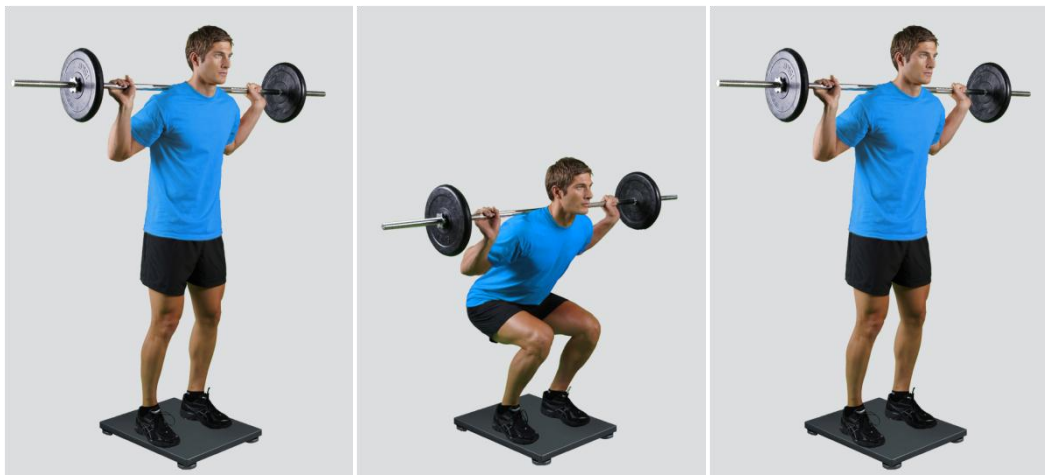# MODULE: SQUAT

BRIEF DESCRIPTION:

Squat is a vertical down-and-up movement. It is one among the most often used strength, strength endurance and injury prevention exercises for the lower extremities. It is commonly performed as a moderate velocity concentric or eccentric/concentric muscle action which involves coordinated active extension of the trunk, hips and knees. However, squat is not only used for exercising, but also as a functional test. Based on the parameters derived from the ground reaction force dynamics of this elementary movement pattern can be thoroughly studied.

The initial position of the subject is usually a standing position. From this position a person performs a vertical downward movement into a squat (knee ~90° and trunk/hips in a flexed position). However, the depth of the squat can sometimes be adjusted to the specific goals of the measurement (e.g. half-squat). The subject then needs to perform vertical upward movement. In this phase, the majority of parameters are calculated.

When the Squat 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 Squat 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 Squat 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:
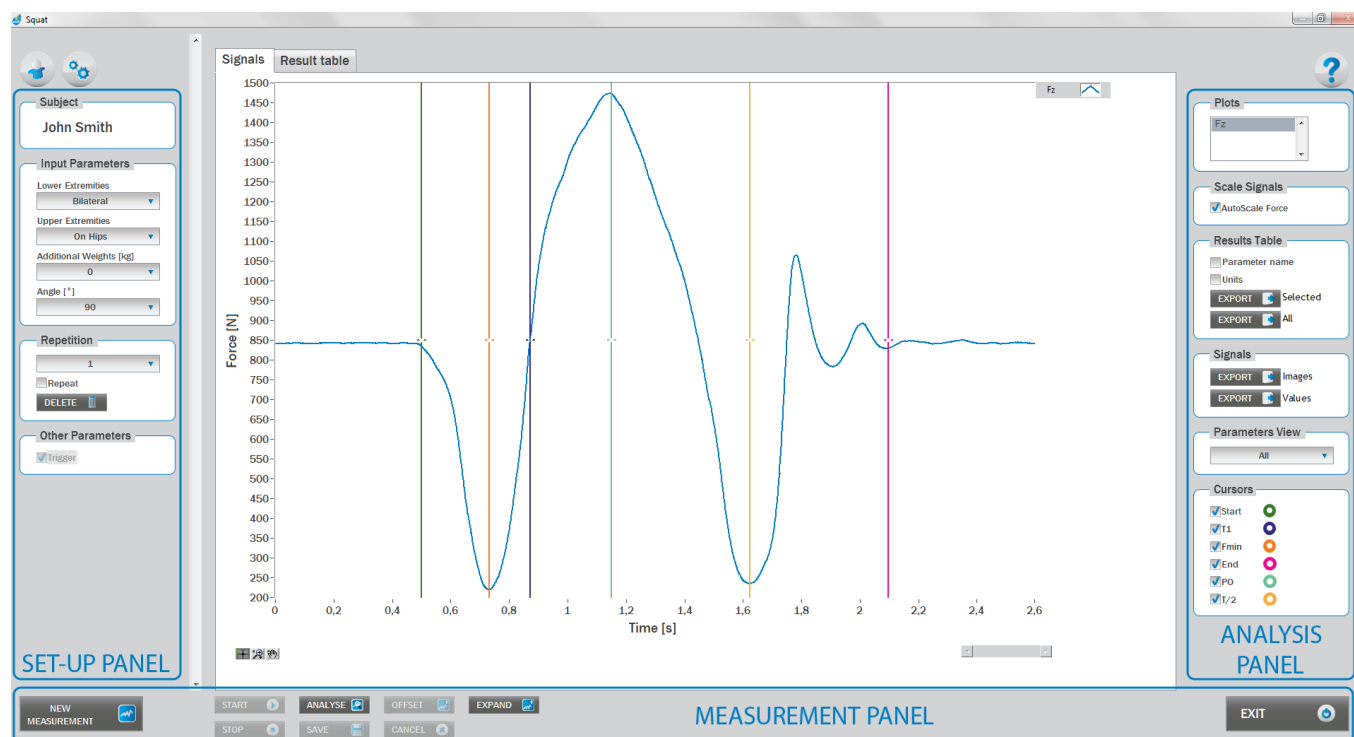
SET-UP PANEL:

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.

OTHER PARAMETERS:

Trigger
When trigger option is selected, software will automatically cut the signal before the »first cursor« (duration is defined with Start buffer parameter) and after the »last cursor«(duration is defined with Start buffer parameter).Start buffer and Stop buffer can be set in settings window. For details about setting the parameters refer to Settings Section.

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.

CURSORS:
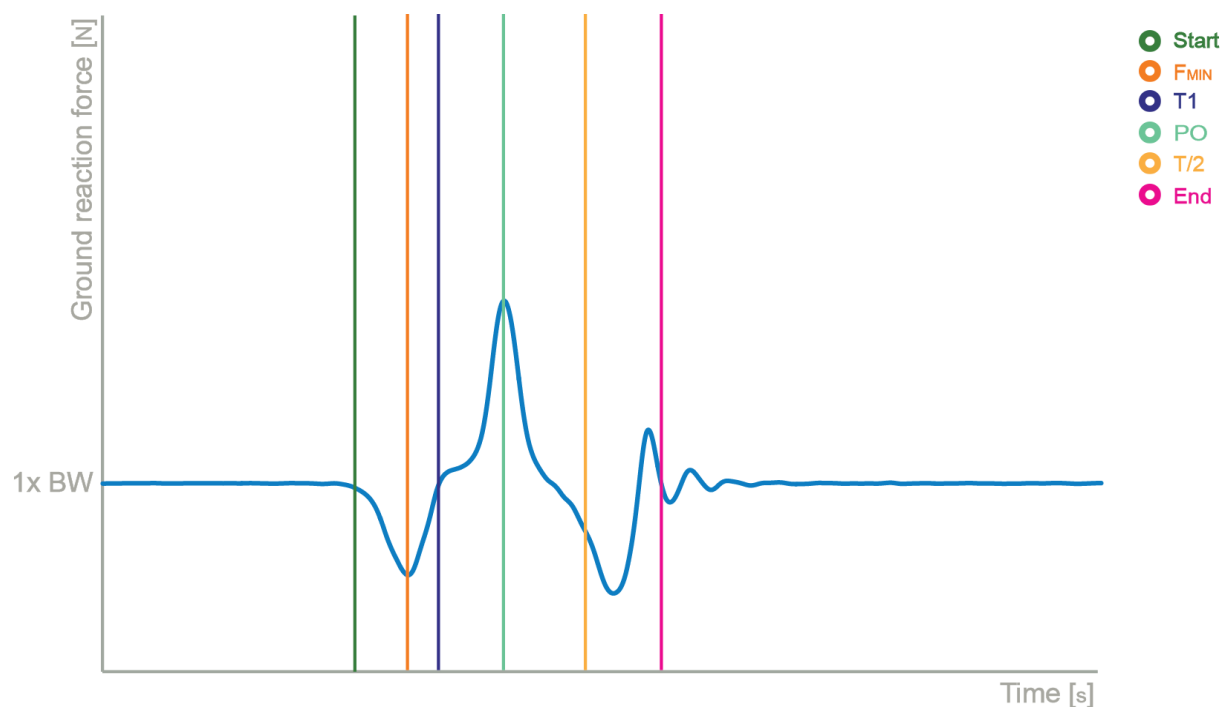
Start

Indicates the start of the squat (start of the movement).

T1

Indicates the event when force reaches the value of body weight during counter movement.

Fmin

Indicates the minimum force during the counter movement.

End
Indicates the end of the squat.

PO
Indicates the start of the push off.

T/2
Indicates the half of the time between the Start and End event.

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 (squat) is specifically defined. These parameters are important for further

analysis, comparisons and reporting. The task`s characteristics are defined by the following parameters:
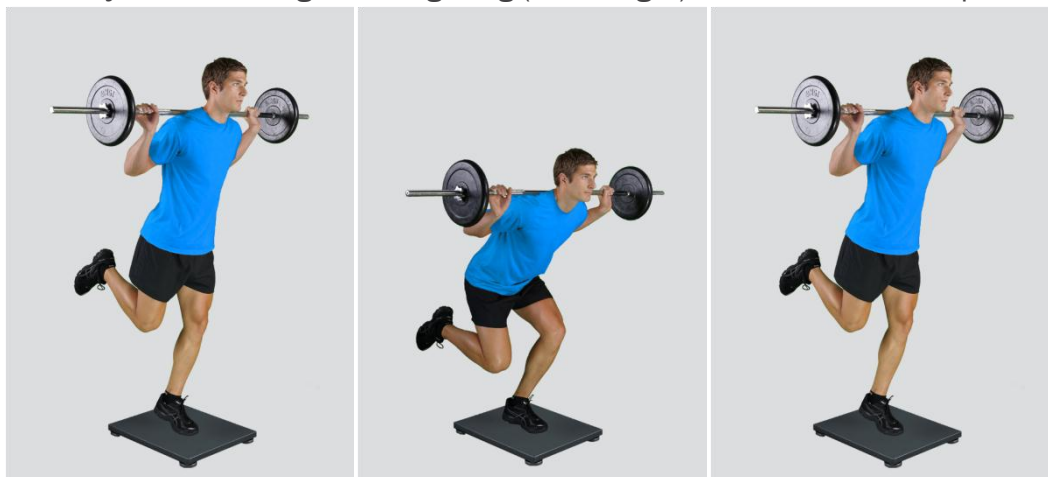
LOWER EXTREMITIES:

Bilateral

The subject is standing in the centre of the plate with the feet placed parallel or with toes pointing slightly outward. Feet should be shoulder-width apart.
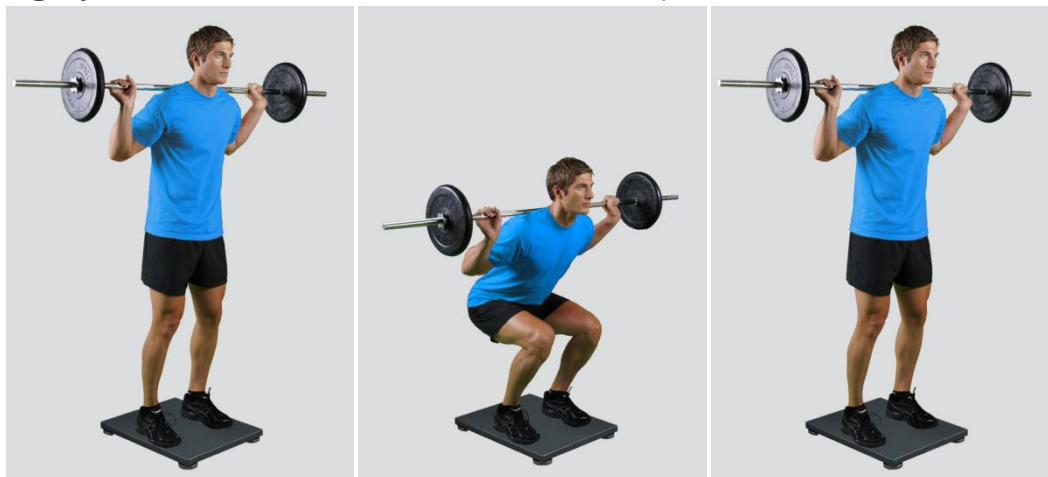
Unilateral-Left / Unilateral-Right

The subject is standing on a single leg (left or right) in the centre of the plate.

UPPER EXTREMITIES:

On barbell

The subject places his/her hands on a barbell which is placed on a shoulders behind the neck.

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

Free
Subject is free to use his/her arms as he/she want. Specifically useful when observing how subjects differ in using arms as a biomechanical advantage.

Other user defined
In case of any other position of the upper extremities, the user can select this option and can define another function/placement 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 Squat measurement module.
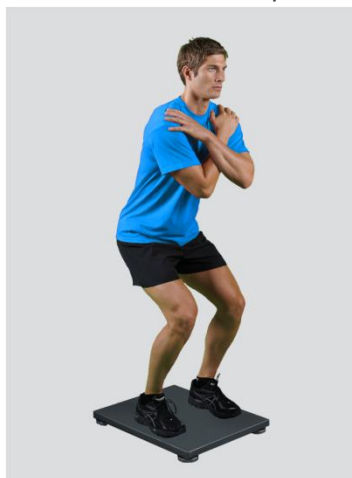

ADDITIONAL WEIGHTS:

0/5/10/15/20/25/30/35/40/45/50/55/60/65/70/75/80/85/90/95/100 kg

Other user defined
In case of different amount of additional weights, the user can select this option and can define other values (see Settings Section for details). After doing so, the newly defined input parameter will from then on appear as an optional choice under the Additional Weights in the Squat measurement module.
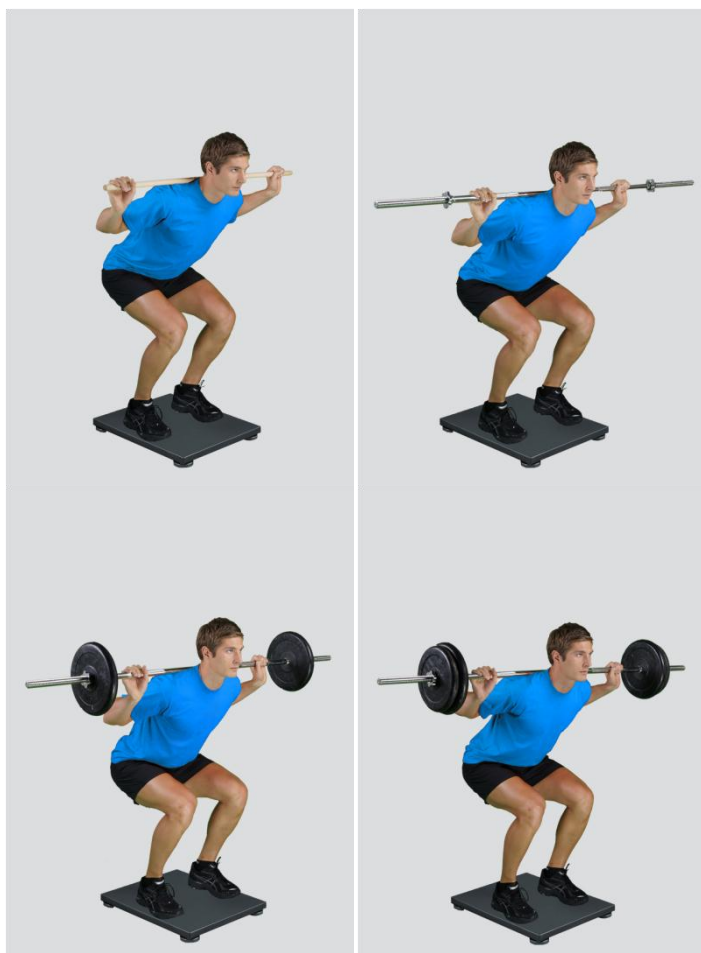
ANGLE:

-90º: the subject performs a squat to the position where the knee angle is 90 degrees
-60º: the subject performs a squat to the position where the knee angle is 60 degrees
-30º: the subject performs a squat to the position where the knee angle is 30 degrees

Other user defined

In case of different angle, the user can select this option and can define other values (see Settings Section for details). After doing so, the newly defined input parameter will from then on appear as an optional choice under the Angle in the Squat measurement module.

MEASUREMENT:

After selecting input parameters, the subject steps on the plate and acquires the required position. Ensure that the subject is standing in the centre of the plate as described above. When the subject acquires the required position and is ready to start the movement, click Start. At that time, the subject is free to start the squat and the software will automatically recognize the start and the end of the squat. 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(s) of the ground reaction force (GRF) and the calculated parameters. Under the Signal tab you can see the signal and markers which are placed automatically. You can move all markers if they were placed incorrectly. 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 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.

All the parameters calculated for analysis are commonly used in biomechanics, kinesiology and rehabilitation[1-5]. Parameters are calculated from the ground reaction force. For more information regarding the parameters see the references below.

For some modules additional analysis routines are available as separate products. See section About the Product for more information.
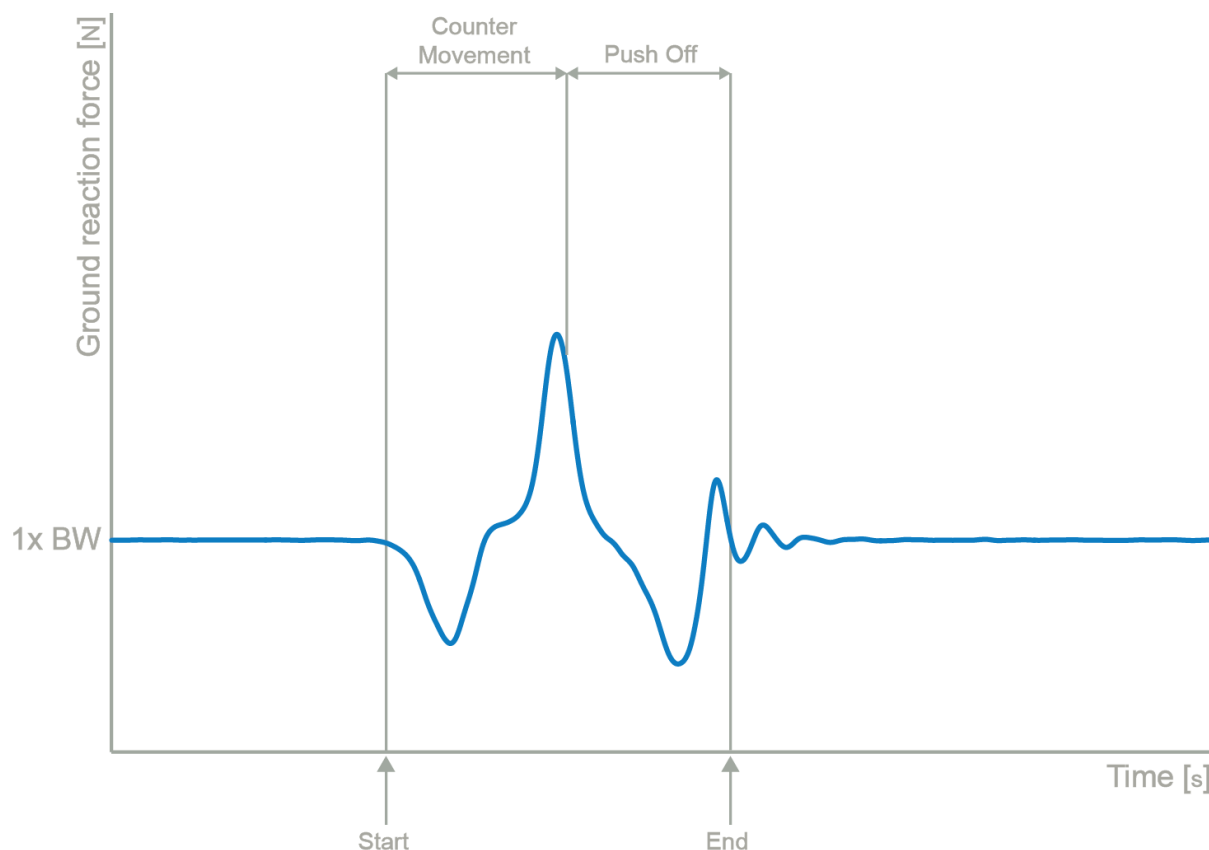
CALCULATED PARAMETERS:

GENERAL

Start interval relative F [%BW]
Average force in the 1st 50 ms after the lowest position divided by the body weight (50 ms is a default value and can be changed under the Settings section).

Start interval relative P [W/kg]
Average power in the 1st 50 ms after the lowest position divided by the body weight (50 ms is a default value and can be changed under the Settings section).

Start interval A [m/s^2]
Average acceleration in the 1st 50ms after the lowest position (50 ms is a default value and can be changed under the Settings section).

Start interval V [m/s]
Average velocity in the 1st 50ms after the lowest position (50 ms is a default value and can be changed under the Settings section).

Relative maximal F [%BW]
Maximal force during the squat divided by the body weight.

Relative maximal F during Counter Movement [%BW]
Maximal force during the Counter Movement divided by the body weight.

Relative maximal F during Push Off   [%BW]
Maximal force during the Push Off divided by the body weight.

Relative maximal F in the 1st half of Push Off [%BW]
Maximal force between the lowest position and the half of the Push Off divided by the body weight.

Relative maximal F in the 2nd half of the Push Off   [%BW]
Maximal force between the half of the Push Off and the End divided by the body weight.

Relative minimal F [%BW]
Minimal force during the Counter Movement divided by the body weight. At this point, the peak acceleration in downward direction occurs and the deceleration begins.

Relative maximal P [W/kg]
Maximal power during the Push Off divided by the body weight.

Relative E [J/kg]
Energy during the Push Off divided by the body weight.

A in the 1st half of Push Off [m/s^2]
Average acceleration between the lowest position and the half of the Push Off.

A in the 2nd half of Push Off [m/s^2]
Average acceleration between the half of the Push Off and the End.

TIME PARAMETERS

Squat T [s]
Time interval between the Start and the End.

Counter Movement T [s]
Time interval between the Start and the lowest position.

Push off T [s]
Time interval between the lowest position and the End.

Braking T [s]
Time interval between the minimal force and the lowest position.

Ratio between Counter Movement and Push Off T [%]
Ratio between the duration of the Counter Movement and the duration of the Push Off.

T to maximal F [s]
Time interval between the Start and the maximal force .

T to minimal F [s]
Time interval between the Start and the minimal force .

FORCE IMPULSE PARAMETERS

Negative FI [Ns]
Force Impulse of the parts where the ground reaction force is below the body weight.

Positive FI [Ns]
Force Impulse of the parts where the ground reaction force is above the body weight.

FI in the 1st half of Push Off [Ns]
Force impulse between the lowest position and the half of the Push Off.

FI in the 2nd half of Push Off [Ns]
Force impulse between the half of the Push Off and the End.

Ratio between FI in both halves of Push Off [%]
Ratio of the force impulse between the Lowest Position and the half of the Upward Movement and the force impulse between the half of the Upward Movement and the End.

REFERENCES:

1.   Hori, N. et al. Comparison of four different methods to measure power output during the hang power clean and the weighted jump squat. The Journal of Strength & Conditioning Research 21, 314 (2007).
2.   Bentley, J.R., Amonette, W.E., De Witt, J.K. & Hagan, R.D. Effects of different lifting cadences on ground reaction forces during the squat exercise. J Strength Cond Res 24, 1414-1420 (2010).
3.   Kellis, E., Arambatzi, F. & Papadopoulos, C. Effects of load on ground reaction force and lower limb kinematics during concentric squats. Journal of Sports Sciences 23, 1045-1055 (2005).
4.   Rahmani, A., Viale, F., Dalleau, G. & Lacour, J.-R. Force/velocity and power/velocity relationships in squat exercise. Eur J Appl Physiol 84, 227-232 (2001).
5.   Zink, A.J., Perry, A.C., Robertson, B.L., Roach, K.E. & Signorile, J.F. Peak power, ground reaction forces, and velocity during the squat exercise performed at different loads. The Journal of Strength & Conditioning Research 20, 658 (2006).