THE EFFECT OF RESPIRATION ON THE *IN-VIVO* MECHANICAL EVALUATION OF *LINEA ALBA* BY SHEARWAVE ELASTOGRAPHY

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Introduction

In vivo characterization of abdominal wall mechanical properties is an important aspect for improving our understanding of the onset and treatment of abdominal hernias. Several methods have been developed to this end, such as the estimation of local tissue strain with optical or magnetic resonance imaging [1,2]. However, only a few studies focused on the mechanical characterization of *linea alba*. Shearwave Elastography (SWE) has provided promising results in assessing this tissue [3,4]. Biomechanical assessment of *linea alba* can be challenging because it has a nonlinear mechanical behavior, i.e., mechanical loading, such as breathing, can alter its tangent stiffness. The aim of this work was to determine the effect of breathing on the biomechanical assessment of *linea alba* using SWE during the normal breathing cycle.

Methods

Fifteen healthy adults (6 females, 9 men, 33 [26;40] years old, 24 [20;27] kg/m² body mass index, BMI) were included, after obtaining their informed consent (ethical committee CPP Ile-de-France VI 6001). SWE was performed with a Mach30 device (Supersonic Imagine, Aix-en-Provence, France) and a SL 18-5 probe. Subjects lied supine, and measurement were performed 1 cm below the navel; first the location of the *linea alba* was determined with a transversal scan, then transversal and longitudinal measurements were performed. Each measurement was a video of sufficient duration to span at least 4 breathing cycles (about 40 seconds). Measurements were repeated three times by one operator; a second operator repeated the protocol on a subcohort of 6 subjects. Breathing cycles were determined by tracking the movement of the abdominal wall in the video (25 Hz). SWE frames (~1 Hz) were postprocessed to extract Shearwave Speed (SWS) and relate it to the breathing cycle. Results were reported as median [1st;3rd quartile].

Results

The measurement was feasible in all subjects, irrespective of BMI. Average SWS was 2.4 [2.0;2.6] m/s in longitudinal direction and 2.2 [1.9;2.7] m/s in the transversal one. The difference was not significant ($p>0.05$).
Uncertainty was 0.2 m/s (8% coefficient of variation) in the longitudinal direction and 0.3 m/s (14%) in the transversal one, with not significant operator effect, which is consistent with previous studies [3].

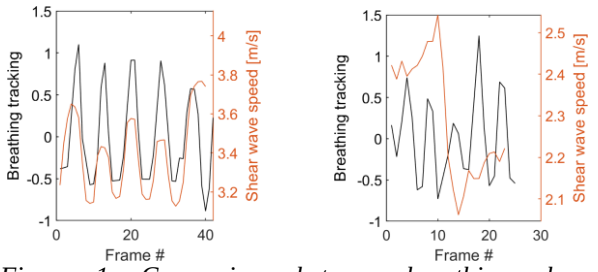

Figure 1: Comparison between breathing phase (arbitrary units) and shear wave speed. Left panel shows an example where breathing cycles are observable in SWS, while in the right panel measurement uncertainty is higher than variations due to breathing.

Figure 1 shows examples of measurement during breathing cycle. SWS showed a clear cyclic pattern only in a small portion of the measurements. In general, variations due to uncertainty were higher than those due to the breathing cycle.

Discussion

Results confirm that SWE of the *linea alba* is sensitive to breathing. This could be considered as a confounding factor when assessing the tissue, but also as a mean to load the tissue and potentially detect pathological alterations which are not evident in the unloaded tissue. The main limitation of this work is that subjects were asked to breath normally and were not specifically invited to use "abdominal breathing" rather than a "thoracic" one. It is possible that abdominal breathing (through the diaphragm) might have enhanced SWS variations during different breathing phases.
In conclusion, this study confirmed that breathing can have a measurable effect on the SWS assessment of the *linea alba*, but further work is needed to refine the measurement protocol, to determine the effect of forced abdominal pressure and to ascertain the clinical relevance of such method.

References

1. Jourdan et al, Comp Methods Programs Biomed, 217: 106667, 2022.
2. Lubowiecka et al, J Mech Behav Biomed Mat, 125:104902, 2022.
3. Tran et al, J Mech Behav Biomed Mat, 60:451-459, 2019.
4. Zememi et al., Phys Med Biol 66:205006, 2021

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