Concurrent Validity of a Markerless Motion Capture System for the Maximal Instep Soccer Kick

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Summary

This work assesses the equivalence of *Theia3D* (Theia Markerless, Kingston, ON) markerless motion capture systems to a traditional marker-based system during an instep soccer kick for concurrent assessment. The ankle joint was assessed in the sagittal plane, and the knee, hip, pelvis, and trunk were evaluated in the sagittal, frontal, and transverse plane using time series and distinct event statistics.

Introduction

Marker-based motion capture is considered the practical gold standard assessment of three-dimensional kinematic measurements with the use of reflective markers and specialized infrared cameras [1]. *Theia3D* is a motion capture system that requires no reflective markers to capture movement to create a 3D skeleton that can be analyzed. It does this by taking an algorithm-based approach that uses deep convolutional neural networks for feature recognition that is trained on digital images of over 500,000 human movements [2]. With the rise in the use of this novel markerless technology, it is necessary to test the equivalence of this system to the practical gold standard using dynamic movements, such as the instep soccer kick. This study aims to investigate the agreement between *Theia3D* and marker-based motion capture for biomechanical assessments in the instep soccer kick.

Methods

Eight healthy division II soccer players were recruited (20.38 ± 1.18 years old, 1.68 ±0.06m, 66.52 ± 7.75 kg, 15.63 ± 1.77 years of playing experience) to be assessed concurrently by a markerless and marker-based system during a maximal instep soccer kick. In a lab setting, each participant approached and kicked a soccer ball into a wall with the top of their foot. The joint range of motion data was analyzed for the ankle's sagittal plane and the knee, hip, pelvis, and torso's sagittal, frontal, and transverse plane. A concordance correlation coefficient, root mean square difference (RMSD), and a modified Bland Altman plot were used to analyze distinct events during the right toe-off (RTO), ball contact (BC), and maximum hip flexion (MHF). Statistical parametric mapping (SPM) t-tests were used to analyze time series data from RTO to MHF of all joints assessed. maximum hip flexion (MHF) distinct events. Statistical parametric mapping (SPM) t-tests were used to analyze time series data from RTO to MHF of all joints assessed.

Results and Discussion

Concordance correlation coefficient measures for the ankle in the sagittal plane at RTO (r=0.608), knee in the sagittal plane at MHF (r=0.838), hip in the sagittal plane at BC (r=0.608), pelvis in the transverse plane at RTO (r=0.902), and trunk in the frontal plane at BC (r=0.876) performed best for distinct measure analysis. Distinct measure RMSD ranged between 5.12° in the knee and 15.37° in the trunk for the sagittal plane, 3.66° in the trunk and 17.3° in the hip for the frontal plane, and from 4.25° in the pelvis to 19.26° in the knee for the transverse plane. SPM t-tests in the ankle showed a statistically significant difference between measures in the sagittal plane throughout the motion. SPM t-tests in the knee and hip showed the best agreement between measures in the sagittal plane. SPM t-tests in the trunk showed the best agreement between measures in the frontal plane and the pelvis in the transverse plane.

Conclusions

These findings indicate that *Theia3D* provides similar results to a marker-based system during the instep soccer kick. *Theia3D* demonstrated moderate to high agreement with marker-based systems across most joints and planes analyzed during a maximal instep soccer kick, but significant differences were also found. This indicates that markerless motion capture technology may have an inherent bias that provides results that are comparable, although not the same as the marker-based system. Practitioners must understand the inherent biases and differences in modeling between systems to truly understand the differences when comparing both systems.

References

[1]*Ceseracciu, E, et al., (2014) PloS one, **9**(3)*
[2]*Kanko, R.M., et al., (2021), Journal of Biomechanics, **127***

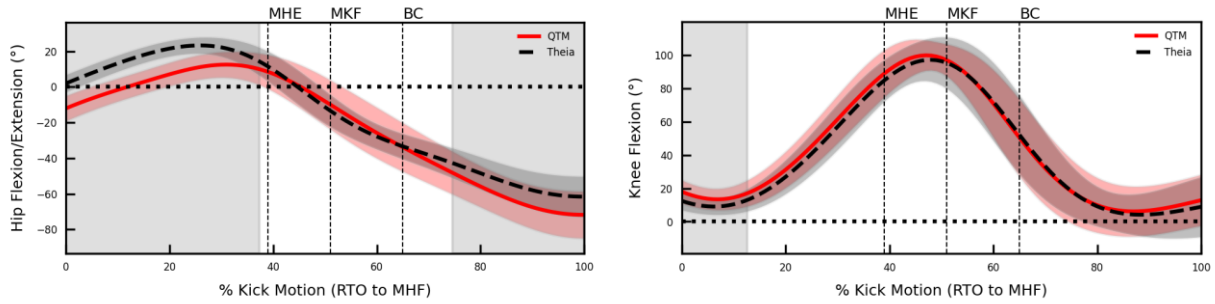

Figure 1: Statistical Parametric Mapping t-tests for the hip and knee in the sagittal plane with distinct events, maximum hip extension (MHE), maximum knee flexion (MKF), and ball contact (BC) with suprathreshold regions highlighted in gray.