IS THE STIFFNESS OF THE RECTUS FEMORIS AND VASTUS LATERALIS INFLUENCED BY MUSCLE LENGTH IN HEALTHY INDIVIDUALS?

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Résumé

Background: Passive muscle stiffness, determined by the intrinsic properties of muscle and connective tissue, is a key physiological factor influencing biomechanics and musculoskeletal function (1). Shear Wave Elastography (SWE) is a reliable ultrasound imaging technique for assessing muscle stiffness, particularly under passive conditions (2). SWE quantifies stiffness based on shear wave propagation speed (m/s) and stiffness values in kilopascals (kPa), reflecting both muscle and connective tissue characteristics (2). By providing quantitative and qualitative data, SWE serves as a valuable tool for evaluating muscle condition and monitoring therapeutic interventions in both clinical and research settings (2). Joint position is critical for torque production by the quadriceps femoris, with optimal muscle length for force generation typically occurring around 60◦ of knee flexion (3). Previous studies have assessed active muscle stiffness using Young's modulus, muscle strength, and architecture in healthy individuals across four positions: supine with 60◦ knee flexion (SUP60), sitting with 60◦ (SIT60), supine with 20◦ (SUP20), and sitting with 20◦ (SIT20) (3). Investigating passive stiffness in both monoarticular and biarticular components of the quadriceps such as the rectus femoris (RF) and vastus lateralis (VL) may clarify how muscle length and joint angle affect stiffness and force production. However, the influence of these variables across different quadriceps regions remains unclear. Thus, our aim was to: 1) Assess the passive stiffness of RF and VL at two knee flexion angles (60◦ and 20◦) and in two body positions (supine and sitting) using SWE. 2) Evaluate passive stiffness variations at different muscle depths. 3) Investigate differences in passive stiffness between males and females.

Methods: Thirty-six healthy participants (mean age: 21.9 ± 3.0 years) were included in a randomized crossover trial. Four conditions were randomly tested: SUP60 (supine with the knee at 60◦), SUP20 (supine with the knee at 20◦), SIT60 (sitting with the knee at 60◦), and SIT20 (sitting with the knee at 20◦). Participants were blinded to the study hypotheses and the numerical order of the joint angles. They were not informed about which position was expected to result in greater muscle stiffness. However, due to the nature of the body positions, evaluator blinding was not feasible. Passive muscle stiffness was assessed in the superficial, intermediate, and deep regions of the rectus femoris (RF) and vastus lateralis (VL) using shear wave elasticity (kPa) and shear wave velocity (m/s). Measurements were obtained using the ACUSON Redwood Ultrasound System (Siemens, USA) set to musculoskeletal configurations ranging from 0 to 300 kPa. Stiffness differences were analyzed using

*Intervenant

the Generalized Estimating Equations (GEE) method, with position, depth, and muscle as factors. Models were adjusted for sex.

Results: Significant interactions ($p < 0.001$) were found between position and muscle type, as well as between position and depth. Stiffness was significantly higher in the SUP60 position (supine with 60$\circ$ knee flexion) compared to all other positions ($p < 0.001$) for both the RF and VL muscles, as measured by kPa and m/s. Additionally, superficial regions consistently exhibited greater stiffness ($p < 0.001$) than intermediate and deep regions across all positions. Men demonstrated significantly higher stiffness than women ($p < 0.001$).

Conclusion / Perspectives: The findings revealed that the quadriceps femoris exhibits non-uniform stiffness across joint positions, muscle depths, and sexes. Higher stiffness was observed in the SUP60 position for both the RF and VL, and superficial regions consistently showed greater stiffness than deeper regions. Additionally, men displayed higher stiffness values compared to women. Clinicians should consider joint position, muscle depth, and sex differences when prescribing quadriceps femoris exercises, as these factors influence the mapping and modulation of muscle stiffness.

References:

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