The capacity of markerless motion capture to detect changes in gait kinematics at different speeds

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INTRODUCTION:

Markerless motion capture (MMC) is increasing in popularity among biomechanists because of the reduced data collection time and removal of subjects needing to wear tight, minimalist clothing [1]. However, gait analysis often requires subjects to walk or run at multiple speeds, such as in an incremental exercise test. The sensitivity of MMC to detect kinematic changes across speeds has yet to be thoroughly explored, so the aim of this study was to compare kinematic responses to changes in gait speed when measured with a widely used marker-based system versus a MMC system.

METHOD:

Fifteen healthy, adult participants walked on an instrumented treadmill (1,000 Hz; Gaitway3D; h/p/cosmos) at 3 and 5 km/h and ran at 10, 11, and 12 km/h. A 14-camera optoelectronic motion capture system (Oqus 7+, Qualisys) was used to collect marker data, where markers were placed according to Cappozzo et al. [2]. Markerless video data were collected synchronously with 12 high-speed video cameras (Miqus, Qualisys). Both systems were sampling at 100 Hz. Markerless data were exported to Theia3D for processing, before being exported to Visual3D for modelling alongside marker data. Gait events were determined using the kinetic data, which was the same for both motion capture systems. Kinematic data were exported to MATLAB to calculate changes in sagittal angular data between gait speeds.

RESULTS:

For walking (changes between 3-5 km/h), MMC demonstrated the capacity to measure similar changes in joint range of motion (ROM), peak flexion, and peak extension for hip, knee, and ankle joints ($ICC[3,1] \geq 0.892$) when compared to marker-based data, and there were no significant differences between the change in joint kinematics between systems ($p > 0.05$). MMC also displayed moderate-to-excellent agreement for knee and ankle joint kinematics during running (changes between 10-11 and 11-12 km/h), including ROM and peak flexion/extension ($ICC \geq 0.626$). However, the hip joint was less consistent, with poor-to-moderate agreement generally being found, especially in peak hip extension ($ICC = 0.198$ when comparing differences between 11-12 km/h). There were no significant differences between systems during running ($p < 0.05$).

CONCLUSION:

MMC was able to measure small changes in joint angles during walking at similar magnitudes to traditional marker-based motion capture, which is promising for clinical biomechanists and gait analysis clinics. However, MMC importantly performs less well when trying to measure joint angle changes during different running speeds, with varying results between lower limb joints. Researchers and practitioners should be cautious when interpreting sagittal-plane kinematic changes during running when employing MMC as the chosen method of motion capture.

REFERENCES:

[1] Kanko, RM et al. (2021) J Biomech;127:110665

[2] Cappozzo, A et al. (1995) Clin Biomech;10:171-8