Can Markerless and Marker-based Systems be Used Interchangeably to Assess 3D Gait Biomechanics in Older Adults?

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Summary

Comparing markerless and marker-based methods for assessing gait biomechanics is highly relevant. Our findings indicate that markerless and marker-based gait kinematics and kinetics in older adults are mostly comparable. However, further validation of frontal and transverse plane kinematics, as well as pelvis angles on the sagittal plane, is required, preventing both systems from being interchangeably used for gait analysis in older adults at this stage.

Introduction

In older adults, illnesses often alter walking patterns, making gait analysis crucial for diagnosis [1]. However, accurate 3D gait analysis is challenging. This study compared markerless and marker-based methods for assessing older adults' gait biomechanics.

Methods

Gait analysis of 30 community-dwelling healthy older adults (75±8 years) was conducted using a marker-based and a markerless system (both 85Hz) separately, in a single laboratory session, with 9 infrared cameras (Oqus, Qualisys, SE), and 8 video cameras (Miqus, Qualysis, SE), respectively. Participants wore tight-fitting clothes allowing the attachment of 46 reflexive markers on the skin/shoes (based on CAST) for marker-based, and wore their usual clothes and sports shoes, for markerless data collection. Markerless video data were processed with Theia3D (Markerless Inc, CA, v2023.1.0.310,), using an IK 3D pose estimation (8Hz filter). For the marker-based data, an 8-segment model (thorax, pelvis, thighs, shanks, and feet) was built according to Robertson et al. [2]. The same IK approach used from Theia3D was followed. Marker-based modeling, lower limb joint angle (XYZ Cardan sequence), and moments (internal, normalized to subject's body mass) computations were executed in Visual3D (Has-Motion, Inc, CA). Cross-correlation coefficient (Rxy) was calculated to measure the similarity between markerless and markerbased time profiles, for each participant and averaged, and functional limits of Agreement (fLoA) analysis for agreement. An Rxy >0.70 was considered a strong correlation. For agreement, kinematic thresholds were set at ≤5º, and a difference of ≤10% of peak signal amplitude was considered acceptable for kinetics.

Results and Discussion

Strong correlations were found for sagittal plane kinematics (except pelvis) (Table 1). A low agreement was detected for sagittal hip and pelvis angles (Figure 1). Weaker correlations and poor agreement were noted for non-sagittal planes. Overall strong correlations were found for joint moments. The bias for most kinetic parameters was lower than the threshold.

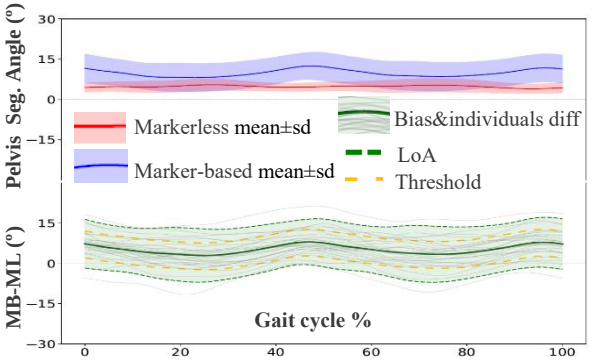

Figure 1: Gait cycle waveforms and fLoA plot comparing marker-based (MB) and markerless (ML) for pelvis angle.

These strong correlations between the marker-based and markerless for the sagittal plane and higher differences between methods for non-sagittal planes are in line with previous studies [3,4].

Conclusions

Markerless sagittal plane gait data in older adults are largely valid (except for the pelvis), while non-sagittal plane gait kinematics require further validation. These results show that markerless systems like Theia3D, whilst being promising tools for gait analysis in older adults, are not yet to be used interchangeably with marker-based systems.

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References

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Table 1: Cross-correlation coefficient (Rxy) for lower-limb joint angles and moments for marker-based and markerless observations.

		Sagittal Plane				Frontal Plane				Transverse Plane			
		Pelvis	**Hip**	**Knee**	**Ankle**	**Pelvis**	**Hip**	**Knee**	**Ankle**	**Pelvis**	**Hip**	**Knee**	**Ankle**
Ryx	**Joint angle**	0.17	0.99	0.99	0.96	0.04	0.49	0.12	0.77	0.77	0.25	0.42	0.30
	Joint moment	-	0.93	0.94	0.99	-	0.99	0.96	0.56	-	0.80	0.98	0.97