Low-frequency ultrasound device for pressure ulcer diagnosis

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Introduction: As a result of pressure ulcer (PU), skin mechanical properties vary [1]. In this project, a new technology for PU diagnosis is proposed, the low-frequency ultrasound (LFU) diagnostics tool. Literature indicates LFU as a complement for PU treatment, reducing pain and time for the recovery of patients [2], [3].

The LFU diagnostic tool consists of a Langevin transducer (LT) of 60kHz vibration connected to a host computer and a microcontroller. Initial results of healthy skin are presented below.

Methods: The device's set-up is presented on Figure 1. The microcontroller & LFU generation are responsible for the vibration of the LT and the assurance that the waves behave as demanded by the user. The holding structure, containing a force sensor, assures the indentation force of 0.2N during the contact. The host computer provides the interface between user and device.

The experiments taken had a ramp-like vibration over the skin, with a controlled velocity using vector control method [4]. As the vibration is the same in both contact and no-load (no contact with skin) operation, it is possible to calculate skin acoustical force with the difference of electrical effort of the device, reflected on its voltage, as shown below:

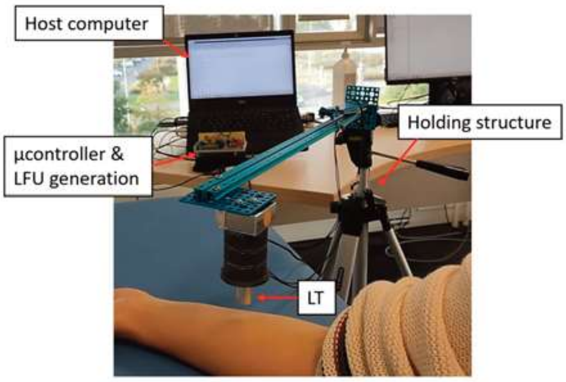

Figure 1. Set-up of the system

$f_r = N(v_{in\text{-}contact} - v_{no\text{-}load})$

In the equation, $v_{in\text{-}contact}$ and $v_{no\text{-}load}$ are the voltages measured in skin tests and no-load operation, f_r is the acoustical force imposed by the skin and N is an LT intrinsic constant. Tests based on this measure were taken in 11 participants (5 female, 6 male) with ages ranging from 26 to 67 yo. Results presented in this abstract were obtained with the mechanical reaction force from skin in the morning (AM) and afternoon (PM) and for each assessment, 2 measurements were taken to guarantee the reproducibility of the measurements.

Results: The results for acoustic mechanical impedance (AMI), defined as the, $\bar{f_r}/\bar{u}$, where $\bar{u}$ is the velocity [5], are presented in Figure 2, where values of AMI range from 0.0017 to 0.0107 Ns/mm. The standard deviation within the population in different shifts is 0.0028 Ns/mm.

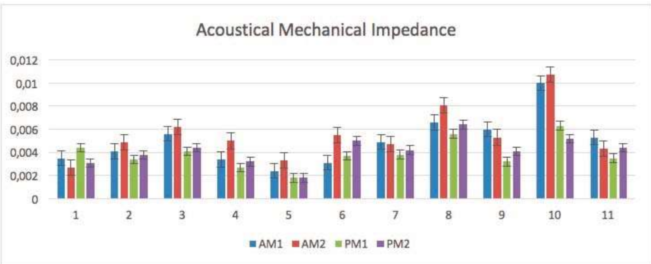

Figure 2. Results of AMI of skin

From the figure, note that the measurements in the same shift (AM or PM) present similar values.

Conclusions: The LFU diagnostic tool has shown consistent measurements for the AMI of skin. It is fair to say it can be an objective instrument to characterize skin mechanics and potentially asses early stage PU. For that, tests on damaged skin are foreseen to validate this application.

References

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