28th ECSS Anniversary Congress, Paris/France, 4-7 July 2023

Reliability of joint angle calculation in running movements using an inertial measurement unit

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INTRODUCTION:
The purpose of this study was to clarify the standard error of measurement (SEM) and minimum detectable change (MDC) of joint angle data in running measured by the inertial measurement unit (IMU), as well as to provide information to help more accurately interpret subject differences and preintervention and postintervention comparisons in field assessments.
METHODS:
The subjects were nine healthy males (28.0 ± 1.3 years old). To investigate the accuracy of joint angle data measurement in the right upper limb, pelvis, and right lower limb, myoMOTION (Noraxson) was applied to a total of 14 locations on the whole body, excluding the hands. During the calibration, the subjects were instructed to face forward and align both upper limbs with the trunk so that the joint angle reference points would not shift, and the feet were grounded parallel to the ground and the distance between the big toes was standardized at 10 cm. To assess the reliability of same-day measurement data, running measurements were taken twice daily on a treadmill (BIODEX, PRO WWT-600) at 10.0 km/h for 30 s. One running measurement was also taken on a different day to assess consistency of the data collected on different days. The acceleration data from the IMU in the foot were used to determine the right heel contact point, which is where the running cycle begins. The analysis included normalized joint angle data averaged over 10 running cycles from 10 s after the start of each running measurement. The SEM and MDC of each joint angle data were calculated using the following equations between measurements taken on the same day or different days: SEM = SDiff [standard deviation of difference in measurements] ÷ √2, MDC = SEM × 1.96 × √2. Further, to estimate the type of error affecting the calculated SEM and MDC, the Bland–Altman plot was used. This study was conducted with the approval of the Ethical Review Committee of Takasaki University of Health and Welfare.
RESULTS:
The SEM and MDC between two measurements on the same day were 0.34–1.76 and 0.95–4.88 at all joints, respectively. For SEM and MDC between data measured on different days, all joints fell within the ranges 0.52–2.57 and 1.45–7.13. The SEM and MDC for ankle joint angle data were less accurate than those for other joint data. Further, fixed systematic error contamination was observed in the Bland–Altman plot for ankle dorsiflexion/plantar flexion angle data with a large measurement error.
CONCLUSION:
It was found that for joint angles excluding the ankle joint angle data, changes of 1°–3° or more between measurements on the same day and 2°–5° or more between measurements on different days could be detected. Although the dispersion of ankle joint angle data is unknown, it is thought that the foot IMU sensor is susceptible to geomagnetism due to its proximity to the ground, which may result in errors in joint angles in a fixed direction.

Topic: Biomechanics

Presentation Poster

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