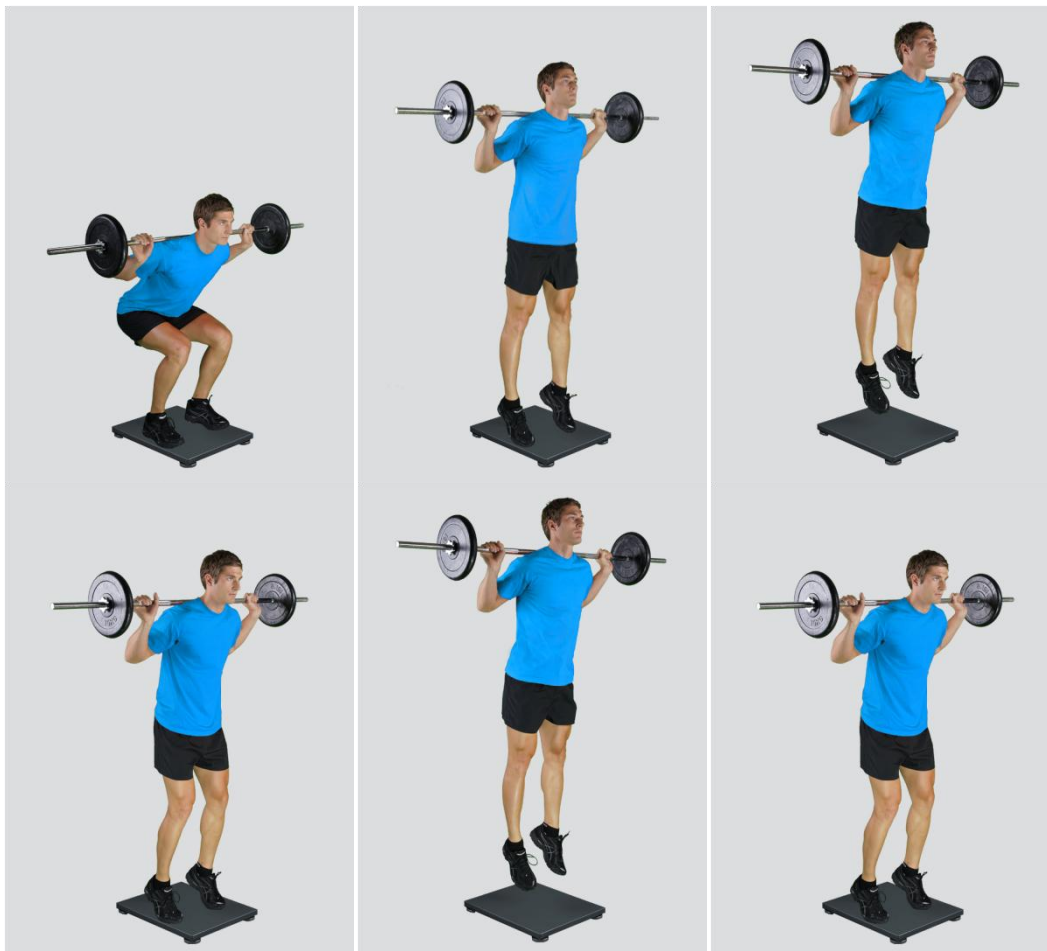


## MODULE: JUMPS WITH ADDITIONAL WEIGHTS

### BRIEF DESCRIPTION:

Vertical jumps with additional weights are used in order to study the load:velocity relationship in this multi-segment coordinated movement that involves lower extremities` and trunk`s muscle groups. Many different test protocols can be used and MARS anticipates the test to be performed as a combination of three consecutive vertical jumps (first one squat jump plus two hops). The required movement task is repeated by an athlete thereby using different (i.e. progressive) load during every trial. These kinds of jumps are among the most often used tests for maximal anaerobic power output of the lower extremities. Squat jump represents the concentric and both hops represent an eccentric-concentric muscle action. Based on the parameters derived from the ground reaction force (GRF) and flight time dynamics of this elementary movement patterns can be thoroughly studied.

The initial position of the subject is usually a semi-squat (knee  $\sim 90^\circ$  and trunk/hips in a flexed position). However, this position can sometimes be adjusted to the specific goals of the measurement. From the starting position the subject performs a vertical push off action (same as squat jump) and then immediately after landing two consecutive hops. All jumps should be performed as quickly and as explosively as possible with a goal to jump as high as possible.

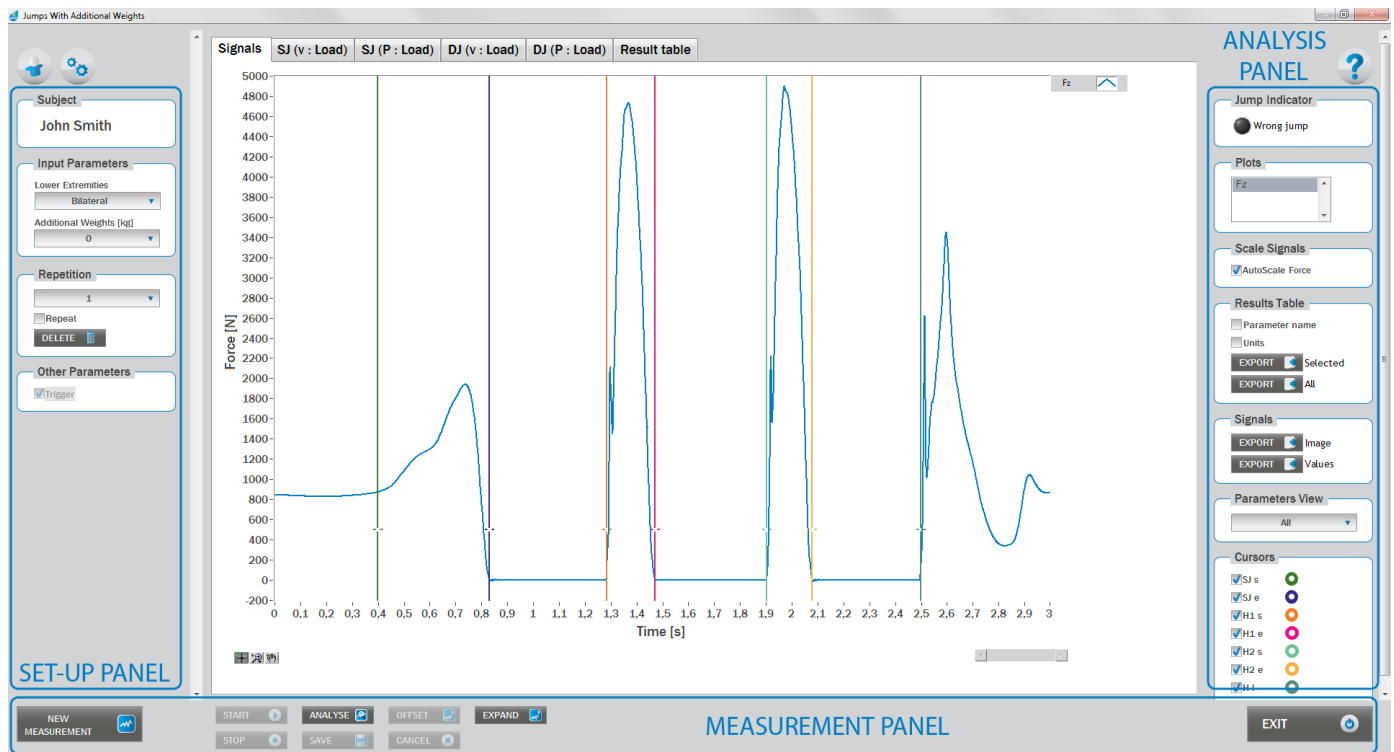




When the Jumps with Additional Weights module opens, the existing measurements of the selected subject inside the current Visit are displayed and the user can review them (see section Analysis for details). If no measurements have yet been done for this subject, than only the option to start a new measurement 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 Jumps With Additional Weights 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 Jumps with Additional Weights 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 Stop 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

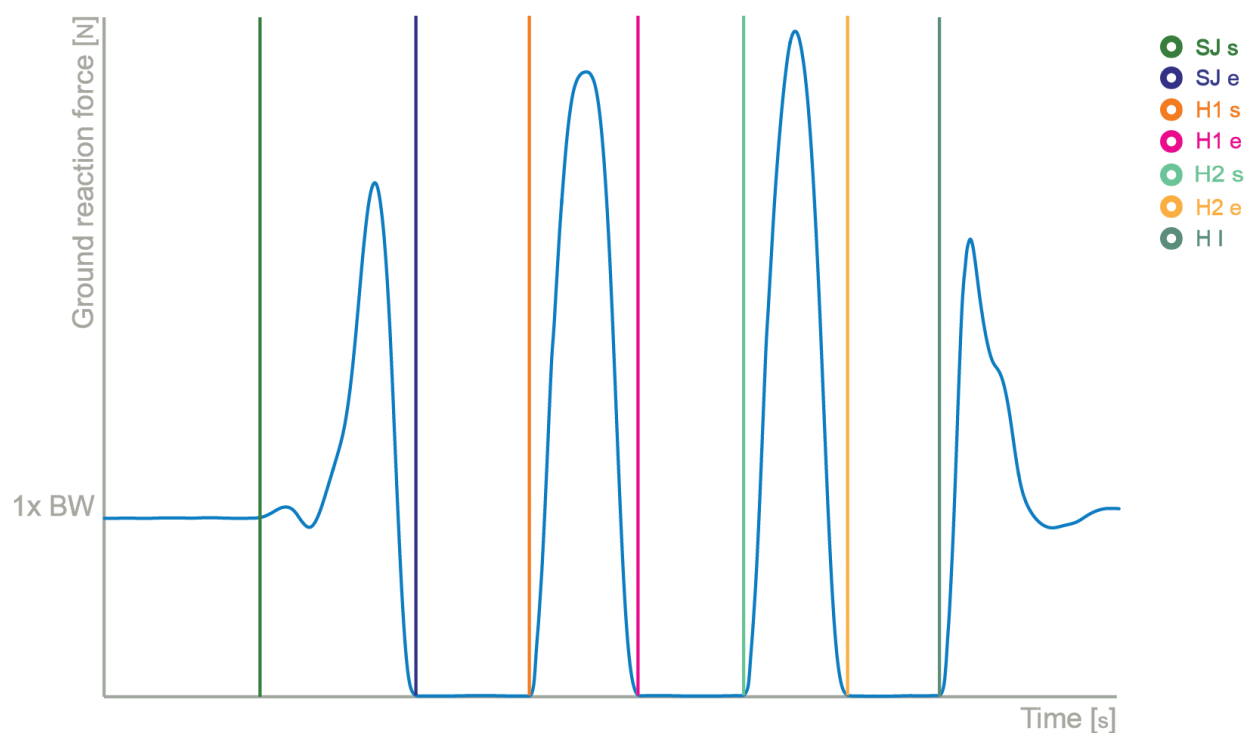
Export values (raw data) of signals (as visible on the graph on the Signals tab) into CSV or TXT format. Format of the file can be set in settings window under export section. For details about setting the parameters refer to Settings Section.

## 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:



### SJ s

Indicates the start of the squat jump.

### SJ e

Indicates the Take Off of the squat jump.



## **H1 s**

Indicates the start of the first hop.

## **H1 e**

Indicates the Take Off of the first hop.

## **H2 s**

Indicates the start of the second hop.

## **H2 e**

Indicates the Take Off of the second hop.

## **H l**

Indicates the landing of the second hop.

## **JUMP INDICATORS:**

Indicates the false movement at the start of the jump (if the eccentric movement is present). Maximal allowed eccentric movement is defined as the percent of body weight exceeded. The percent of body weight is defined with parameter Criteria which can be set under General settings in Settings window.

## **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.

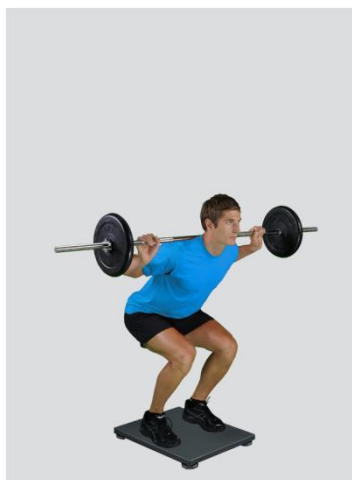
## SELECTING INPUT PARAMETERS:

Before the measurement can start, the user has to choose some input parameters with which the measured motor task (jumps-hops) is specifically defined. These parameters are important for further analysis, comparisons and reporting. The jumps` 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 (dominant or non-dominant) in the centre of the plate.



### UPPER EXTREMITIES:

#### On a barbell

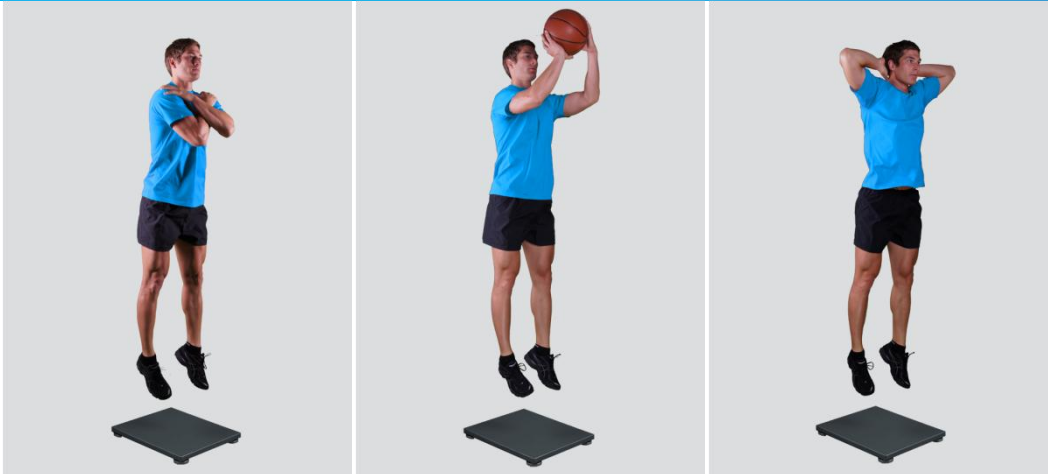
The subject holds the barbell with additional weights.



#### 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). This might be interesting in case when another way of additional loading, such as a load vest, is applied. After a new hands position has been set, it will from then on appear as an optional choice under the Upper extremities in the Jumps with Additional Weights measurement module.



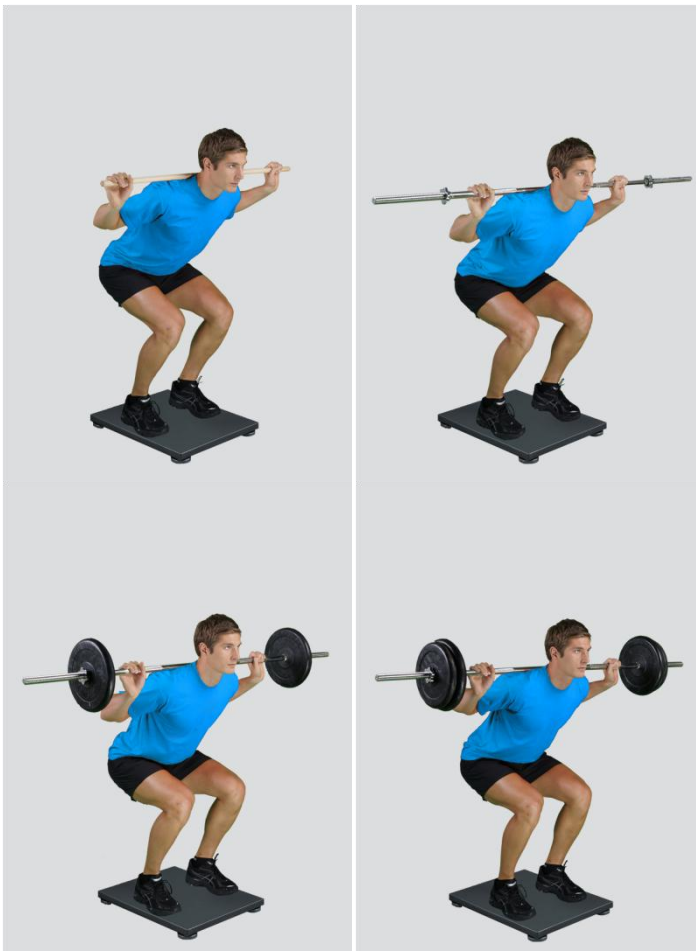


### ADDITIONAL WEIGHTS:

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 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 Additional Weights in the Jumps with Additional Weights 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 movement task and the software will automatically recognize the beginning and the end of the jumps. For details about this automatic acquisition please see Settings Section.

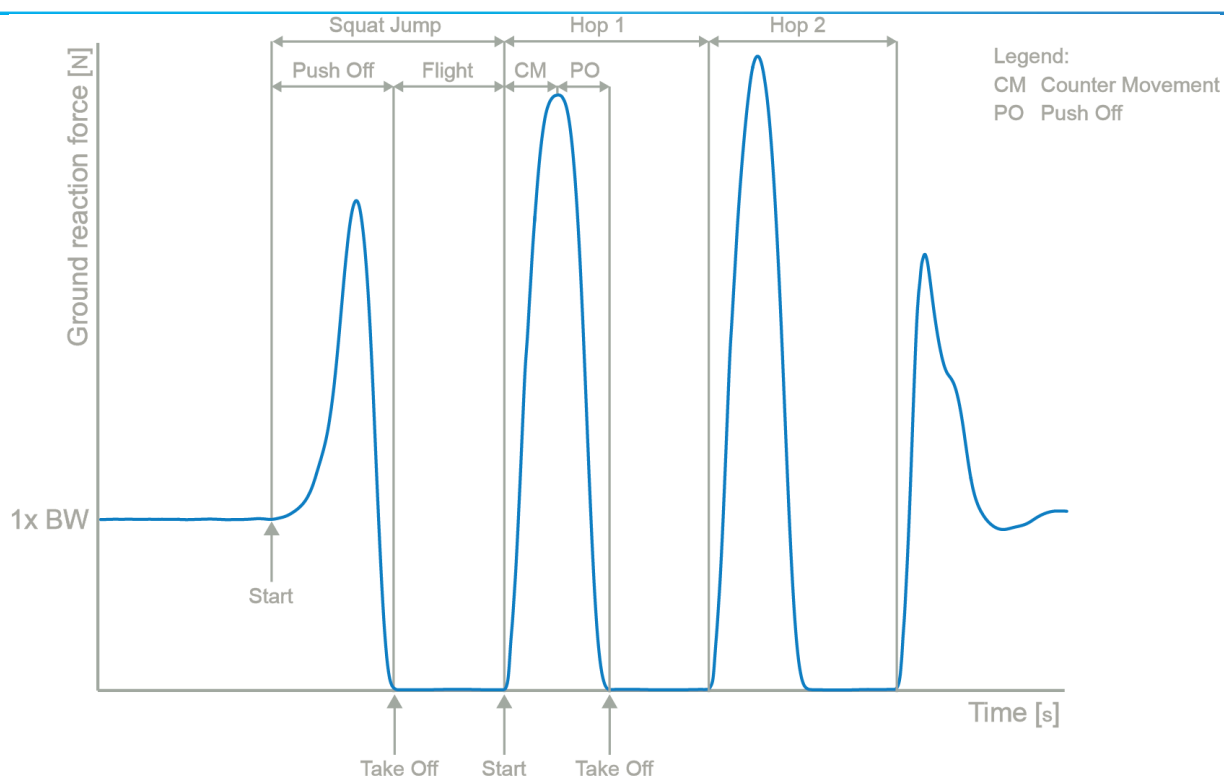
If you want to start a new measurement, click the New Measurement button and repeat the procedure. Before doing so, you can change the Input Parameters; if not, the Input Parameters of the previous measurements will be used. If you want to repeat a certain measurement, click on the drop down menu, select 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 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<sup>1-5</sup>. Parameters are calculated from the ground reaction force and flight time. For more information regarding the parameters see the references below.

For some modules additional analysis software routines can be developed as separate products according to the wishes of the customer. See section About the Product for more information.



## CALCULATED PARAMETERS:

### CALCULATED PARAMETERS - SQUAT JUMP:

#### GENERAL

##### Jump Height from Take Off V [m]

The height of the jump calculated from the Take Off velocity as calculated from the force impulse.

##### Jump Height from Flight T [m]

The height of the jump calculated from the Flight Time.

##### Start interval relative F [%BW]

Average force in the 1<sup>st</sup> 50 ms of the Push Off 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 1<sup>st</sup> 50 ms of the Push Off divided by the body weight (50 ms is a default value and can be changed under the Settings section).

##### Start interval A [m/s<sup>2</sup>]

Average acceleration in the 1<sup>st</sup> 50ms of the Push Off (50 ms is a default value and can be changed under the Settings section).



## **Start Interval V [m/s]**

Average velocity in the 1<sup>st</sup> 50ms of the Push Off (50 ms is a default value and can be changed under the Settings section).

## **Relative maximal F [%BW]**

Maximal force during the jump (i.e. Push Off) divided by the body weight.

## **Relative maximal F in the 1<sup>st</sup> half of Push Off [%BW]**

Maximal force between the Start and the half of the Push Off divided by the body weight.

## **Relative maximal F in the 2<sup>nd</sup> half of Push Off [%BW]**

Maximal force between the half of the Push Off and the Take Off divided by the body weight.

## **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 [m/s<sup>2</sup>]**

Average acceleration during the jump.

## **A in the 1<sup>st</sup> half of Push Off [m/s<sup>2</sup>]**

Average acceleration between the Start and the half of the Push Off.

## **A in the 2<sup>nd</sup> half of Push Off [m/s<sup>2</sup>]**

Average acceleration between the half of the Push Off and the Take Off.

## **Vertical Take Off V [m/s]**

Velocity of the vertical movement at the Take Off.

## **TIME PARAMETERS**

### **Push Off T [s]**

Time interval between the Start and the Take Off.

### **Flight T [s]**

Time interval between the Take Off and the Start of the first hop that follows.

### **T of the 1<sup>st</sup> half of FI [s]**

Time interval between the Start and the half of the total force impulse.

### **T of the 2<sup>nd</sup> half of FI [s]**

Time interval between the half of the total force impulse and the Take Off.

### **T to maximal F [s]**

Time interval between the Start and the maximal force.

### **T from maximal F to Take Off [s]**

Time interval between the maximal force and the Take Off.



## FORCE IMPULSE PARAMETERS

### Total FI [Ns]

Force impulse (i.e. integral of a force with respect to time) between the Start and the Take Off.

### Total FI from Flight T [Ns]

Total force impulse calculated from the Flight Time.

### FI in the 1<sup>st</sup> half of Push Off [Ns]

Force impulse (i.e. integral of a force with respect to time) between the Start and the half of the Push Off.

### FI in the 2<sup>nd</sup> half of Push Off [Ns]

Force impulse (i.e. integral of a force with respect to time) between the half of the Push Off and the Take Off.

### Ratio between FI in both halves of Push Off [%]

Ratio of the force impulse (i.e. integral of a force with respect to time) between the Start and the half of the Push Off and the force impulse between the half of the Push Off and the Take Off.

### FI between Start and maximal F [Ns]

Force impulse (i.e. integral of a force with respect to time) between the Start and the maximal force.

### FI between maximal F and Take Off [Ns]

Force impulse (i.e. integral of a force with respect to time) between the maximal force and the Take Off.

### Ratio of FI before and after maximal F [%]

Ratio between the force impulse (i.e. integral of a force with respect to time) between the Start and the maximal force and the force impulse between the maximal force and the Take Off.

## CALCULATED PARAMETERS – HOP:

**NOTE: The Hop related parameters are calculated from the higher of the two hops being performed.**

## GENERAL

### Jump height from Take Off V [m]

The height of the jump calculated from the Take Off velocity as calculated from the force impulse.

### Jump Height from Flight T [m]

The height of jump computed from the Flight Time.

### Ratio between jump height and Contact T [m/s]

Ratio between the height of the jump and the time interval between the Start and the Take Off.

### Start interval relative F [%BW]

Average force in the 1<sup>st</sup> 50 ms of the Push Off divided by 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 1<sup>st</sup> 50 ms of the Push Off divided by the body weight (50 ms is a default value and can be changed under the Settings section).

### **Start interval A [m/s<sup>2</sup>]**

Average acceleration in the 1<sup>st</sup> 50 ms of the Push Off (50 ms is a default value and can be changed under the Settings section).

### **Start interval V [m/s]**

Average velocity in the 1<sup>st</sup> 50 ms of the Push Off (50 ms is a default value and can be changed under the Settings section).

### **Relative maximal F [%BW]**

Maximal force during the Contact period 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 1<sup>st</sup> 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 2<sup>nd</sup> half of Push Off [%BW]**

Maximal force between the half of the Push Off and the Take Off divided by the body weight.

### **Relative maximal P [W/kg]**

Maximal power during the Contact divided by the body weight.

### **Relative E [J/kg]**

Energy during the Contact divided by the body weight.

### **Counter Movement A [m/s<sup>2</sup>]**

Average acceleration during counter Movement phase.

### **Push Off A [m/s<sup>2</sup>]**

Average acceleration during Push Off.

### **Vertical Take Off V [m/s]**

Velocity of the vertical movement at the Take Off.

### **Hop / Squat Jump height ratio [%]**

Ratio between the Hop height and the Squat Jump height – for the same repetition, i.e. additional weight condition.

## **TIME PARAMETERS**

### **Contact T [s]**

Time interval between the Start and the Take Off.



### **Flight T[s]**

Time interval between the Take Off and the Landing.

### **Counter Movement T [s]**

Duration of the Counter Movement phase from the Start to the Push Off.

### **Push Off T [s]**

Duration of the Push Off phase, from Counter Movement end to Take Off..

### **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 between maximal F and Take Off [s]**

Time interval between the maximal force and the Take Off.

## **FORCE IMPULSE PARAMETERS**

### **Total FI [Ns]**

Force impulse (i.e. integral of a force with respect to time) between the Start and the Take Off.

### **Push Off FI from Flight T [Ns]**

Force impulse calculated from the Flight Time.

### **Counter movement FI [Ns]**

Force impulse (i.e. integral of a force with respect to time) between the Start and begin of the Push Off.

### **Push Off FI [Ns]**

Force impulse (i.e. integral of a force with respect to time) between the beginning of the Push Off and Take Off.

### **Ratio between Counter Movement and Push Off FI [%]**

Ratio between Counter Movement and the Push Off force impulse (i.e. integral of a force with respect to time).

### **FI between Start and maximal F [Ns]**

Force impulse (i.e. integral of a force with respect to time) between the Start and the maximal force.

### **FI between maximal F and Take Off [Ns]**

Force impulse (i.e. integral of a force with respect to time) between the maximal force and the Take Off.

### **Ratio between FI before and after maximal F [%]**

Ratio between the force impulse (i.e. integral of a force with respect to time) between the Start and the maximal force and the force impulse between the maximal force and the Take Off.



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## REFERENCES:

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