Mobile gait analysis: evaluating mobile applications for kinematic analysis in dogs

Motion Analysis Laboratory
Veterinary Health Center
University of Missouri

Tucker D. Graham, Cristopher E. Zelaya, Rowan A. Seabolt, Bryan T. Torres
Department of Veterinary Medicine and Surgery, College of Veterinary Medicine, University of Missouri, Columbia, MO

Veterinary Research Scholars Program
University of Missouri

Introduction

- The use of kinematic gait analysis provides veterinarians with a way to objectively evaluate joint motion in dogs with orthopedic disease.
- Historically, kinematic analysis has been limited to universities and specialty clinics.
- The recent development of kinematic phone applications has increased the accessibility of this testing method to a wider veterinary audience; therefore, a comparison with more professional gait analysis software is needed.
- The objective of this study was to compare kinematic measurements obtained by two different mobile applications (OnForm and Dartfish Express) to those obtained using a computerized software program (Kinovea).
- We hypothesized that joint angle values obtained from mobile applications and computerized software would be comparable and that no significant differences would be found between measured variables.

Materials & Methods

- Data was obtained from 5 normal dogs and evaluated by 3 investigators.
- Thoracic and pelvic limb kinematic data was obtained from dogs during a trot and walk in a defined collection space with high-contrast markers applied to the skin at specific anatomic landmarks.
- Optical video was recorded at 60 Hz on an iPhone camera.
- For all dogs, maximum joint extension and flexion as well as overall joint range-of-motion were determined and measured in triplicate for all major appendicular joints using each programs.
- Comparisons were performed with an ANOVA and a Tukey test. All tests were two-sided with $p<0.05$.

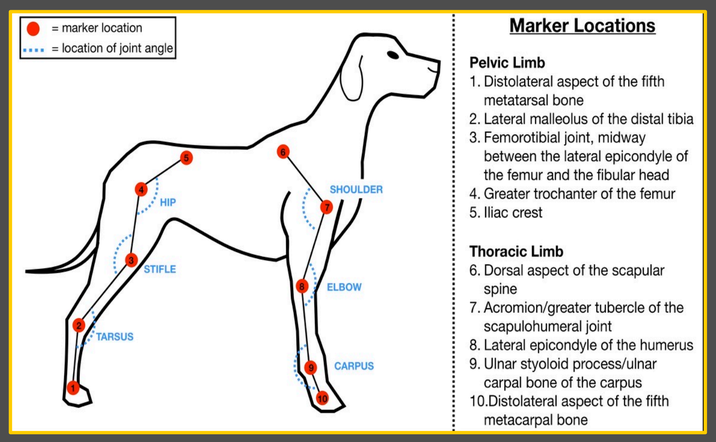

Figure 1: This figure describes the anatomic landmarks used to outline the joints of interest including the hip, stifle, tarsus, shoulder, elbow and carpus.

Results

Walk

	Tarsus			Stifle			Hip			Carpus			Elbow			Shoulder		
	OnForm	Dartfish	Kinovea	OnForm	Dartfish	Kinovea	OnForm	Dartfish	Kinovea	OnForm	Dartfish	Kinovea	OnForm	Dartfish	Kinovea	OnForm	Dartfish	Kinovea
Max Ext	150.5	148.9	151.6	131.6^{a}	131.7^{b}	144.1^{ab}	136.0	135.4	137.0	192.2^{a}	193.8^{b}	204.5^{ab}	151.2	153.1	151.0	139.8	138.9	142.1
SD	6.9	7.3	6.0	5.8	6.7	8.7	6.7	6.8	6.1	13.5	13.1	9.7	5.7	9.0	7.5	11.9	11.9	15.4
Max Flex	114.1	116.4	115.4	109.2	108.1	107.1	97.6	97.2	95.3	96.3	98.5	100.4	92.4	91.7	91.6	111.6^{a}	110.9^{b}	105.3^{ab}
SD	6.8	6.8	6.6	6.1	6.1	6.0	7.1	7.2	9.2	15.3	15.3	14.4	9.2	8.7	7.2	10.4	10.9	8.9
ROM	36.4^{a}	32.5^{ab}	36.1^{b}	22.5^{a}	23.6^{b}	37.0^{ab}	38.4^{a}	38.2^{b}	41.7^{ab}	95.9^{a}	95.3^{b}	104.1^{ab}	58.9	61.4	59.4	28.3^{a}	28.0^{b}	36.8^{ab}
SD	6.5	8.0	3.5	6.3	6.8	6.9	5.4	5.6	7.2	16.2	14.2	14.0	6.3	7.0	4.7	6.9	8.3	10.3

Trot

	Tarsus			Stifle			Hip			Carpus			Elbow			Shoulder		
	OnForm	Dartfish	Kinovea	OnForm	Dartfish	Kinovea	OnForm	Dartfish	Kinovea	OnForm	Dartfish	Kinovea	OnForm	Dartfish	Kinovea	OnForm	Dartfish	Kinovea
Max Ext	151.4	150.1	153	136.8^{a}	134.7^{b}	144.6^{ab}	130.5	128.6^{a}	132.6^{a}	193.1^{a}	200.7^{a}	212.9^{a}	149.6	148.2^{a}	152.6^{a}	145.2	141.8	144.3
SD	7.174	6.8	13.4	7.0	10.8	7.7	6.9	6.6	8.0	16.6	13.0	9.7	6.2	7.2	8.3	14.6	15.9	13.4
Max Flex	97.7	100.2	100.4	93.4	95.3	93.5	99.6	97.4	96.2	88.4	87.2	88.5	88.1	86.3	86.9	109.1	108.1	104.1
SD	6.8	8.2	7.3	4.9	6.1	5.4	8.3	7.3	8.3	10.0	7.5	8.4	6.4	7.0	6.5	12.1	10.5	9.3
ROM	53.7	49.9	52.6	43.3^{a}	39.4^{b}	51.1^{ab}	31.0^{a}	31.2^{b}	36.4^{ab}	104.7^{a}	113.5^{a}	124.4^{a}	61.5^{a}	61.9^{b}	65.8^{ab}	36.2	33.6^{a}	40.2^{a}
SD	7.9	6.2	12.9	7.8	11.3	9.0	7.9	5.9	7.2	19.5	12.6	13.3	7.5	8.7	5.0	10.1	10.0	9.2

Figure 3: Mean (SD) joint excursion angles (Max Flex=maximum joint flexion; Max Ext=maximum joint extension) and overall range-of-motion (ROM) as measured by 3 investigators using OnForm, Dartfish Express and Kinovea. Values with similar letters are significantly different ($p<0.05$).

Hip – At a walk, ROM was significantly different between individual phone apps and Kinovea. There was no difference in maximum joint flexion or extension. At a trot, there was a significant difference in maximum joint extension between Dartfish and Kinovea and a significant difference between both phone applications and Kinovea for ROM. There was no difference in maximum joint flexion.

Stifle – At both a walk and trot, maximum joint extension and ROM were significantly different between individual phone apps and Kinovea. There was no difference in maximum joint flexion.

Tarsus – At a walk, there was no difference in maximum joint angles determined from any program, but there was a significant difference in ROM between Dartfish and OnForm and between Dartfish and Kinovea. At a trot, there was no difference in maximum joint angles or ROM.

Shoulder – At a walk, maximum joint flexion and ROM were significantly different between individual phone apps and Kinovea. There was no difference in maximum joint extension. At a trot, ROM was significantly different between Dartfish and Kinovea. There was no difference in maximum joint flexion or extension.

Elbow – At a walk, there was no difference in any measurement between all programs. At a trot, maximum joint extension was significantly different between Dartfish and Kinovea, and ROM was significantly different between individual phone apps and Kinovea. There was no difference in maximum joint flexion.

Carpus – At a walk, maximum joint extension and ROM were significantly different between individual phone apps and Kinovea. There was no difference in maximum joint flexion. At a trot, maximum joint extension and ROM were significantly different between all programs. There was no difference in maximum joint flexion.

Kinovea
Computer-based program
Automatic marker tracking
Automated angle calculation

OnForm
Phone application
Manual marker tracking
Manual angle calculation

Dartfish
Phone application
Manual marker tracking
Manual angle calculation

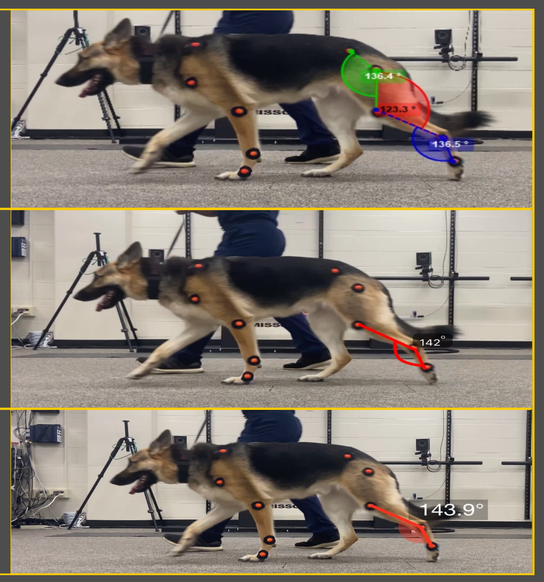

Figure 2: This figure shows a visual comparison between the two phones apps used and the professional Kinovea software.

Conclusions

- Our hypothesis was rejected. Significant differences were found between kinematic variables obtained from (2) phone applications and (1) computerized program.
- These results suggest that the use of phone-based applications for joint angle measurements in dogs are not comparable to those obtained using an established computerized program.
- The reasons for measurement differences were not fully elucidated in this study but may be secondary to inherent app- or program-related differences or investigator variability.
- Further research is warranted to identify sources of variability and optimize the clinical application of phone-based kinematic applications.

Student Support

- A gift from Dr. Natalie Rabiner, alum of the University of Missouri College of Veterinary Medicine