INTER AND INTRA MUSCULAR VARIABILITY OF RIGIDITY IN HEALTHY AND PARETIC MUSCLES: ULTRASOUND IMAGING

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Introduction

Through the estimation of shear wave velocity propagation in muscle tissue, shear wave ultrasound (SWE) assessments provide a reliable local quantification of rigidity during different positions and movements [1]. Several studies have investigated healthy and paretic muscle rigidity using SWE [2]. However, the assessments may not consider the most affected regions within the same muscle tissue nor the intramuscular variability of rigidity between muscles of the same muscle group, e.g., plantar flexors. This study aimed to explore the inter–and intramuscular variability of plantar flexors stiffness during prone and standing positions at different muscle lengths in healthy and paretic individuals.

Methods

A randomized controlled trial was set. Twenty-eight subjects were recruited and divided into two groups. The control group (CG) consisted of 14 healthy individuals with no history of neurological or muscular disorders (CG, n=14; age=43.9±9.6 years; BMI=24.5±2.5 kg/m²) and the stroke survivor group (SSG) consisted of 14 stroke survivors with spastic hemiparesis (SSG, n=14; age=43.9±9.6 years; BMI=24.5±2.5 kg/m²). Shear modulus (μ) of three plantar flexors (Gastrocnemii Medialis (GM) and Lateralis (GL), and Soleus (SOL)) was performed using shear wave elastography during two conditions: prone and standing position, at different muscle lengths (0°, 10°, 20°). Measurements were also performed in different proximo-distal regions of each muscle. During the two conditions, muscle activation of GM, GL, SOL and the tibialis anterior were evaluated.

Results

Our Results showed a high spatial stiffness variability between and within plantar flexors during dorsiflexion and the highest stiffness was observed in GM, especially in the distal region at 20°. In the prone position, the paretic muscle exhibits greater stiffness than in the healthy muscle ($p<.05$) and plantar flexor muscle activations were lower than 5% of maximum activation. However, in the standing position, an increase of stiffness in the healthy muscle compared to the paretic muscle was observed ($p<.05$). and plantar flexor muscle activations were higher than 5% of maximum activation.

Discussion

Active and passive states of ankle muscles could change differently the spatial distribution of stiffness in healthy and paretic muscles during ankle dorsiflexion. The contribution of the contractile component in the development of muscle stiffness in response to stretch should be taken into consideration in the quantification of the mechanical properties of paretic muscle.

Figure and Tables

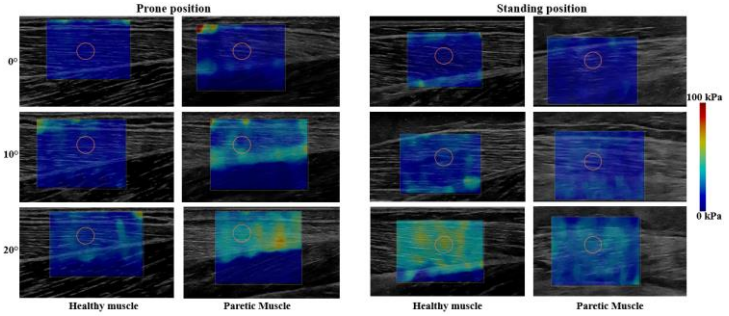

Figure 1: Shear wave ultrasound images of the distal region of gastrocnemii medialis in prone position (left) and standing position (right) at different angle of dorsiflexion

Equations

Ultrafast ultrasound sequences are used to measure the shear wave velocity (Vs) using a time-of-flight algorithm in each pixel of the map [3]. Assuming a linear elastic behavior [4], a shear modulus is calculated using Vs as follows:

$$\mu = \rho Vs^2 \quad (1)$$

where ρ the density of the tissue (1000 kg m^{-3} for muscle)

References

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