

ABSTRACT

Conventional foot biomechanical analysis has limitations in providing a real-time and comprehensive assessment for detecting abnormal conditions. This study developed an innovative wearable insole system that integrates piezoresistive sensors with EMG technology to improve the accuracy of foot biomechanical analysis. The system uses an eight-sensor piezoresistive configuration placed on critical zones of plantar load distribution, operating at a sampling rate of 10 Hz. Six healthy subjects performed four activities (static standing, walking, climbing/descending stairs) with surface EMG on the gastrocnemius and tibialis anterior muscles (sampling rate 500 Hz). The Multiquadric Radial Basis Function (MQ-RBF) interpolation algorithm was implemented for real-time data enhancement. The system achieved excellent performance with an average R^2 of 0.98 (range 0.92–0.99). Significant findings indicated that biomechanical abnormalities were detected more clearly during static standing than during dynamic activities. Normal subjects exhibited balanced pressure distribution on the heel and forefoot (200–300 kPa), while supinated subjects showed extreme lateral pressure concentration (>300 kPa) with minimal medial contact (<100 kPa). EMG-plantar pressure correlation analysis revealed significant neuromuscular compensation patterns, with abnormal subjects showing high tibialis anterior activity (0.851 V) and low gastrocnemius activity (0.247–0.448 V). The intelligent insole system successfully integrated dual-sensor modality for accurate detection of abnormal biomechanical conditions.

Keywords: Biomechanics, EMG, Piezoresistive, RBF