NEG1 - Ankle Dinamometer

The NEG1 is a dinamometer for the ankle. It based on a load cell and it can measure force during flexion or extension.

The force measured by the load cell can be used to estimate the torque at the ankle since the lever arm of the load cell is known.

Leg Positioning

The leg has to be placed in the dinamometer and the positioning system (see Fig. 1) can be moved to fit the most confortable position for the subject.

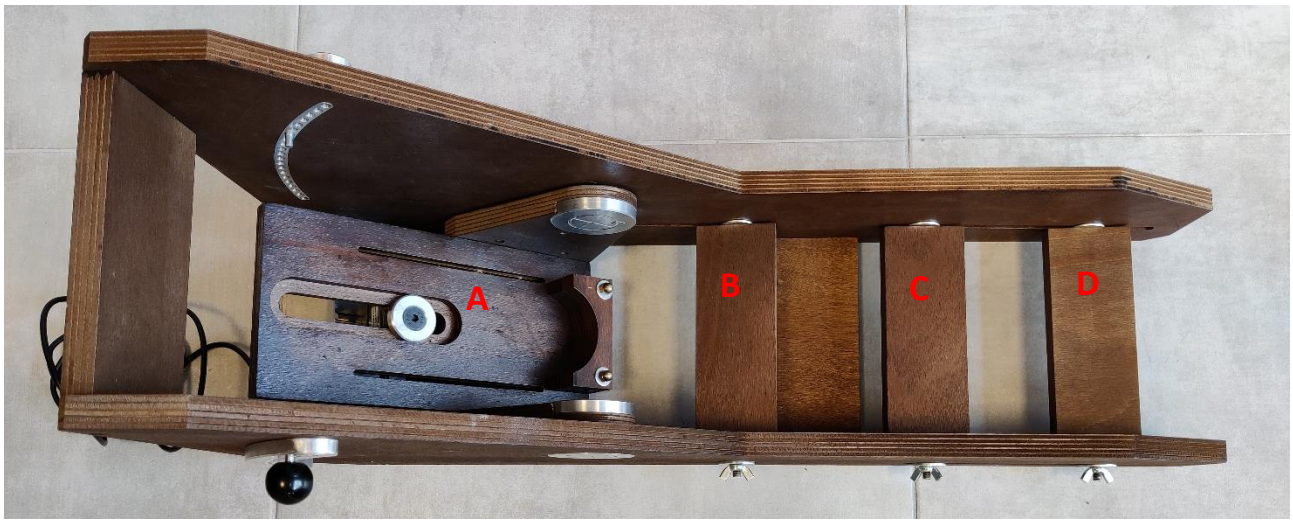

Fig. 1. *The ergometer NEG1. A: the footplate. B, C and D: positioning system for the leg.*

For reliable measurements it is important that the ankle center of rotation is aligned with the dinamometer center of rotation (see Fig. 2). In case, it is possible to add layers with different thickness between the foot and the footplate.

The foot has to be fixed using straps or bands. The footplate has two cuts to allow the fixation of the foot.

The angle can be changed between 90° and 120° by removing the two knobs and mooving the footplate together with the load cell (see Fig. 3).

Fig. 2. *Alignment between ankle and ergometer centers of rotation.*

Fig. 3. *Ankle angle set.*

Use NEG1 with forza, forza-b and forza-j devices

Forza, Forza-b and Forza-j have been designed to be used as force measurement devices for signal produced by load cells or torquemeters with differential output.

Forza and Forza-b are designed as two accessories of the Quattrocento device, while the Forza-j has been designed as an accessory to the Sessatanquattro device.

In all three cases, the following steps must be followed to use the accessory:

- Connect the dynamometer connector to the forza device using the Load Cell Input.
- Connect the device to an acquisition system using the cable called J-BNC cable or a BNC to BNC cable.
- Adjust the gain of the system using the button/wheel Gain Select.
- Delete the offset using the button Offset or the potentiometer.

Fig. 6. *Forzab, forza and forzaj load cell amplifier.*

Force and torque estimation

To calculate the force read by the load cell in Volts it is necessary to use the following function:

$$\text{Force [kg]} = \frac{V_{out\ measured}\ [V] * F.S.\ [kg]}{\text{Sensitivity [mV/V]} * 5\ [V] * \text{Gain [V/V]}}$$

Where:

- F.S. : Full-Scale, it is indicated on the load cell;
- Sensitivity: it is indicated on the load cell, usually around 2mV/V
- Gain = it is sets with the Gain button or the gain knob can be 100, 200, 500 or 1000 V/V

When using OT BioLab + it is necessary to provide a scale factor, a factor that regulates the conversion between the input force (or torque, angle, speed ...) and the voltage at the input of the auxiliary input of quattrocento or sessantaquattro. Therefore, for the load cell and its amplifier the scale factor can be estimated as:

$$SCAL_{FACT} = \frac{1000\ x\ LC_{FS}}{LC_{SENS} x\ LC_{SUP} x\ FA_{GAIN}}$$

Where:

- 1000 is needed to get the output in V since the input should be expressed in mV and the gain is a pure number
- LC_{FS} = load cell full scale, typically 100 Kg
- LC_{SENS} = load cell sensitivity, typically 2 mV/V
- LC_{SUP} = load cell supply, 5 V
- FA_{GAIN} = forza amplifier gain, sets by the user between 100, 200, 500 and 1000

What is obtained from previous equations is the force measured by the load cell, but the NEG1 is intended for measuring the ankle torque generated by a subject. In fact, the footplate is bounded and can only rotate around its center of rotation. The system geometry of NEG1 applies to the load cell a force that is proportional to the torque applied to the sistem by the subject.
A mechanical analisys of the system shows that the torque generated by the ankle produces a force that is not parallel to the the load cell axis. Therefore, part of the torque is not transferred to the load cell (see Fig. 7).

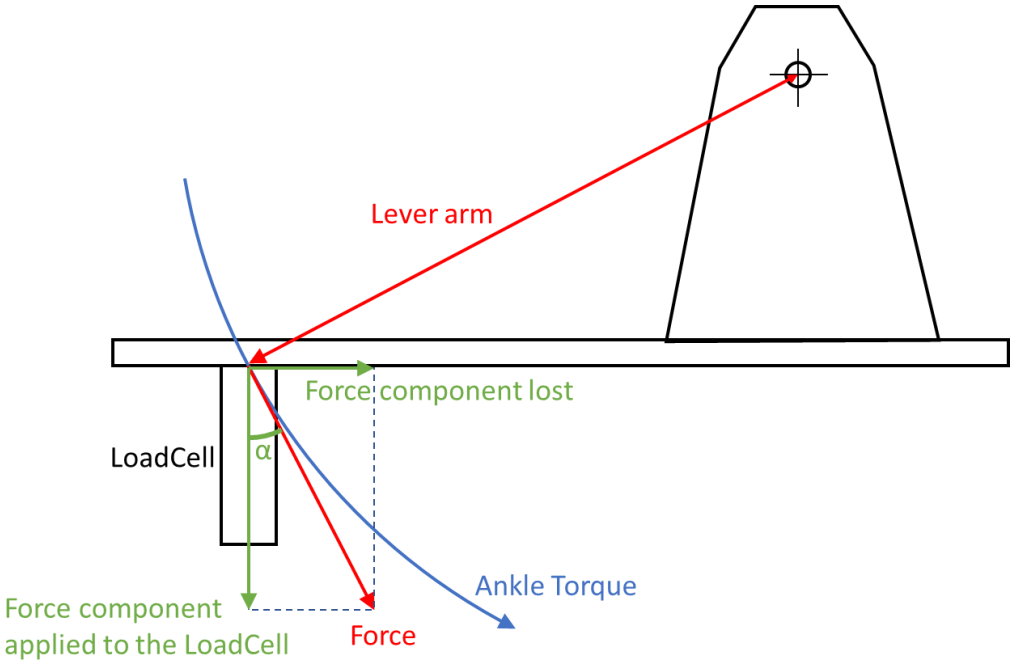

Fig. 7. *NEG1 force estimation.*

In most of the cases the the load cell output is used to provide a feedback to the subject as a percentage of its maximal voluntary contraction. In this case, the force obtained from the load cell can be used directly. In case the absolute value of the ankle torque is needed, a conversion have to be done for getting the torque corresponding to the force measured by the load cell. Rather than an analitic aproach, for a more precise calibration of the system, an empirical aproach is suggested using the setup shown in figure 8.

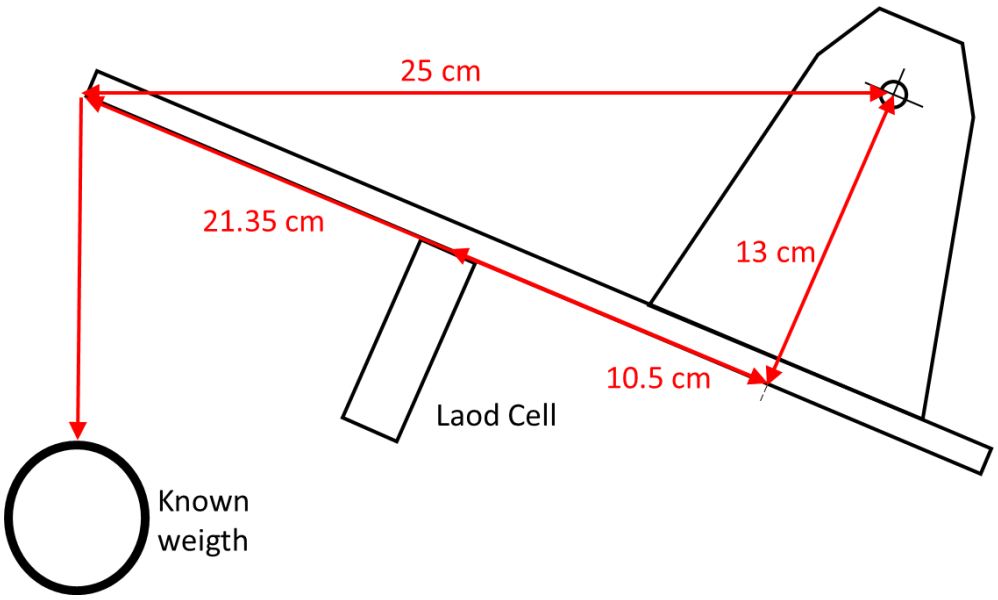

Fig. 8. *NEG1 calibration scheme. The footplate must be positioned so that the weigth is applied at the same heigth of the center of rotation and the torque generated is obtained by multiplying the weigth byt the level arm that is 25 cm.*

Technical details

In Tab. 1 load cell technical details and mechanical dimensions are reported.

	Parameter	Value
S-Type Load Cell	Range	100 kg
	Recommended Supply	10 V
	Non linearity	± 0.02 % F.S.
	Sensitivity	2 mV/V
	Load cell distance from the projection of the centor of rotation to the footplate	105 mm

Tab. 1. *Load cell Technical details.*