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Quantitative assessment of spasticity using EMG and IMU signal in stroke patient: A case study

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Introduction

Spasticity leads to excessive muscle contraction and abnormal muscle tone, severely affecting the patient's function and quality of life. Current methods of spasticity assessment are limited by non-standardized measurement protocols, restricted reliability, low accuracy, and qualitative nature of evaluations that rely heavily on the subjective judgement of the examiner. To address the need for reliable spasticity measurement, we aimed to quantify spasticity assessment Using EMG and IMU sensors, and conducted a pilot study on stroke patients for data collection.

Methods

Spasticity assessment was conducted on one stroke patient with spasticity and one healthy individual without spasticity, following the protocol of the Modified Tardieu Scale, which involves manually flexing and extending the joints as quickly and slowly as possible. The focus was on measuring spasticity in the elbow and ankle joints. EMG electrodes were attached to the agonist and antagonist muscles, and IMU sensors were positioned at the extremity of the joint to collect signal data as each joint moved. This data collection enabled the evaluation of joint angles, movements, and muscle responses (Fig 1, Table 1).

Fig 1. Spasticity assessment using EMG and IMU sensor

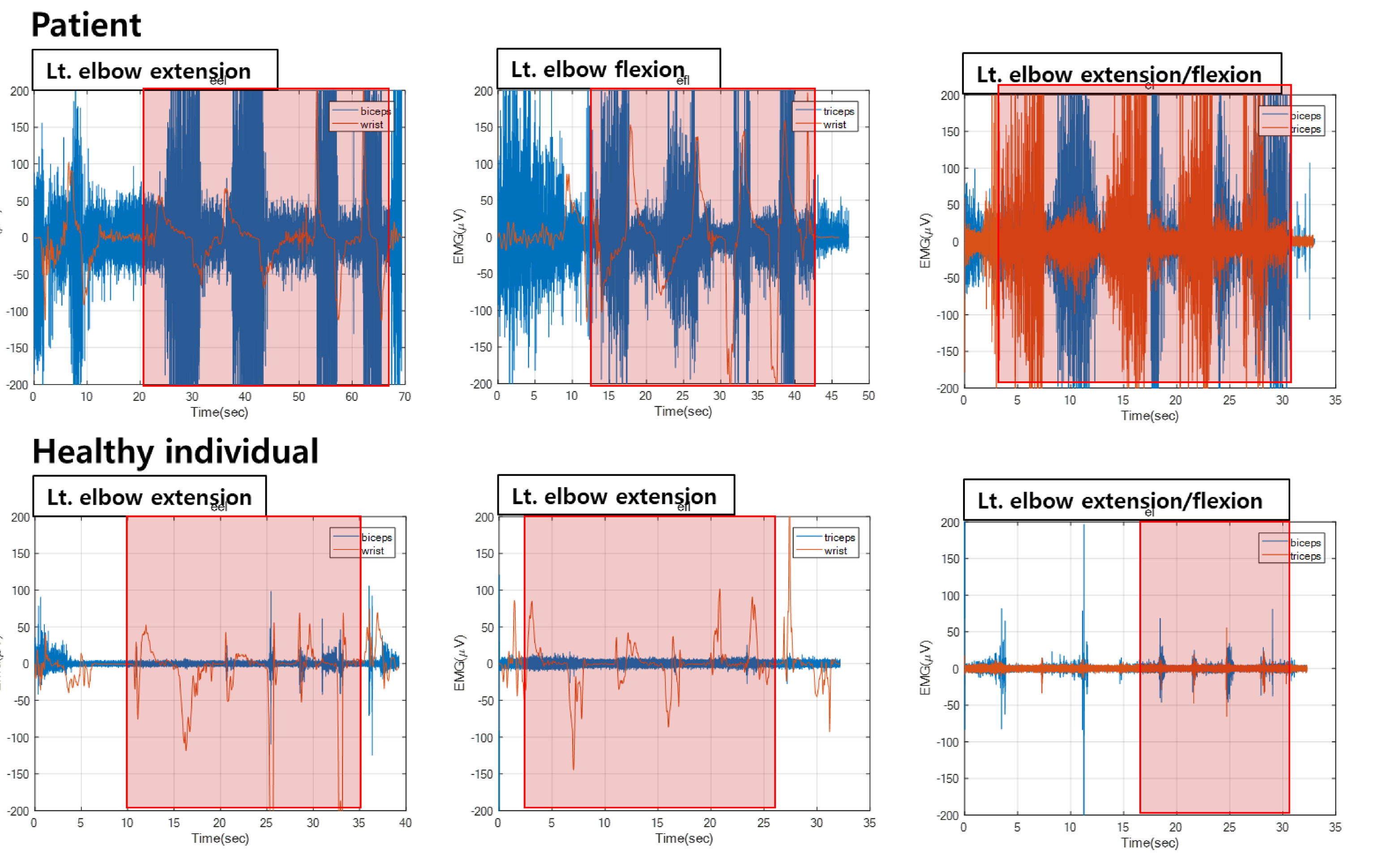
Results

For comparison, measurements were conducted on one stroke patient with spasticity and one healthy individual without spasticity. In the elbow joint, an increase in muscle activity of the antagonist muscles during flexion and extension was observed on the affected left side of the patient with spasticity, compared to the healthy individual. In the healthy individual, muscle responses did not appear during manual flexion and extension of the elbow, but movements could be distinguished using IMU sensor data (Fig 2). In the ankle joint, muscle responses were observed in the patient during plantarflexion and dorsiflexion, but there was no significant increase in muscle activity levels. Thus, muscle signals and IMU sensor data allow the identification of each movement during joint flexion and extension, not only enabling the determination of the presence or absence of spasticity but also showing that the response and level of muscle activity vary according to the degree of spasticity across different joints. However, further refinement of algorithms for accurately assessing the level of spasticity in patients requires the accumulation of additional data.

Table 1. Participants Characteristics

		1st Spasticity Assessment		2nd Spasticity Assessment	
	Passive Motion	The 1st sensor location (Proximal)	The 2nd sensor location (Distal)	The 1st sensor location (Agonist)	The 2nd sensor location (Antagonist)
Elbow Joint	Extension	Biceps brachii	Center of wrist	Triceps brachii	Biceps brachii
	Flexion	Triceps brachii	Center of wrist	Biceps brachii	Triceps brachii
Ankle Joint	Plantarflexion	Tibialis anterior	Center of the dorsum of the foot	Gastrocnemius	Tibialis anterior
	Dorsiflexion	Gastrocnemius	Center of the dorsum of the foot	Tibialis anterior	Gastrocnemius

Fig 2. Results of Spasticity assessment using EMG and IMU sensors between the stroke patient and healthy individual



Conclusion

The study underscores the need to improve spasticity assessment methods to enhance care for patients with central nervous system. It confirms the potential for developing a system to monitor spasticity level changes based on assessment data and to advance quantitative spasticity assessment technology. The use of EMG and IMU sensors marks a advancement towards more accurate, reliable, and objective evaluations of spasticity, which could lead to improved treatment planning, monitoring, and patient outcomes. Future research will aim to further validate this technology and explore its applications.

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