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The performance of two in-clinic markerless motion capture systems compared to a laboratory standard

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Introduction

New markerless systems have the potential to not only provide easy access to kinematic data, but also collect data from multiple joints simultaneously during almost any type of movement. The result is a new data stream for clinicians that has the potential to better document human movement during routine clinical assessments of musculoskeletal disorders.

The goal of this study was to compare two low-cost, markerless motion capture systems against a laboratory gold standard when collecting human movements data.

Methods

One subject was recorded simultaneously by three different motion capture systems as she performed 3 trials each of quiet standing, squats, vertical jumps, and lunges (Table 1 and Figure 1). Displacement versus time plots of the movements were generated and examined visually. Measures of ankle, knee, and hip height changes during each movement were calculated, and agreement estimates between the Vicon system and each of the two markerless systems were reported in terms of mean error, mean absolute error, standard deviation of the error, and range of the error.

Results

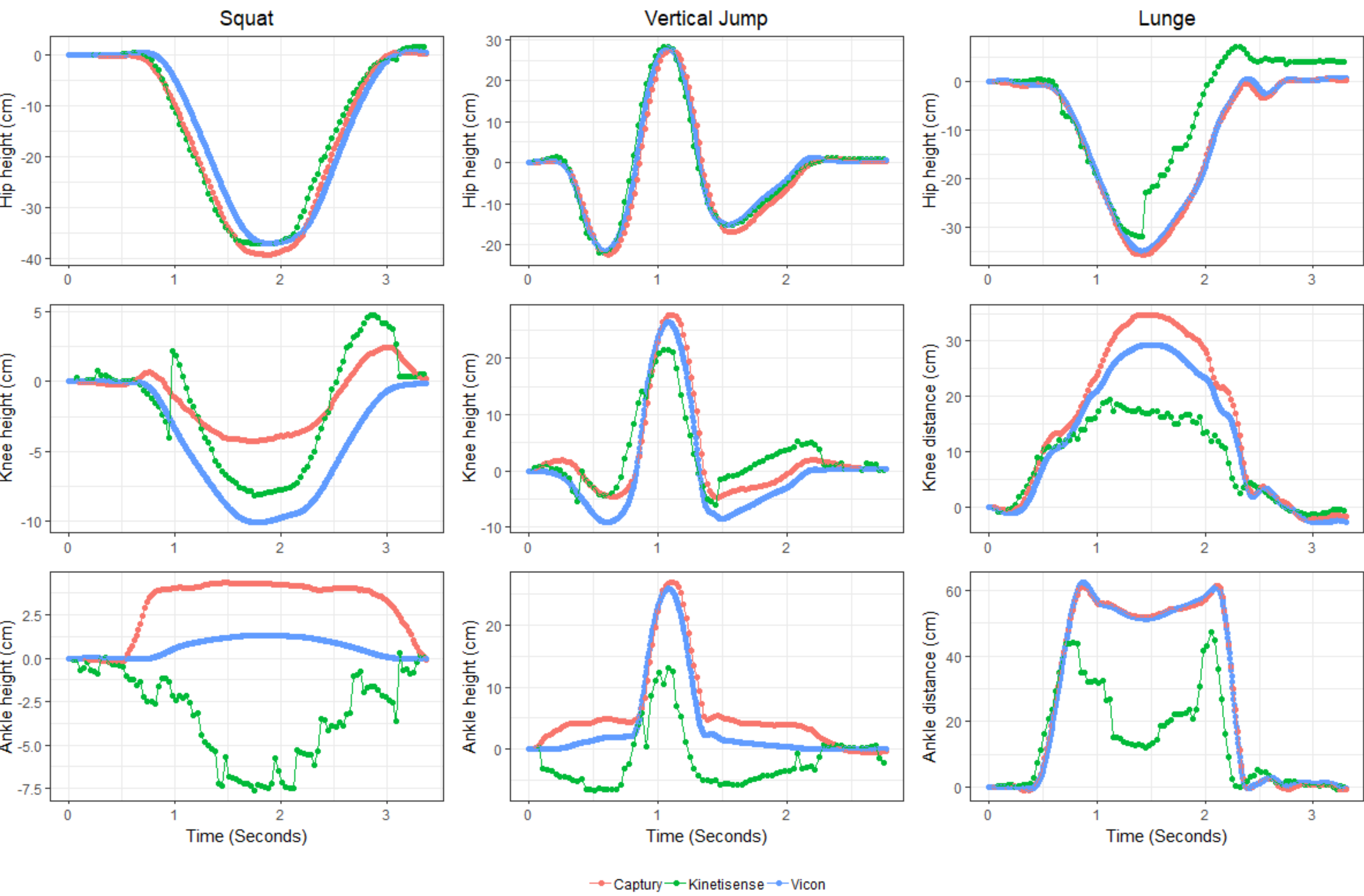
Displacement versus time plots using absolute joint positions consistently demonstrated baseline offsets in measurement of all anatomic locations with the Kinetisense system having the greatest offset when compared to the Vicon system.

Plots of change in joint position over time, showed the Kinetisense to have some variability in especially the knee and ankle joint positions (Figure 2).

Agreement estimates are reported in Table 2.

Figure 2

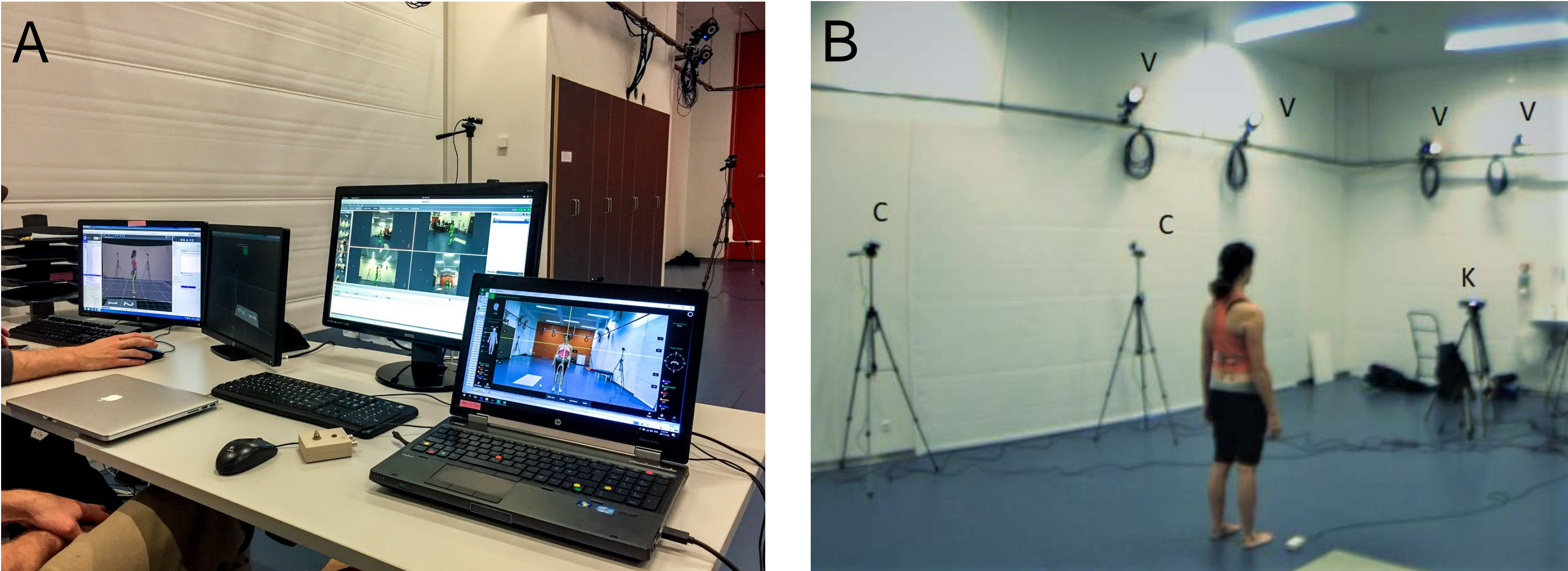
Displacement versus time plots showing change in joint position relative to start location.



Note:
The data shown for all three movements is the first of three repetitions performed by the subject.
Knee distance refers to the distance between the knee joints.
Ankle distance refers to the distance between the ankle joints.

Figure 1

Biomechanical laboratory setup



A: From left to right Vicon (2 monitors), Capture, and Kinetisense

B: The subject standing in the center of the capturing volume of all three systems. Hardware from the three systems are marked with C (Capture), K (Kinetisense), and V (Vicon).

Table 1
Characteristics of the three motion capture systems.

System	Capture	Kinetisense	Vicon
Company	The Capture GmbH www.thecapture.com	Kinetisense www.kinetisense.com	Vicon www.vicon.com
Software version	CaptureLive 1.0.99	Kinetisense 3.6	Nexus 2.3
Frame rate (fps)	50 ^a	30	200 ^a
Number of cameras	8 colour ^a	2 3d depth sensors 1 colour	16 infrared ^a 2 colour ^a
System set up time	~ 1 hour	~ 5 min	Not applicable
Calibration time	~ 5 min	Negligible	~ 5 min
Participant preparation time	~ 1 min	~ 1 min	~ 20 min
Capture volume (length x width x height)	4m x 3m x 2.5m ^a	70 degrees horizontal and 60 degree vertical FOV. ~6.5 ft capturable depth.	~ 6m x 2m x 2.5m ^a
Note: ^a The value can change according to setup. Value refers to the current setup.			

Table 2

Agreement estimates between the Capture and Kinetisense and the reference Vicon system.

Movement	Measure	Joint	System	Mean Error to Vicon (mm)	Mean Absolute Error to Vicon (mm)	Standard Deviation of Error to Vicon (mm)	Range of Error to Vicon (mm)
Squat	Depth	Hip	Capture	-20.5	20.5	1.6	2.8
			Kinetisense	3.4	4.1	6.2	11.5
		Knee	Capture	60.4	60.4	2.7	5.3
			Kinetisense	25.3	25.3	5.8	11.5
		Ankle	Capture	-1.0	1.0	0.7	1.3
			Kinetisense	-73.4	73.4	3.9	6.7
Jump	Height	Hip	Capture	3.2	5.2	5.7	11.1
			Kinetisense	0.3	4.6	6.2	11.3
		Knee	Capture	-13.5	13.5	4.2	8.4
			Kinetisense	54.0	54.0	5.0	10.1
		Ankle	Capture	-11.6	11.6	7.4	14.3
			Kinetisense	120.0	120.0	9.1	18.0
Lunge	Depth	Hip	Capture	-5.4	5.4	2.1	3.8
			Kinetisense	29.1	29.1	1.6	3.2
	Length	Knee	Capture	-40.4	40.4	5.5	10.6
			Kinetisense	75.1	75.1	21.3	37.2
		Ankle	Capture	-3.1	7.3	11.0	21.5
			Kinetisense	119.9	119.9	19.6	38.8

Conclusion

Both markerless motion capture systems were sufficiently similar to the laboratory standard to warrant further investigation



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