PhD project Graduate+ MUSKLE

Characterization of structural stresses during transient soft tissue vibrations induced by foot/ground impacts

Laboratory: Laboratoire Interuniversitaire de Biologie de la Motricité (LIBM), UR7424

Research team: Sport Performance and Injury Prevention

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Project Description

Sport involves numerous foot-ground impacts, generating shock waves that propagate through the bones and soft tissues (muscles, tendons, adipose tissue, ligaments and skin). These shock waves cause temporary deformation of the soft tissues, resulting in oscillations when the tissues return to their resting position. These oscillations, known as soft tissue vibrations (STV), exhibit viscoelastic behavior and are characterized by specific frequencies, amplitudes and damping properties. Although understanding of the effects of repetitive transient vibration is limited, exposure to vibration has been shown to accelerate muscle fatigue and induce muscle damage (1). STVs are commonly measured by accelerometry, a reliable method but one that does not measure tissue deformations and internal stresses. However, it has been shown that intramuscular shear stresses can partially explain post-exercise damage (2). Calculating the stresses induced by muscle deformation would therefore provide a better understanding of the origin of damage, enabling effective prevention strategies to be developed. Random speckle coupled with digital image correlation (DIC) is commonly used for mechanical testing to assess the strength of metals and alloys, and some studies show that it can be used to characterize deformations within soft tissues (3).

The aim of this PhD will be to characterize soft tissue deformation during STV induced by shocks mimicking running, using an ergometer developed and validated by LIBM (4), in order to calculate and localize mechanical stresses in the knee extensors.

The first study will compare the results from DIC with the results obtained using accelerometers. The aim is to assess the ability of DIC technique to measure soft tissue vibrations. The values obtained on different areas of the muscle studied will be compared between the two methods.

The second study will aim to calculate the deformations and stresses generated by impacts during simulated running. DIC will permit to calculate surface modifications during the vibrations generated by the shocks. Next, the resulting stretch and compression will be calculated to localize the parts of the muscle and skin that are predominantly exposed to mechanical stress.

The third study will attempt to compare the muscular stresses with and without compression garments using DIC. Analyzing the influence of different pressure levels and thigh areas which are compressed (lower, middle or upper thigh).

References

[1] Gassier R, Espeit L, Ravel A, Beaudou P, Trama R, Edouard P, Thouze A, Féasson L, Hintzy F, Rossi J, Hautier C. Beneficial effects of reduced soft tissue vibrations with compression garments on delayed neuromuscular impairments induced by an exhaustive downhill run. Front Sports Act Living. 2025 May 7;7:1516617. doi: 10.3389/fspor.2025.1516617. PMID: 40400783; PMCID: PMC12092359.

[2] Fouré A, Ogier AC, Guye M, Gondin J, Bendahan D. Muscle alterations induced by electrostimulation are lower at short quadriceps femoris length. Eur J Appl Physiol. 2020 Feb;120(2):325-335. doi: 10.1007/s00421-019-04277-5.

[3] Lionello G, Sirieix C, Baleani M. An effective procedure to create a speckle pattern on biological soft tissue for digital image correlation measurements. J Mech Behav Biomed Mater. 2014 Nov;39:1-8. doi: 10.1016/j.jmbbm.2014.07.007.

[4] Gassier R, Hintzy F, Malisoux L, Hautier C. Development and validation of a new simulator of running impacts. J Biomech. 2025 Oct;191:112926. doi: 10.1016/j.jbiomech.2025.112926. Epub 2025 Aug 20. PMID: 40848388.

Skills required

Training in sports science and biomechanics of movement - Experience in movement analysis, accelerometry, muscle function analysis and programming; Spoken and written English - Thoroughness, initiative, ability to work independently and as part of a team.