

## MODULE: LONG JUMP

### BRIEF DESCRIPTION:

Long jump is a jump where a subject's task is to jump as long as possible. Long jump is one of the most often used tests for maximal anaerobic power output of the lower extremities. It is an eccentric-concentric muscle action which involves coordinated extension of the trunk, hips, knees and ankles all aimed to produce an optimal angle of the propulsion force vector. Based on the parameters derived from the ground reaction force (GRF), dynamics of this elementary movement pattern can be thoroughly studied. Somehow different from the vertical jumps, the horizontal distance of the long jump strongly depends also on the coordinated movements in the flight and landing phase of the jump.

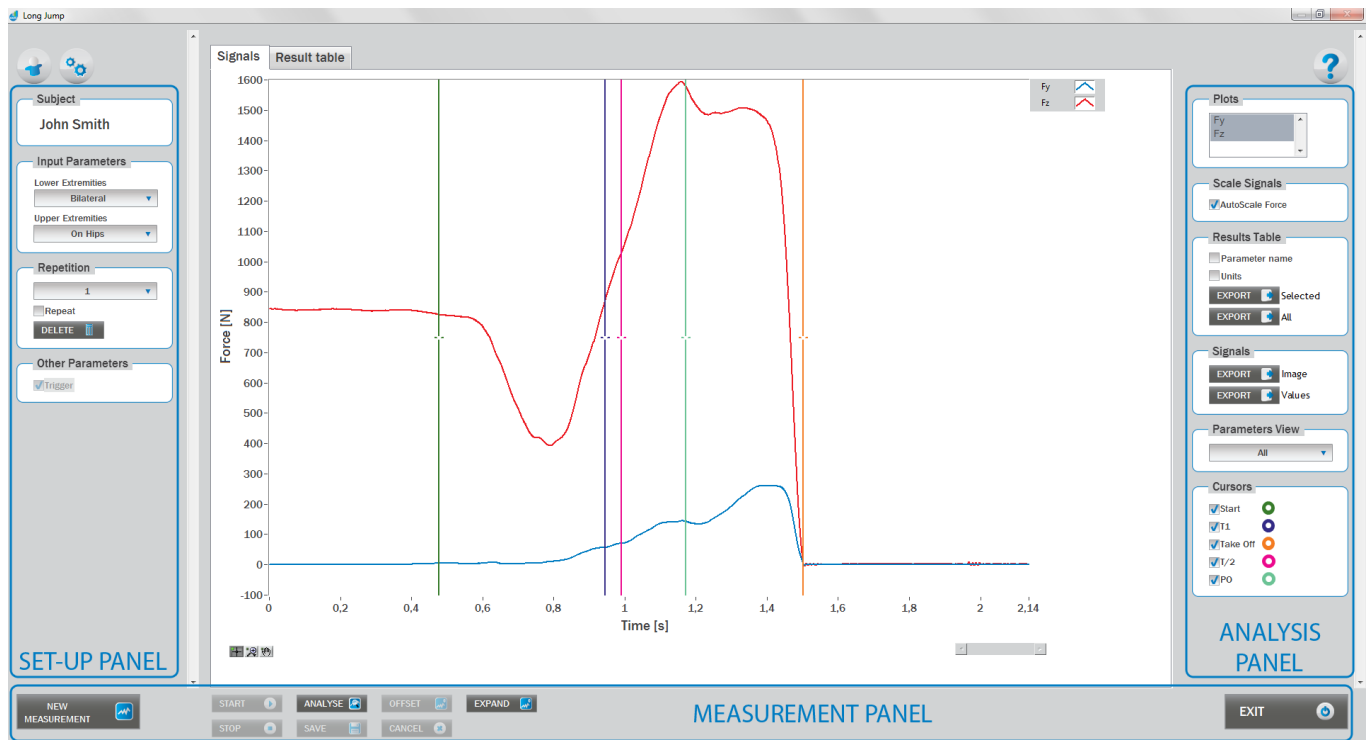
The initial position of the subject is usually a standing position and then a counter movement into a semi-squat (knee  $\sim 90^\circ$  and trunk/hips in a flexed position) follows. However, this position can sometimes be adjusted to the specific goals of the measurement. From the starting position the subject performs a counter movement and then a push-off action at the angle approximately at the 45 degrees forward as quickly and as explosively as possible in order to perform the longest possible jump.



When the Long Jump 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 Long Jump 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 Long Jump 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

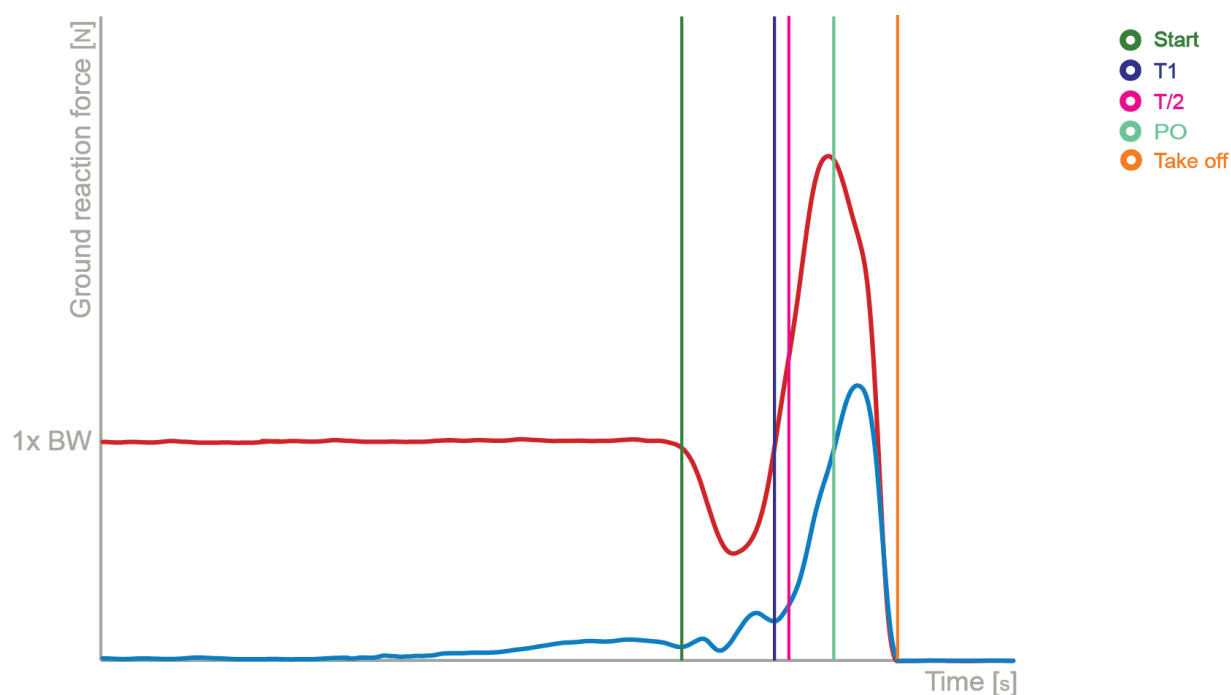
Export values (raw data) of signals (as visible on the graph on the Signals tab) into CSV or TXT format. Format of the file can be set in settings window under export section. For details about setting the parameters refer to Settings Section.

## 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:



#### Start

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

#### Take Off

Indicates the start of the flight phase.

#### T1

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



## **T/2**

Indicates the half of the time between the Start and Take Off event.

## **PO**

Indicates the start of the push off.

## **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.

### **Exit**

Closes the measurement module.

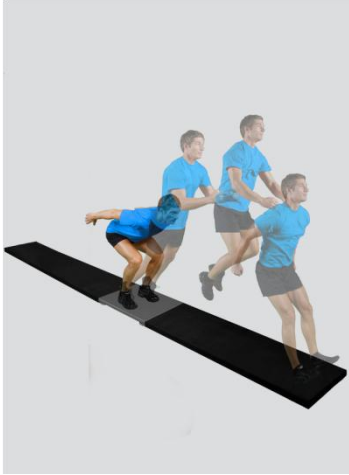
## **SELECTING INPUT PARAMETERS:**

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

## LOWER EXTREMITIES:

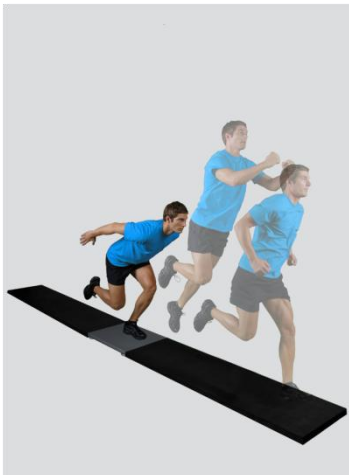
### Bilateral

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

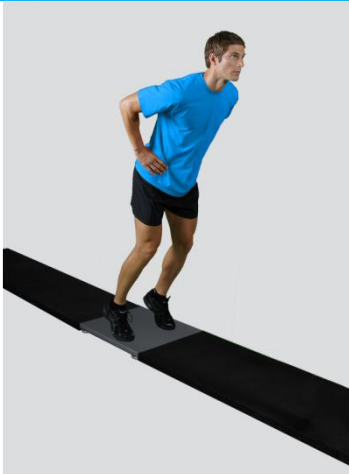
The subject is standing on a single leg (dominant or non-dominant) in the centre of the plate.



## UPPER EXTREMITIES:

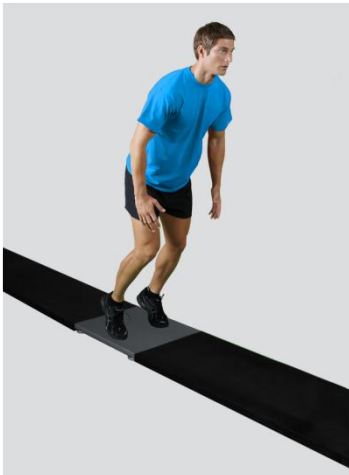
### On Hips

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



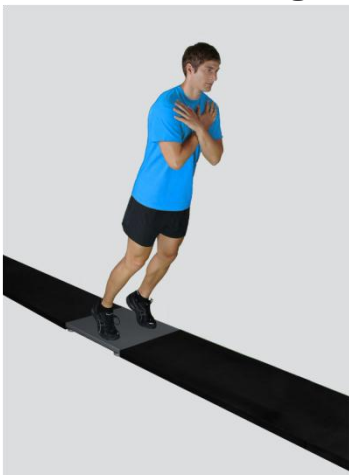
### Free

Subjects are free to use their arms as they want. 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 Long Jump measurement module.





## MEASUREMENT:

After selecting input parameters, the subject steps on the plate and acquires a 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 with the jump and the software will automatically recognize the beginning and the end of the jump. 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.

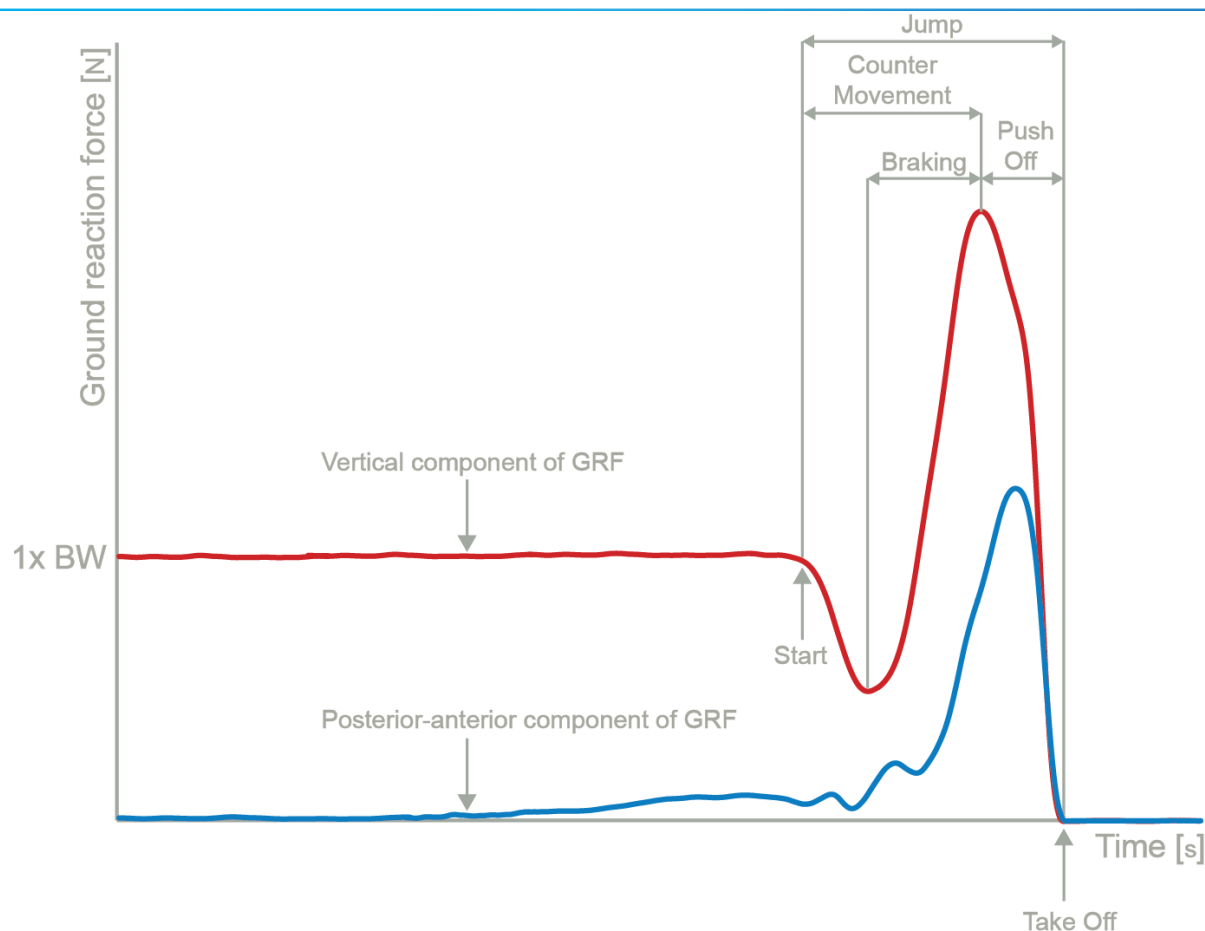
## ANALYSIS:

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<sup>1-4</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 routines are available as separate products. See section About the Product for more information.





## CALCULATED PARAMETERS:

### GENERAL

#### Calculated horizontal COG distance [m]

Predicted horizontal displacement of the centre of gravity (COG) of the subject calculated from the Take Off velocity vector.

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

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

#### Height/distance ratio [%]

Ratio between the height and the distance of the jump.

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

Average resultant 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 resultant 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 resultant 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 resultant 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 resultant force during the Push Off divided by the body weight.

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

Maximal horizontal force during the jump divided by the body weight.

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

Maximal vertical force during the jump divided by the body weight.

**Relative maximal F during Counter Movement [%BW]**

Maximal resultant force during the Counter Movement divided by the body weight.

**Relative maximal F during Push Off [%BW]**

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

**Relative minimal F [%BW]**

Minimal resultant 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 resultant power during the Push Off divided by the body weight.

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

Maximal power during the Jump in horizontal direction divided by the body weight.

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

Maximal power during the Jump in vertical direction divided by the body weight.

**Relative E [J/kg]**

Energy, calculated from the resultant force, during the Push Off divided by the body weight.

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

Average resultant acceleration during the jump.

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

Average resultant acceleration between the Lowest Position and the half of the Push Off.



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

Average resultant 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.

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

Velocity of the horizontal movement at the Take Off.

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

Velocity at the Take Off.

## **TIME PARAMETERS**

### **Jump T [s]**

Time interval between the Start and the Take Off.

### **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 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.

### **Braking T [s]**

Time interval between the minimal force and the Lowest Position.

### **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**

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

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

### **Horizontal FI [Ns]**

Force impulse in horizontal direction (i.e. integral of a horizontal force with respect to time).

### **Vertical FI [Ns]**

Force impulse in vertical direction (i.e. integral of a vertical force with respect to time).

### **Negative FI [Ns]**

Force Impulse (i.e. integral of a vertical force with respect to time) between the Start and the moment where the ground reaction force equals the body weight again.

### **Positive FI [Ns]**

Force Impulse (i.e. integral of a vertical force with respect to time) between the moment where the ground reaction force equals the body weight again and the Take Off.

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

Resultant force impulse (i.e. integral of a resultant force with respect to time) between the Lowest Position and the half of the Push Off.

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

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

## **REFERENCES:**

1. Ashby, B.M. & Heegaard, J.H. Role of arm motion in the standing long jump. *J Biomech* 35, 1631-1637 (2002).
2. Luhtanen, P. & Komi, P.V. Force-, power-, and elasticity-velocity relationships in walking, running, and jumping. *Eur J Appl Physiol Occup Physiol* 44, 279-289 (1980).
3. Muraki, Y., Ae, M., Yokozawa, T. & Koyama, H. Mechanical properties of the take-off leg as a support mechanism in the long jump. *Sports Biomech* 4, 1-15 (2005).
4. Ridderikhoff, A., Batelaan, J.H. & Bobbert, M.F. Jumping for distance: control of the external force in squat jumps. *Med Sci Sports Exerc* 31, 1196-1204 (1999).