Comparison of gait parameters during overground and treadmill trotting

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Motivation

Most canine gait analysis studies have been performed while walking overground; however, the use of instrumented treadmills for gait analysis in human is becoming more common. The objective of this study was to compare the movement and forces around the hind limb joints during trotting overground and on a treadmill.

Methods

- 7 healthy Labrador Retrievers.
- Inertial properties of hind limb segments (mass, location of the center of mass and mass moment of inertia of each segment) were determined using morphometric measures and previously published predictive equations.
- 13 spherical reflective skin markers identified bilateral thigh, crus and foot segments (Figure 1).

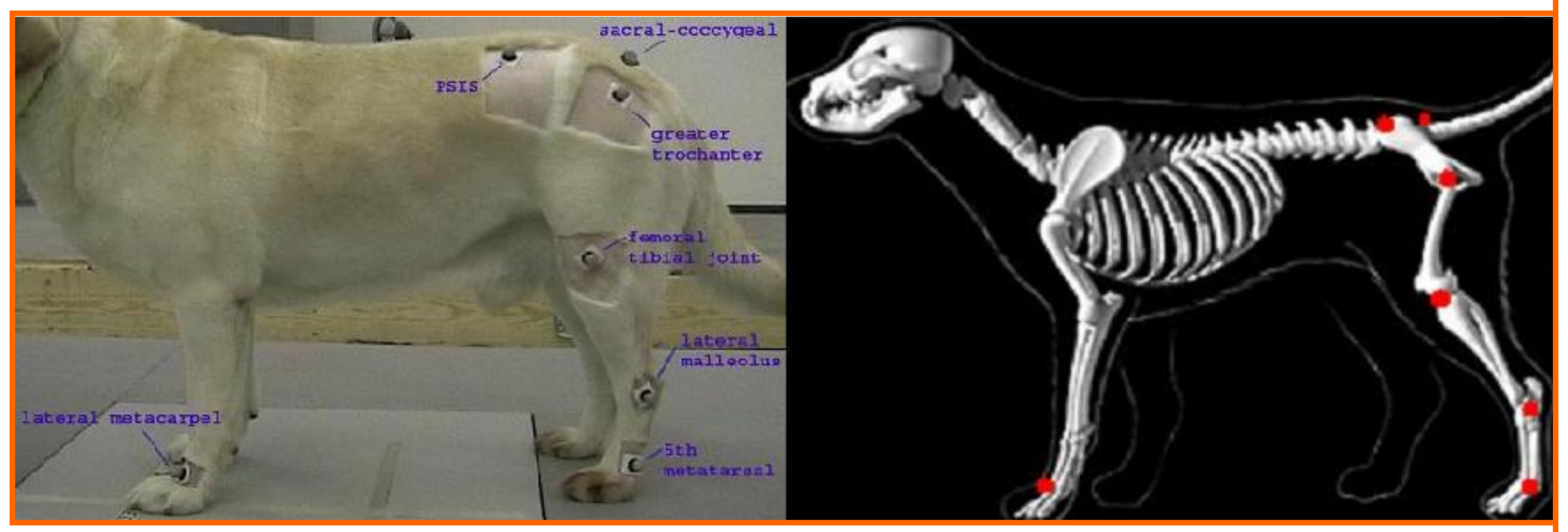
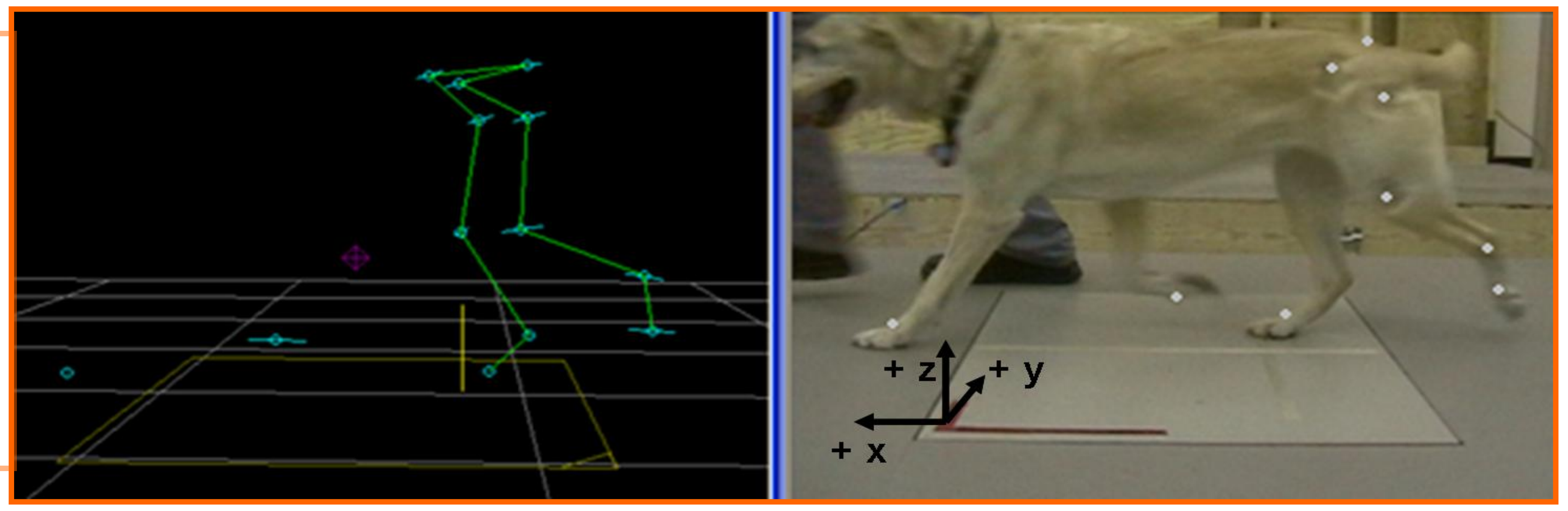


Figure 1: Dog with reflective markers on specific bony prominences: cranial dorsal iliac spine (PSIS), sacro-coccygeal articulation, greater trochanter, most distal point of the lateral femoral epicondyle (femoral tibial joint), lateral malleolus of the fibula, and the 5th metatarsophalangeal joint. Two markers on the front feet (lateral metacarpal) to distinguish the forelimbs.

- Kinematic data of trotting dogs were collected using a 6-camera optical motion capture system (Vicon 460, Lake Forest, CA) and synchronized with force data.
- Ground reaction force (GRF) data were collected via a force plate (AMTI, model BP600900, Watertown, MA) for overground trials or instrumented treadmill (Bertec, Columbus, OH).
- 5 valid trials were collected for the right hind limb for each overground and treadmill
- x-, y- and z- directions were defined as forward-backward, medio-lateral, and vertical, respectively (Figure 2).

Figure 2: Computer assisted acquisition of ground reaction forces and kinematic data in a trotting subject. The coordinate system represents the vertical (z), cranio-caudal (x) and medio-lateral (y) direction for the motion recording system.



- An inverse dynamic approach was used to compute, in the sagittal plane, hock (ankle), stifle (knee), and hip net moment (in Nm/kg), power (in W/kg) and joint reaction force (JRF, N/kg) during the stance of the gait cycle. These parameters were normalized by body mass.

Results

Similar shapes, but different amplitudes for kinematic data were apparent between overground and treadmill trials. A paired *t*-test was performed to asses these differences. For all analyses, $p<0.05$ was considered significant (Table 1).

- The **GRF and angular position data were similar** between overground and treadmill trials.
- Hock velocity during flexion and extension and stifle velocity during flexion were larger for treadmill trials.
- Stifle flexor and hip extensor moments were greater for the treadmill trials.
- The power generation and absorption around the hock and the power generation around the stifle were increased for treadmill compared to overground trials.
- The hock and stifle reaction force in the horizontal direction during braking was greater for treadmill trials compared to overground trials.
- On the treadmill, stance time was shorter; thus the dogs unloaded their limb faster.

Table 1:		OG		TM		p-value
		Average	*SD*	*Average*	*SD*	
Hock Joint Vel *(degrees/s)*	*Flexion*	-602.94	87.51	-839.28	172.15	<0.01
	Extension	482.52	80.79	575.7	58.65	0.04
Stifle Joint Vel *(degrees/s)*	*Flexion*	-290.93	51.11	-462.41	135.46	0.01
Stifle Moment *(m/s)*	*Flexor*	-0.26	0.07	-0.39	0.09	0.02
Hip Moment *(m/s)*	*Extensor*	0.54	0.11	0.77	0.18	0.02
Hock Power *(N.m/Kg)*	*Absorption*	-2.51	1.12	-3.93	1.61	0.01
	Generation	0.46	0.27	1.19	0.50	<0.01
Stifle Power *(N.m/Kg)*	*Generation*	1.20	0.44	2.36	0.85	<0.01
Hock JRF *(N/Kg)*	*Braking x*	-0.61	0.14	-0.96	0.18	0.01
Stifle JRF *(N/Kg)*	*Braking x*	-0.92	0.22	-1.51	0.35	0.02
Stance Time *(s)*		0.24	0.02	-0.22	0.02	0.01

Table 1: Mean ± SD of significantly different joint velocity, moment, power, Joint Reaction Force (JRF) and stance time for the right hind limb joints of healthy Labrador Retrievers. T-test p-values less than 0.05 are significant.

Conclusion

During the treadmill trials, the dogs moved their hock and stifle joints faster in order to unload their limb faster. This lead to increased energy generation and absorption around these joints compared to overground trials. These differences may reveal an inadequate habituation to treadmill trotting or a real difference between overground and treadmill gait.

This study highlighted the differences and similarities in canine overground and treadmill gait. In future studies, this method may be used to study abnormal gait and identify potential predisposing factors for orthopedics or neurological injuries.

Acknowledgments

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