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Validation of inertial measurement unit for knee joint kinematics during free-living walking

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Background: Assessment of gait/walking, especially kinematics of the lower limb, may allow subtle problems to be detected and treated within clinics (Favre et al. 2008). Traditionally, this has been done using costly devices such as motion systems or electronic goniometers. Inertial measurement units (IMUs) provide cost-effective opportunities for digitising gait with additional advantages e.g., use during free-living. Digitally constructed lower limb segments can be useful by providing insightful habitual data about joint movements when investigating gait and falls after knee replacements (Celik et al. 2020).

Aim: To investigate IMU validity for knee flexion angle using an electronic goniometer.

Methods: Ten healthy participants were recruited, and ethical approval was granted. Each participant wore four IMUs with straps on the lateral side of the thighs and shanks and walked inside and outside of the lab, Figure 1. Kinematic joint angles were calculated from the orientations of IMUs (Takeda et al. 2009). An electro-goniometer was attached to the lower limb as a reference system and collected simultaneously.

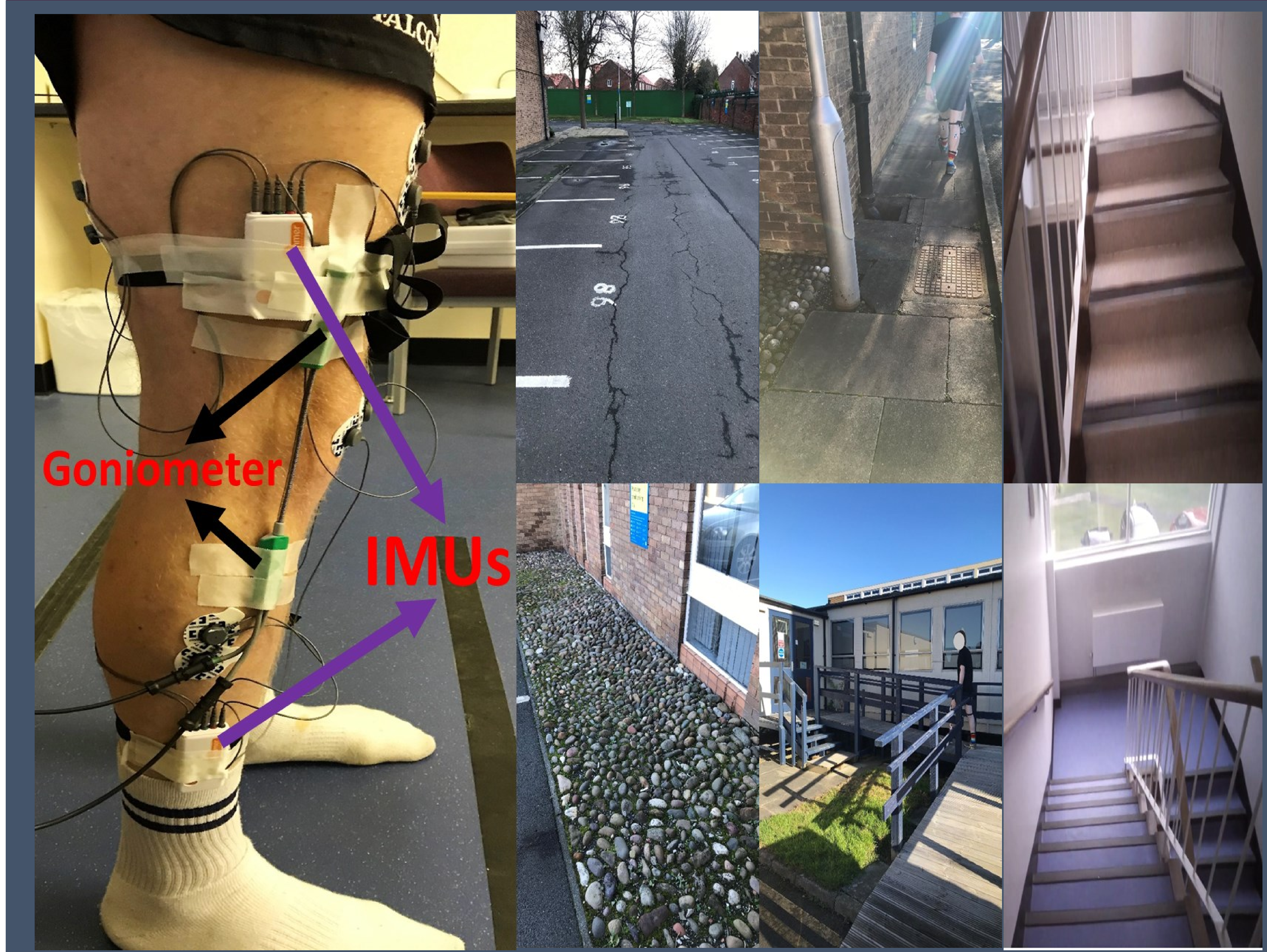

Figure 1. Sensor placement and walking experiments

Results and discussion: The results of knee flexion angles extracted by IMUs for all participants had high agreement to the reference system. There was a small difference (~3°) observed during laboratory and free-living walking, reflecting a highly linear response. Correlation coefficient value Overall results were significantly correlated r=0.916 (statistically significant at the 0.01 level, 2-tailed) and showed excellent agreement ICC2,1= 0.913.

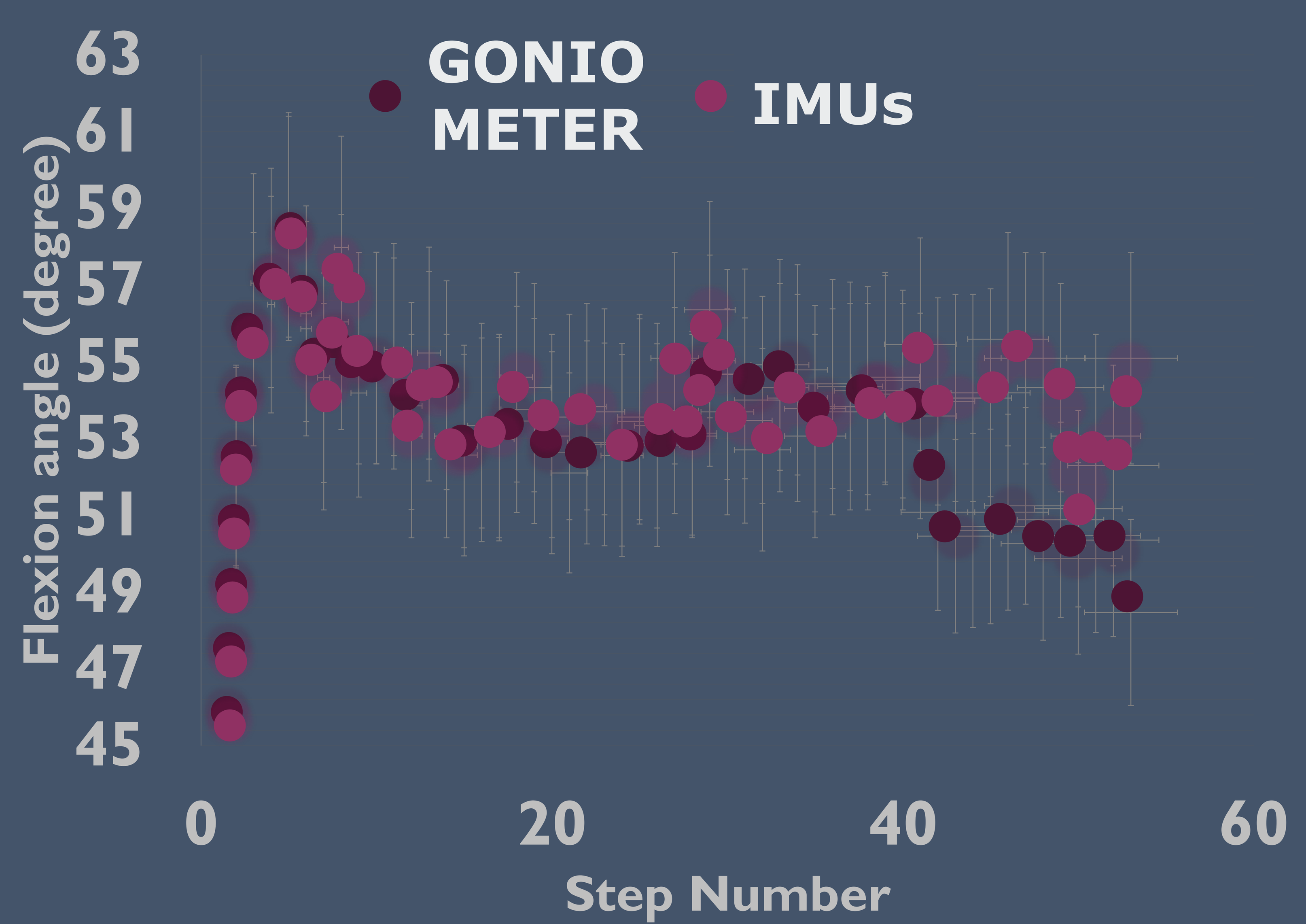

Figure 2. Scatter plot of estimated knee flexion angles

Conclusion: Results suggest IMUs as a very promising and cost-effective in providing knee flexion-extension angle during free-living walking. es ranged between very good (r=0.773) and excellent (r=0.975) for all participants.

Reference:

Celik, et al. 2020. 'Gait analysis in neurological populations: Progression in the use of wearables', Medical engineering & physics.

Favre, et al. 2008. 'Ambulatory measurement of 3D knee joint angle', J of Biomechanics, 41: 1029-35.

Takeda, et al. 2009. 'Gait posture estimation using wearable acceleration and gyro sensors', J of Biomechanics, 42: 2486-94.