



# DD System ELITE

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## User Manual



 **Made in Switzerland**

Robotic Personal Training Technology  
by Dynamic Devices



## Safety Regulations

### WARNINGS

- Always consult a physician, physical therapist or personal trainer before you begin or modify any training program on the DD System ELITE. For product warnings and other important information, please refer to Chapter 5: Safety Precautions and Chapter 15: Notes on Safety of this manual.
- If at any time during training of the DD System ELITE, the user experiences discomfort, dizziness, nausea, unusual fatigue, or pain, stop the training. Resume it after re-consultation with the physician, physical therapist or personal trainer.
- Never let the user exceed the range of pain free motion. Failure to follow this precaution may result in serious injury.
- To ensure safe and smooth operation, make sure the DD System ELITE has been properly set up by qualified personnel. The DD System must be connected to a functioning air compressor equipped with an air dryer as specified in Chapter 3.
- The maintenance and service may only be provided by qualified personnel. Please do not perform the base installation or any repairs by yourself.
- Make sure that children and pets are kept away from your training device while exercising.



## Scope of this Document

This is a quick start reference to orientate a first-time user or operator to the basic concepts and operations of the DD System ELITE. This document will walk you through the steps of setting up and starting the DD System ELITE for the first time.

## More Information

The latest version of this User Manual can be obtained by sending an email to the following address:  
[info@ddrobotec.com](mailto:info@ddrobotec.com)



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# 1. Introduction

Congratulations, you have made an excellent choice!

By selecting the DD System ELITE, you have acquired the most advanced and versatile Robotic Personal Training Technology ever developed for training, rehabilitation and testing of the human neuromusculoskeletal system. You have also joined the Dynamic Devices team of satisfied customers who benefit from unsurpassed product education, customer service, promotional and clinical support.

With your new DD System, you can offer training, testing and rehabilitation services for the legs, hips, and pelvic floor. Modes of operation for exercise and testing include eccentric, concentric, isometric, isokinetic and all combinations thereof. What is more, you will be able to test and exercise over the broadest range of speeds available today. Visual feedback is provided by a high-resolution display to encourage user motivation with exercise protocols.

You will also appreciate the graphical user interface that comes with your system. Our user database prompts quick and easy retrieval of user information while Windows flexibility makes protocol selection and user setups a snap. The wide variety of output reports allows numeric and graphic information to be printed in a number of different formats.

The versatility of the graphical user interface simplifies effective performance enhancement and recovery at all levels. The future certainly looks bright for you, your customers, your users, and your athletes!

Thank you for allowing Dynamic Devices AG to be a part of it.

Follow us on:

- [instagram.com/ddrobotec/](https://www.instagram.com/ddrobotec/)
- [twitter.com/ddrobotec/](https://twitter.com/ddrobotec/)
- [linkedin.com/company/dynamicdevices/](https://www.linkedin.com/company/dynamicdevices/)

Due to continuous product enhancements and modifications, the DD System ELITE you have purchased may differ slightly from the system depicted in the photographs and illustrations used in this manual. Also, some pictures show a DD Air Tower, our integral compressed air solution which includes a display. The air compressor and the display are optional pieces of equipment. The compressed air can be supplied through another air compressor and the display can be mounted on a wall.



## 2. DD System ELITE

The DD System ELITE is a closed kinetic chain, force-controlled interactive training and testing device for the lower extremities. It features low-latency multimodal (visual, auditory and haptic) feedback (< 30 ms), intrinsically compliant pneumatic actuation, forces and speeds matching those of humans (rate of force development > 15 kN/s), and a wide range of online sensory-motor testing and measuring tools. The DD System ELITE has a leg press layout and consists of two independent pedals and free footplates. The pedals are connected to a force generating linear actuation mechanism through shafts and levers under the main hood. Seat height can be adjusted with additional cushions, the back rest comfortably reclines into 9 positions.

With many different training and testing protocols, the system allows to increase leg muscle force, stamina, coordination, symmetry, flexibility and muscle tone by the state-of-the-art bionic training technology. Weight plates, as used in conventional weight training equipment, have been replaced by artificial muscles, which allow a continuous adjustment of the load.

The DD System ELITE offers optimal exercise conditions through its user-specific training and test protocols, including for users with minimal motor and cardiopulmonary performance. It also allows you to advance to a higher level of training earlier than on conventional devices by increasing the efficiency of the training by continually adjusting the training load and intensity.

The risk of injury is reduced with special arc-design pedals and swivel footplates (see chapter 2.4) reducing pressure on the patella and increasing ankle strength and control.

The DD System is used in the treatment of people with cardiopulmonary, neurological or orthopedic motor impairments, as well as in prevention, performance diagnostics and sports rehabilitation. The unique combination of strength training, motor learning and performance diagnostics, combined into a modern training and diagnostics system, makes the DD System ELITE much more efficient than conventional solutions and leads to a clear market advantage.

### 2.1. Areas of application

- Sports medicine
- Sports sciences
- Athletic performance enhancement
- Performance diagnostics
- Neuro-muscular post-rehabilitation
- Pre- and post-operative training
- Prevention

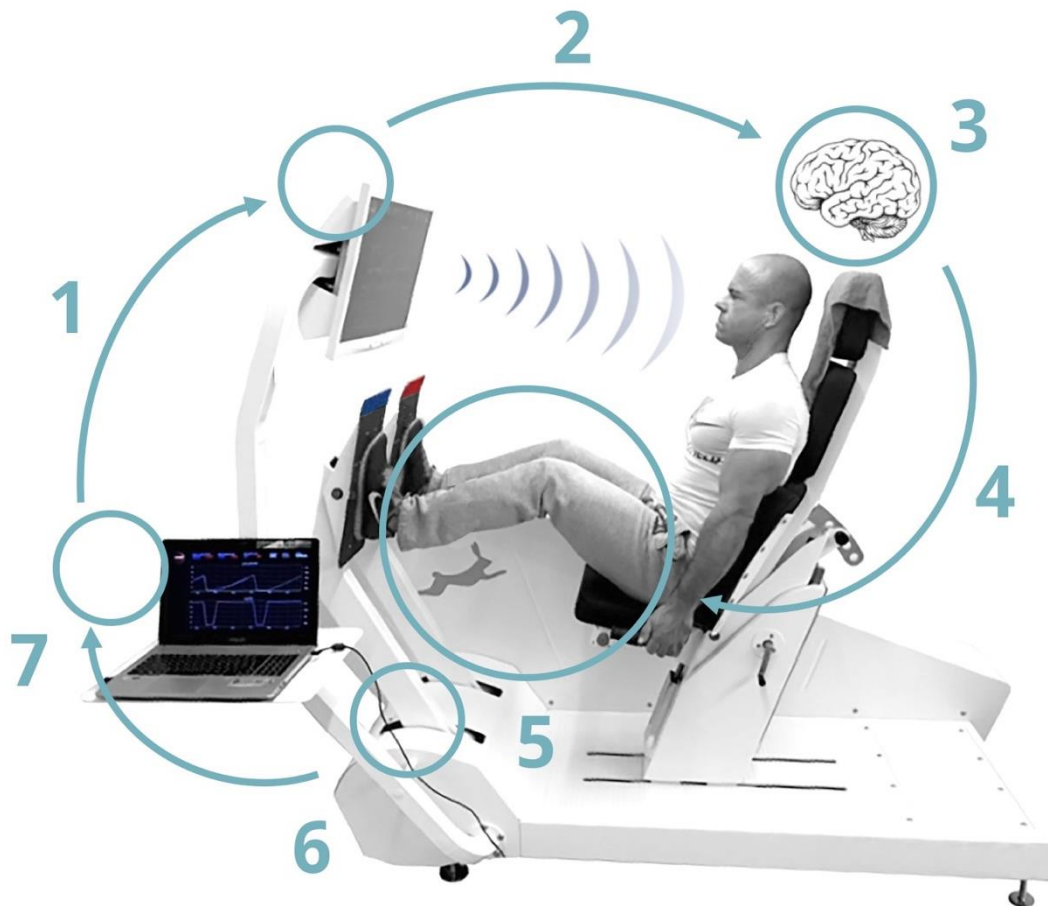
#### Usage & Accuracy Class: SA

Intended areas of application are training areas of organizations such as sports associations, educational establishments, clubs and studios, where access is specifically regulated by the owner.



## 2.2. Principle of operation

- 1 Task-oriented training and functional tests
- 2 Visual real-time feedback
- 3 Visuomotor coordination, control and correction allows motor learning and re-learning
- 4 Motor commands
- 5 Muscle activity in a sitting and lying position: hip opening angle from 80 deg – 160 deg
- 6 Measurement: force [N], knee angle [deg], velocity [m/s], rate of force dev. [N/s], etc.
- 7 Evaluation and interpretation of training results





## 2.3. Setup and hardware



1 Large display

2 DD System ELITE

3 External device with WiFi

4 Compressor  
(Picture shows 'DD Air Tower Burj')

### Minimal dismount area

The space of the dismount area must be at least 0.6 m wide. A detailed description can be found in the separate document 'Installation Requirements'.

## 2.4. Hardware features



Adjustable backrest (9 positions)



Arc-shaped, bilateral,  
pedal movement



Swivel footplates



### 3. Technical specifications

|                                     |                                                                                                  |
|-------------------------------------|--------------------------------------------------------------------------------------------------|
| <b>Usage and Accuracy Class</b>     | SA (Studio Class; High Accuracy), ISO 20957-2<br>Intended for professional and/or commercial use |
| <b>Maximum User Body Mass</b>       | 150 kg                                                                                           |
| <b>Maximum Force / Load</b>         | 2'700 N / leg (275 kg / leg)                                                                     |
| <b>Minimum Force / Load</b>         | 0 N / leg (0 kg / leg)                                                                           |
| <b>Load Resolution</b>              | +/- 10 N / leg (1 kg / leg)                                                                      |
| <b>Rate of Force Development</b>    | > 15'000 N/sec                                                                                   |
| <b>Sampling Time</b>                | 5 ms                                                                                             |
| <b>Reclinable Seat</b>              | 9 positions (80° - 160°)                                                                         |
| <b>Adjustable Seat Height</b>       | with paddings                                                                                    |
| <b>Swivel Footplates</b>            | with different foot support systems                                                              |
| <b>Number of Training Protocols</b> | > 100                                                                                            |
| <b>Display</b>                      | 49 inches                                                                                        |
| <b>Length</b>                       | 220 cm                                                                                           |
| <b>Width</b>                        | 96 cm                                                                                            |
| <b>Height</b>                       | 160 cm                                                                                           |
| <b>Mass</b>                         | 450 kg                                                                                           |
| <b>Electrical</b>                   | 100 – 230 VAC / 4 A / 50-60 Hz / max. 500 W                                                      |
| <b>Operating Pressure</b>           | 7 bar (relative pressure)                                                                        |
| <b>Air Quality</b>                  | According to ISO 8573-1 (*)                                                                      |

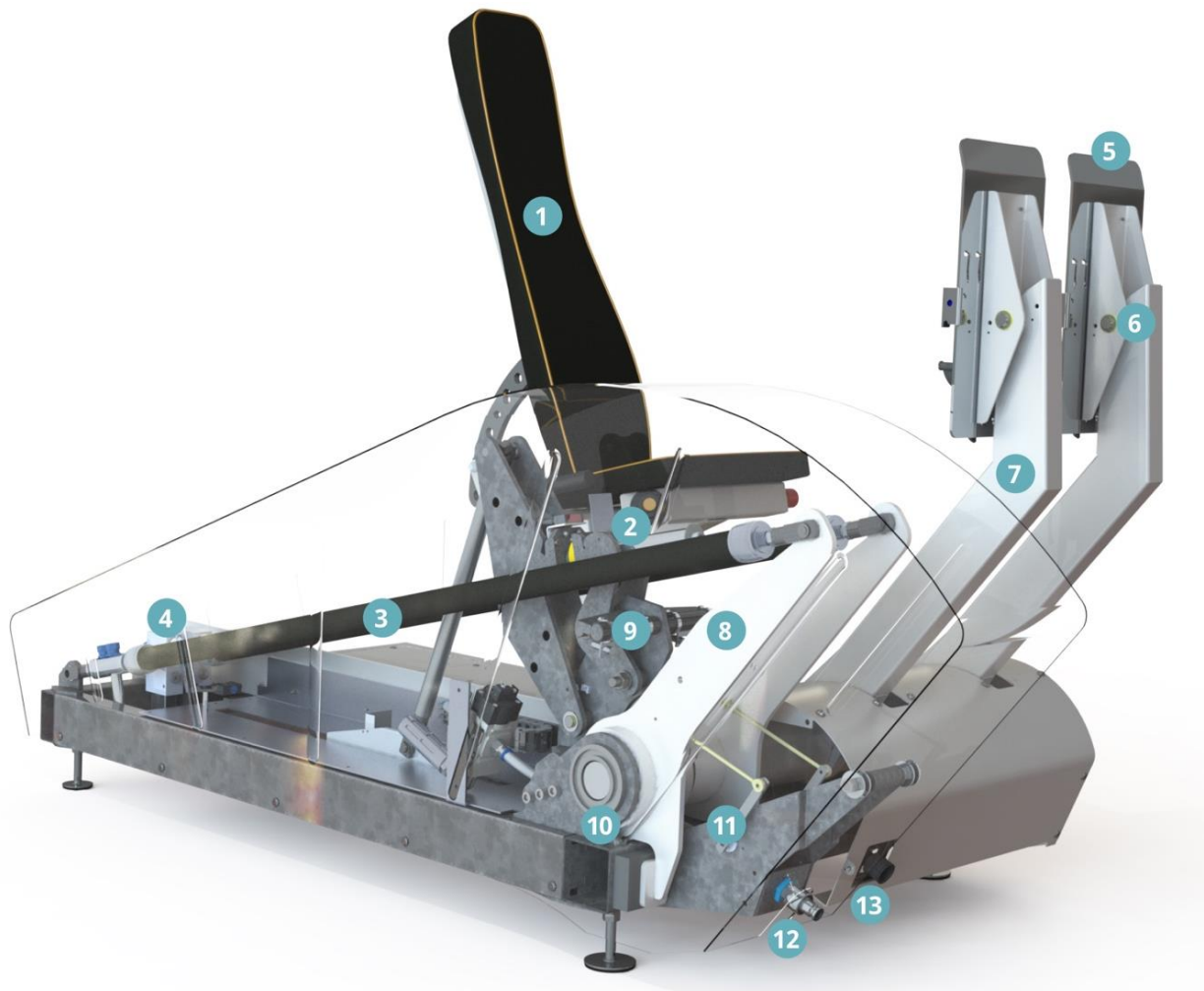
#### (\*) IMPORTANT

The DD System be will be void of warranty and product liability if the quality of the air used does not comply to the following standards

- *Max. particle size and concentration of solid contaminants: ISO 8573-1:1991, class 2*
- *Max. pressure dew point: ISO 8573-1:2001, class 4*
- *Max. oil content: ISO 8573-1:2001, class 2*



### 3.1. Mechatronic components



- |                       |                                   |                                 |
|-----------------------|-----------------------------------|---------------------------------|
| 1 Adjustable backrest | 5 Footplates                      | 10 Drive shaft                  |
| 2 Joystick            | 6 Axial footplate support         | 11 High resolution angle sensor |
| 3 Artificial muscles  | 7 ARC Pedals                      | 12 Air supply                   |
| 4 Force control unit  | 8 Drive lever                     | 13 Electrical connection        |
|                       | 9 Automatic knee angle limitation |                                 |



## 4. Turn on/off the DD System ELITE

### 4.1. DD System without DD Air Tower

You can turn on your DD System in three simple steps:

1. Make sure the air pressure line is pressurized, that is, compressor is switched on and ball valve is open (handle in line with air hose).
2. Power up the DD System ELITE and wait for 30 seconds (the main switch is located in front of the DD System).
3. Turn on dedicated computing unit – software starts automatically.

Turn off the DD System in four steps:

1. To quit DD System, press the ESC button on the keyboard and enter the administrator password (default password: admin).
2. After exiting the software, press power button on the computing unit.
3. Turn off the DD System using the main switch located in the front.
4. Optional: switch off the compressor and close air pressure line (ball valve handle orthogonal to air hose).

### 4.2. DD System equipped with a DD Air Tower

You can turn on your DD System ELITE in four steps:

1. Press the button labelled AIR located on the DD Air Tower or on the compressor to start the compressor.
2. Press the button labelled SYSTEM located on the DD Air Tower to start the DD System.
3. Press the power button on the computing unit.
4. Switch on wireless keyboard (switch on GREEN).

Turn off the DD System in five steps:

1. To quit DD System, press the ESC button on the keyboard and enter the administrator password (default password: admin).
2. Press the power button on the computing unit.
3. Press the button labelled SYSTEM located on the DD Air Tower to turn off the DD System.
4. Press the button labelled AIR located on the DD Air Tower or on the compressor to turn off the compressor.
5. Switch off wireless keyboard (switch on RED).



## 5. Safety precautions

### 5.1. General precautions and warnings

- **MAINTENANCE WARNING:** Regular inspections for worn and/or damaged parts is required for safe usage and proper maintenance. Preventive maintenance is the key to proper operation and keeping user liability to a minimum.
- **ATTENTION:** The following parts are susceptible to wear – seat cushions; hand grips, and screws
- **DAMAGE WARNING:** Do not use any equipment that is damaged, worn out or broken. Use only replacement parts supplied by Dynamic Devices AG.
- **QUALIFICATION:** Ensure that any person(s) adjusting the system or performing maintenance or repair of any kind is qualified to do so. Dynamic Devices AG will provide service and maintenance training at its corporate facility upon request or in the field if proper arrangement is made.
- The DD System ELITE shall only be used in supervised areas where access and control is specifically regulated by the owner; where the extent of control depends on user-specific qualities) e.g. degree of reliability, age, experience, etc)

### 5.2. Specific operating warnings

- **UNDERSTANDING EACH AND EVERY WARNING** to the fullest is important. If any of these warning is unclear, ask for clarification from Dynamic Devices AG personnel.
- When adjusting the seat backrest or any other type of adjuster with a pin, ensure that the adjusting pin is fully engaged in the hole to avoid injury.
- It is the purchaser's sole responsibility to properly instruct its end users and supervising personnel as to the proper operating procedures of all Dynamic Devices AG equipment.

### 5.3. Proper usage

- Do not use the DD System in any way other than designed or intended by Dynamic Devices AG. It is imperative that the DD System is used properly in order to avoid injury.
- Be cautious with moving parts at all times to avoid injury.
- During calibration, testing and training make sure that both feet are on the footplates at all times.
- **INSTALLATION WARNING:** Equipment should only be installed and used on a stable and levelled base.
- **USAGE WARNING:** Excessive or improper usage may result in discomfort and/or injury.
- **PROJECTION WARNING:** If any of the adjustment devices are left projecting, they could interfere with the user's movement.
- Use shoes with flat soles or exercise barefoot.





## 6. Biomechanical Positioning

Before starting any training, feet, legs and hands of the trainee need to be placed adequately. Follow the following four steps:

1. Sit on the DD System ELITE's seat with your lower back firmly against the seat rest. See to it that your lower back never moves away from the seat rest, especially at large anatomic knee angles. If it does your range of motion is set too high. This may result in lower back discomfort.
2. Place both feet on the swivel footplates. Your knees should be slightly flexed (anatomical knee angle  $> 5^{\circ}$ - $10^{\circ}$ ). NEVER start an exercise with stretched legs unless you know what you are doing.
3. Grasp the hand grips located on the side of the seat.
4. Engage your abdominal muscles. Keep these engaged throughout the entire exercise to support your lower back. Use a lumbar cushion support pillow if required.

For proper initial posture on the DD System, please refer to Figure 1.



**Figure 1:** Proper initial posture. Sit in the seat, place the feet in the footplates, bend your legs slightly, grasp the hand holds, and engage abdominal muscles.



**Figure 2:** Total range of movement on the DD System. Maximum flexion (right leg) and minimum extension angles (left leg).

### (\*) ESCAPE ASSIST

In the event the escape assist is required, the push button on the side of the seat will immediately cut off the power to all actuated (active) components of the machine; and the pedals will not move. The user can then exit on their own unhindered, or a third party can aid the user dismount the DD System ELITE.



## 7. DD launcher

The DD Launcher appears at boot time and normally does not require any user interaction through the keyboard. If the user does not interact with the DD Launcher for 10 seconds the DD System ELITE user interface starts automatically.

If the LAUNCH countdown has been stopped due to user interaction, e.g. by pressing any of the keys on the keyboard, the user can start the user interface (Fig. 3) by clicking on LAUNCH.

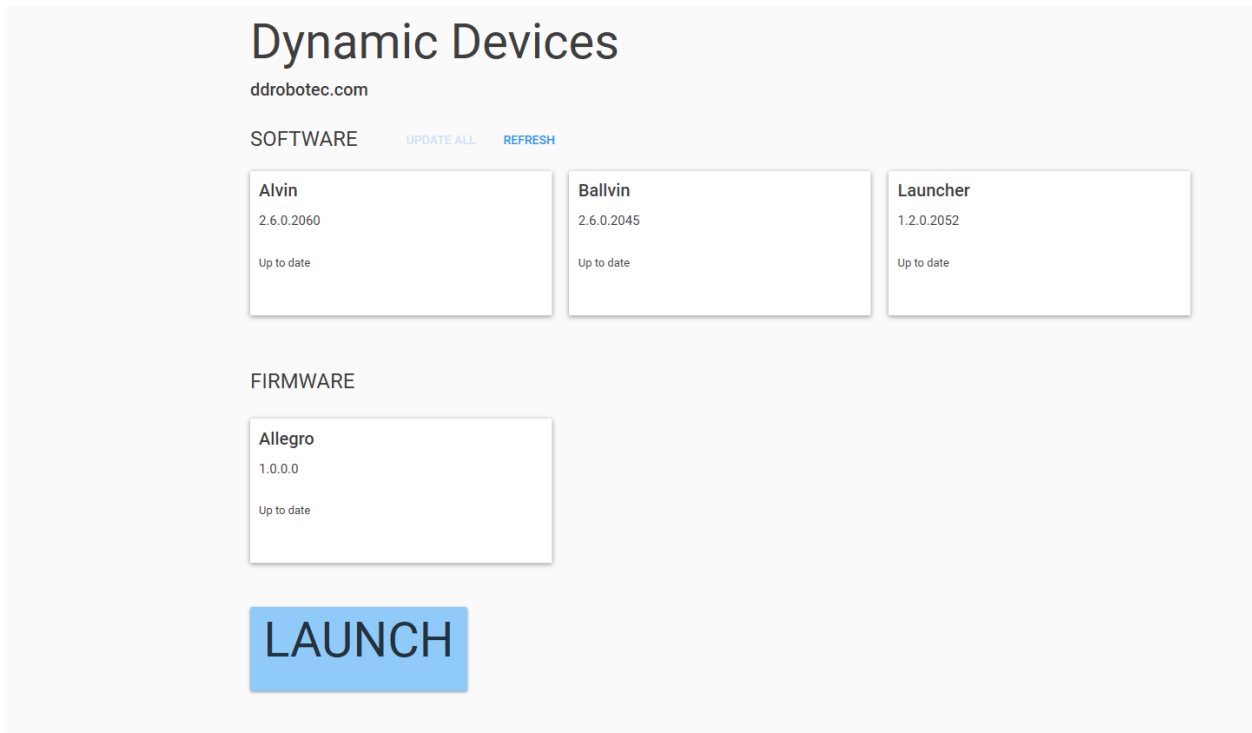


**Figure 3:** Interface of DD Launcher screen

### 7.1. Software updates

If the DD System ELITE has a stable connection to the Internet, the DD Launcher can be used to update the DD System ELITE software.

If updates are available the UPDATE ALL button is enabled and the user can update all the software with one click.

The REFRESH button can be used to check if there are any updates.



## 7.2. Software maintenance mode

To customize the software and the computing unit of your DD System ELITE press the key \*F10\*. With the included wireless keyboard press the key combination \*FN+F10\* to activate the maintenance mode.

A panel with options appears on the left side of the DD Launcher screen (Fig. 4). Those options should never be changed during regular use of the DD System ELITE (unless otherwise specified).

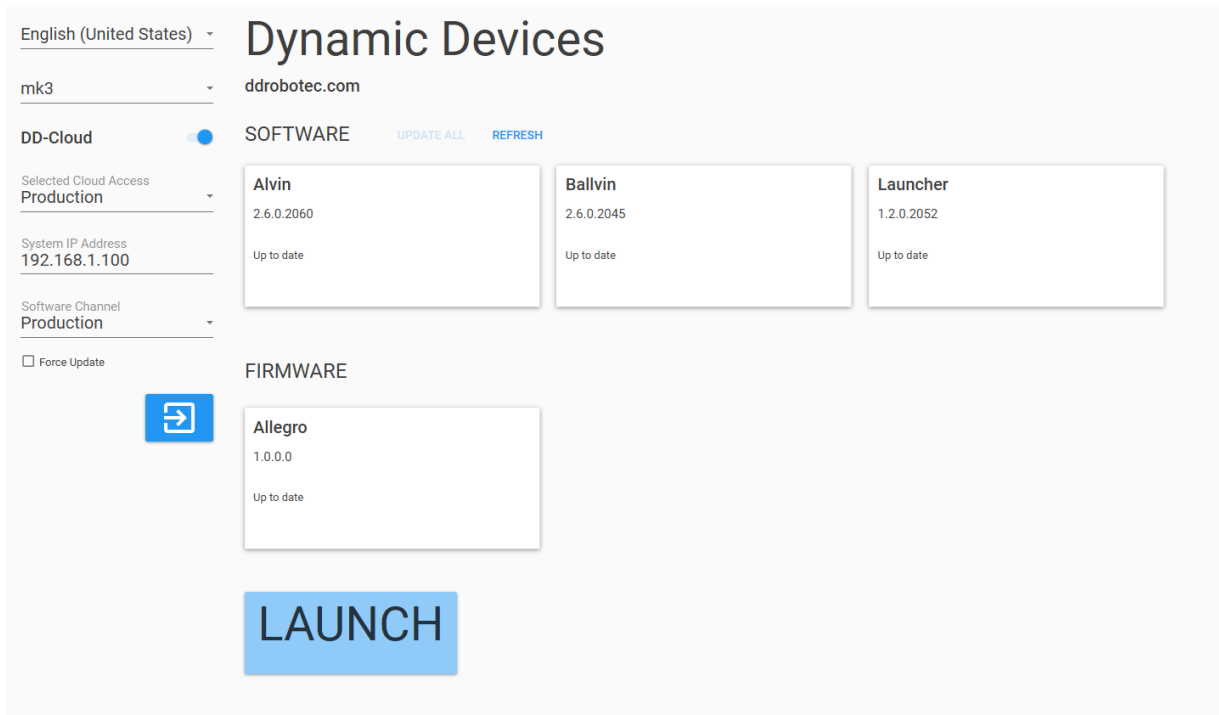


**Figure 4:** Interface of DD Launcher screen with setting options on the left

The button at the bottom of the maintenance panel can be used to access the underlying Microsoft Windows 10 operating system and configure things such as the Internet connectivity using WiFi for example.

Ask your local system administrator to setup a connection to the Internet in order to receive Software updates. Once Windows has been configured as needed (Internet connection for example) restart the system by choosing the Restart action in the standard Windows menu at the bottom left of the desktop.

The DD System ELITE software will start automatically once the computer has finished booting.



## 8. Graphical user interface

The graphical user interface (GUI) of the DD System ELITE runs on the computing unit which communicates with the DD System through an Ethernet patch cable (see 2.3.).

The graphical user interface is the only software required to operate the DD System. The graphical user interface starts automatically when the computing unit has booted. Once started the user is presented with the login screen (Fig. 5).

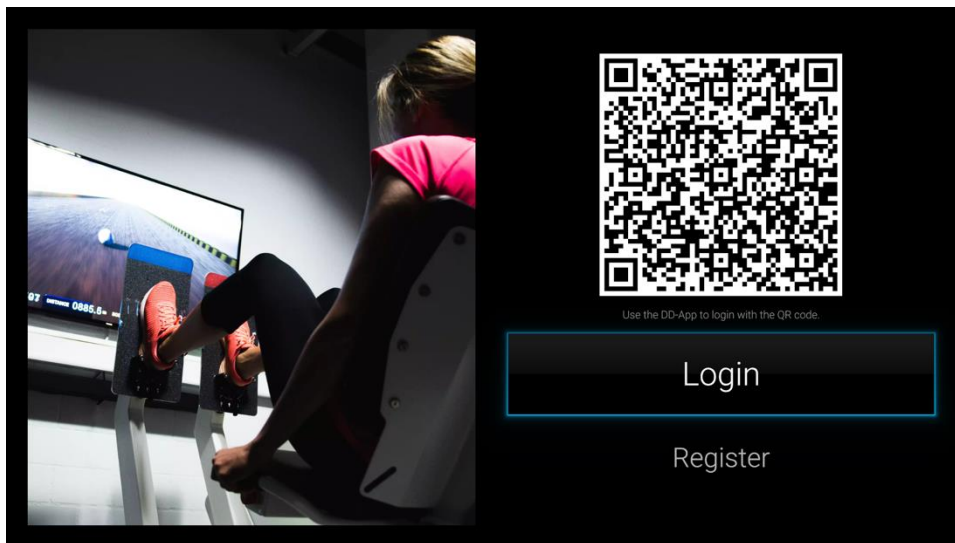


**Figure 5:** DD System login screen

### 8.1. Navigation

The DD System ELITE can be operated either through the keyboard or touchpad of the computing unit (*guided mode*), or through the joystick mounted on the lower-right side of the seat (*individual mode*). The menus can be navigated through the up, down, left and right arrow keys. Selections are confirmed by hitting the ENTER key. Alternatively, it is possible to use the joystick: up and down movements are mapped onto up and down movements on the screen, front and back movements are mapped into left and right movements, respectively. The joystick button is used to confirm user selections and abort training and test sessions.



## 9. Registration and login

If the user is already registered, it is possible to login by scanning the presented QR code (Fig. 6), using the DD App (9.1) or manually selecting the Login button (see 9.3.).

Newcomers who are not yet registered must first create a user account. There are two ways to do this:

- Online: <https://ddrobotec.com/en/register/>
- On a DD System: Please note that only the DD System administrator, an already installed user named "admin" with special administrator rights, can register a new account on the DD System. To do this, use the mouse (or touchpad) and select "Register".



**Figure 6:** Login into the DD System by scanning the QR code on the login screen with the DD App.

### 9.1. DD App

To scan the QR code on the DD System, the user must download the DD App (Fig. 7).

The DD App is free and is available for iOS and Android phones:

App Store <https://apps.apple.com/is/app/ddrobotec/id1457988915>

Google Play: [https://play.google.com/store/apps/details?id=com.ddrobotec.ddios&hl=de\\_CH](https://play.google.com/store/apps/details?id=com.ddrobotec.ddios&hl=de_CH)



**Figure 7:** The DD App simplifies the usability of the DD System.



## 9.2. User registration and management

Only the DD System administrator ("admin") is allowed to register and manage users. For the administrator a password is required (Fig. 8). The admin password is provided after the installation of the DD System.

The user management page can be used to:

- Add/register new users
- Select an already registered user
- Edit the user
- Delete a registered user from the user database

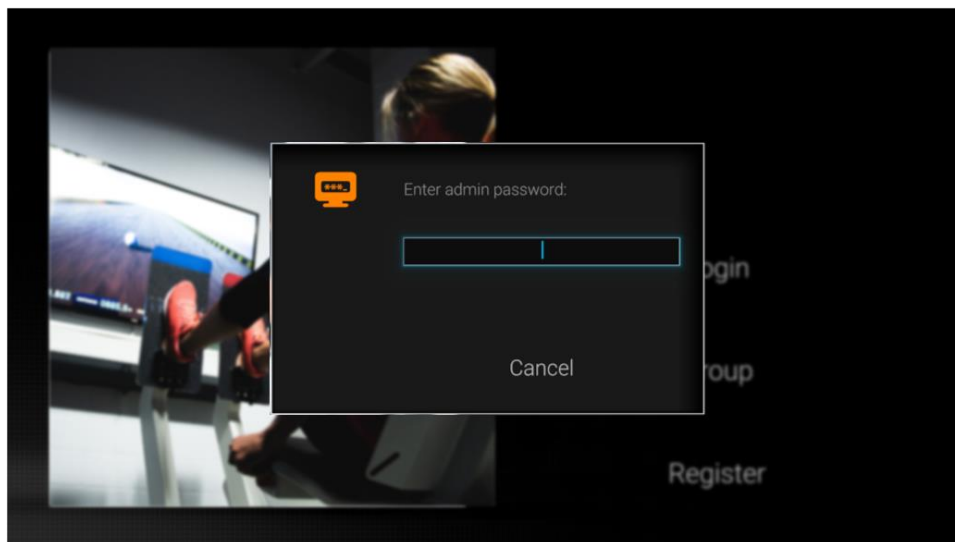


**Figure 8:** Admin password pop-up window

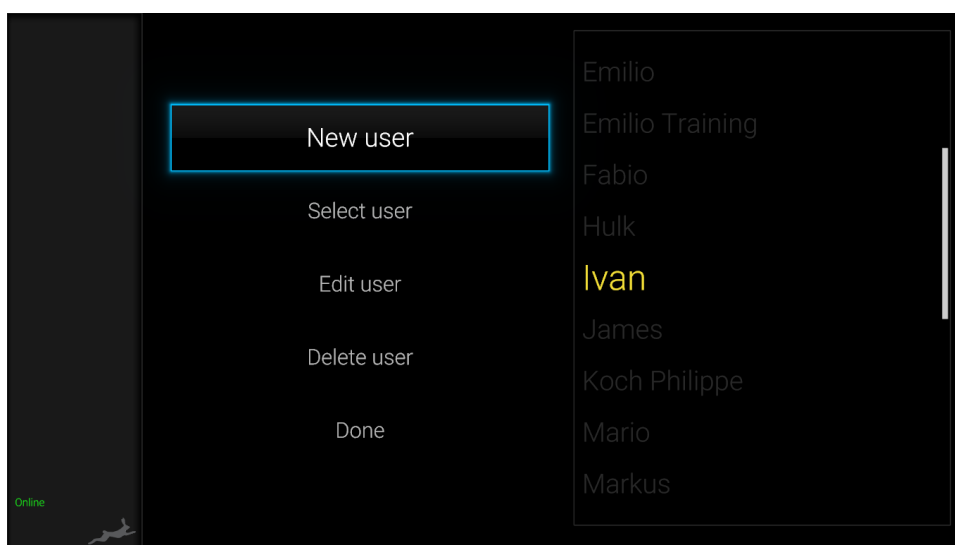


**Figure 9:** User registration screen



To register a user, provide the following information in the format specified in the left column (Fig.10):

|                      |                                                                                                                                                    |
|----------------------|----------------------------------------------------------------------------------------------------------------------------------------------------|
| <b>Username</b>      | Required. This is the screen (login) name used to identify the user. It should be a pseudonym or an ID and <i>*not*</i> the real name of the user. |
| <b>Date of birth</b> | Required. This is the birthday of the user.                                                                                                        |
| <b>Group</b>         | Required. For groups of people training on the DD System, enter a group name. This will simplify the login process.                                |
| <b>Email address</b> | Optional. This is the user's email address.<br>(Required when using the DD App.)                                                                   |
| <b>Password</b>      | Required. User password.                                                                                                                           |
| <b>Height</b>        | Required. The user's height in cm. This value will be used to set the seat to an initial default position.                                         |
| <b>Weight</b>        | Required. The user's weight in kg. This value will be used to initialize the training resistance.                                                  |
| <b>Gender</b>        | Optional. The user's gender (F=female, M=male).                                                                                                    |

When finished, select "OK" and then hit "Done" on the next page. The user will then be presented with the "User Registration Page". Note the "OK" will only appear when all necessary information has been provided and *all* checkmarks are green.

|                            |                    |   |
|----------------------------|--------------------|---|
| Username                   | Demo               | ✓ |
| Date of Birth [yyyy-mm-dd] | 1980-10-20         | ✓ |
| Group                      | Demo               | ✓ |
| Training Type              | Fitness            | ✓ |
| Email Address              | demo@ddrobotec.com | ✓ |
| Height [cm]                | 170                |   |
| Weight [kg]                | 53                 |   |
| Gender                     | Female             |   |

Ok Cancel

**Figure 10:** User registration screen. Demo User born on 1980-10-20 belonging to group Demo.



### 9.3. Single user login

By selecting the login button, the user is presented with the login screen names of the users registered on the DD System (Fig. 11). Identify the correct one by scrolling up or down – either by using the joystick or the up and down arrows on the keyboard. Once the appropriate login is identified, press the button on the joystick or hit the ENTER key.

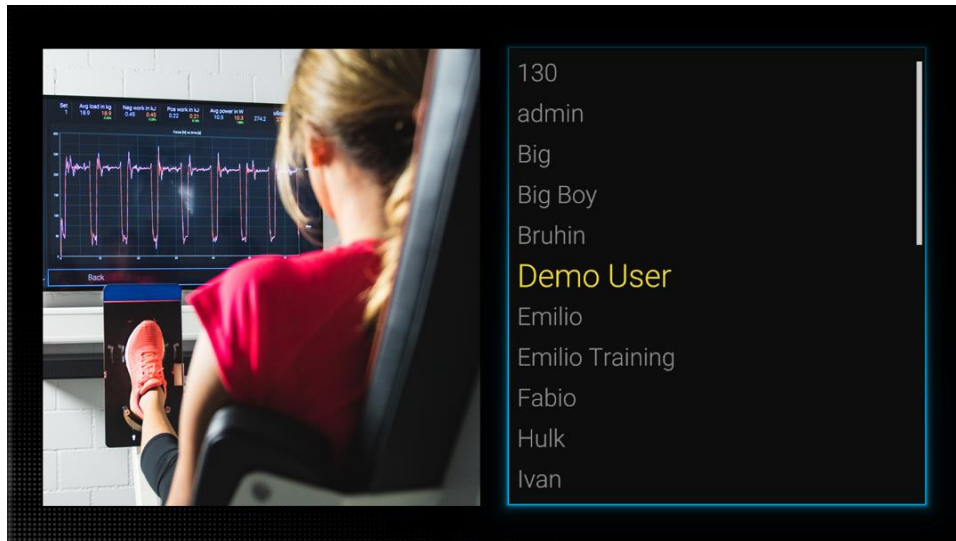


**Figure 11:** User selection screen. Current selection: Demo User

### 9.4. Group login

For groups of users the Group Login speeds up the login process (Fig. 12).

Please note: This mode is mainly used for demo purposes and is only accessible if the DD System is not connected to the DD Cloud.

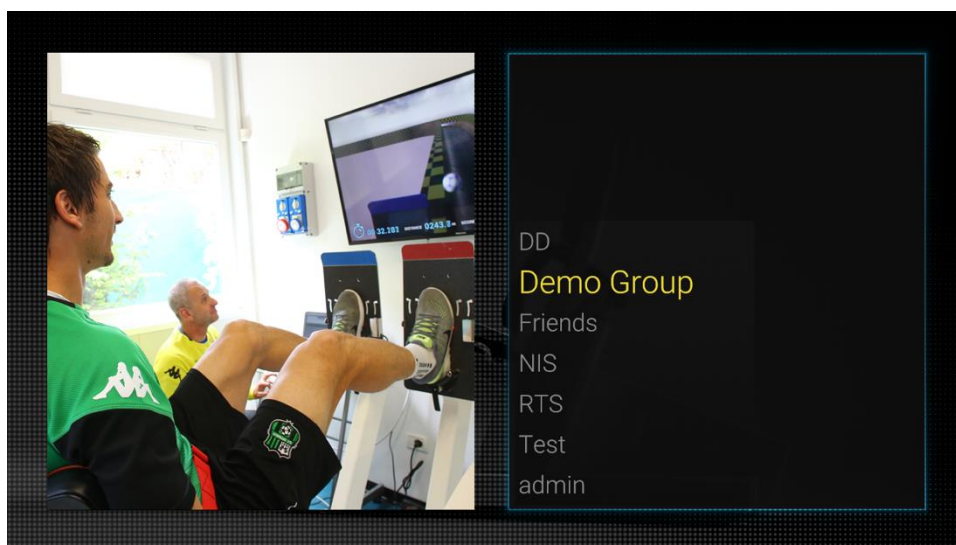


**Figure 12:** Group login screen



## 10. Calibration

In order to accurately measure knee angles, it is essential to calibrate users upon first use of the DD System ELITE. This usually only has to be done once.

There are two ways to do this:

- Easy Calibration, recommended for most users (see 10.1)
- Expert Calibration, for experts who want to calibrate with the four-point calibration method using a goniometer (see 10.2)

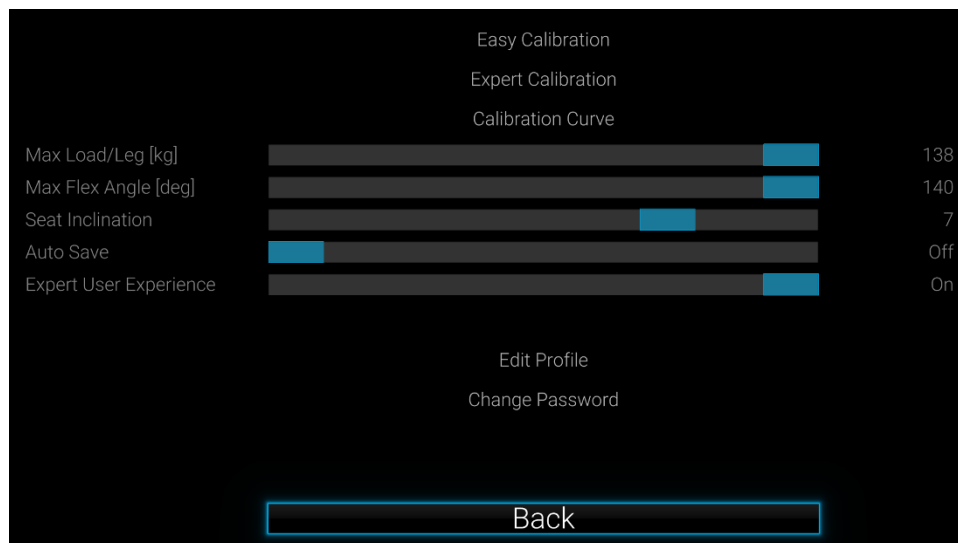


**Figure 13:** Calibration setting menu screen



**NOTE:** It is important to note that the calibration assumes that the user is capable of a full range of motion, where the range of motion refers to the angular distance and direction the knee joint can move between the flexed position and the extended position.



**NOTE:** Both feet must be on the footplates during the calibration (Fig. 14).

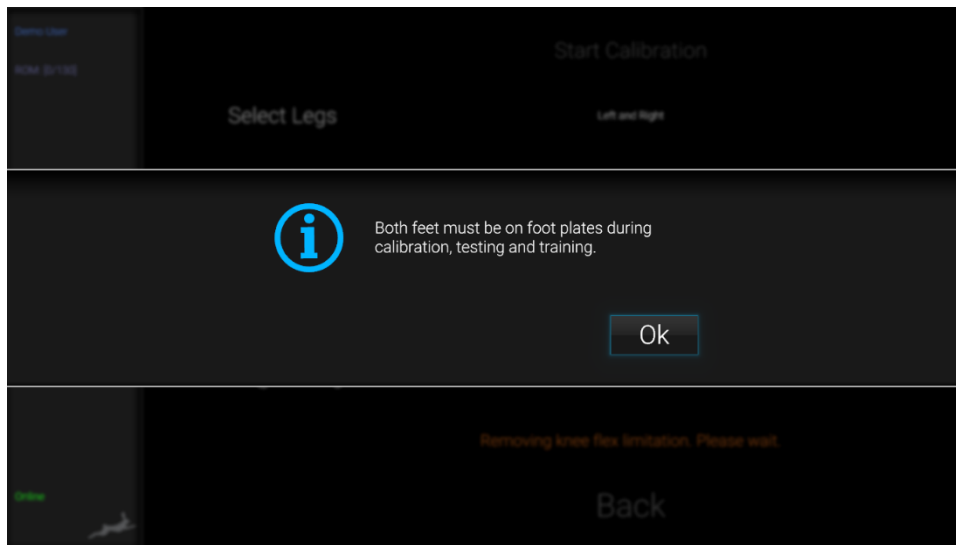


**Figure 14:** Make sure that both feet are on the footplates during calibration!

## 10.1. Easy Calibration

To begin the calibration, the user first enters the Settings menu and selects the “Easy Calibration” button.

The user is asked which leg to measure (Fig. 15). Healthy users measure both legs. For users in a recovery phase, the dominant (healthy) leg should be measured.

Then follow the instructions on the screen (Fig. 16)

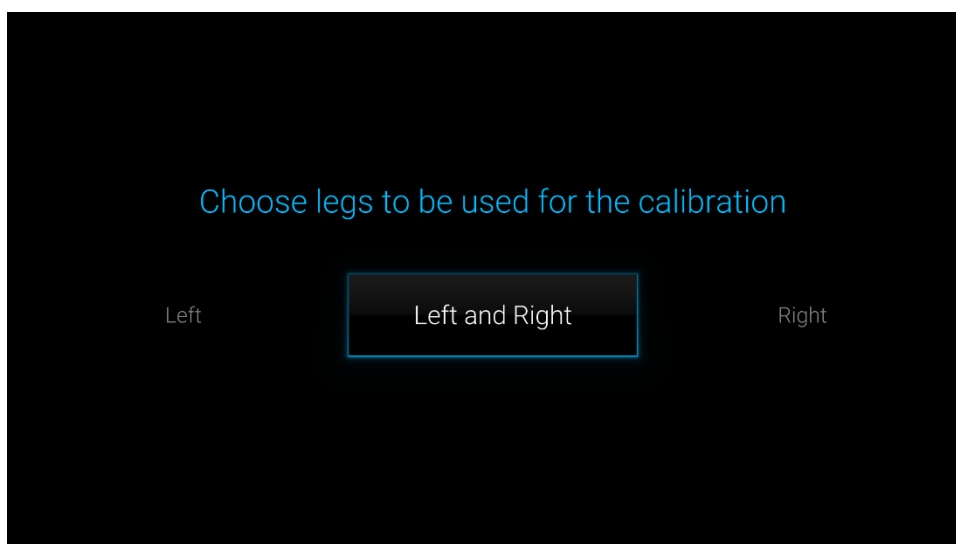


**Figure 15:** Easy Calibration leg selection screen



**Figure 16:** By following the instruction on the screen the user will be calibrated

## 10.2. Expert Calibration

The user is calibrated with a four-point calibration method and a goniometer. The knee angle depends on the position of the pedals and the position of the seat. The four measurement points are necessary to calculate all possible knee angles. The deviation from the real value is about 5 degrees and is a function of the measurement accuracy of the goniometer used. The four measurement points are necessary to calculate all possible knee angles with a precision of  $\pm 3$  degrees.

To begin the calibration, the user first enters the Settings menu, selects the “Expert Calibration” button, and then “Start”.

- First select which leg should be used as a reference for the calibration, the left leg, the right leg, or the average between the left and right anatomic knee angles of the legs (Fig. 17). A good rule of thumb is to use the dominant (healthy) leg.
- Then the user is asked to move the seat until its legs are fully extended, i.e. at  $0^\circ$  degrees measured in anatomical angles (Fig. 18). Please make sure that in this position the user’s legs are not over-extended and that he or she is sitting properly in the seat with the lower back in firm contact to the back rest. Once OK, hit the ENTER key or press the joystick button – a green check mark will appear.
- Then the user moves the seat until its legs are flexed at  $5^\circ$  degrees. This is the initial/starting position used for the training units and tests (slightly bent knees). At this point, the user or operator should press the joystick button or hit the ENTER key on the keyboard.
- The pedals will then move towards the user with a small but fixed load. The user should flex the legs until the anatomic knee angle of the selected leg/legs is  $45^\circ$  degrees. At this point, he or she should press the joystick button or the ENTER key on the keyboard.
- Finally, the user should flex its legs until the anatomic knee angle of the selected leg/legs is  $90^\circ$  degrees. Again, press the joystick button or the ENTER key on the keyboard when you are done.
- The user should now be calibrated (Fig. 19).

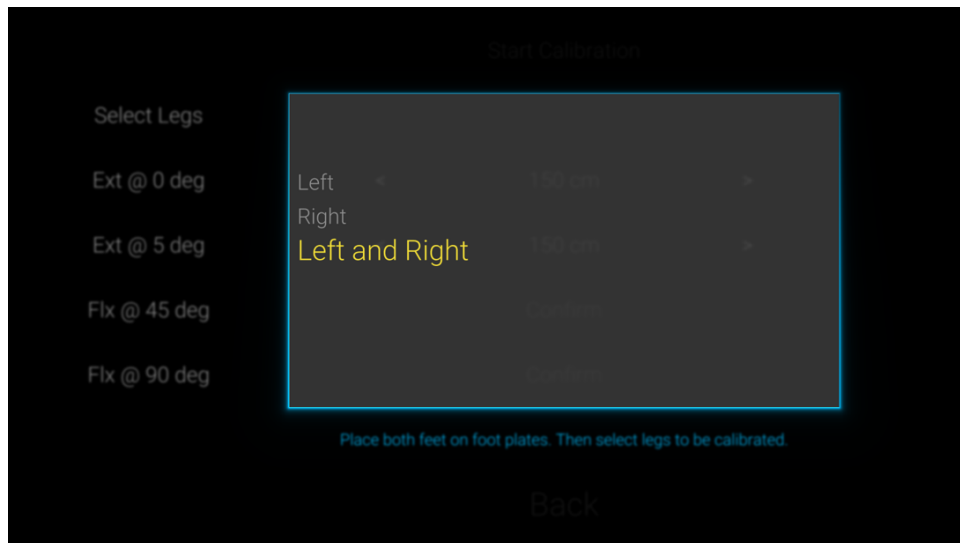


**Figure 17:** Expert Calibration leg selection screen

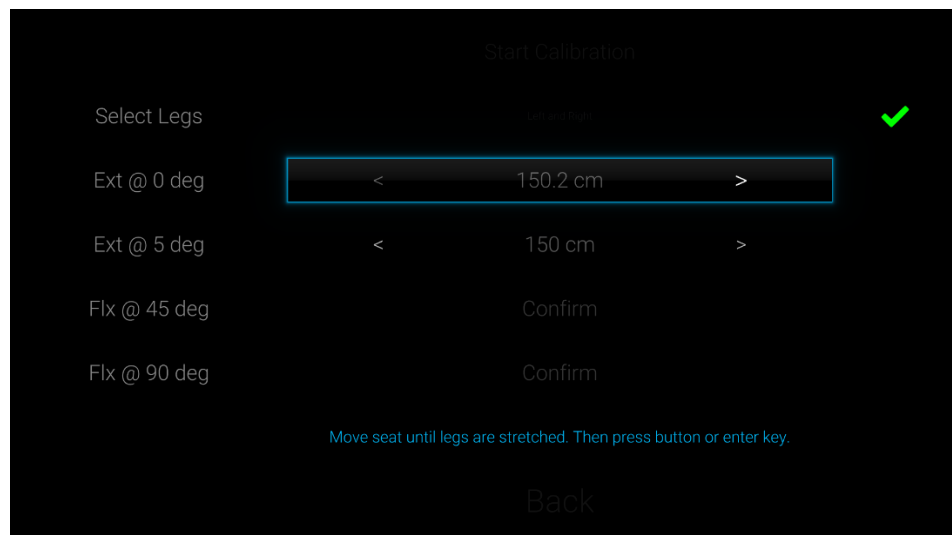


**Figure 18:** Expert Calibration four-point calibration screen

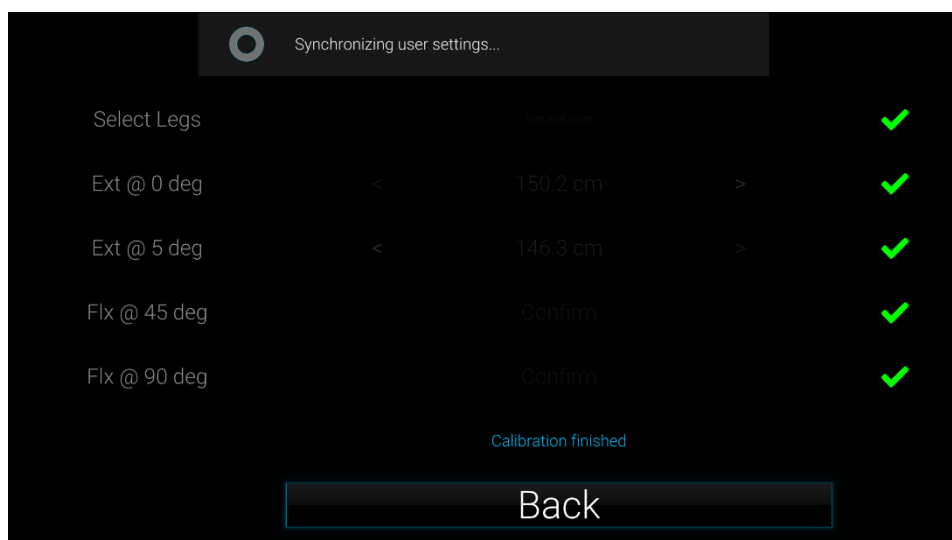


**Figure 19:** Expert Calibration completed successfully screen



## 11. Settings

Apart from performing calibrations, in the “Settings” menu one can also change the PERSONAL settings of the DD System ELITE. With the sliders on this page it is possible to set specific parameters and for a single user (Fig. 20).

Procedure:

1. Max load per leg: set the maximally possible load in kg per leg for all training units.
2. Max flex angle: set the maximally possible flex angle in deg for all training units.
3. Seat height: set the seat height position.
4. Seat inclination: set the seat inclination position.
5. Graphs: enable or disable knee angles or load graphs.
6. User mode: set user mode (ready, advanced, expert).
7. Auto save: enable or disable saving time series data. Note: lots of data will be saved.
8. Access level: set user access level (the user has no access, the manager has access).

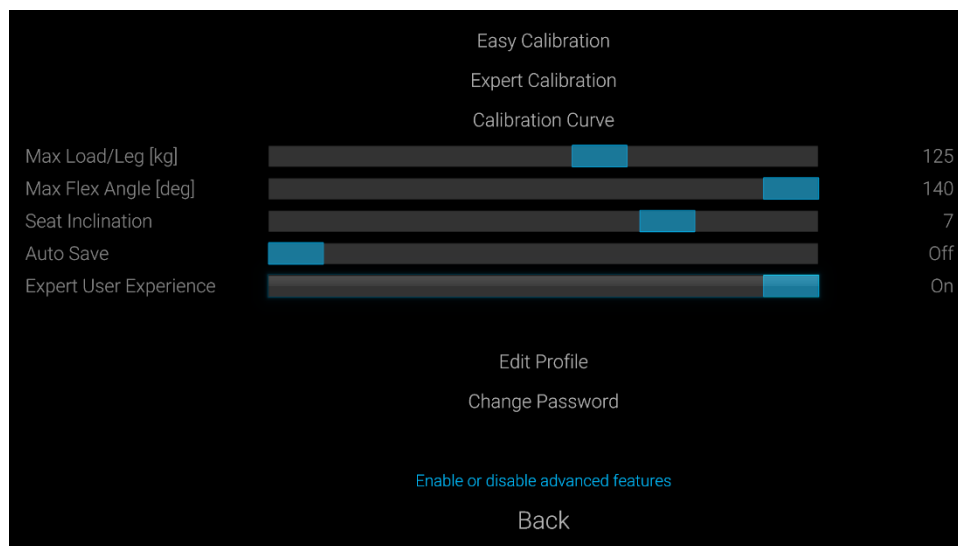


**Figure 20:** Main settings screen



## 12. Using the DD System

After logging in, the user must read and confirm the 'HEALTH WARNING' banner on the screen.

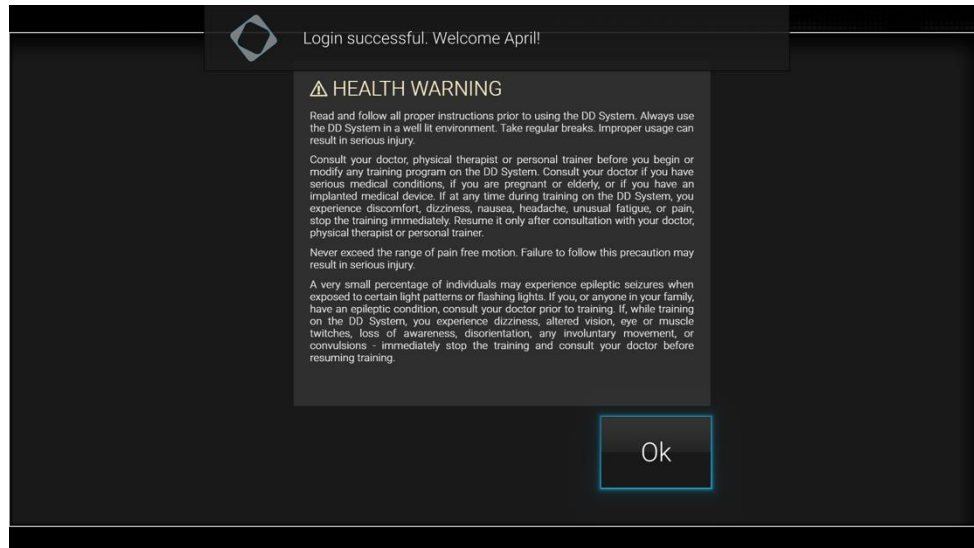


**Figure 21:** Screen that appears after login to read and confirm.

The DD System welcome screen displays an overview of the workouts completed so far. Press "Start Workout" to get to the workout selection screen.

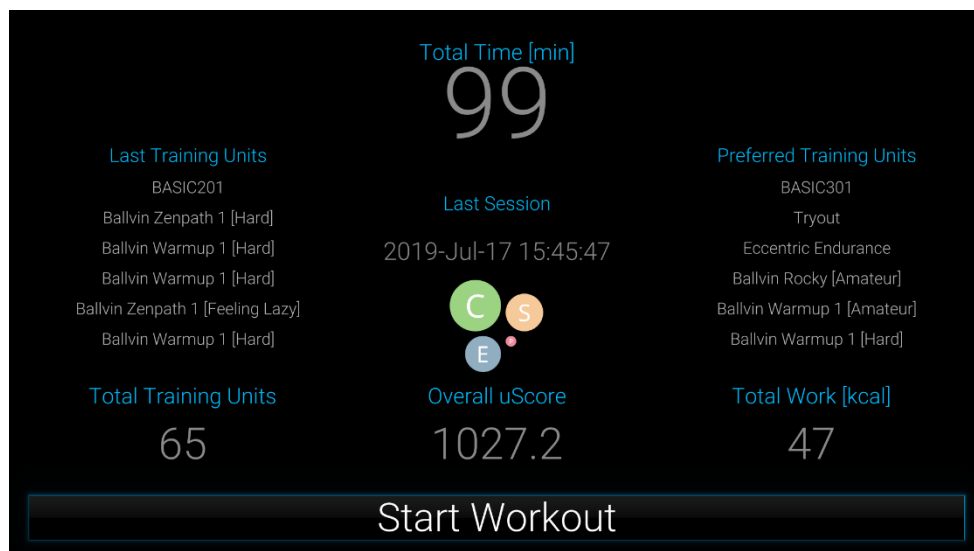


**Figure 22:** Personalized welcome screen



## 12.1. Workout selection

In the main menu, the user can select among different ways of using the DD System ELITE (Fig. 23).

- Plans
- Simulations
- Training
- Tests
- Specials

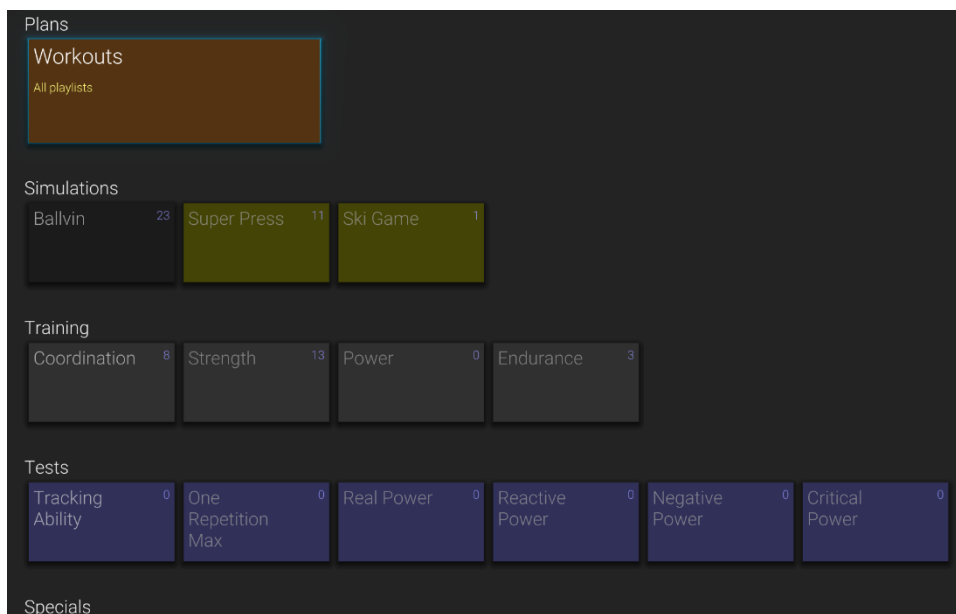


**Figure 23:** Workout selection screen

Within **Plans** the user can find personalized workout plans (see 12.2.)

In **Simulations** the user will find a selection of serious games (see 14.)

The DD System training protocols in the category **Training** are organized in four different neuro-motor capabilities (Fig. 24):

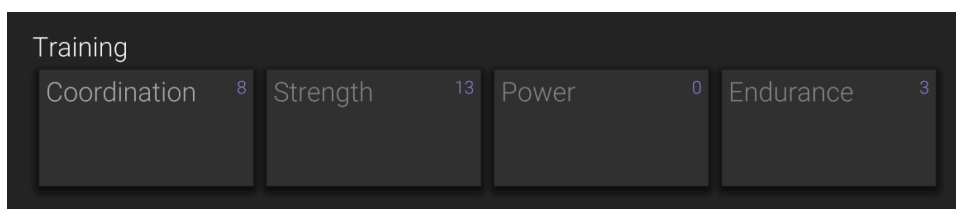


**Figure 24:** Training selection for neuro-motor capabilities



1. Coordination: training protocols used to warm up, for training inter-muscular coordination, improving speed of nerve impulse conduction, etc. The goal of these training units is to improve movement quality and precision, as well as the effectiveness of subsequent training.
2. Strength: training protocols used to increase the largest force that is possible in a single maximum contraction. These protocols lead to muscular hypertrophy and strengthen bones, ligaments, tendons and joints.
3. Power: training protocols used to improve the ability to apply the greatest amount of maximal strength in the shortest period of time.
4. Endurance: training protocols used to improve the ability to generate forces many times over.

In **Tests** the user will find a selection of test protocols. For a more detailed description go to 13. Tests. The training protocols in the **Specials** category (Fig. 25) have a special field of application which goes beyond the training of neuro-motor abilities, e.g. training protocols for people suffering from cardio-respiratory weakness.

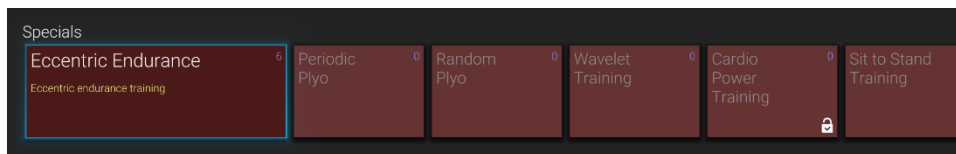


**Figure 25:** Training selection in the **Specials** category

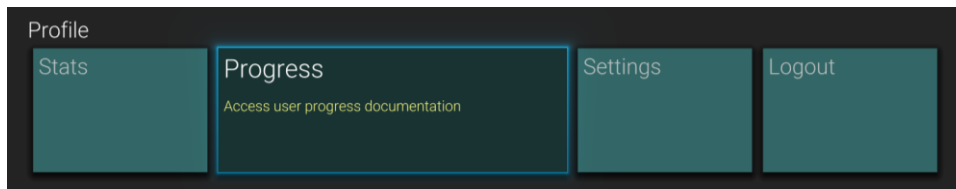


**Figure 26:** User menu within the category 'Profile' to access user progress documentation

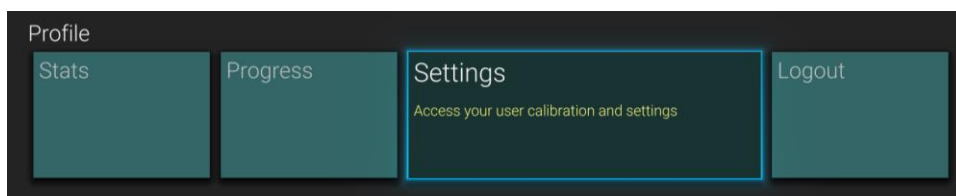


**Figure 27:** User menu within the category 'Profile' to access user calibration and settings



## 12.2. Personalized workout plan

There are two ways to create a personalized workout plan composed of individual training units:

- DD App: Within the DD App the user finds a selection of ready-made workout plans.
- DD System Software: On the DD System the user can combine any training units and group them into entire workout plans.

The user can either select among a dozen of ready-made workout plans or compose its own workout plans. This is done by choosing any training unit and then hitting the hamburger+ icon located on the lower right of the training unit settings screen. You will be able to give the plan a name and then repeat this action with any other training unit.

The personalized workout plan is saved under **Workouts** within the category **Plans** (Fig. 28).

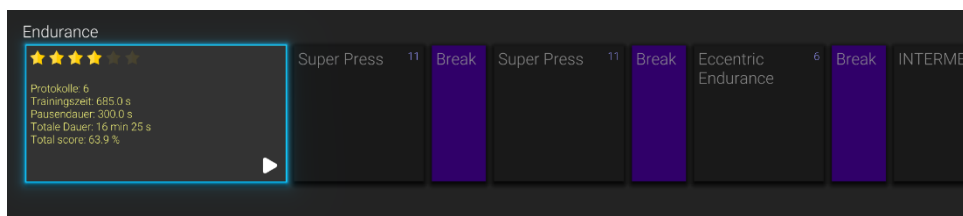


**Figure 28:** Example of a personalized workout plan

You can increment the difficulty level of an existing plan by 10 percent by hitting the key “+”.

## 12.3. Parameters

For each training unit it is possible to change up to 9 parameters.

| Setting                    | Action                                                                                                                                                                                                                                                           |
|----------------------------|------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| <b>Min/Max-angle [deg]</b> | Sets the angular range of the training. The slider on the left sets the minimum extension angle, the slider on the right, the maximum flexion angle.                                                                                                             |
| <b>Min/Max-load [kg]</b>   | Sets the load range of the training in kg. Important note: the load indicated is always per leg. The slider on the left sets the minimum load during the training. The slider on the right sets the maximum possible load in kg during the training (peak load). |
| <b>Set/Break time [s]</b>  | The slider on the left sets the duration of the set. The slider on the right sets the length of the rest period between the sets (in case the number of sets is >1). Note: After the rest, the system initiates the countdown for the next set automatically.    |
| <b>Num sets</b>            | Sets the number of sets trained.                                                                                                                                                                                                                                 |



## Legs

Choose which leg to train. It is possible to train the legs independently, together or alternatively (first the right leg and then the left leg, or vice versa).

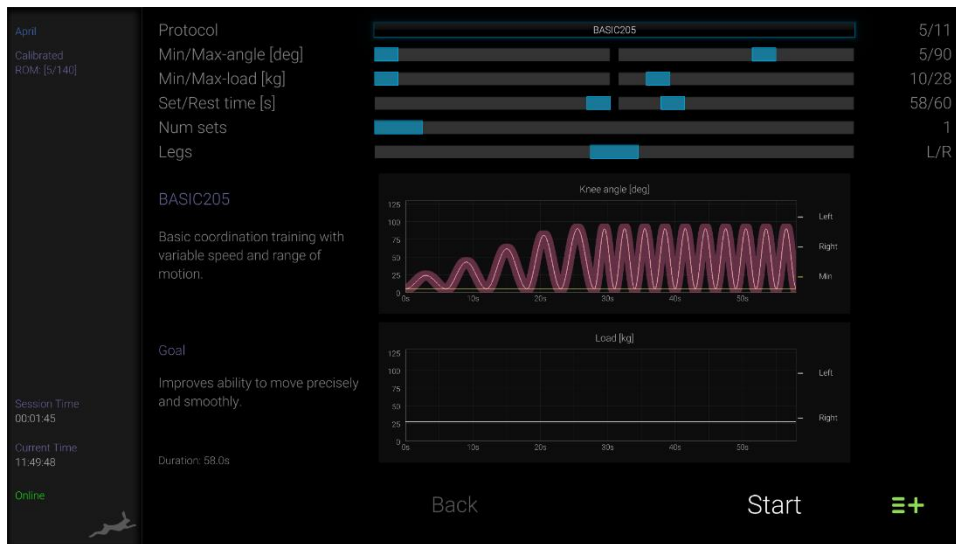


**Figure 29:** Training parameters screen

## 12.4. Performing a training unit

The virtual trainer shows the user how to perform the workout (Fig. 30). To begin exercising the user has to first confirm by selecting “Start”, upon which a countdown will appear.

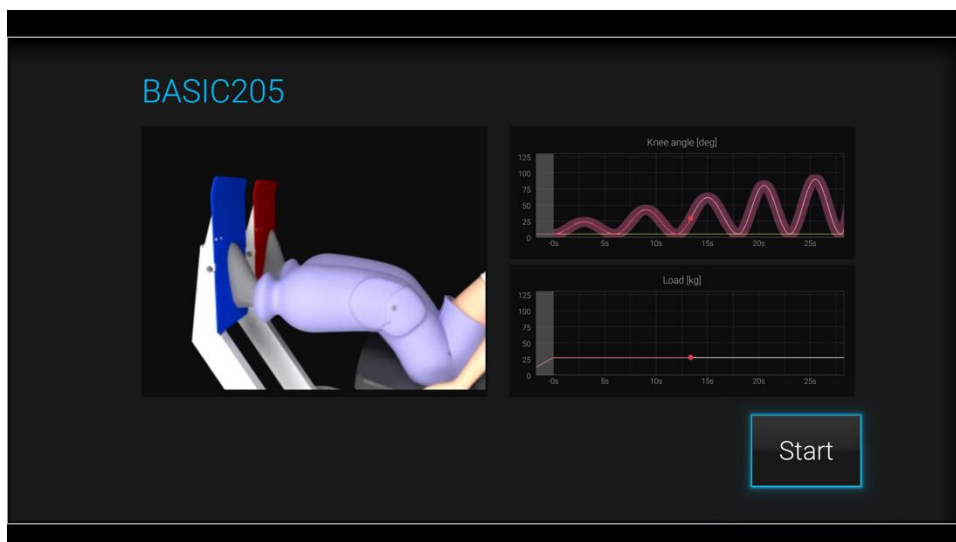


**Figure 30:** Screenshot of the virtual trainer screen



The DD System exhibits a performance feedback feature, the user's exercise data is displayed on the graph in real-time. During training and testing sessions, the user's progress (Fig. 31) can be observed by looking at the feedback graph on the DD System's display.

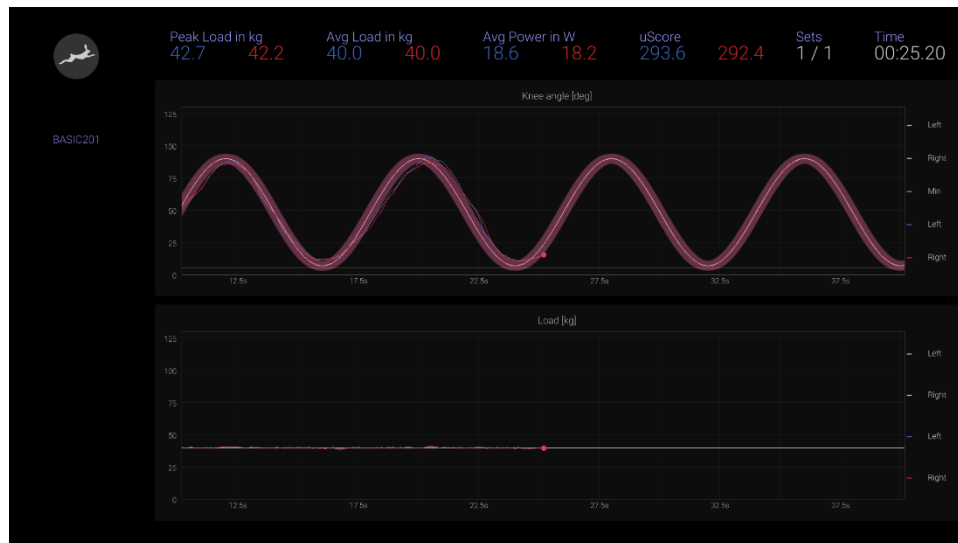


**Figure 31:** Screenshot of a workout in progress screen

## 12.5. Evaluation

Once the training unit has been completed the results are visualized in the "Result Page" (Fig. 32):

|                        |                                                                                                                     |
|------------------------|---------------------------------------------------------------------------------------------------------------------|
| <b>Peak load [kg]</b>  | Peak load measured in kg of left and right leg, in blue and red, respectively                                       |
| <b>Aver. load [kg]</b> | Average load measured in kg of left and right leg, in blue and red, respectively                                    |
| <b>Avg. power [W]</b>  | Average power measured in W of left and right leg, in blue and red, respectively                                    |
| <b>Score / uScore</b>  | The score allows the operator to set a feedback goal for the user. The higher the score, the better the performance |
| <b>Rank</b>            | The user's training units are stored and ranked according to the score                                              |



**Figure 32:** Result page screen

## 12.6. Reporting

A report of the performed training unit or test is automatically generated and saved in the user's folder.



**Figure 33:** Example of a workout report



## 13. Testing

Tests are special training protocols that are used to assess lower extremity functions.

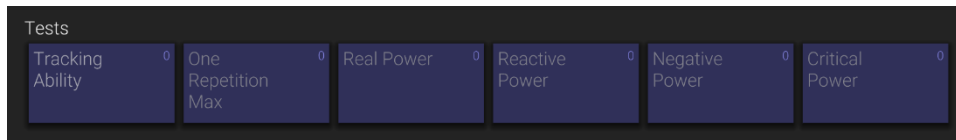


**Figure 34:** User menu of the test protocols within the category 'Tests'

Available test protocols:

|                         |                                                                                                                                                                                                       |
|-------------------------|-------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| <b>Tracking Ability</b> | Assess inter-muscular and visuo-motor coordinative ability and proprioception.                                                                                                                        |
| <b>One Rep Maximum</b>  | Assess quasi-static (MVC) peak force during <u>one repetition</u> (eccentric + concentric, only eccentric, only concentric).                                                                          |
| <b>Real Power</b>       | Assess power during maximum concentric action, "concentric" power                                                                                                                                     |
| <b>Reactive Power</b>   | Assess power during a maximal stretch-shortening cycle (SSC), transition eccentric to concentric muscle action.                                                                                       |
| <b>Negative Power</b>   | Assess ability to absorb energy (i.e. dampening of impacts), "eccentric" power.                                                                                                                       |
| <b>Critical Power</b>   | Assess the critical power (the power output that can be sustained without fatigue) and energy store (the amount of work that can be performed when exercising at power outputs above critical power). |

## 14. Simulations

The DD System is the world's first resistance training system with which the user can play interactive, physics-based 3D serious games and experience simulations with a truly realistic feel!

We call it headset free physics-based virtual reality training.

As part of the standard package, Dynamic Devices offers **Ballvin**, an exciting game where the user controls a ball through a series of increasingly difficult virtual worlds and a ski-game where the user controls a penguin through a virtual snow world.

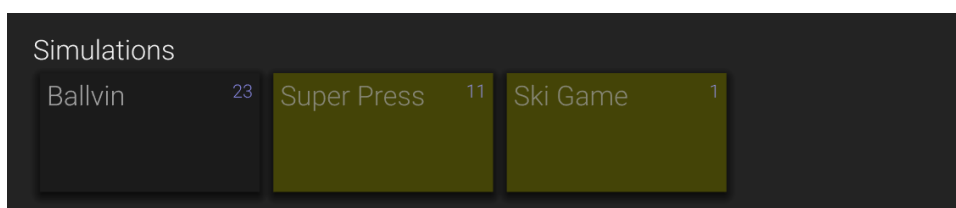


**Figure 35:** User menu of the simulations and serious games within the category 'Simulations'



## 14.1. Ballvin Game

Choose from different levels and different intensities - it's fun and motivates people who don't like to do sports to sports.

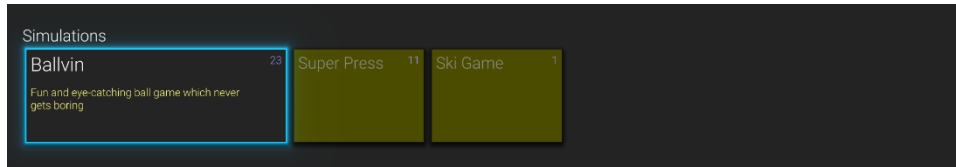


**Figure 36:** The main menu with the Ballvin game selected

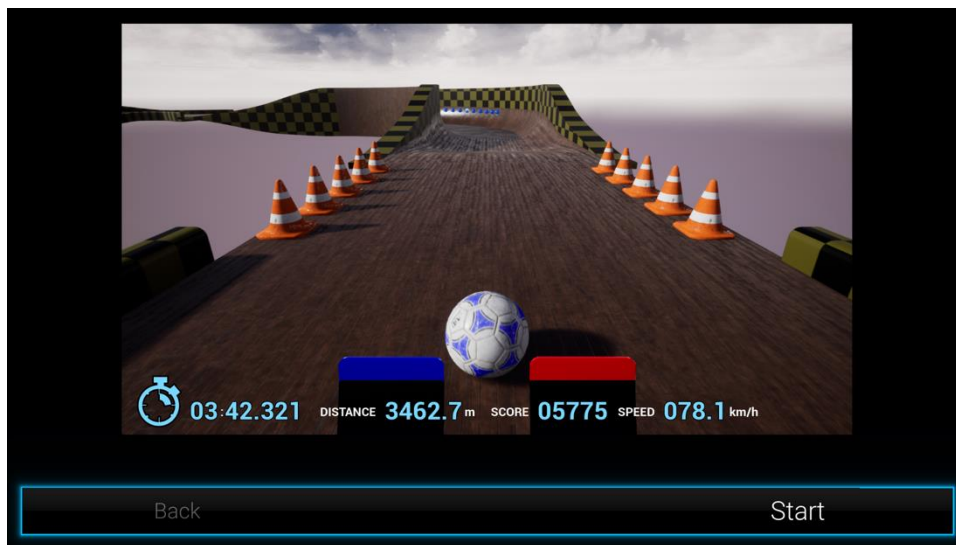


**Figure 37:** Ballvin launching screen

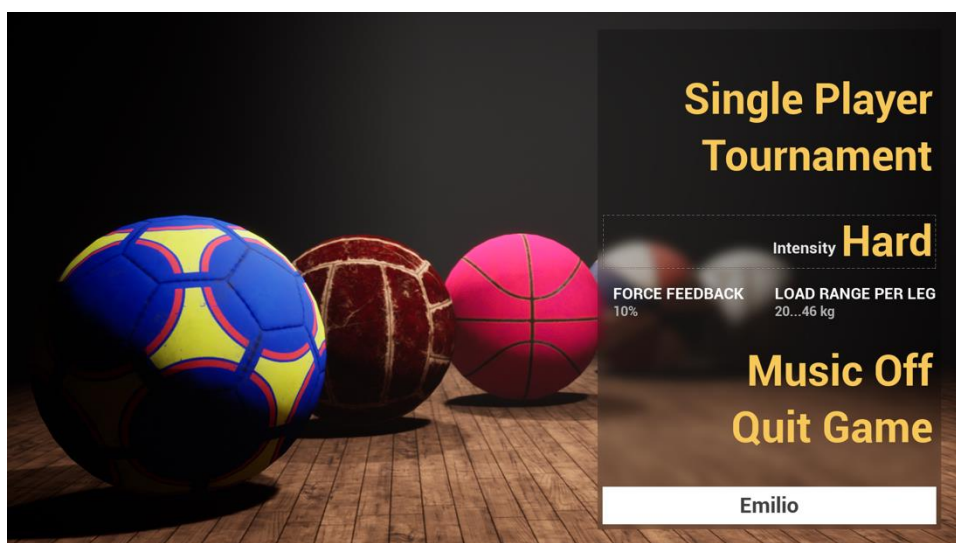


**Figure 38:** Ballvin setting screen



Back

Basic

Zenpath 1

Duration: 1m

Zenpath 2

Duration: 2m

Warmup 1

Duration: 1m

Warmup 2

Duration: 2m

Left and Right 1

Duration: 1m 30s

Left and Right 2

Duration: 2m

Intermediate

Rocky

Duration: 1m

Rocky 2

Duration: 2m

Redgates 1

Duration: 1m

Redgates 2

Duration: 2m

Easy 1

Duration: 1m

Easy 2

Duration: 2m

Jumps 1

Duration: 1m

Jumps 2

Duration: 3m

Half Pipe 1

Duration: 1m

Half Pipe 2

Duration: 3m

Soft Plyo 1

Duration: 1m

TOP SCORERS

IN THE LAST 30 DAYS

For Ballvin Rocky [Hard]

| RANK | NAME              | TEAM         | uSCORE | WHEN     |
|------|-------------------|--------------|--------|----------|
| 1    | Ferati Jasin      | OK H & E     | 2821.4 | 5 days a |
| 2    | Hulk              | DD           | 2799.7 | 12 days  |
| 3    | earlybird         | extra strong | 2702.8 | 6 days a |
| 4    | Keller Otmar      | OK H + E     | 2572.6 | 6 days a |
| 5    | Senn Urs          | OK H & E     | 2380.6 | 29 days  |
| 6    | Bertschinger Walo | OK H & E     | 2284.2 | 2 days a |
| 7    | Wind Christian    | OK H & E     | 2115.4 | 6 days a |
| 8    | Kuhn Corinne      | OK H + E     | 1933.9 | 2 days a |
| 9    | MaHo              |              | 1051.3 | 5 days a |

PERSONAL TOP SCORES

IN THE LAST 30 DAYS

For Ballvin Rocky [Hard]

| RANK | NAME | TEAM | uSCORE | WHEN |
|------|------|------|--------|------|
|------|------|------|--------|------|

**Figure 39:** Ballvin levels to choose from screen



**Figure 40:** Ballvin game starting screen

## 14.2. Ski Game

Before starting a race, it always highly recommended to move to the CONFIGURATION page and double check the settings.



**Figure 41:** Ski-game configuration screen

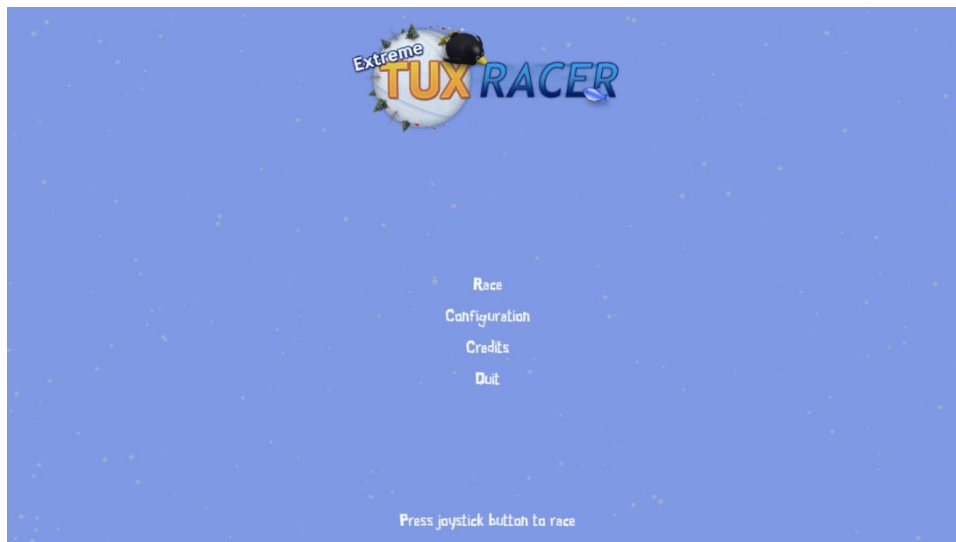


**Figure 42:** Ski-game main menu screen

*In the configuration page the user will find her / his name. The seat position is identical to the one in Alvin, so there will not be any need to adjust it. It is important, however, to adjust the load and the intensity, the lowest combination is (25, "Easy going") and the highest one is (150, "Heavy Metal").*

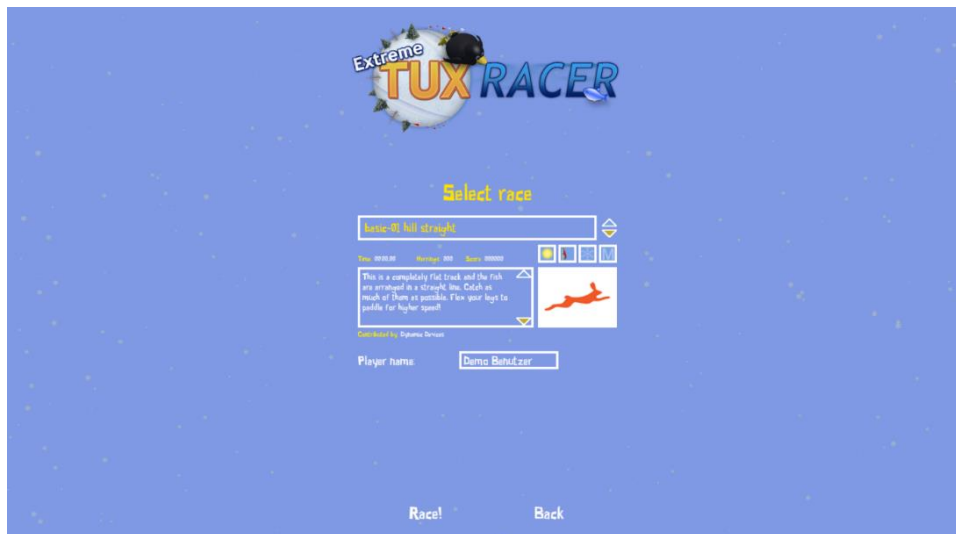


**Figure 43:** Ski-game race/hill selector screen



**Figure 44:** Penguin race



**Figure 45:** Ski-game end-of-race page



## 15. Notes on safety

The DD System ELITE is conceived and built around the safety of its user.

Six levels of safety exist:

1. Light barrier sensor on footplates. If feet are not on the footplates the pedals will not move and a pop-up message will appear (with the exception of the ski-game).
2. The adaptive knee angle limiter (AKAL) is used to limit the knee angle flexion. By putting the seat in a specific position and using the AKAL the minimal knee extension angle and the maximal knee flexion angle is set.
3. If the load exceeds the maximum load specified in the user settings page, the DD System ELITE interrupts the current training session, and a warning pop-up message appears (Fig. 46).
4. The user can interrupt any training and test at any time by pressing the joystick button on the joystick placed on the lower-right side of the seat.
5. The trainer or physical therapist can interrupt the training anytime by hitting the ENTER key or the ESC key on the computer keyboard.
6. If the emergency stop button is pressed neither seat nor pedals will move and a pop-up message appears (Fig. 47).

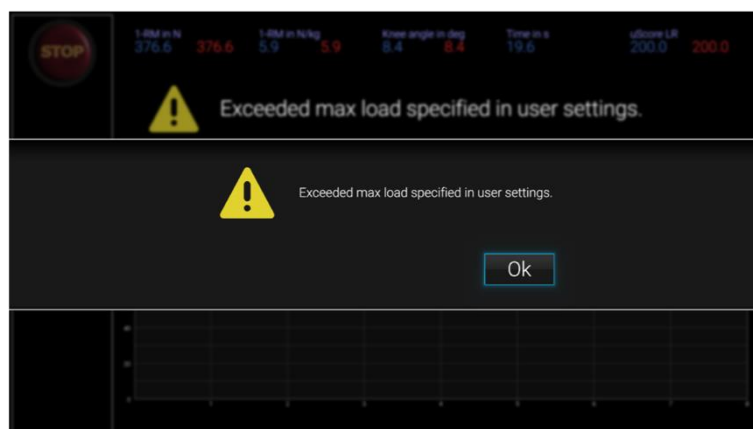


**Figure 46:** Pop-up message indicating that max. flexion angle was exceeded.

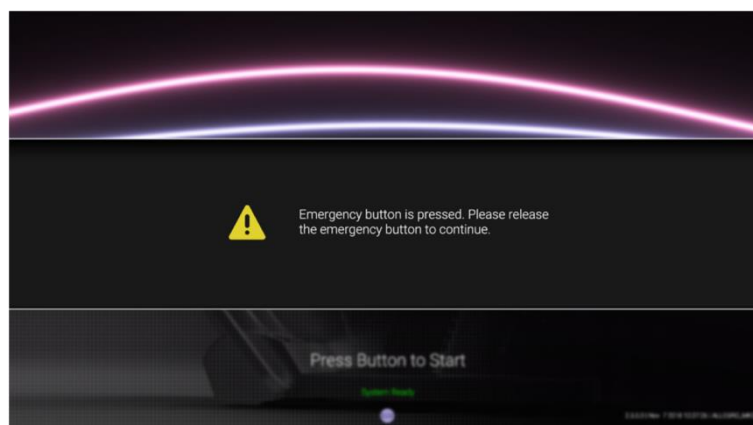


**Figure 47:** Pop-up message indicating that the emergency button is pressed.



## 16. Appendices

### 16.1. Calibration curve

For practical reasons, we decided that training on the DD System does not require an external goniometer. The user's knee angle is calculated by using the angle of the pedal with respect to the horizontal (i.e. the pedals are all the way in the front). This angle is approximately 132 degrees. In order to map the pedal angle measured by a highly accurate encoder to the user's anatomical knee angle, we use a calibration curve (Fig. 48). The calibration curve is the mapping between the user's anatomical knee angle (average between left and right knee angle) and the pedal angle of the DD System.

The calibration curve that you find in the software (in the menu "Settings") is composed as follows: the green circles represent the pedal angle values at 5, 45 and 90 degrees (these are the values collected during the calibration). Based on these values, we can calculate all knee angle values between 5 and 90 degrees. The yellow circle is the maximum possible flexion angle. Due to our safety mechanism, for "smaller" people that angle is smaller.

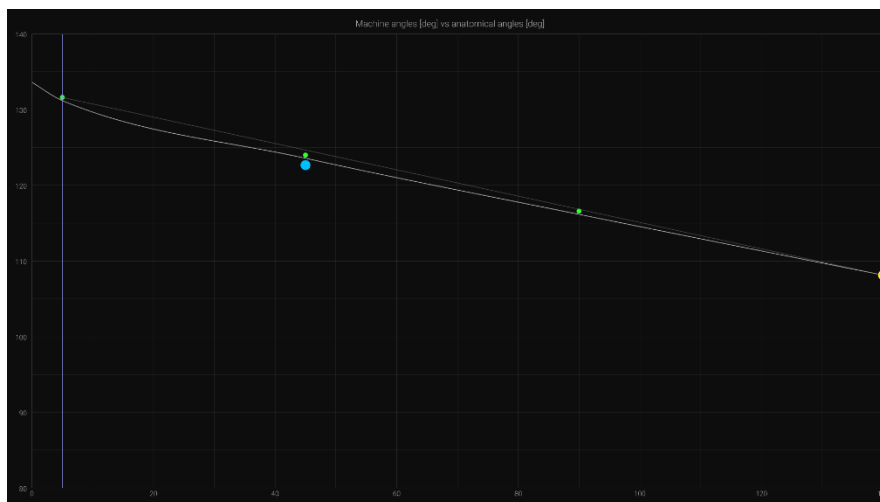


**Figure 48:** Calibration curve found in menu "Settings"/FRoM.

### 16.2. Bionic actuation mechanism

At the core of the DD System's actuation mechanism are pneumatic artificial muscles (PAMs). These are tube-like actuators characterized by a smooth, accurate and fast response that are able to produce a strong pulling force while contracting. PAMs have many advantages over conventional motors or pneumatic cylinders, such as a high force to weight ratio, no mechanical parts and less wear-and-tear. The PAM's main element is a flexible closed reinforced membrane attached at both ends of the tube. When compressed air enters the interior of the rubber tube, the artificial muscle contracts axially (up to 35% of its initial length) and expands radially (doubling its volume at full contraction), exerting a mechanical force in the process. As the air exits the tube, the membrane acts as a spring that restores the tube to its original form. The force exerted by the PAM when pressurized with air is a function of



its internal (chamber) pressure and its length. For each device a high precision factory-calibrated load cell is used to accurately model the nonlinear relationship between force, pressure, and PAM length.

The DD System is equipped with pressure sensors (accuracy: 0.1% full scale) which measure the pressure inside each PAM and high precision 18bit encoders at the base of each pedal used to calculate the PAM's length. By using these two variables and the model above, it is possible to calculate and precisely control the force exerted by the PAM (accuracy: 2% full scale), its contraction speed and hence also the external mechanical power applied to the user (time resolution: 5ms). Through the device's geometry it is further possible to estimate the speed of the user's leg movements, and all other kinetically and kinematically relevant variables.

Among the several advantages of the PAM actuator, is the ability to provide high power outputs (in terms of force and speed) despite their light weight. The PAMs mounted on the DD System, for instance, weigh 1.5kg and are capable of exerting a pulling force of up to 6300N each and to fully contract in less than 100ms. Factoring in the mechanics of the device the peak external mechanical force exerted on the user is 2700N per leg. The DD System is equipped with several fundamental test protocols. These tests can also be used for weak and deconditioned individuals – in particular, if these individuals cannot perform any standard tests, e.g. isokinetic dynamometry, or force plate measurements (mechanography). These fundamental tests include: motor accuracy, peak force, positive impulse, negative impulse, net impulse and power for cyclic movements, reaction time, force control and force steadiness.

### 16.3. Swivel footplates

The swivel footplates and hence the plantar flexion are integral part of the DD System training and testing concept, i.e. closed kinetic chain using as many degrees of freedom as possible (hip, knee and ankle joint). Like this we get a much better activation of the muscles in the lower leg, e.g. tibialis anterior and gastrocnemius, and over time a better control over the ankle joint (and more stability).

If the user wants to avoid an involuntary plantar flexion, make sure that the user's feet are located on the bottom of the foot plate and that the users pushes through the heels.



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