Integrated Measurement and Management System for Sarcopenia Diagnosis

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Abstract

Sarcopenia is the progressive loss of mass and muscular function. The goal of this work is to develop an integrated technological system, consisting of measuring devices, including mobile and wearable devices, interfacing with a data collection and processing software system, for clinical monitoring and management of the analyzed case studies. The system has been designed to both preventive (early diagnosis) and monitoring purposes of the patient's condition over time. The diagnosis will support medical personnel in identifying appropriate interventions to prevent or reduce sarcopenia, which can be communicated via apps on smartphones to patients and caregivers, and monitored by medical personnel.

Activity Description

First, we have identified the **clinical parameters** to be measured and the operating conditions in which these parameters will be measured; then we have defined the requirements of the technological devices for interfacing with the software platform.
We have defined two use scenarios: hospital and home scenario.
Fig. 1 shows the **system architecture**. It consists of three main components:

- *Wearable measuring devices*. There are two prototypal devices. A prototype hardware device capable of detecting muscle strength, walking speed and EMG has been designed and built. The device created satisfies the requirements identified, namely portability, low cost, non-invasiveness and low consumption. A preliminary study of the operating procedures for the use of the surface EMG system has also been *started.*
- *Gateway* app. It is designed to be installed on an Android smartphone. It is able to connect to the sarcopenia device by means of Bluetooth connection in order to receive the data measured by that device and to send those data to the SIMMS web-application back-end server. The gateway app can be used by both patients and doctors, on smartphones owned by patients or supplied by the hospital.
- *Web application*. It is designed to be installed on a PC or tablet. It enables doc-tors to access the patients' registry and to diagnose sarcopenia by analyzing the data received from the gateway app as well as the data received directly from the EMG device.

The system hardware architecture also includes:

- *Communication technologies* such as Bluetooth REST type web services;
- *Remote data collection servers*.

The prototype of the proposed solution is completed. A first version of the prototype is available for the next testing phase.
The clinical trial protocol has been designed. The **testing phase** will take 6 months and will be performed at Casa Sollievo della Sofferenza Hospital on a randomized cohort of 100 patients aged ≥ 65 years and at risk or suffering from sarcopenia (i.e. ADL ≥ 4 and SARC-F ≥ 4), either admitted to the Geriatrics Operational Unit or evaluated at the Geriatrics clinic.

Figure 1. System architecture.

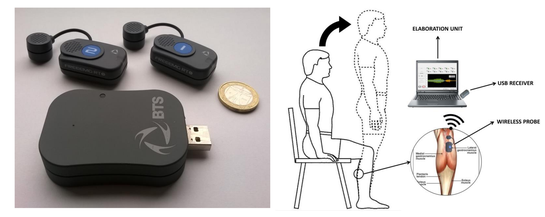
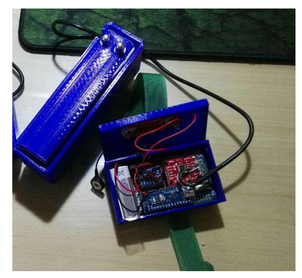


Fig. 2. (a) EMG FREEEMG1000 acquisition system; (b) Sit To Stand test setup.



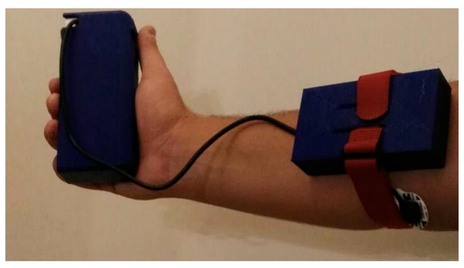


Fig. 3. (a) The proposed prototypal wearable device; (b) the realized device worn by a patient.

Findings

A **surface ElectroMyoGraphy (sEMG) based hardware-software platform** was realized for the minimally invasive and long-term monitoring of the lower limb muscles. Through the platform it will be possible to detect, over time, a muscle decay in users who wear sEMG sensors and perform exercises normally used to evaluate muscle loss, in clinical contest. The hardware platform consists of an elaboration unit and a data acquisition system. For the acquisition setup system, the BTS Bioengineering FREEEMG1000 device has been used. It is made up of wireless, wearable sEMG probes and an USB receiver, produced by the BTS Bioengineering. The main computational steps of the software architecture are: a) Pre-processing; b) Calibration; and c) Feature extraction. For the Feature extraction phase, the Sit To Stand test will be performed,
In the **second prototypal device**, an Arduino Nano board has been equipped with small and low-cost sensors able to provide these parameters and, in details:

- *Muscle mass*. The MyoWare boardhas been used to detect EMG measures useful to obtain information about the muscle mass.
- *Muscle strength*. This measure has been obtained by exploiting a HX711 board. This board embeds both a load cell and a circuit to amplify the signal.
- *Gait speed*. To detect this parameter, a GY-521 board embedding the InvenSense MPU-6050 chip with a 3-axis MEMS accelerometer and a 3-axis MEMS gyroscope is used.

For a correct operation, the patient (alone or supported by the caregiver or doctor) has to perform a few simple actions before starting the acquisition procedure:

- wear the device at the level of the forearm, in correspondence of the dominant hand for detecting muscle strength, through the appropriate bands with Velcro placed on the box;
- attach the two adhesive EMG electrodes placed on the back of the device along the superficial extensor muscles of the forearm whereas place the third adhesive electrode (reference electrode) away from the same muscle (e.g. in correspondence of the cartilage);
- switch on the device end proceed with the measures using the mobile application.

The **testing phase** involves a first step in which the assessment of sarcopenia will be carried out according to the 2019 EWGSOP guidelines. For the determination of muscle strength, we will use a portable electronic dynamometer certified as a medical device. The execution of the handgrip will be carried out following the standard protocol indicated by the American Society of Hand Therapists. The patient will undergo an assessment of body composition including the determination of muscle mass and total body fat by means of Dual energy X-Ray absorptiometry (DXA) . The physical performance will be assessed through the gait test; the patient will be asked to walk, at a speed not different from his usual one, wearing comfortable footwear, in a straight line along a path of 4 meters, timing the time taken and deriving the average speed. All data will be recorded and subsequently entered in a digital platform through the mobile app. We are starting to execute the experimentation and then we will gather and analyze data from experiments, as well as verify and validate the experimentation.
Casa Sollievo della Sofferenza began testing the device developed by IDA Lab and the two apps developed in the project in February. The trial was stopped due to the emergency related to COVID-19, since the Geriatrics Operational Unit at Casa Sollievo della Sofferenza operated as a Covid-19 center.