Validation of Markerless Technology for Biomechanical Assessment in ACLr Recovery

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Summary

Markerless technology may improve access to biomechanical assessments of functional recovery following anterior cruciate ligament reconstruction (ACLr). Transition to this technology is supported by excellent agreement and consistency for ankle and knee sagittal plane mechanics. Notably, limits of agreement (LoA) for knee extensor moment limb symmetry (LSI-KEM) are smaller than expected deficits in this population, reinforcing its clinical applicability.

Introduction

Reduced data capture and processing time using markerless motion capture technologies may improve access to biomechanical assessments of recovery progress following ACLr. Knee function in early recovery is assessed using between limb comparison of sagittal plane angles and moments during double and single limb squats. At 3 months post-op KEM deficits are on average 38% during squats (LSI-KEM 0.62) [1]. To transition to more efficient clinical testing, it is essential to understand how impairments quantified using marker-based data correspond to markerless data. Purpose: Determine concurrent validity of kinematic and kinetic data using marker and markerless technologies during double and single limb squat tasks in individuals post-ACLr.

Methods

Kinematic and kinetic data were collected concurrently with 12 infrared, 8 video cameras and force plates while 10 individuals (122.3 ± 21.75 days) post-ACLr performed double (DLSQ) and single limb squats (SLSQ). Kinematic models created from pose estimations based off maker (Qualysis) and video (Theia3D) data were used to calculate hip, knee and ankle angles. These data were used along with anthropometric and ground reaction force data in inverses dynamics equations to calculate net joint moments (V3D, HASMotion). Peak sagittal plane angles and moments in surgical (Sx) and nonsurgical (Nsx) limbs were considered for analysis. In addition, between limb difference in knee flexion angle (Sx-Nsx; KF-diff) and LSI-KEM (Sx/Nsx) were considered. Three trials were used to examine the agreement (linear regression, R^2) and consistency (ICC 2,2) between methods (marker v. markerless) for each task and variable. Bias (average difference between systems) and LoA (95% confidence interval of average difference) were calculated.

Results and Discussion

R^2 and ICC values (Table 1) were excellent (>0.9) for knee and ankle peak angles and moments during both tasks, good for hip variables during DLSQ and good-excellent during SLSQ. When considering between limb differences, R^2 and ICC values were excellent (>0.9) for KF-diff during SLSQ and LSI-KEM for both tasks, poor to good for KF-diff during DLSQ. Bias and LoA for LSI-KEM were small relative to average measures, despite being relatively large for KF-diff. (Figure1).

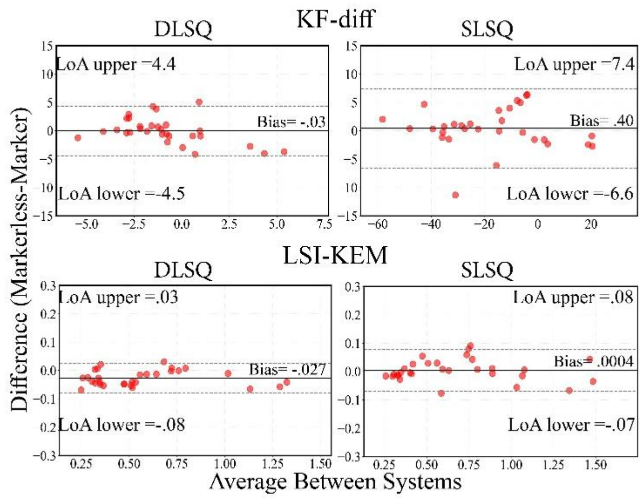

Figure 1: Bland-Altman Plots for between limb difference in knee flexion angle (KF-diff) and limb symmetry index for knee extensor moment (LSI-KEM). Limits of agreements (LoA) upper and lower bounds.

Conclusions

Marker and markerless data correspond well, with good to excellent agreement for peak sagittal plane angles and moments. When considering limb differences relevant to ACLr recovery, small LoA for LSI-KEM support the transition to markerless assessments of recovery in these tasks for this population.

References

[1] Sigward SM et al. (2018). *J. Orthop. Sports Phys. Ther.*, **48(9)**: 719-718.

Table 1: ICC, R^2 values for peak sagittal plane angles and moments at the hip, knee and ankle and between limb comparisons (BTW) of knee flexion angle difference (KF-diff) and knee extensor moment limb symmetry (LSI-KEM)

		Hip	Knee	Ankle		Hip	Knee	Ankle		KF-diff	KEM
DLSQ	**Angle**	.76, .82	.99, .98	.92, .95	**Moment**	.76, .84	.99, .99	.96, .97	**BTW limb**	.77, .45	.99, .99
SLSQ		.90, .89	.99, .98	.93, .91		.79, .92	.99, .99	.92, .95		.99, .97	.99, .99