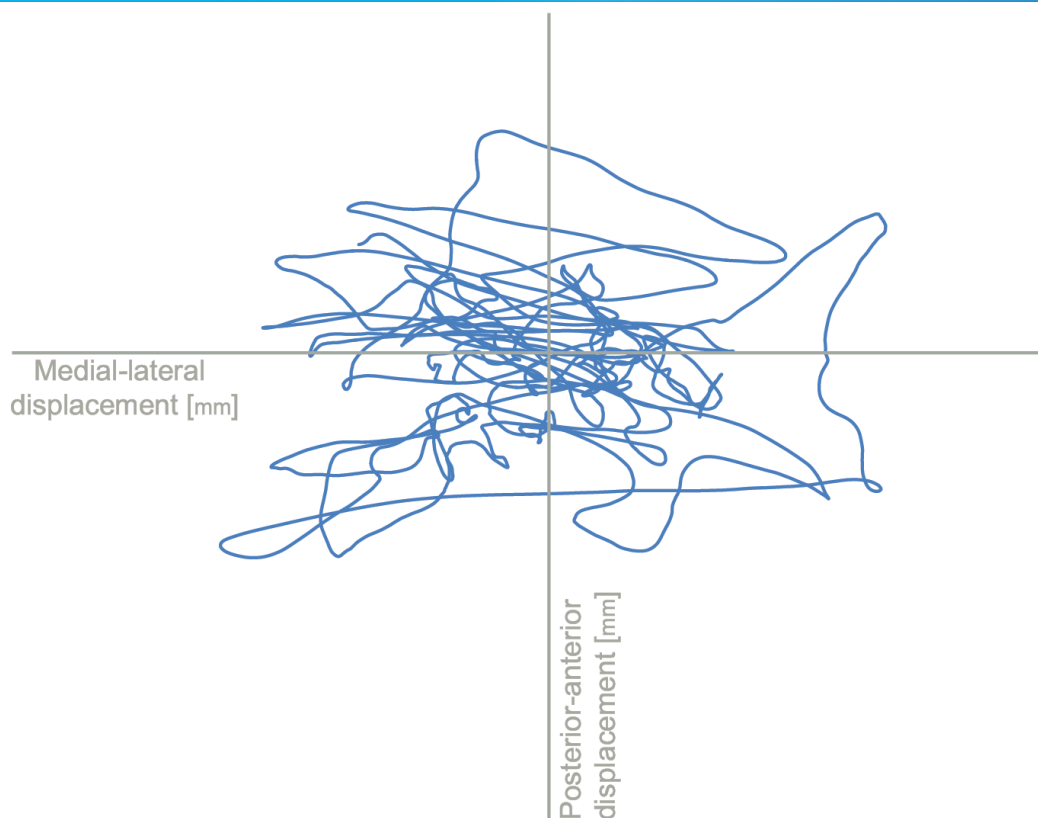
CALCULATED PARAMETERS:

GLOBAL PARAMETERS - GENERAL

Global parameters estimate the overall size of the COP sway. Regarding the direction, parameters can be calculated as two-directional and/or one-directional (i.e. anterior-posterior (A-P) and medio-lateral (M-L)). The following global parameters are calculated:

Sway path – total [mm]
The common length of the trajectory of the COP sway calculated as a sum of the point-to-point Euclidian distances.

Sway path – A-P [mm]
The common length of the trajectory of the COP sway only in the anterior-posterior direction.

Sway path – M-L [mm]
The common length of the trajectory of the COP sway only in the medial-lateral (i.e. left-right) direction.

Sway V – total [mm/s]
The common length of the trajectory of the COP sway calculated as a sum of the point-to-point Euclidian distances divided by the measurement time.

Sway V – A-P [mm/s]
The common length of the trajectory of the COP sway only in the anterior-posterior direction divided by the measurement time.

Sway V – M-L [mm/s]
The common length of the trajectory of the COP sway only in the medial-lateral direction divided by the measurement time.

Sway average amplitude – A-P [mm]
The average amount of the COP sway in anterior-posterior direction calculated as the common length of the trajectory of the COP sway only in the anterior-posterior direction divided by the number of changes in this direction (i.e. from moving forward to backward or *vice versa*).

Sway average amplitude – M-L [mm]
The average amount of the COP sway in medial-lateral (i.e. left-right) direction calculated as the common length of the trajectory of the COP sway only in the medial-lateral direction divided by the number of changes in this direction (i.e. from moving left to right or *vice versa*).

Sway maximal amplitude – A-P [mm]
The amplitude between the two most distant samples of the COP sway in anterior-posterior direction.

Sway maximal amplitude – M-L [mm]
The amplitude between the two most distant samples of the COP sway in medial-lateral (i.e. left-right) direction.

Sway area – total [mm^2]
Area swayed by the COP trajectory with respect to the central stance point (i.e. mean value of anterior-posterior and medial-lateral components respectively).

Sway area – A-P [mm*s]
The time integral of the anterior-posterior component of the COP with respect to the mean value of anterior-posterior component. Note: don`t be miss led by the name "area" that is commonly used in the literature in this context. This direction-specific area is namely a time integral which results also in the mm*s units and not mm^2.

Sway area – M-L [mm*s]
The time integral of the medial-lateral component of the COP with respect to the mean value of medial-lateral component. Note: don`t be miss led by the name "area" that is commonly used in the literature in this context. This direction-specific area is namely a time integral which results also in the mm*s units and not mm^2.

Sway area per second – total [mm^2/s]
Area swayed by the COP trajectory with respect to the central stance point (i.e. mean value of anterior-posterior and medial-lateral components respectively) divided by the measurement time.

Sway area per second – A-P [mm]
The time integral of the anterior-posterior component of the COP with respect to the mean value of anterior-posterior component divided by the measurement time. Note: don`t be miss led by the name "area" that is commonly used in the literature in this context. This direction-specific area is namely a time integral which results also in the mm*s units and not mm^2.

Sway area per second – M-L [mm]
The time integral of the medial-lateral component of the COP with respect to the mean value of medial-lateral component divided by the measurement time. Note: don`t be miss led by the name "area" that is commonly used in the literature in this context. This direction-specific area is namely a time integral which results also in the mm*s units and not mm^2.

Area of 100% ellipse [mm^2]

The area of the ellipse fitted over the COP trajectory so that it contains 100% of all the data points.

FRE from peaks – A-P [Hz]

The frequency of the oscillations of the COP calculated as the number of peaks in anterior-posterior direction (i.e. changes in direction from forward to backward or *vice versa*) divided by the measurement time.

FRE from peaks – M-L [Hz]

The frequency of the oscillations of the COP calculated as the number of peaks in medial-lateral direction (i.e. changes in direction from left to right or vice versa) divided by the measurement time.

Mean FRE of total spectrum – A-P [Hz]

The frequency of the oscillations of the COP calculated as the mean frequency of the power spectrum for the anterior-posterior direction.

Mean FRE of total spectrum – M-L [Hz]

The frequency of the oscillations of the COP calculated as the mean frequency of the power spectrum for the medial-lateral (i.e. left to right) direction.

Peak FRE of total spectrum – A-P [Hz]

The frequency of the oscillations of the COP calculated as the peak value on the power spectrum for the anterior-posterior direction.

Peak FRE of total spectrum – M-L [Hz]

The frequency of the oscillations of the COP calculated as the peak value on the power spectrum for the medial-lateral (i.e. left to right) direction.

Mean FRE of 0.1-1 spectrum band – A-P [Hz]

The frequency of the oscillations of the COP calculated as the mean frequency of the power spectrum for the anterior-posterior direction; for the frequency band 0.1 Hz to 1 Hz.

Mean FRE of 0.1-1 spectrum band – M-L [Hz]

The frequency of the oscillations of the COP calculated as the mean frequency of the power spectrum for the medial-lateral direction; for the frequency band 0.1 Hz to 1 Hz.

Mean FRE of 1-2 spectrum band – A-P [Hz]

The frequency of the oscillations of the COP calculated as the mean frequency of the power spectrum for the anterior-posterior direction; for the frequency band 1 Hz to 2 Hz.

Mean FRE of 1-2 spectrum band – M-L [Hz]

The frequency of the oscillations of the COP calculated as the mean frequency of the power spectrum for the medial-lateral direction; for the frequency band 1 Hz to 2 Hz.

Mean FRE of 2-10 spectrum band – A-P [Hz]

The frequency of the oscillations of the COP calculated as the mean frequency of the power spectrum for the anterior-posterior direction; for the frequency band 2 Hz to 10 Hz.

Mean FRE of 2-10 spectrum band – M-L [Hz]

The frequency of the oscillations of the COP calculated as the mean frequency of the power spectrum for the medial-lateral direction; for the frequency band 2 Hz to 10 Hz.

GLOBAL PARAMETERS – INTERVAL SPECIFIC

Global parameters estimate the overall size of the COP sway. Regarding the direction, parameters can be calculated as two-directional and/or one-directional (i.e. anterior-posterior (A-P) and medio-lateral (M-L)). The "Interval Specific" subgroup of the COP global parameters encompasses values for the initial, middle and final sub-interval of the measurement. The default duration of these intervals is 10 s, but the user can change it under the Settings panel. Based on the chosen interval specific global parameters, fatigue/endurance related indexes are further calculated. The following interval specific global COP parameters and related indexes are calculated:

Sway V of the 1st interval – total [mm/s]
The common length of the trajectory of the COP sway calculated as a sum of the point-to-point Euclidian distances in the initial interval (i.e. start + the interval duration) divided by the duration of the initial time interval. The default duration of this interval is 10 s, but it can be changed in the Settings panel.

Sway V of the 2nd interval – total [mm/s]
The common length of the trajectory of the COP sway calculated as a sum of the point-to-point Euclidian distances in the middle time interval (i.e. mid-time ± ½ of the interval duration) divided by the duration of the middle time interval. The default duration of this interval is 10 s, but it can be changed in the Settings panel.

Sway V of the 3rd interval – total [mm/s]
The common length of the trajectory of the COP sway calculated as a sum of the point-to-point Euclidian distances in the final time interval (i.e. end - the interval duration) divided by the duration of the final time interval. The default duration of this interval is 10 s, but it can be changed in the Settings panel.

Sway V endurance index – total [%]
The COP sway total velocity of the middle (2nd) time interval divided by the COP sway total velocity of the initial (1st) time interval. Total velocities are calculated as the common length of the trajectory of the COP sway (i.e. the sum of the point-to-point Euclidian distances) in the time interval divided by the duration of the time interval. The default duration of these time intervals is 10 s, but it can be changed in the Settings panel.

Sway V fatigue index – total [%]
The COP sway total velocity of the final (3rd) time interval divided by the COP sway total velocity of the initial (1st) time interval. Total velocities are calculated as the common length of the trajectory of the COP sway (i.e. the sum of the point-to-point Euclidian distances) in the time interval divided by the duration of the time interval. The default duration of these time intervals is 10 s, but it can be changed in the Settings panel.

Sway V of the 1st interval – A-P [mm/s]
The length of the trajectory of the COP sway in anterior-posterior direction in the initial time interval (i.e. start + the interval duration) divided by the duration of the initial time interval. The default duration of this interval is 10 s, but it can be changed in the Settings panel.

Sway V of the 2nd interval – A-P [mm/s]
The length of the trajectory of the COP sway in anterior-posterior direction in the middle time interval (i.e. mid-time ± ½ of the interval duration) divided by the duration of the middle time interval. The default duration of this interval is 10 s, but it can be changed in the Settings panel.

Sway V of the 3rd interval – A-P [mm/s]

The length of the trajectory of the COP sway in anterior-posterior direction in the final time interval (i.e. end - the interval duration) divided by the duration of the final time interval. The default duration of this interval is 10 s, but it can be changed in the Settings panel.

Sway V endurance index – A-P [%]

The COP sway anterior-posterior velocity of the middle (2nd) time interval divided by the COP sway anterior-posterior velocity of the initial (1st) time interval. The anterior-posterior velocities are calculated as the length of the trajectory of the COP sway in anterior-posterior direction in the time interval divided by the duration of the time interval. The default duration of these time intervals is 10 s, but it can be changed in the Settings panel.

Sway V fatigue index – A-P [%]

The COP sway anterior-posterior velocity of the final (3rd) time interval divided by the COP sway anterior-posterior velocity of the initial (1st) time interval. The anterior-posterior velocities are calculated as the length of the trajectory of the COP sway in anterior-posterior direction in the time interval divided by the duration of the time interval. The default duration of these time intervals is 10 s, but it can be changed in the Settings panel.

Sway V of the 1st interval – M-L [mm/s]

The length of the trajectory of the COP sway in medial-lateral direction in the initial time interval (i.e. start + the interval duration) divided by the duration of the initial time interval. The default duration of this interval is 10 s, but it can be changed in the Settings panel.

Sway V of the 2nd interval – M-L [mm/s]

The length of the trajectory of the COP sway in medial-lateral direction in the middle time interval (i.e. mid-time ± ½ of the interval duration) divided by the duration of the middle time interval. The default duration of this interval is 10 s, but it can be changed in the Settings panel.

Sway V of the 3rd interval – M-L [mm/s]

The length of the trajectory of the COP sway in medial-lateral direction in the final time interval (i.e. end - the interval duration) divided by the duration of the final time interval. The default duration of this interval is 10 s, but it can be changed in the Settings panel.

Sway V endurance index – M-L [%]

The COP sway medial-lateral velocity of the middle (2nd) time interval divided by the COP sway medial-lateral velocity of the initial (1st) time interval. The medial-lateral velocities are calculated as the length of the trajectory of the COP sway in medial-lateral direction in the time interval divided by the duration of the time interval. The default duration of these time intervals is 10 s, but it can be changed in the Settings panel.

Sway V fatigue index – M-L [%]

The COP sway medial-lateral velocity of the final (3rd) time interval divided by the COP sway medial-lateral velocity of the initial (1st) time interval. The medial-lateral velocities are calculated as the length of the trajectory of the COP sway in medial-lateral direction in the time interval divided by the duration of the time interval. The default duration of these time intervals is 10 s, but it can be changed in the Settings panel.

Sway average amplitude of the 1st interval – A-P [mm]

The average amplitude of the COP sway in anterior-posterior direction in the initial time interval (i.e. start + the interval duration). The average amplitude of the COP sway in anterior-posterior direction is calculated as the common length of the trajectory of the COP sway only in the anterior-posterior

direction divided by the number of changes in this direction (i.e. from moving forward to backward or *vice versa*). The default duration of this interval is 10 s, but it can be changed in the Settings panel.

Sway average amplitude of the 2nd interval – A-P [mm]
The average amplitude of the COP sway in anterior-posterior direction in the middle time interval (i.e. mid-time ± ½ of the interval duration). The average amplitude of the COP sway in anterior-posterior direction is calculated as the common length of the trajectory of the COP sway only in the anterior-posterior direction divided by the number of changes in this direction (i.e. from moving forward to backward or *vice versa*). The default duration of this interval is 10 s, but it can be changed in the Settings panel.

Sway average amplitude of the 3rd interval – A-P [mm]
The average amplitude of the COP sway in anterior-posterior direction in the final time interval (i.e. end - the interval duration). The average amplitude of the COP sway in anterior-posterior direction is calculated as the common length of the trajectory of the COP sway only in the anterior-posterior direction divided by the number of changes in this direction (i.e. from moving forward to backward or *vice versa*). The default duration of this interval is 10 s, but it can be changed in the Settings panel.

Sway average amplitude endurance index – A-P [%]
The average amplitude of the COP sway in anterior-posterior direction in the middle (2nd) time interval divided by the average amplitude of the COP sway in anterior-posterior direction in the initial (1st) time interval. The average amplitudes of the COP sway in anterior-posterior direction are calculated as the common length of the trajectory of the COP sway only in the anterior-posterior direction divided by the number of changes in this direction (i.e. from moving forward to backward or *vice versa*). The default duration of these time intervals is 10 s, but it can be changed in the Settings panel.

Sway average amplitude fatigue index – A-P [%]
The average amplitude of the COP sway in anterior-posterior direction in the final (3rd) time interval divided by the average amplitude of the COP sway in anterior-posterior direction in the initial (1st) time interval. The average amplitudes of the COP sway in anterior-posterior direction are calculated as the common length of the trajectory of the COP sway only in the anterior-posterior direction divided by the number of changes in this direction (i.e. from moving forward to backward or *vice versa*). The default duration of these time intervals is 10 s, but it can be changed in the Settings panel.

Sway average amplitude of the 1st interval – M-L [mm]
The average amplitude of the COP sway in medial-lateral direction in the initial time interval (i.e. start + the interval duration). The average amplitude of the COP sway in medial-lateral direction is calculated as the common length of the trajectory of the COP sway only in the medial-lateral direction divided by the number of changes in this direction (i.e. from moving left to right or *vice versa*). The default duration of this interval is 10 s, but it can be changed in the Settings panel.

Sway average amplitude of the 2nd interval – M-L [mm]
The average amplitude of the COP sway in medial-lateral direction in the middle time interval (i.e. mid-time ± ½ of the interval duration). The average amplitude of the COP sway in medial-lateral direction is calculated as the common length of the trajectory of the COP sway only in the medial-lateral direction divided by the number of changes in this direction (i.e. from moving left to right or *vice versa*). The default duration of this interval is 10 s, but it can be changed in the Settings panel.

Sway average amplitude of the 3rd interval – M-L [mm]
The average amplitude of the COP sway in medial-lateral direction in the final time interval (i.e. end - the interval duration). The average amplitude of the COP sway in medial-lateral direction is calculated as the common length of the trajectory of the COP sway only in the medial-lateral direction divided by the

number of changes in this direction (i.e. from moving left to right or *vice versa*). The default duration of this interval is 10 s, but it can be changed in the Settings panel.

Sway average amplitude endurance index – M-L [%]

The average amplitude of the COP sway in medial-lateral direction in the middle (2nd) time interval divided by the average amplitude of the COP sway in medial-lateral direction in the initial (1st) time interval. The average amplitudes of the COP sway in medial-lateral direction are calculated as the common length of the trajectory of the COP sway only in the medial-lateral direction divided by the number of changes in this direction (i.e. from moving left to right or *vice versa*). The default duration of these time intervals is 10 s, but it can be changed in the Settings panel.

Sway average amplitude fatigue index – M-L [%]

The average amplitude of the COP sway in medial-lateral direction in the final (3rd) time interval divided by the average amplitude of the COP sway in medial-lateral direction in the initial (1st) time interval. The average amplitudes of the COP sway in medial-lateral direction are calculated as the common length of the trajectory of the COP sway only in the medial-lateral direction divided by the number of changes in this direction (i.e. from moving left to right or *vice versa*). The default duration of these time intervals is 10 s, but it can be changed in the Settings panel.

Sway FRE from peaks of the 1st interval – A-P [Hz]

The average frequency of the oscillations of the COP calculated as the number of peaks in anterior-posterior direction (i.e. changes in direction from forward to backward or *vice versa*) in the initial time interval (i.e. start + the interval duration) divided by the duration of the initial time interval. The default duration of this interval is 10 s, but it can be changed in the Settings panel.

Sway FRE from peaks of the 2nd interval – A-P [Hz]

The average frequency of the oscillations of the COP calculated as the number of peaks in anterior-posterior direction (i.e. changes in direction from forward to backward or *vice versa*) in the middle time interval (i.e. mid-time ± ½ of the interval duration) divided by the duration of the middle time interval. The default duration of this interval is 10 s, but it can be changed in the Settings panel.

Sway FRE from peaks of the 3rd interval – A-P [Hz]

The average frequency of the oscillations of the COP calculated as the number of peaks in anterior-posterior direction (i.e. changes in direction from forward to backward or *vice versa*) in the final time interval (i.e. end - the interval duration) divided by the duration of the final time interval. The default duration of this interval is 10 s, but it can be changed in the Settings panel.

Sway FRE from peaks endurance index – A-P [%]

The average frequency of the COP sway in anterior-posterior direction in the middle (2nd) time interval divided by the average frequency of the COP sway in anterior-posterior direction in the initial (1st) time interval. The average frequencies of the COP sway in anterior-posterior direction are calculated as the number of peaks in anterior-posterior direction (i.e. changes in direction from forward to backward or *vice versa*) in the time interval divided by the duration of the time interval. The default duration of the time intervals is 10 s, but it can be changed in the Settings panel.

Sway FRE from peaks fatigue index – A-P [%]

The average frequency of the COP sway in anterior-posterior direction in the final (3rd) time interval divided by the average frequency of the COP sway in anterior-posterior direction in the initial (1st) time interval. The average frequencies of the COP sway in anterior-posterior direction are calculated as the number of peaks in anterior-posterior direction (i.e. changes in direction from forward to backward or *vice versa*) in the time interval divided by the duration of the time interval. The default duration of the time intervals is 10 s, but it can be changed in the Settings panel.

Sway FRE from peaks of the 1st interval – M-L [Hz]

The average frequency of the oscillations of the COP calculated as the number of peaks in medial-lateral direction (i.e. changes in direction from left to right or *vice versa*) in the initial time interval (i.e. start + the interval duration) divided by the duration of the initial time interval. The default duration of this interval is 10 s, but it can be changed in the Settings panel.

Sway FRE from peaks of the 2nd interval – M-L [Hz]

The average frequency of the oscillations of the COP calculated as the number of peaks in medial-lateral direction (i.e. changes in direction from left to right or *vice versa*) in the middle time interval (i.e. mid-time ± ½ of the interval duration) divided by the duration of the middle time interval. The default duration of this interval is 10 s, but it can be changed in the Settings panel.

Sway FRE from peaks of the 3rd interval – M-L [Hz]

The average frequency of the oscillations of the COP calculated as the number of peaks in medial-lateral direction (i.e. changes in direction from left to right or *vice versa*) in the final time interval (i.e. end - the interval duration) divided by the duration of the final time interval. The default duration of this interval is 10 s, but it can be changed in the Settings panel.

Sway FRE from peaks endurance index – M-L [%]

The average frequency of the COP sway in medial-lateral direction in the middle (2nd) time interval divided by the average frequency of the COP sway in medial-lateral direction in the initial (1st) time interval. The average frequencies of the COP sway in medial-lateral direction are calculated as the number of peaks in medial-lateral direction (i.e. changes in direction from left to right or *vice versa*) in the time interval divided by the duration of the time interval. The default duration of the time intervals is 10 s, but it can be changed in the Settings panel.

Sway FRE from peaks fatigue index – M-L [%]

The average frequency of the COP sway in medial-lateral direction in the final (3rd) time interval divided by the average frequency of the COP sway in medial-lateral direction in the initial (1st) time interval. The average frequencies of the COP sway in medial-lateral direction are calculated as the number of peaks in medial-lateral direction (i.e. changes in direction from left to right or *vice versa*) in the time interval divided by the duration of the time interval. The default duration of the time intervals is 10 s, but it can be changed in the Settings panel.

STRUCTURAL PARAMETERS – DIFFUSION PLOTS

Different from the global body sway parameters, the structural parameters estimate the elements or smaller parts of the COP sway. The structural parameters are divided on parameters based on the computation of diffusion plots or variograms and on parameters based on the analysis of sway density plots.

Diffusion plots model the stabilograms as fractional Brownian motions and thus decompose the sway patterns into two stochastic processes: (1) a short-term process (interpreted as an open-loop control mechanism) in a logarithmic and linear scale and (2) a long-term process (interpreted as a closed-loop mechanism) in a logarithmic and linear scale.

The following diffusion plots based structural parameters are calculated:

Short-range slope on linear scale – total [mm^2/s]

Long-range slope on linear scale – total [mm^2/s]

Short-range slope on logarithmic scale – total [mm^2/s]

Long-range slope on logarithmic scale – total [mm^2/s]

Short-range slope on linear scale – A-P [mm^2/s]

Long-range slope on linear scale – A-P [mm^2/s]

Short-range slope on logarithmic scale – A-P [mm^2/s]

Long-range slope on logarithmic scale – A-P [mm^2/s]

Short-range slope on linear scale – M-L [mm^2/s]

Long-range slope on linear scale – M-L [mm^2/s]

Short-range slope on logarithmic scale – M-L [mm^2/s]

Long-range slope on logarithmic scale – M-L [mm^2/s]

STRUCTURAL PARAMETERS – DENSITY PLOTS

The analysis of sway density plots is based on idea that the feed-forward control is the prevalent mechanism in the postural stabilization process, thus breaking down the control process into a sequence of anticipatory motor commands. Parameters based on density plots are: (1) mean value of the peaks in the sway density curve and the corresponding variability, (2) mean value of the time interval between successive peaks in the sway density curve and the corresponding variability, and (3) mean value of the distance between successive peaks in the sway density curve and the corresponding variability.

The following density plots based structural parameters are calculated:

Mean value of peaks [s]

Variability of peaks [s]

Mean T interval between successive peaks [s]

Variability of T interval between successive peaks [s]

Mean distance between successive peaks [mm]

Variability of distance between successive peaks [mm]

STRUCTURAL PARAMETERS – RECURRENCE QUANTIFICATION ANALYSIS

Recurrence quantification analysis is a nonlinear and multi-dimensional technique which does not assume data stationary and which provides a characterization of a variety of features of a given time series, including a quantification of deterministic structure and of nonstationarity. All the parameters are calculated for the medial-lateral and anterior-posterior direction.

Parameters of recurrence quantification analysis are:

Recurrence rate – A-P [%]

Recurrence rate – M-L [%]

Average diagonal line length – A-P [%]

Average diagonal line length – M-L [%]

Entropy – A-P [bits]

Entropy – M-L [bits]

Laminarity – A-P [%]

Laminarity – M-L [%]

Trapping time – A-P [%]

Trapping time – M-L [%]

Determinism – A-P [%]

Determinism – M-L [%]

STRUCTURAL PARAMETERS – SAMPLE ENTROPY

Sample entropy provides information about the regularity or predictability of a time-series (COP path) and it is used to analyse complex stochastic systems. Small values of sample entropy are associated with great regularity (high possibility of the same data) while large values of sample entropy reflect great irregularity (low possibility of the same data).

Parameters based on sample entropy are:

Sample entropy in medio-lateral direction [a.u]

Sample entropy in anterio-posterior direction [a.u]

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