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A New Quantitative MAS Based on Joint Angle Data Measured With IMU Sensors for Spasticity

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Background & Objective

Quantitative measurement of spasticity has not been developed yet. Modified Ashworth scale (MAS) had long been used to measure the spasticity, but it is not quantitative. Recently developed modified Tardieu scale(mTS) seems to be quantitative but the inter and intra-rater reliability is low especially in the angle of catch (AOC) measurement. Since spasticity causes major disabilities in brain injured patients, it is necessary to develop a quantitative scale for spasticity measurement. Joint angle during passive range of motion (ROM) can be quantitatively measured with recently developed inertial measurement unit (IMU) sensors. With IMU sensors attached to the spastic limb during the measurement of mTS and MAS, a new quantitative MAS measurement is suggested.

Methods

Patients with spastic upper or lower limb were included. With IMU sensors securely attached to the proximal and distal segments, two independent examiners measured spasticity using standard methodology for measuring MAS and MTS. Each limb was examined for 5 times. The two examiners rated the spasticity in MAS and angle of catch for MTS. The data driven during the examination were stored in a PC based system and using MATLAB program the angles of total range of motion, AOC, and acceleration rate of the movements were calculated. For measured MAS, inter and intra-rater reliability was calculated. From the data driven with IMU sensors, an angle-time curve was plotted. From this curve, authors could classify the patterns of curve that correspond to the MAS grade. AOC measured manually (or conventionally) was compared to the IMU data.

Results

Inter and intra-rater reliability using IMU for MAS and AOC measurement was higher compared to manual examination. Especially, AOC measured with IMU was more consistent than manual examination. Based on angle-time curve by IMU data, it was possible to classify spasticity and a new quantitative MAS and AOC can be easily defined. (Fig 1.& 2)

Conclusion

Spasticity measurement using IMU sensors provides an objective measurement method. MAS and AOC measured with IMU sensors were highly reliable. With the angle-time curve, a new standardized IMU-based MAS could be provided.

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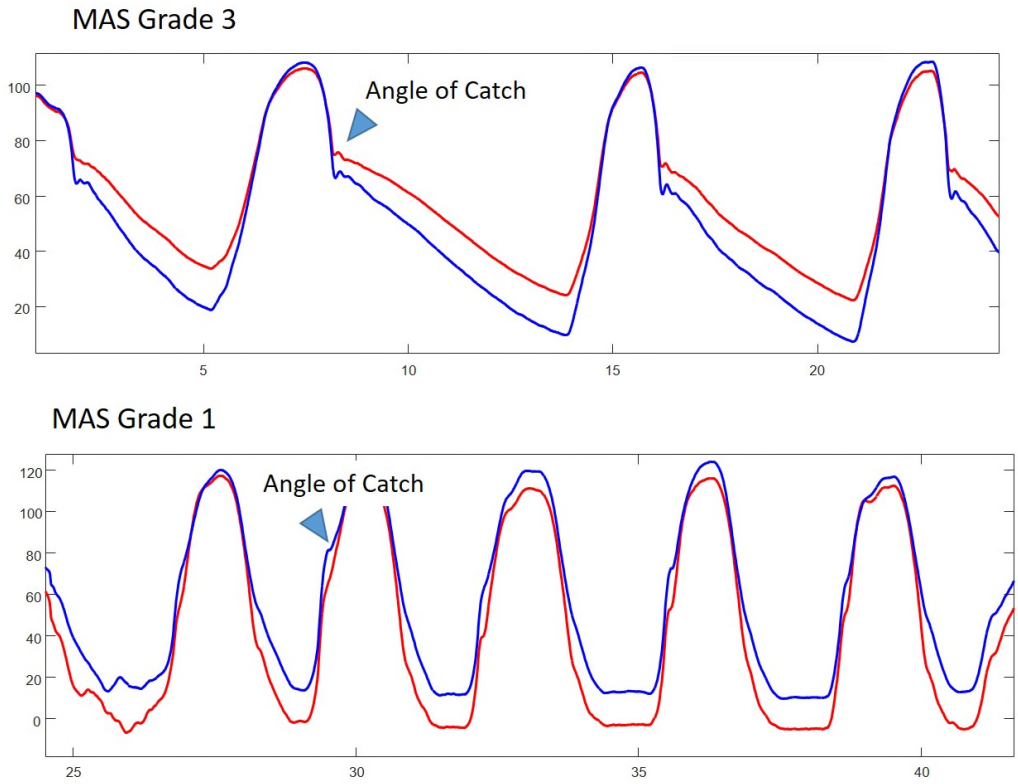

Angle-time curve of MAS 3 (upper) and 1 (lower) drived from joint angle data measured with IMU sensors during passive ROM