Evaluating the Reliability of Mechanomyography in Muscle Spasticity: Inter and Intra-Rater Consistency in Flexion and Extension Upper Limb Movements with Machine Learning Model

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Abstract:

The measurement of muscle spasticity in clinical settings traditionally relies on therapists using established clinical tools. The predominant approach employed in conventional clinical assessments for assessing spasticity is the Modified Ashworth Scale (MAS), which depends on the subjective judgements of therapists. This method involves assessing spasticity by applying passive movements to joints and assigning grades based on the level of muscle resistance encountered. However, this approach often results in inconsistencies in evaluation, potentially hindering the effectiveness of the rehabilitation process. Consequently, the development of the Quantitative Spasticity Assessment Technology (QSAT) Platform, which utilizes Mechanomyography (MMG) signals integrated with machine learning models to evaluate spasticity from the forearm muscles during both flexion and extension movements, can address the inconsistencies in spasticity measurement. Thirty subjects with neurological diseases participated in the data collection. The extracted data underwent a one-way MANOVA test to identify significant features with a p-value below 0.05, indicating statistically significant differences that were selected for the machine learning models for both movements. The KNN approach, utilising a 90/10 data split for both flexion and extension, demonstrates superior accuracy of 90.12% and 86.42% across all three datasets when compared to other algorithms. Reliability testing for both clinical assessments and QSAT measurements was conducted through inter-rater and intra-rater evaluations, revealing an exceptional Kappa value of 1.000 for the QSAT, while the clinical method exhibited poor agreement of 0.391 and 0.057 for flexion and extension movement respectively. These findings confirm the reliability of the QSAT machine learning model, highlighting strong inter-rater and intra-rater agreement. QSAT presents significant potential for improving physiotherapists' assessments of spasticity in affected limbs, providing a more reliable and objective alternative to conventional methods.

Keywords:

Spasticity, Modified Ashworth Scale, Mechanomyography, Machine Learning and Reliability.