FOUR LEG NEWS

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Outcome Measures - GONIOMETRY

So, we're all in this canine rehab game now. We all bought the equipment, and we all likely own a goniometer. Truth telling… all physiotherapists hate the goniometer. We avoid using it if we can. However, canine rehab is new, so perhaps we should look at its usefulness as an outcome measure to validate what we do. Well, this led me to doing a literature search to find out what has been done in regards to using or validating the goniometer in dogs. So… here we go!

Cheers!

Laurie Edge-Hughes,
BScPT, MAnimSt (Animal Physio. CAFCI, CCRT

TABLE OF CONTENTS:

The first paper to evaluate the validity of the goniometer as an objective outcome measure in dogs.

Jaegger G., Marcellin-Little DJ, David Levine D. Reliability of goniometry in Labrador Retrievers. American Journal of Veterinary Research, 2002, 63 (7): 979-986.

Pre-amble: Goniometry is used to measure joint angles with the use of a plastic tool called a goniometer. In dogs, however, goniometry has not been validated, and only scant information is available regarding goniometric methods and reference values.

Materials & Methods: 16 adult Labrador Retrievers were used. Fourteen joint positions were evaluated 3 times each by each investigator, including flexion and extension of the carpal, elbow, shoulder, tarsal, stifle, and hip joints, as well as valgus and varus movements of the carpus. Three investigators independently evaluated each dog awake (but sedated) within a 1-week period. All measurements were made in triplicate and were read and recorded by an independent observer.

The paper goes on to describe how the axis was determined and how the arms of the goniometer were lined up.

The investigators also fully sedated the dogs and radiographed the carpi in maximal flexion and extension. One investigator then took measurements of the radiographs.

Statistical analysis was conducted to determine intertester variability of the median measurements for the 3 investigators for each joint position.

Results: Results of goniometric and radiographic measurements were not significantly different. Results of measurements made by the 3 investigators were not significantly different. Sedation did not influence the range of motion of the evaluated joints.

Table 1—Range of motion (degrees) of various appendicular joints measured by goniometry in 16 healthy Labrador Retrievers

Joint	Position	Mean	SD	95% CI of the mean	Median
Carpus	Flexion	32	2	31–34	32
	Extension	196	2	194–197	196
	Valgus	12	2	11–13	12
	Varus	7	1	6–8	7
Elbow	Flexion	36	2	34–38	36
	Extension	165	2	164–167	166
Shoulder	Flexion	57	2	54–59	57
	Extension	165	2	164–167	165
Tarsus	Flexion	39	2	37–40	38
	Extension	164	2	162–166	165
Stifle	Flexion	42	2	40–43	41
	Extension	162	3	160–164	162
Hip	Flexion	50	2	48–52	50
	Extension	162	3	160–164	162

CI = Confidence interval.

Discussion: The mean variability in measurements of several proximal joints (shoulder, hip, and stifle joints) was larger than the mean variability in measurements of several distal joints (elbow and tarsus). This may be because a larger amount of soft tissue is present around proximal joints, compared with distal joints, potentially interfering with the palpation of body landmarks, and because the larger muscle mass around proximal joints appears to complicate the goniometric measurements (i.e., bulge of the triceps brachii during shoulder flexion).

Conclusion: Goniometry is a reliable and objective method for determining range of motion of joints in healthy Labrador Retrievers.

And one of my favourite papers:

Cook, J.L., Renfro, D.C., Tomlinson, J.L. and Sorensen, J.E. (2005), Measurement of Angles of Abduction for Diagnosis of Shoulder Instability in Dogs Using Goniometry and Digital Image Analysis. Veterinary Surgery, 34: 463-468

Objective: To compare abduction angles of shoulders with medial instability and unaffected shoulders in the same dogs and in age- and breed-matched dogs.

Materials & Methods: 33 dogs with medial instability of the shoulder and 26 controls. Dogs were sedated and positioned in lateral recumbency. With the elbow and shoulder in extension, the non-recumbent limb was maximally abducted and the angle between the scapular spine and lateral aspect of the brachium measured with a goniometer; a digital image was taken from the cranial aspect. Both techniques were performed in triplicate by 2 examiners.

Results: Mean abduction angles for shoulders with instability (53.7±4.7° goniometric, 51.2±4.9° image) were significantly (P<.001) larger than for all unaffected shoulders (32.6±2.0° goniometric, 30.9±2.3° image). In dogs diagnosed with instability, affected shoulders had significantly (P<.001) larger abduction angles than the contralateral (unaffected) shoulders.

Conclusions: Shoulder abduction angles measured under sedation provide objective data for diagnosis of shoulder instability in dogs.

Laurie's thoughts:
This is such a groundbreaking paper. Always check shoulder abduction, but technique is CRITICAL!! Get it into extension! I've also found that dogs with chronic MSI tend to resist abduction. So, feel for the resistance and pay attention to end feel as well!

"You can't manage what you can't measure."
- Peter Drucker

And here's a paper that comes out of Turkey!!

Sabanci SS, Ocal MK. Comparison of goniometric measurements of the stifle joint in seven breeds of normal dogs. Vet Comp Orthop Traumatol 2016; 29(03): 214-219.

Pre-amble: The loss of extension or flexion by 10° or greater is related to clinical lameness. The aims of the present study were: 1) to compare the standing, extension, flexion, and ROM degrees in seven dog breeds; and 2) to determine if sex and side are factors affecting these angles, and to determine whether there is any relationship among the goniometric measurements of the stifle joint, age, body weight, tibial plateau angle, crus and thigh circumferences, and the widths of quadriceps, hamstring, and gastrocnemius muscles in normal dogs.

Materials & Methods: They used a total of 126 dogs from seven different breeds: Belgian Malinois, German Shepherds, Dobermanns, Boxers, Labrador Retrievers, Golden Retrievers, and Rottweilers. All dogs were 12 months of age or older, had no lameness or history of orthopaedic problems, and showed no radiographic evidence of hindlimb disease according to the hip extended, standard mediolateral femoral and tibial radiographs, including the stifle and tarsus.

They measured the joint angles in standing, as well as full flexion and extension. They also recorded thigh circumference and looked at width of the quads, hams and gastrocs (via radiographs).

Results: Neither sex nor side affected the joint angles. The standing, extension, flexion, and ROM angles were different among the breeds. Body weight and muscular measurements were the most influential factors on the stifle flexion angle and ROM.

Table 2 Comparison of the standing, extension, flexion and range of motion angles (degree) among the seven breeds.

	German Shepherd (n = 25)	Labrador Retriever (n = 23)	Golden Retriever (n = 23)	Belgian Malinois (n = 20)	Rottweiler (n = 16)	Boxer (n = 10)	Dobermann Pinscher (n = 9)	p<
Standing (°)	119 ± 4.98^{a} (110 – 130)	141 ± 3.89^{be} (134 – 149)	134 ± 4.17^{c} (126 – 144)	139 ± 2.24^{bf} (134 – 143)	138 ± 3.38^{df} (133 – 146)	141 ± 4.14^{bde} (132 – 148)	144 ± 4.57^{e} (136 – 151)	0.001
Extension (°)	151 ± 4.48^{a} (142 – 159)	157 ± 5.69^{bc} (148 – 168)	156 ± 3.48^{bc} (150 – 163)	156 ± 1.88^{ce} (153 – 160)	154 ± 2.63^{b} (150 – 160)	159 ± 4.00^{cd} (151 – 167)	164 ± 6.16^{d} (156 – 173)	0.001
Flexion (°)	34.0 ± 2.36^{a} (29.5 – 38.2)	37.6 ± 3.95^{b} (31.5 – 46.0)	34.1 ± 3.30^{a} (29.2 – 40.2)	29.3 ± 2.36^{c} (25.0 – 34.2)	34.1 ± 4.09^{a} (29.7 – 41.0)	39.1 ± 9.05^{ab} (28.0 – 54.7)	29.8 ± 1.73^{c} (27.8 – 33.7)	0.001
ROM (°)	117 ± 5.65^{a} (105 – 127)	119 ± 7.67^{ab} (104 – 133)	122 ± 5.11^{bc} (110 – 130)	127 ± 3.05^{e} (122 – 132)	120 ± 6.24^{ac} (109 – 130)	120 ± 7.10^{ac} (103 – 130)	134 ± 7.13^{d} (125 – 145)	0.001

Different superscript letters in the same line are given where significant differences ($p < 0.05$) were detected with post hoc comparisons among breeds by ANOVA. Values are reported as mean ± standard deviation (range).

Clinical significance: Breed differences, body weights, and muscle mass should be taken into consideration during assessment of the stifle function using goniometric measurements.

Laurie's thoughts: Well this just makes sense. Stifle flexion is impeded by soft tissue apposition in normal dogs (that's the end feel). So, the lesson is, compares between sides, not between dogs!

What about other oddly shaped dogs?

Thomovsky SA, Chen AV, Kiszonas AM, Lutskas LA, "Goniometry and Limb Girth in Miniature Dachshunds," Journal of Veterinary Medicine, vol. 2016, Article ID 5846052, 5 pages, 2016.

Introduction: One difficulty with joint angle measurements in animals versus humans is the variety of limb shape and girth differences among breeds and between animal species. The purpose of this study was to look at thigh circumference and goniometric measurements of the pelvic limb in miniature Dachshunds with ambulatory paraparesis, nonambulatory paraparesis, and paraplegia secondary to thoracolumbar intervertebral disc extrusion.

Methods: 15 Mini-Daxies were studied. An 8-inch plastic goniometer was used. All the dogs were away and put in lateral recumbency for the taking of measurements.

Results:

Table 1: Median and mean (with standard deviation) flexion angles at the hip, stifle, and hock in miniature Dachshunds. Each value was viewed independently, meaning dog 1 left limb hock flexion was one variable and right limb hock flexion was a second variable.

Group	Median flexion hip (°)	Median flexion stifle (°)	Median flexion hock (°)	Mean flexion hip (°)	Standard deviation	Mean flexion stifle (°)	Standard deviation	Mean flexion hock (°)	Standard deviation
Group 1: ambulatory paraparetic group	55	54	39	54.3	4.6	56	12.9	39.2	5.3
Group 2: nonambulatory paraparetic group	49	50	40	49.1	8.4	48.2	13.2	39.5	7.1
Group 3: paraplegic group	50	43.5	40	51.3	11.9	46	11.0	39.3	5.7
Pooled data combining all three groups	50	50	40	51.6	2.61	50.1	5.3	39.3	0.15

Table 2: Median and mean (with standard deviation) extension angles at the hip, stifle, and hock in miniature Dachshunds. Each value was viewed independently, meaning dog 1 left limb hock extension was one variable and right limb hock extension was a second variable.

Group	Median extension hip (°)	Median extension stifle (°)	Median extension hock (°)	Mean extension hip (°)	Standard deviation	Mean extension stifle (°)	Standard deviation	Mean extension hock (°)	Standard deviation
Group 1: ambulatory paraparetic group	155	163.5	167.5	155	9.4	164.2	6.9	169.2	9.2
Group 2: nonambulatory paraparetic group	151.5	160	172.5	152.5	10.6	157.3	7.7	171.5	8.0
Group 3: paraplegic group	160	160	167.5	156.5	10.1	159.4	10.0	167.5	9.7
Pooled data combining all three groups	155	160	167.5	154.7	2.0	160.3	3.5	169.4	2.0

Conclusion: There were no significant differences in joint angles or girth among the three groups (ambulatory paraparetic, nonambulatory paraparetic, or paraplegic)

Another goniometric study on funny-shaped dogs…

Formenton MR , de Lima LG, Vassalo FG, Joaquim JGF, Rosseto LP, Fantoni DT. Goniometric Assessment in French Bulldogs. Front. Vet. Sci., 13 December 2019.

Preamble: French Bulldogs have recently enjoyed increasing popularity among brachycephalic breeds. Still, popular as French Bulldogs may be, joint angles have not been quantified in this breed. This study set out to determine normal ROM of the shoulder, elbow, carpus, hip, stifle and tarsus joints in healthy, non-sedated French Bulldogs using goniometry.

Methods: Health, fit, male or female French Bulldogs, aged between 16 – 48 months, with no orthopaedic history and no observed or evaluated anomalies or dysfunctions were selected for inclusion. 20 dogs made the cut.

Measurements were conducted with the dog in lateral recumbency, non-sedated, with manual restraint. One examiner conducted the measurement process and three measurements each of flexion and extension were made per joint using a 35cm-arm plastic goniometer (appx 12 inch).

Results: See the Table below.

Conclusion: Similar flexion angles and ROM were detected in right and left limb joints (as compared to previous studies evaluating Labrador retrievers, Dachshunds, and German Shepherds. Findings of this study suggest similar ROM in French Bulldogs and other dog breeds.

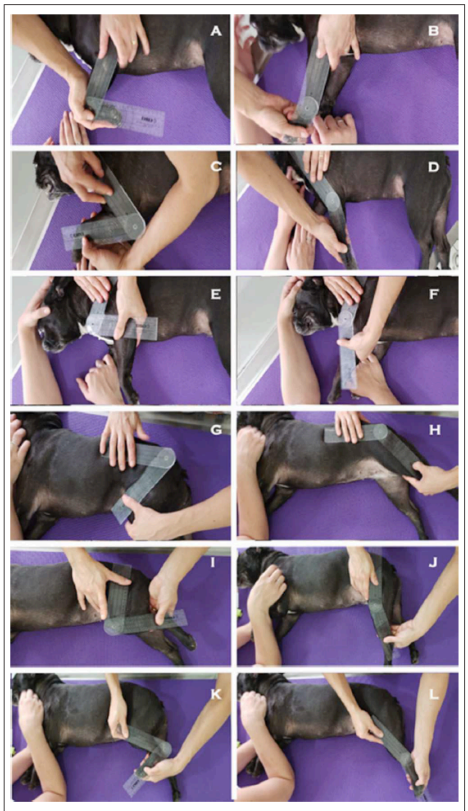

FIGURE 1 | Correct goniometer positioning **(A)** carpal flexion; **(B)** carpal extension; **(C)** elbow flexion; **(D)** elbow extension; **(E)** shoulder flexion; **(F)** shoulder extension; **(G)** hip flexion; **(H)** hip extension; **(I)** stifle flexion; **(J)** stifle extension; **(K)** tarsal flexion; and **(L)** tarsal extension.

TABLE 2 | Mean maximum flexion and extension angles and range of motion of right and left thoracic and pelvic limb joints of French Bulldogs, and respective standard deviations (SD) and coefficients of variation (CV).

Joint	Extension		Flexion		Range of motion	
	Right limb Mean ± SD CV	Left limb Mean ± SD CV	Right limb Mean ± SD CV	Left limb Mean ± SD CV	Right limb Mean ± SD CV	Left limb Mean ± SD CV
Shoulder	160 ± 19	160 ± 20	51 ± 8	52 ± 9	109 ± 24	108 ± 24
	12.09%	12.34%	16.29%	17.50%	21.84%	21.77%
Elbow	174 ± 11	175 ± 9	51 ± 13	49 ± 12	123 ± 18	126 ± 16
	6.24%	5.00%	24.67%	23.98%	14.63%	12.78%
Carpus	204 ± 8	204 ± 8	32 ± 7	32 ± 7	172 ± 10	172 ± 10
	4.03%	4.01%	22.69%	21.53%	5.54%	5.75%
Hip	181 ± 7	179 ± 7	58 ± 10	59 ± 10	123 ± 14	121 ± 14
	4.14%	4.07%	17.47%	16.84%	11.05%	11.23%
Stifle	172 ± 8	174 ± 8	58 ± 8	59 ± 10	114 ± 12	115 ± 12
	4.72%	4.33%	14.22%	17.02%	10.28%	10.70%
Tarsus	188 ± 7	188 ± 6	40 ± 6	39 ± 7	149 ± 8	149 ± 9
	3.74%	3.05%	16.33%	16.60%	5.36%	5.76%

What about using other types of goniometric devices?

Freund KA, Kieves NR, Hart JL, Foster SA, Jeffery U, Duerr FM. Assessment of novel digital and smartphone goniometers for measurement of canine stifle joint angles. American Journal of Veterinary Research, July 2016, Vol. 77, No. 7, Pages 749-755.

Objective: To evaluate accuracy and reliability of 3 novel goniometers for measurement of canine stifle joint angles and compare the results with those obtained with a universal goniometer (UG).

Methods: This group measured 8 pelvic limbs from 4 canine cadavers. The limbs were fixed into set arbitrary joint angles and secured to a wooden platform. Goniometry was performed with 2 smartphone–based applications, a digital goniometer and a universal goniometer (UG) and 3 evaluators performed measurements in triplicate on each joint with each device. Results were compared with stifle joint angle measurements on radiographs.

The novel goniometer apps / devices:

a. Smartphone-based application iHandy Carpenter, version 2.2.2, iHandySoft Inc, New York, NY.
b. Smartphone-based application DrGoniometer, version 2.9, CDM Srl, Milano, Italy.
c. Handheld digital goniometer HALO, HALO Medical Devices, Subiaco, WA, Australia.

Results: The UG had the greatest reliability for stifle joint angle measurements, with a mean CV of 4.88%, and novel goniometer C had the least reliability, with a mean CV of 12.71%. Mean CVs for novel goniometers A (7.57%) and B (7.37%) fell between these values.

However…

Constant bias was present for all devices except novel goniometer B. The UG and novel goniometer A had positive constant bias; novel goniometer C had negative constant bias. Total error at 50° and 100° angles was > 5% for all devices.

Discussion: Bias, an expression of inaccuracy, is an assessment of the closeness of a measurement with that of the true value.

Authors of 1 study (see below) found that dogs with a ≥ 10° loss in range of motion in the stifle joint (as measured with a UG) after tibial plateau leveling osteotomy had significantly higher clinical lameness scores than dogs with no loss in range of motion, and reported that this degree of change should be considered clinically relevant. If a patient's stifle joint range of motion is 121° (the difference in median extension and flexion values reported in a study1 of clinically normal Labrador Retrievers), then 5% device error would result in a 6° change in a given measured stifle joint angle or a potential 12° change in measured range of motion. This total allowable error was subjectively compared with estimates of total observed error for each device at an obtuse (100°) and an acute (50°) angle. No device, including the UG, had acceptable performance at either angle as judged by this criterion.

Conclusion: None of the devices accurately represented radiographically measured stifle joint angles.

Snippets of other studies…

1. The one eluded to in the Freund et al study above.
   Jandi AS, Schulman AJ. Incidence of motion loss of the stifle joint in dogs with naturally occurring cranial cruciate ligament rupture surgically treated with tibial plateau leveling osteotomy: longitudinal clinical study of 412 cases. Vet Surg 2007;36:114–121.

   Loss of extension or flexion > or =10 degrees was responsible for higher clinical lameness scores. Osteoarthrosis in the cranial femorotibial joint led to extension loss.

2. And one with similar findings.
   Little D, Johnson S, Hash J, Olson SA, Estes BT, Moutos FT, Lascelles BD, Guilak F. Functional outcome measures in a surgical model of hip osteoarthritis in dogs. J Exp Orthop. 2016 Dec;3(1):17.

   I'll paraphrase: Scoring of histological cartilage degeneration negatively correlated with goniometric ROM, meaning that those dogs with worse cartilage degeneration (higher score) had reduced ROM.

3. Looking at electrogoniometers AND comparing GSDs to Labs:
   Thomas TM, Marcellin-Little DJ, Roe SC, Lascelles BDX, Brosey BP. Comparison of measurements obtained by use of an electrogoniometer and a universal plastic goniometer for the assessment of joint motion in dogs Todd. AJVR. (2006) 67:1974–9.

   A universal goniometer (UG) is reliable for obtaining measurements in German Shepherd Dogs. There was higher variability for the electrogoniometer (EG) than for the UG, and an EG cannot be recommended for use.

   German Shepherd Dogs had lower values in flexion and extension than did Labrador Retrievers for all joints, except the carpal joints. German Shepherd Dogs had less motion in the tarsal joints, compared with motion for the Labrador Retrievers, but had similar motion in all other joints. *(P.S. This study compared the ROM values to those in the Jaegger et al (2002) study mentioned earlier in this newsletter.)*

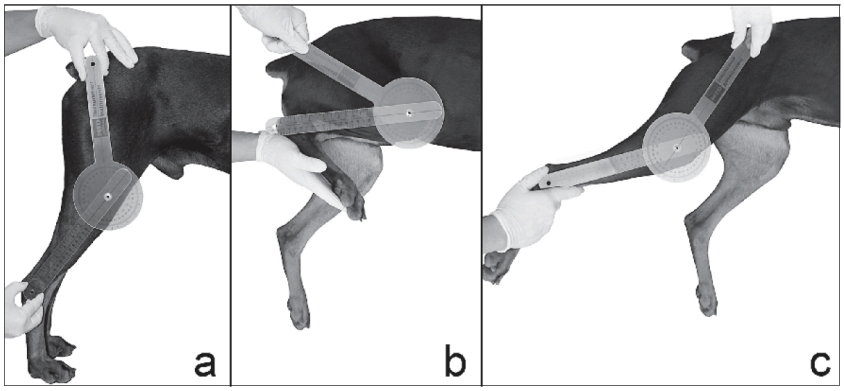

Figure 1
The goniometric measurements of standing (**a**), flexion (**b**), and extension (**c**) positions of the stifle joint.

Physio Humour!