

Canine hip extension range during gait

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ABSTRACT

Assessment of canine gait is frequently used by veterinary clinicians to establish the presence of orthopaedic pain. As up to 30 % of canine orthopaedic conditions affect the pelvic limb, knowledge of pelvic limb biomechanics during gait is very important. Previous studies have investigated the biomechanics at the tarsus and stifle, but little information is available regarding hip motion during gait. The aim of this study was to determine the maximum hip extension range achieved during the stance phase of gait in normal canines. In addition, this study aimed to determine the difference between maximum passive hip extension and maximum hip extension during gait. Using a sample of 30 morphologically similar normal dogs, mean maximum passive hip extension was measured using a goniometer and mean maximum hip extension range during gait was determined videographically. Inter- and intra-assessor reliability studies performed at the start of the study showed that the measurement tools and techniques used in this study were valid and reliable. The goniometric data showed that mean maximum passive hip extension range was 162.44° (± 3.94) with no significant difference between the left and the right hind limbs. The videographic data showed that mean maximum hip extension range during gait was 119.97° (± 9.26) with no significant difference between the left and right hind limbs. The results of this study provided reference values for active and passive hip extension range and showed that the degree of hip extension range required for normal gait is significantly less than maximum passive hip extension range.

Key words: active hip extension range, canine gait, passive hip extension range.

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INTRODUCTION

Gait analysis forms an integral part of the orthopaedic assessment of canine patients^{1,6}. A dog cannot verbally express discomfort arising from musculoskeletal structures such as joints, tendons or muscles. Therefore, the onus is upon those responsible for its well-being to obtain an indication of the presence of pain from the dog's movement or behaviour. While a change in behaviour is often the deciding factor for an animal owner to seek professional advice, the clinician relies on assessment tools such as gait analysis and palpation to determine whether pain is present¹⁰.

In clinical practice, gait analysis is mostly subjective and the experience of the clinician performing the assessment

often determines the amount of information gained from an observation of the dog's gait. Some efforts have been made to quantify normal gait by force plate studies to measure ground reaction forces⁷ and videographic studies aimed at measuring joint angles during gait². The methods used in these studies require specialised equipment and are unlikely to be implemented in everyday practice.

Up to 30 % of the orthopaedic conditions found in dogs affect the pelvic limb⁸, the most common in large breed dogs being hip dysplasia and cranial cruciate ligament strain or rupture. A study by Colborne *et al.*² examined joint angles of the tarsus and stifle during trotting. They used 3 cameras in tandem to capture 5 stride cycles, from which joint angles were measured. However, the hip joint was not included in their study. The canine hip joint is often affected by orthopaedic disease such as hip dysplasia. It is a joint with a large range and 6 degrees of freedom of motion⁹. As such it is a likely area of compensation during gait for either direct or indirect pain originating from the hind limb. It would therefore be

useful to know the normal characteristics of canine hip movement during gait.

The main aim of this study was to determine the maximum hip extension range achieved during the stance phase of gait in normal canines. It was an important factor of the study that the method used should be simple and inexpensive enough to be used in clinical practice. An additional aim was to show that there is a difference between maximum passive hip extension range and the maximum hip extension range used for normal gait. Maximum passive hip extension range has been determined in a previous study on a homogeneous group of Labrador Retrievers⁵. It was found that the mean maximum passive hip extension range was 162°. As this study assessed a non-homogeneous population, passive hip extension range was re-measured. To ensure that the measurement tools and techniques used were clinically relevant, intra-assessor and inter-assessor reliability studies were also performed.

MATERIALS AND METHODS

This was a prospective, cross-sectional study of normal dogs. Assuming that normal weight-bearing hip extension range is 90 % of full range, determined to be 162° with a standard deviation of 2 in a previous study⁵, this becomes 145.8°, still with a standard deviation of 2. If a difference in the study population of 5° was considered significant, then at a confidence interval of 95 %, the number of dogs in the sample would have been 13. However, 30 dogs were included in the sample used to determine normal values, based on the convention that normality can be assumed when $n = 30$ or more¹¹.

This study restricted its attention to healthy working and gundog group dogs as published by the Federation Cynologique Internationale (FCI)³, between 1 and 7 years of age, weighing between 20 to 35 kg, and with a body condition score of 2 to 4⁴ as they have similar morphology and gait patterns. All dogs included in the study had hip radiographs on file, as they were either from breeding stock or were in training to become guide dogs, where hip radiographs are routinely taken at the start of their training. Dogs were excluded from the study if they had any radio-

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graphic signs of hip dysplasia, any history of lameness arising from a joint, any signs of degenerative joint disease, or were currently on nutritional supplements designed to alleviate the symptoms of joint pain such as additives containing glucosamine, MSM or other nutraceuticals and homeopathic remedies. They were also excluded if they had been on a course of anti-inflammatory medication within the 2 weeks preceding assessment.

As this is purely an observational study, no ethical problems were foreseen. The nature and purpose of the study was explained to the owners of the dogs. The owners were asked to sign an informed consent form before the assessment was done. The study only commenced once ethical clearance had been obtained from the Animal Ethics Committee of the University of the Witwatersrand.

Markers made of self-adhesive paper dots of 3 cm diameter were placed on the following bony landmarks on each pelvic limb:

For the pelvic axis: A line connecting the midpoint between the cranial dorsal iliac spine and the cranial ventral iliac spine, and the *tuber ischii*.

For the femoral axis: a line connecting the apex of the greater trochanter of the femur and the midpoint of the lateral femoral epicondyle.⁵

Fifteen-second digital videoclips of the dogs' gait trotting at a speed of 1.5 to 2 m/s were taken with a digital camera (HP Photosmart 753, Hewlett-Packard Company, Palo Alto, USA) placed at the level of and directly opposite the dog's coxo-femoral joint, at a distance of 1 m, with no zoom function used and the camera held in a static position. The 1m distance was determined as the most accurate in terms of angle variability, using a sequence of 4 static models. Three stance phases were recorded per videoclip taken and the middle stance phase was used for data collection. Three clips were recorded for each dog in each direction, therefore there were 3 clips recorded for each pelvic limb. These videoclips were downloaded onto a computer and digital still images obtained at the point of the caudal stride phase where the dog's foot leaves the ground. The angle formed between the 2 axes described above were measured using siliconCOACH software (siliconCOACH Ltd, Dunedin, New Zealand).

Passive hip extension range was obtained in lateral recumbency by stabilising the pelvis and drawing the femur caudally until passive resistance was felt, or the dog exhibited pain. The angle between the pelvic axis and the femoral axis was then measured using a standard goniometer.

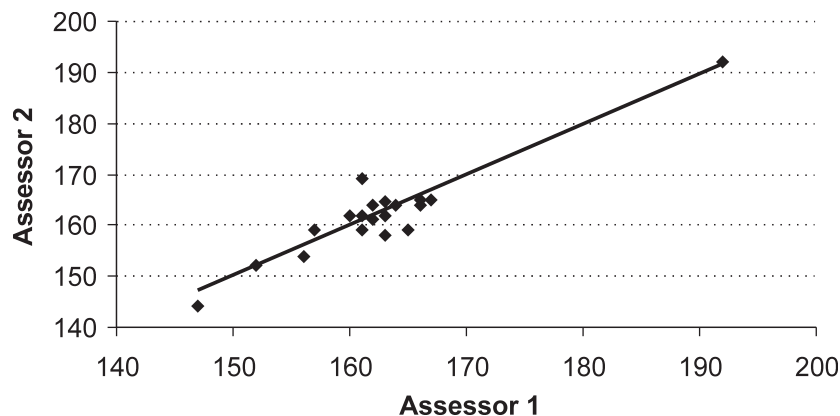


Fig. 1: Inter-assessor correlation: goniometry.

The mean for the 2 angles measured in each dog (left and right pelvic limb) was determined. These means ($n = 30$) were grouped together in a single set of data for each measurement type, namely videographic and goniometric. An independent 2-way *t*-test was performed on each data set, and the mean for the sample was obtained. In addition, the standard deviation (SD), confidence interval (CI) and *P*-value, set at 0.05, were determined.

The data collected were also grouped into separate measurements for the left and the right limbs (30 values in each group). An independent *t*-test was then performed to determine whether there was any difference between the means for the left and right limbs. This was done for each of the measurements, namely videographic and goniometric. *P*-values were also calculated for each test to determine the possibility that any results obtained from the *t*-tests were due to chance alone.

RESULTS

Intra-assessor reliability

The method of videographic measurement used in this study has not been well described and tested for reliability in the literature. To test the ability of the researcher to reproduce the measurements taken, a random sample of 10 of the normal group was used. A new still was taken from each of the videoclips, and the hip extension range was re-measured on these still images. The 2 sets of measurements were compared and found to have a high correlation of $R = 0.91$ ($P = 0.03$). This showed that the method used to obtain the videographic data was reliable.

Inter-assessor reliability

Goniometric measurements

The goniometric study on Labrador Retriever dogs mentioned above⁵ showed the validity and reliability of goniometric measurements for assessing hip extension range in dogs of this type. However, an inter-assessor reliability study was performed on 10 test dogs of the appropriate age and morphology. The dogs used had been excluded from the study owing to the presence lameness or a history of orthopaedic surgery. Two assessors independently measured the hip extension range for both hips of each of the 10 dogs in the same environment using the same equipment and the results were compared (Fig. 1).

This pilot study was carried out to double-check the reliability of goniometry for the hip measurements required in this study. As there was excellent correlation between assessors ($R = 0.92$), the results of the previous study on the reliability of goniometry could be accepted.

Videographic measurements

Ten dogs were used to test inter-assessor reliability on the videographic measurements. The video clips of the dogs were independently assessed by 2 assessors and the results compared (Fig. 2).

When the values obtained by the 2 assessors were compared using linear regression, there was a positive correlation co-efficient ($R = 0.74$), indicating that there was good correlation between the assessors, and thus that the videographic measurement technique used in this study was reliable.

It can be seen from the results (Table 1)

Table 1: Hip extension for the group of normal dogs as measured by videography and goniometry.

	Normal (L)	Normal (R)	Mean
Video	119.41 (± 8.14)	120.53 (± 10.38)	119.97 (± 9.26)
Goniometric	162.77 (± 3.88)	162.12 (± 4.01)	162.44 (± 3.94)

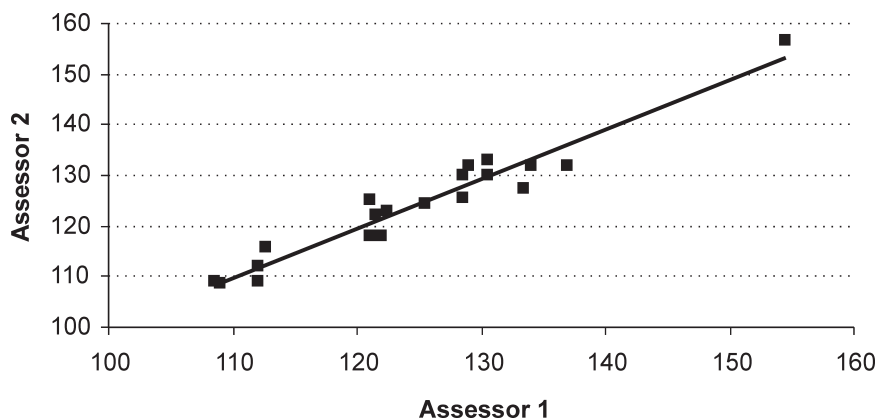


Fig. 2: Inter-assessor correlation: videography.

that the degree of hip extension required for gait in this population as assessed videographically ranges from a mean of $119.41 (\pm 8.14)$ for the left pelvic limb to a mean of $120.53 (\pm 10.38)$ for the right pelvic limb, with a sample mean of $119.97 (\pm 9.26)$. Average maximum passive hip extension ranges as measured with a goniometer ranges from a mean of $162.11 (\pm 4.01)$ for the left hind limb to a mean of $167.77 (\pm 3.88)$ for the right hind limb, with a sample mean of $162.44 (\pm 3.94)$. This means that the active hip extension required for normal gait is 25.65–28.83 % (mean difference = 42.47) less than the average maximum passive hip extension ($P < 0.001$ at a 95 % confidence interval).

DISCUSSION

Thirty healthy adult dogs were included in the study. All underwent videographic as well as goniometric measurements of both hind limbs to determine maximum hip extension range, both passively and during gait. As expected, the range of hip extension required for gait was significantly less than the maximum passive hip extension range that could be measured by goniometer.

The 1st outcome of this study was that the results of a previous study⁵ were corroborated. The mean passive hip extension range determined in that study was $162^\circ (\pm 3^\circ)$, while the data collected from this group yielded a mean of $162.44^\circ (\pm 3.94^\circ)$. The population sampled in this study was less homogeneous than the population sampled in the previous study. This indicates that adult dogs of a morphological type similar to those classified as working or gundogs by the FCI can be expected to have a range of passive hip extension that does not vary

more than 4 degrees from 162° .

The 2nd outcome of this study was to establish that the range of hip extension required for gait in normal canines at a speed of 1.5–2 m/s was $119.97^\circ (\pm 9.26^\circ)$ in the sample used. The range of hip extension required for normal gait at low speeds is therefore considerably less (by 43.63°) than the normal average maximum passive hip extension range. The standard deviation from this figure is markedly higher than when passive hip extension range was measured. There were 3 variables that were difficult to control, and are the most likely explanations for this high SD. These are:

- a) **Variability in walking speed:** the dog handlers were asked to walk their dogs at a brisk pace past the camera. However, there were possibly differences in the speed at which the dogs were walked, which may affect hip extension range at the end of the stance phase of the gait cycle.
- b) **Variability in camera angle:** the handlers were given a line to walk their dogs along, which was at a set distance from the camera (1 m). This is a practical and clinically useful assessment technique, but one must be aware that the dogs will not always keep precisely to the given line, and this may result in small variations in angle of the pelvic limb to the camera, which in turn has an effect on the angle measured.
- c) **Variability in the dog's attitude and training:** all dogs used in this study had basic training and could walk at heel on a lead. However, environmental distractions and degree of obedience had an effect on the dog's desire to go forward in a straight line. This may have affected the consistency of

the measurements taken for each individual dog. However, this was compensated for by taking multiple videoclips (3) of each dog in each direction.

In spite of these variations, this provided a baseline for comparison of data for a future study on CCL-deficient dogs, and has contributed to the understanding of normal canine gait.

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