Validation of a Spine Specific Wearables as Clinical Tool: The Facts that You Should Know

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INTRODUCTION:

New technological advancements, along with a renewed focus on self-awareness in the post-COVID-19 era, have led to an increased need for practical and easy-to-use tools to quantify the health of a patient's spine. Telehealth has also become increasingly important, and wearables have proven to be a useful adjunct for providing data that increases the effectiveness of remote clinical care. Literature on wearables usage in spine patients presents metrics information about general health rather than specific impairments caused by spinal conditions. In particular, current wearable devices are able to track a patient's walking time, heart rate, and level of activity among other health-related criteria, but lack defining clinical studies for applications in spine. Therefore, the purpose of this study was to validate spine specific wearable in comparison to a motion lab gold standard.

METHODS:

A prospective, single-center, concurrent cohort study. Thirty-four healthy controls and 12 Lumbar Degenerative surgical candidates (sample dose) were enrolled for this study. Spine specific wearables were applied to patients and control on the posterior skin at the approximate T1 level along with fully body motion capture markers. Patients were asked to perform the following activities in a lab setting: walking, standing, lifting, sitting, time up and go (transition), and laying down. Spine wearable stayed on patients for an additional 3 days to passively record patients' level and amount of activity and trunk motion. Outcome Measures included Disability and function outcome measurements (DFOMs) using a spine-specific wearable and motion capture. One-way ANOVA was used to compare outcomes between spine-specific wearable to the gold standard using SPSS (IBM 2023).

RESULTS: Spine specific wearable was successfully able to measure DFOMs by detecting free-living physical activity (walking, standing, sitting, laying down, and driving times in addition to trunk 3-dimensional range of motion; Figure 1) using artificial intelligent and deep learning algorithms. Moreover, the wearable DFOMs were moderately correlated with gold standard (motion lab) in motion capture of patient sway, balance effort, and gait parameters ($r=0.3$-0.45, $p<0.05$, Figure 2). During the 3 days period of wearing the sensor at their home environment, the spine specific wearable was able to detect significant differences in free-living physical function and trunk kinematics in LD patients (walking: 4.7%, standing: 11.6%, sitting: 25.3%, and laying down: 41.7% of the day, trunk flexion: 15.8°) in comparison to healthy controls (walking: 8.9%, standing: 19.1%, sitting: 17.1%, and laying down: 36.2% of the day, trunk flexion: 10.3°; $p<0.05$, Figure 2).

DISCUSSION AND CONCLUSION: Spine specific wearable are a valid approach to track a patient's disability and functional level in their real-life environment. However, detailed disability and functional analyses still requires referral to a motion lab. A combination of DFOMs using a wearable device with PROMIS and radiographic measurements may provide a more comprehensive evaluation of a spine patient's health and function and assist the physician in better treatment decision-making, in developing a customized definition of return to work, and mitigate risk exposure. Further applications can include the ability of providers to view their patient's DFOMs in real-time to monitor their progress and further refine patient-specific care.

Figure 2. Trunk kinematics as measured by spine-specific wearable (blue/black) and gold standard motion capture (green) during standing, walking, and transition from sitting

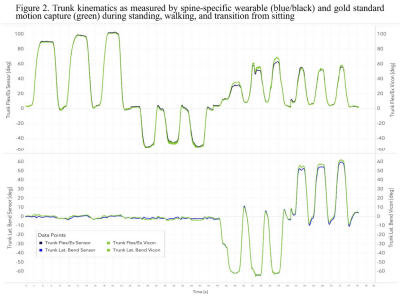

Figure 3. Analysis of trunk motion based on the predict activity data of the wearable sensor. A. Balance/Cone of Economy Analysis; B. Gait Analysis, C. Lifting Analysis, D. Sitting Analysis, E. Sleeping Analysis.

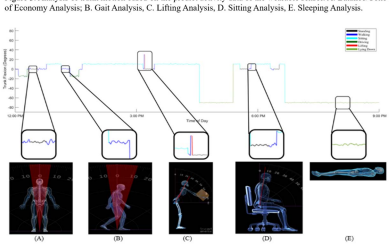

Figure 1. Example of detecting the Cone of Economy at home using spine-specific wearables and artificial intelligence (AI)