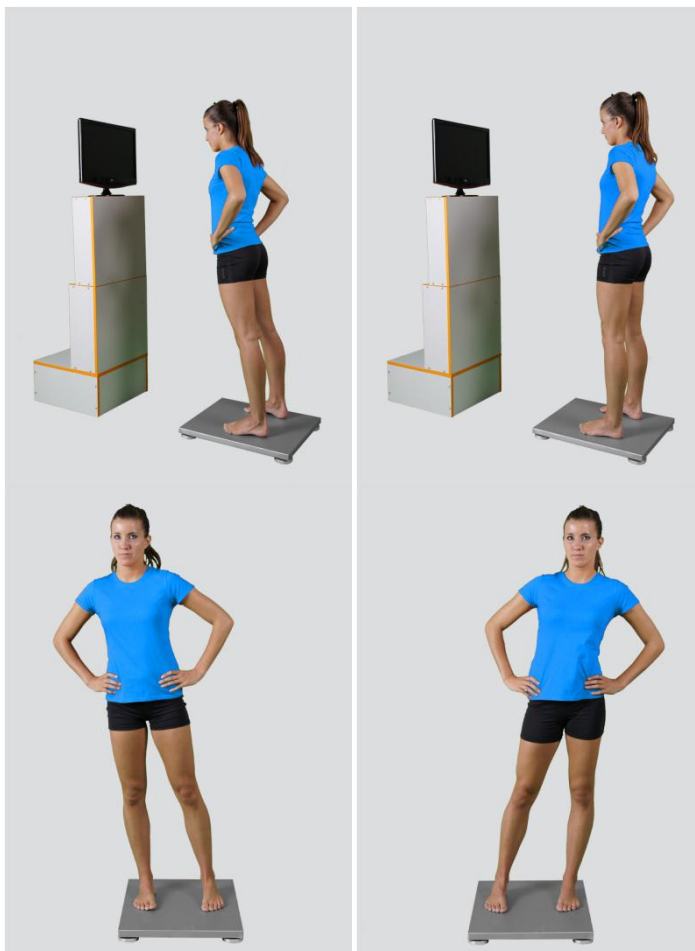# MODULE: CURVE TRACKING

BRIEF DESCRIPTION:

Different from the quiet stance, every day functional situations often require more demanding dynamic balance situations and corresponding balance control. A typical example are those motor tasks in which a subject has to voluntarily shift the body`s centre-of-gravity above the support area. Such leaning of the body in different directions will result in an evident centre-of-pressure (COP) displacement. It can be done with a maximal or submaximal range of COP excursions. Range and precision of voluntary body leaning in different directions can be assessed by measuring the COP displacements. The ability of a subject to finely control the dynamics of the COP excursions can be assessed with visuo-motor integration tasks in which the real COP is displayed in front of the subject and he/she tries to precisely follow the predefined dynamics of the COP shifts.

Evaluation of such visual feed-back based dynamic balance tasks gives us the information about the volitional balance control of the centre-of-gravity and can be quantitatively evaluated using force plate measurements. In case of the Curve Tracking task the subject is instructed to follow the reference curve by voluntarily shifting his/her COP in a pre-defined direction. Such a measurement set-up will enable us to identify direction specific weak points of the subject`s balance and to gather additional information about the balance dynamic control. These tasks can be also used as a motivation exercise tool.

When the Curve Tracking 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 Curve Tracking 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 Curve Tracking 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:
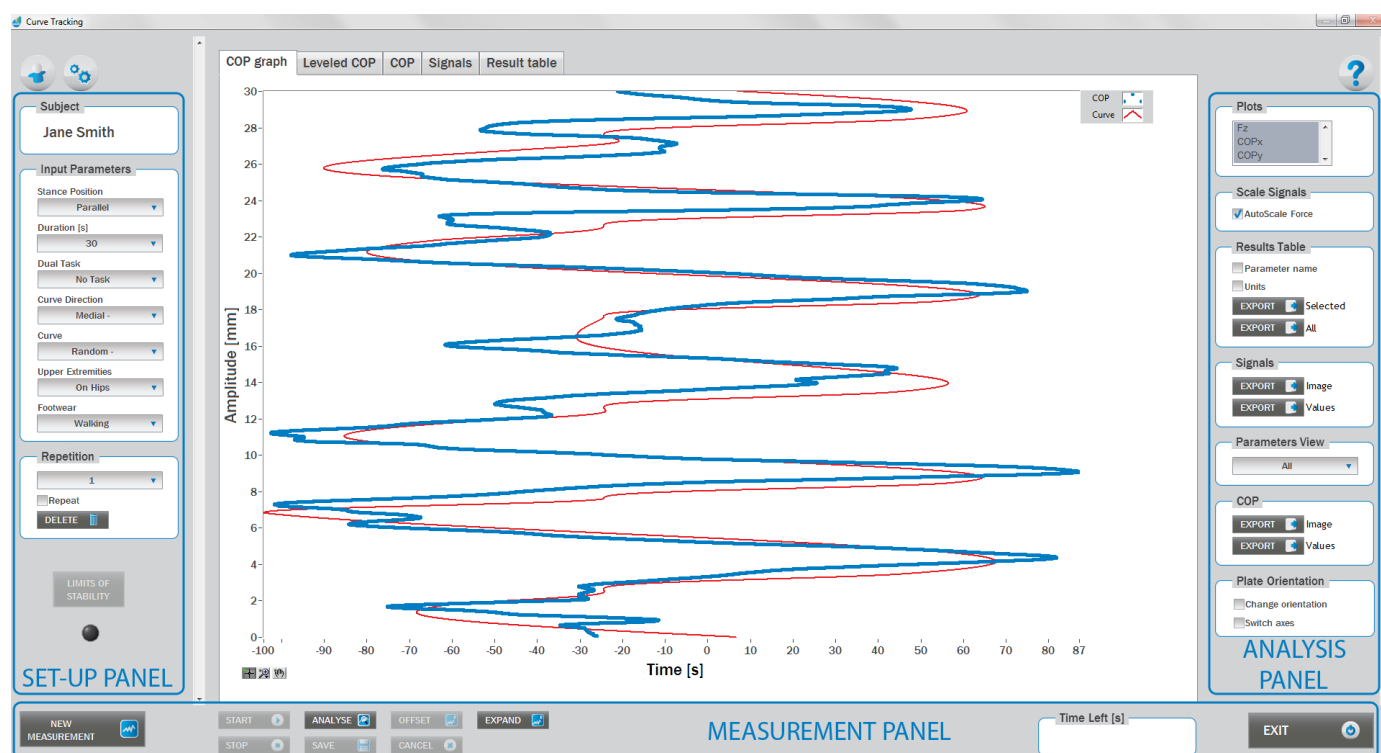
SET-UP PANEL:

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.

LIMITS OF STABILITY:

If the button LOS is enabled and indicator is off, the selected subject did not perform the Limits of stability test for selected input parameters yet. In this case, the Limits of stability test have to be performed to start the Tracking test. Limits of stability test acquire maximal deviations in all directions that are mandatory for the definition of the Tracking test.

If LOS button is disabled and the indicator is blue, the selected subject has already performed the Limits of stability test for the selected input parameters and can start with the Tracking test.

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 (voluntary single direction COP transfer) is specifically defined. These parameters are important for further analysis, comparisons and reporting. The balance characteristics 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 standing 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.
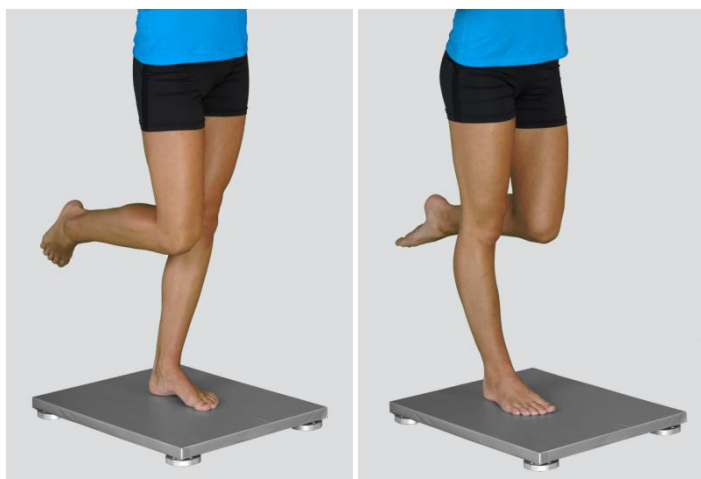
Other user defined

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 Curve Tracking measurement module.

DURATION:

10/20/30/40/50/60/70/80/90/100 s
The user selects the duration of the Curve Tracking 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 Curve Tracking 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 dynamic balance task the subject has to perform a required mental task. For this purpose different tasks have been used, from which 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 Curve Tracking measurement module.

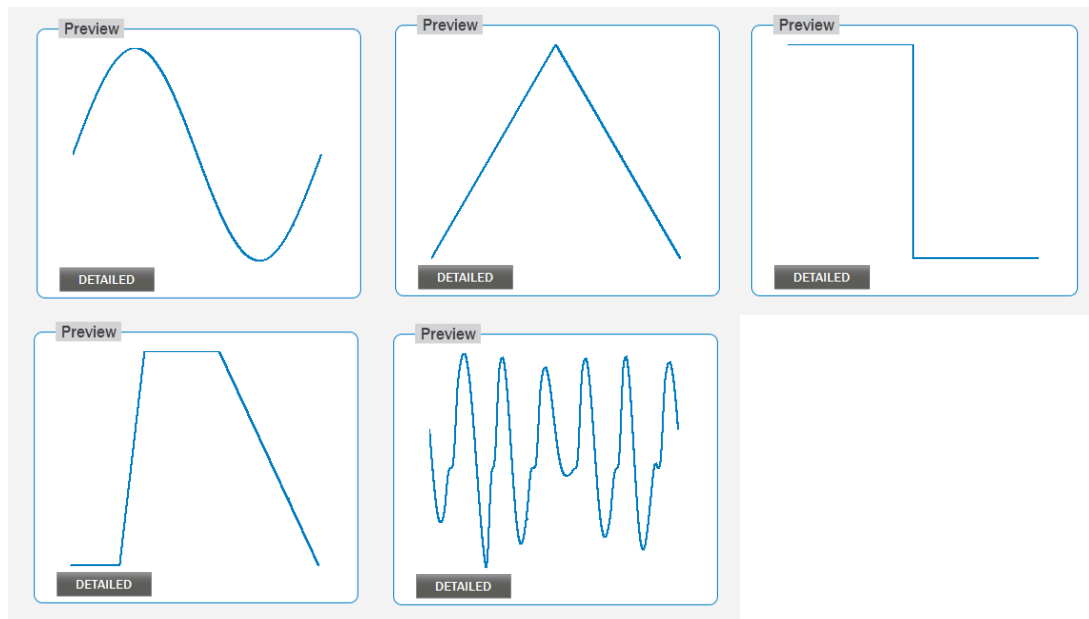## CURVE DIRECTION:

Medial - Lateral

Anterior - Posterior

CURVE:

Sinus

Triangle

Square

Ramp

Random

UPPER EXTREMITIES:

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

Free
The subject is free to use his/her arms as he/she wants. In case of an easy dynamic balance 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 Curve Tracking measurement module.
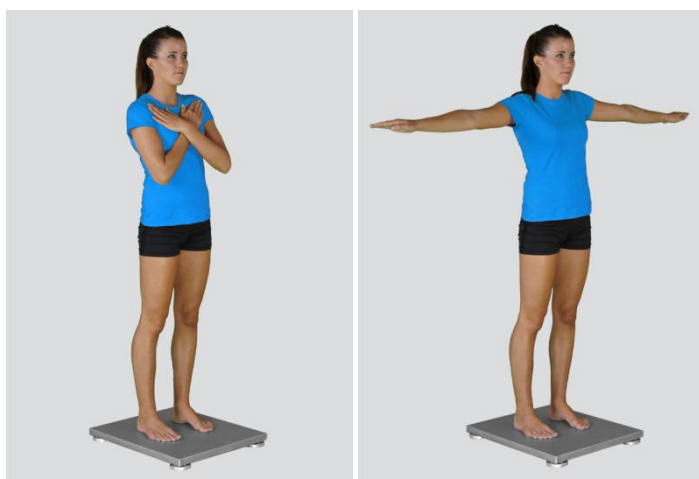
FOOTWEAR:

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 Curve Tracking measurement module.

MEASUREMENT:

After selecting the input parameters, the subject steps on the force plate and gets into the requested 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 standing 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 signals of the ground reaction force 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 this dynamic balance 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.

Actual COP signal

Reference curve

Time [s]

Medial-lateral displacement [mm]
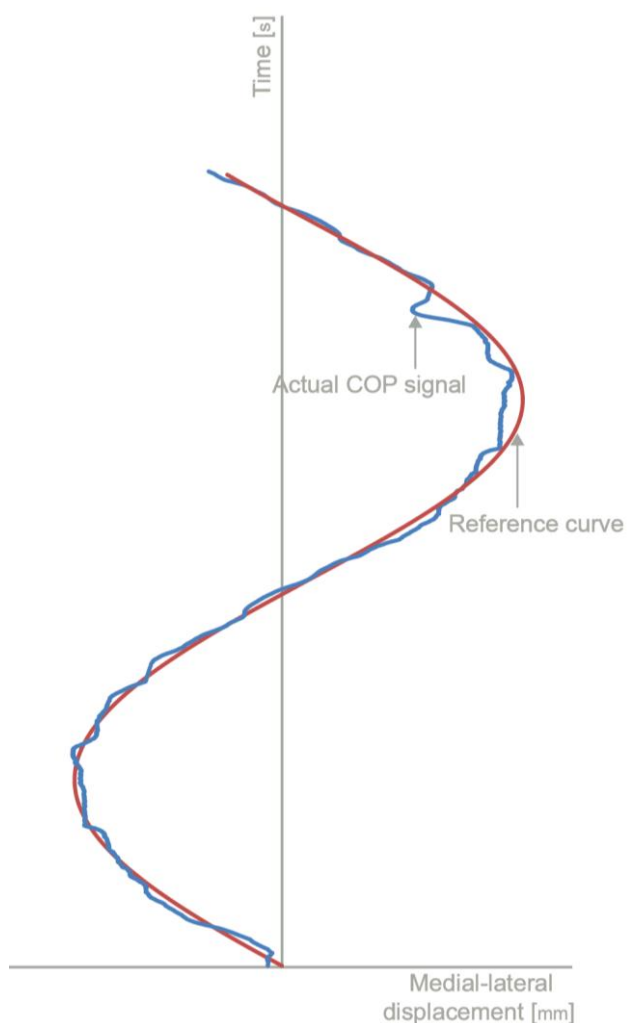
CALCULATED PARAMETERS:

GENERAL PARAMETERS

Mean absolute error [mm]
Mean absolute error between the reference curve and the actual COP signal.

SD of absolute error [mm]
Standard deviation calculated from deviations between the reference curve and the actual COP signal.

RMS error [mm]
Root mean squared error between the reference curve and the actual COP signal.

Area [mm*s]
Area between the reference curve and the actual COP signal calculated as the integral of absolute deviations between the two curves.

Normalized error [%]

The error defined as $Normalized\ error = \sqrt{((\sum(COPa - R)^2)/(Amax)^2)/N)} * 100$, where COPa is the actual COP signal, R is the reference trajectory, Amax is the maximal amplitude of the referenced trajectory and N is the number of samples. For the value 0 the performance was perfect, while for the value 100% the deviation between the referenced trajectory and the actual COP signal was equal to maximal amplitude of the referenced trajectory on average.

Mean FRE [Hz]

Mean frequency of the COP in the tracking direction calculated as mean frequency of the power spectrum.

Median FRE [Hz]

Mean frequency of the COP in the tracking direction calculated as median frequency of the power spectrum.

Peak FRE [Hz]

Mean frequency of the COP in the tracking direction calculated as peak frequency of the power spectrum.

T share on side 1 [%]

The time share spent on the left side of the reference curve in case of a side-to-side task or the time share spent on the anterior side of the reference curve in case of an anterior-posterior tracking task.

T share on side 2 [%]

The time share spent on the right side of the reference curve in case of a side-to-side task or the time share spent on the posterior side of the reference curve in case of an anterior-posterior tracking task.

Cross-correlation

Cross-correlation between the reference curve and the actual COP signal.

Weighted normalized error – common [%]

The error defined as $Weighted\ normalized\ error = (\sum((COPa - R)^2 * (R/Asmax)^2))/(\sum(R^2 * (R/Asmax)^2)) * 100$ where COPa is the actual COP signal, R is the reference trajectory, Asmax is the maximal amplitude of the referenced trajectory either on the side 1 or the side 2 (if R is on the side 1 then maximal amplitude on the side 1 is used and if R is on the side 2 then maximal amplitude on the side 2 is used). This parameter weights more deviations close to maximal amplitudes on both sides of the reference trajectory and less those close to origin (value of COP when subject stands upright).

Weighted normalized error – outside [%]

The error for those parts of the performance where actual COP signal is on the outside of the referenced trajectory defined as $Weighted\ normalized\ error = (\sum((COPa - R)^2 * (R/Asmax)^2))/(\sum(R^2 * (R/Asmax)^2)) * 100$ where COPa is the actual COP signal, R is the reference trajectory, Asmax is the maximal amplitude of the referenced trajectory either on the side 1 or the side 2 (if R is on the side 1 then maximal amplitude on the side 1 is used and if R is on the side 2 then maximal amplitude on the side 2 is used). This parameter weights more deviations close to maximal amplitudes on both sides of the reference trajectory and less those close to origin (value of COP when subject stands upright).

Weighted normalized error – inside [%]

The error for those parts of the performance where actual COP signal is on the inside of the referenced trajectory defined as $Weighted\ normalized\ error = (\sum((COPa - R)\textasciicircum 2 * (R/Asmax)\textasciicircum 2))/(\sum(R\textasciicircum 2 * (R/Asmax)\textasciicircum 2)) * 100$ where COPa is the actual COP signal, R is the reference trajectory, Asmax is the maximal amplitude of the referenced trajectory either on the side 1 or the side 2 (if R is on the side 1 then maximal amplitude on the side 1 is used and if R is on the side 2 then maximal amplitude on the side 2 is used). This parameter weights more deviations close to maximal amplitudes on both sides of the reference trajectory and less those close to origin (value of COP when subject stands upright).

T share on outside [%]

Time while the actual COP signal is on the outside of the referenced trajectory.

T share on inside [%]

Time while the actual COP signal is on the outside of the referenced trajectory.