PRIN 2012

Mechanical measurements for the musculoskeletal apparatus: novel and standardizable methodologies for metrological assessment of measurement systems.

WP1
Summary of 2nd meeting

Date: July the 16th 2014

Version: 1.1

2nd Meeting

The meeting took place on July the 16th at Sapienza University of Rome, faculty of Engineering, Via Eudossiana 18, Roma, IT.

The meeting was attended by:

- RM1: Paolo Cappa, Andrea Ancillao
- CBM: Carlo Massaroni, Emiliano Schena
- RM3: Salvatore Sciuto, Andrea Scorza, Giulia Lupi

The meeting marked the conclusion of WP2: *Literature review* and the start of WP3: *Design of instrumentation*, (See the following GANTT).

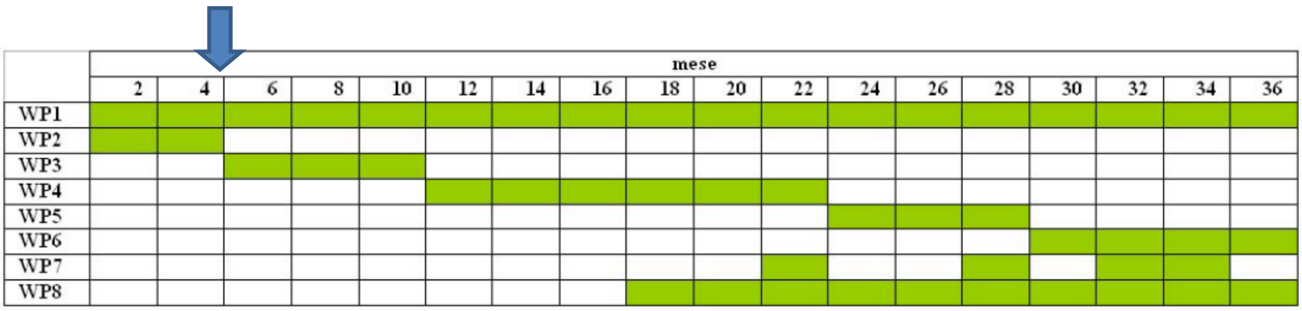

Figure 1: GANTT

Each partner prepared a literature review according to the following topics:

RM1: Kinematics data quality

RM3: Kinetics data quality

CBM: Data quality of optoelectronic plethysmography

The reviews were discussed and will be merged in a single document representing the Deliverable D2 of WP2.

The meeting started with a brief discussion about the instrumentation available in the lab of each partner.

It was stressed the importance of publishing the results of measurements as soon as possible, acknowledging the funding organization.

The importance of respecting deadlines was also stressed.

Each partner presented a few slides about the work already carried on. Each partner also explained plans and proposals for the forthcoming work-packages.

The first to speak is RM3:

They completed a literature review about data quality and calibration of force plates used in human motion analysis (typically Gait Analysis).

After the review they designed a lever mechanism, based on a cantilever and a shaker, that may allow dynamic calibration of force plates. See figure 2.

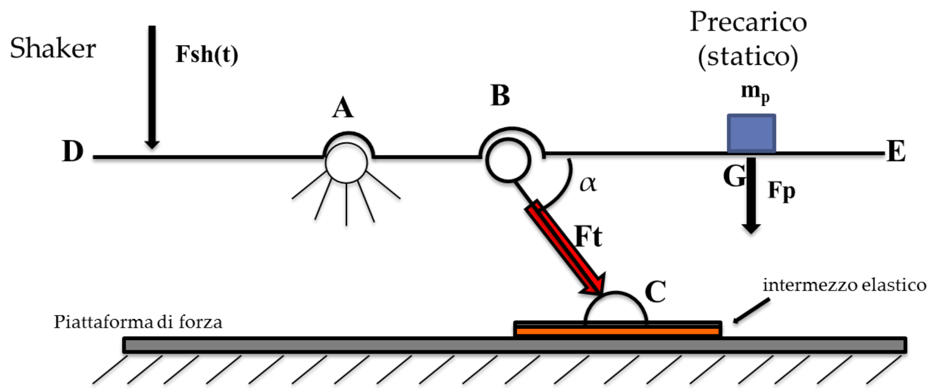

Figure 2: Device designed by RM3

The mechanism allows the controlled application of variable loads to the force plates. Some preliminary tests were performed to the mechanism in order to establish the optimum configuration. Tests were performed with a pre-load of 1 kg and 1 Hz shaking.

The following issues of the system were pointed out:

The shaker normally works at high frequencies, while the force plate works at low frequencies (less than 20 Hz). The shaker may be replaced with an actuator.

The system actually works with low weights and therefore low applied forces (10 N) while higher forces are necessary to test the force plate.

The system needs to be connected to the force plate without damaging it, therefore a solid system to quickly connect and disconnect the mechanism to the platform needs to be designed. A decoupler may also be useful at the interface with the platform.

CBM:

CBM completed a literature review about optoelectronic plethysmography (OEP) (Figure 3). Most of the literature is about the clinical application of OEP while few studies focused on the metrological analysis of the OEP system.

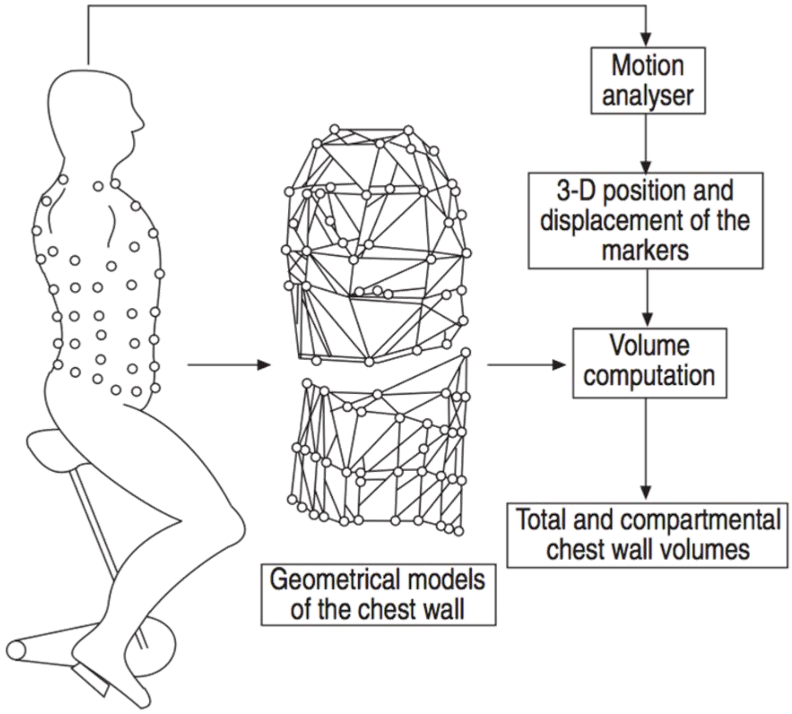

Figure 3: OEP system.

The tests used to assess quality of OEP system are basically the same tests used for optoelectronic systems, as OEP uses an optoelectronic system with small calibrated volume to reconstruct markers placed on the chest.

CBM already developed a method to asses quality of OEP by the use of an electromechanical system with 1+ degrees of freedom to moving a set-of-marker placed at defined distance between them (Fig. 4).

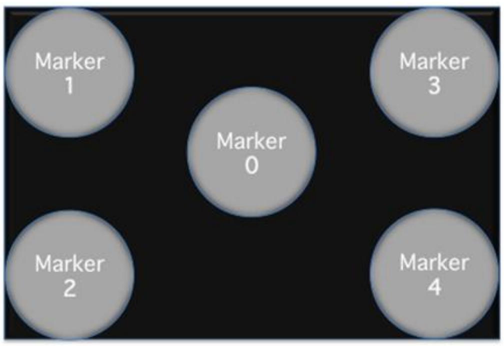

Figure 4

The marker set is mounted on a black background and it is moved by a mechatronic device.

Test are conducted by changing influence factors:

- Number of cameras
- Camera setup and configuration (circle, different heights).
- Type of marker (size, spherical, hemispherical)
- Presence of marker base

CBM is also interested in improving the test by making it compatible across different motion analysis systems. They also designed an ad-hoc device for dynamic calibration of OEP system, that simulates the natural motion of human chest (Figure 5).

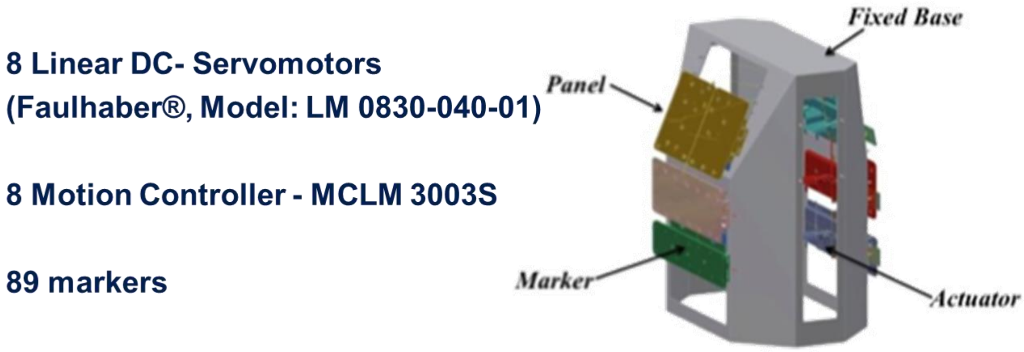

Figure 5: Dynamic calibration of OEP system

They are actually preparing a draft for publication that should be ready within august 2014.

RM1:

RM1 completed a literature review about Kinematic calibration and data quality of optoelectronic motion capture systems used for human motion analysis.

Many methods were proposed in the literature. The simplest one is the static and dynamic recording of a stick equipped with two markers at the extremities (Figure 6). The length of the reconstructed segment is compared to its nominal length.

Figure 6: Wand with markers

Some advanced methods involve the use of robots as shown in figure 7. The main limitation are the dimensions of measurement volume 180×180×150 mm^3 that are not comparable with the ones typically used for gait analysis

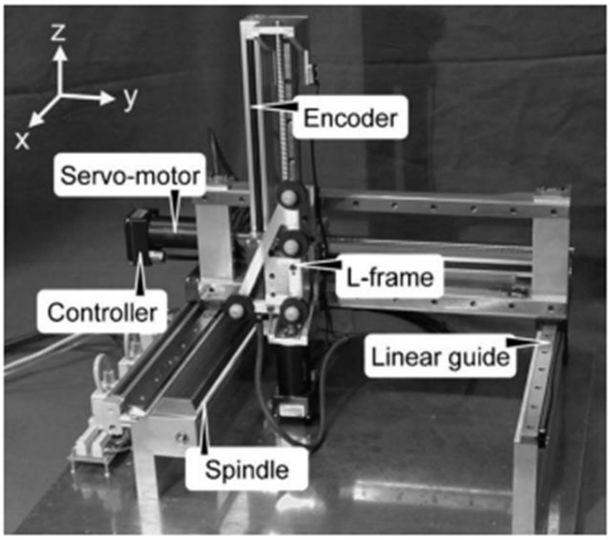

Figure 7: Calibration robot

After reviewing the literature, RM1 proposed the following calibration method .

First step is the motion of a markerized wand along the whole calibration volume.

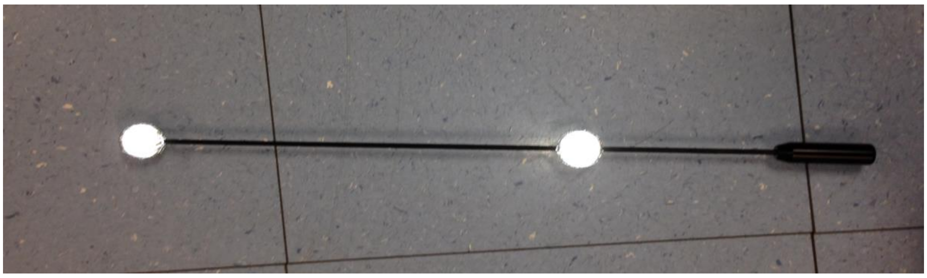
Figure 8: Markerized wand

Accuracy will be measured as the difference between the measured length of the wand and it's nominal length.
The wand should be moved across the whole volume, allowing detailed evaluation of accuracy.

The second step is the acquisition and processing of a Gait Analysis clinical exam according to the following workflow:

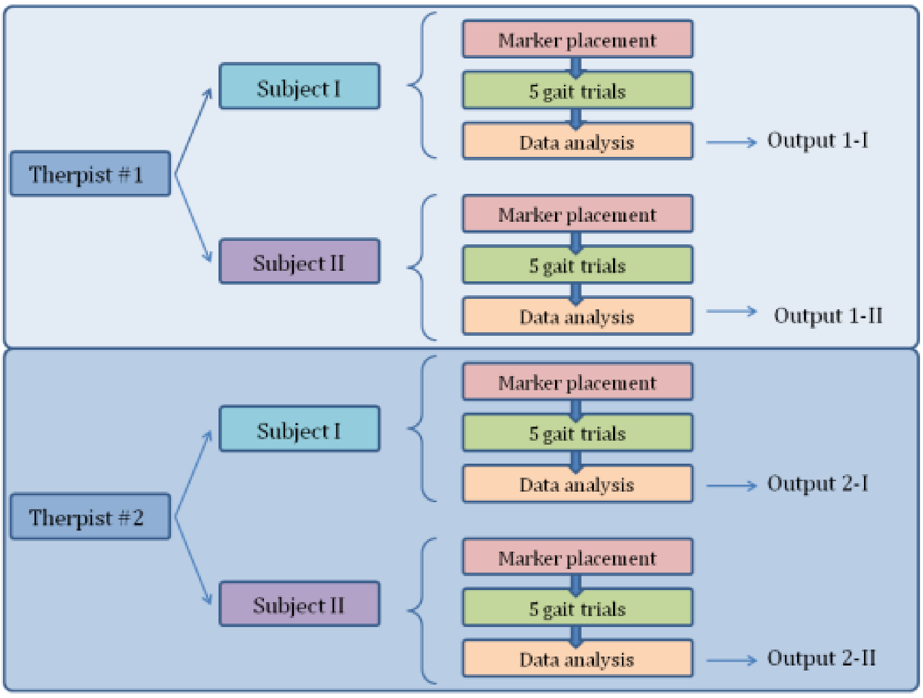

Figure 9: Workflow

The protocol applies to:
2 healthy subjects
2 trained and experienced clinicians
Trials repeated for 5 times

For each lab we will have:
2 subj x 5 trials x 2 terapists = 20 trials to process

Data processing will include:
Labelling
Fill gaps
Filtering and smoothing
Comparison between computed parameters (velocity, angles, etc.).

RM1 also proposed a device for static calibration of force plates (Fig. 10).
The device is composed of a 6-components load cell and it is equipped with markers that allow the tracking and reconstruction of its position inside the calibrated volume.

The device is applied on different points of the force plate (Figure 11) and output data from the force plate is compared to output data of the load cell.
A variable load and torque is applied by the operator on the load cell. The articulated joint allows application of forces and torques along different directions.

This device allows quantification of accuracy in reconstruction of :

- COP
- Intensity of force
- Intensity of torque
- Direction of force
- Direction of torque

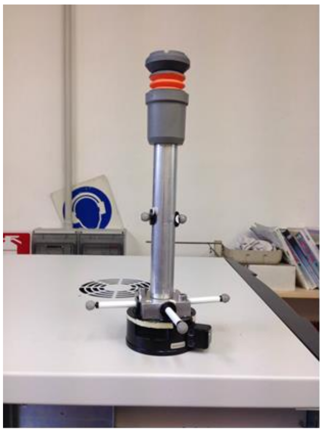

Fig. 10: Load cell equipped with markers

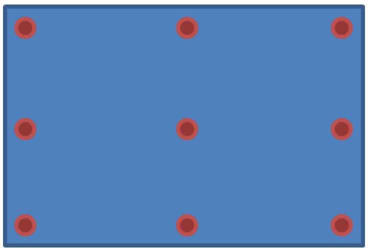

Figure 11: Test points over the surface of the force platform

Conclusion

The conclusion of the meeting was to proceed as follows:

- Merging of the literature reviews and preparation of the D2.
- Partners will be in touch to decide when starting data acquisition.
- RM3 will finalize the design of the device for dynamic calibration within December 2014
- CBM will prepare a draft for a possible publication of their results within August 2014
- Each partner will soon finalize the protocol and data acquisition procedures will begin as soon as possible.