Digitalized fall risk assessment for community-dwelling older adults: a wearable sensor-based solution K.-J. LI, A.K.-L. CHUNG, C.Z.-H. Ma. *Gerontechnology 25(s)*

Purpose Falls represent a significant global health concern in older adults, primarily attributed to gait and balance impairments. Current clinical fall risk evaluation methods vary a lot, hindering the development of standardized prevention protocols. This study aimed to develop and validate a digitalized assessment method using wearable technology to enhance the personalization and scalability of fall prevention. **Method** Fifty community-dwelling older adults were recruited via convenience sampling and stratified into high (HFR, *n*=25) and low fall risk (LFR, *n*=25) groups based on fall history and balance/gait performance, following international fall prevention guidelines [1]. A smart wearable insole system ("iBalanx" system) was developed, comprising force-sensitive insoles (FlexiForce A301 sensors) and four inertial measurement units (IMUs) (MPU-9250) affixed to bilateral foot dorsum and anterior shanks. The system's validity was previously established against a standard motion capture system (VICON). Participants underwent a 2-hour multifactorial fall risk assessment while wearing the iBalanx system, including demographic data collection, instrumented functional task assessment (quiet standing, normal walking, and Otago exercise), and clinical tests. Data were processed and analyzed using Matlab and SPSS. **Results and Discussion** Significant biomechanical and functional differences were observed between HFR and LFR groups. During static balance tasks, the HFR group consistently exhibited higher Metatarsal Force Ratio (MTHRatio; MTH1/MTH5) metrics (Max and RMS), with differences exceeding 10% across all tasks and statistical significance in side-by-side, semi-tandem, and tandem stances ($p < 0.05$) (Figure 1). Notably, the RMS of MTHRatio in the side-by-side stand and tandem stance tasks, as well as the Max of MTHRatio in the side-by-side stand and semi-tandem stance tasks, demonstrated acceptable discriminative power for identifying high fall risk (AUC > 0.7). In resistive tasks, the HFR group demonstrated reduced limb acceleration in the eccentric phase in all resistive tasks. Clinical tests revealed that the HFR group required significantly longer time to complete both the Chair Stand Test ($p < 0.001$) and Timed Up-and-Go test ($p = 0.013$), with lower scores on the Performance-Oriented Mobility Assessment as compared to the LFR group ($p < 0.001$). The elevated MTHRatio metrics in the HFR group indicate increased postural sway and reduced stability, reflecting impaired medio-lateral balance control. The reduced limb acceleration during eccentric phases suggests diminished movement dynamism, likely due to decreased muscle strength or impaired motor control. These objective biomechanical findings align with the group's poorer clinical test performance, highlighting the sensitivity of the wearable system in distinguishing fall risk among older adults, particularly through static balance tasks. This scalable, user-friendly system offers a practical tool for community or home-based screening. By providing objective biomechanical data, it can both identify fall risk and reveal the specific balance and dynamic impairments underlying it, thereby supporting future personalized prevention strategies.

References

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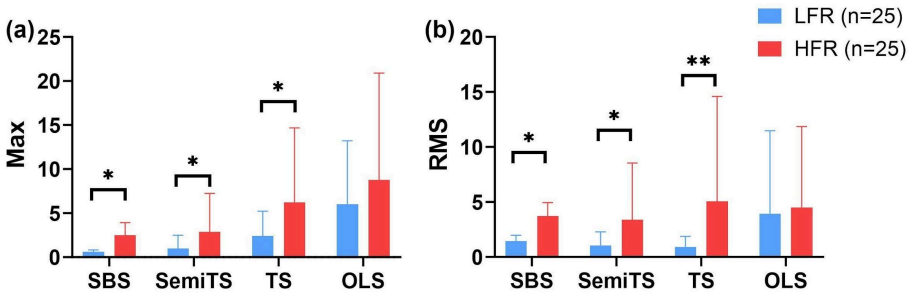

Figure 1. The MTHRatio across different static balance tasks in LFR and HFR groups: (a) Comparison of the maximum MTHRatio; (b) Comparison of the RMS of the MTHRatio. Abbreviations: SBS, Side-by-side Stand; SemiTS, Semi-tandem Stance; TS, Tandem Stance; OLS, One Leg Stand; LFR, Low Fall Risk Group; HFR, High Fall Risk Group (*p < 0.05; **p < 0.001)