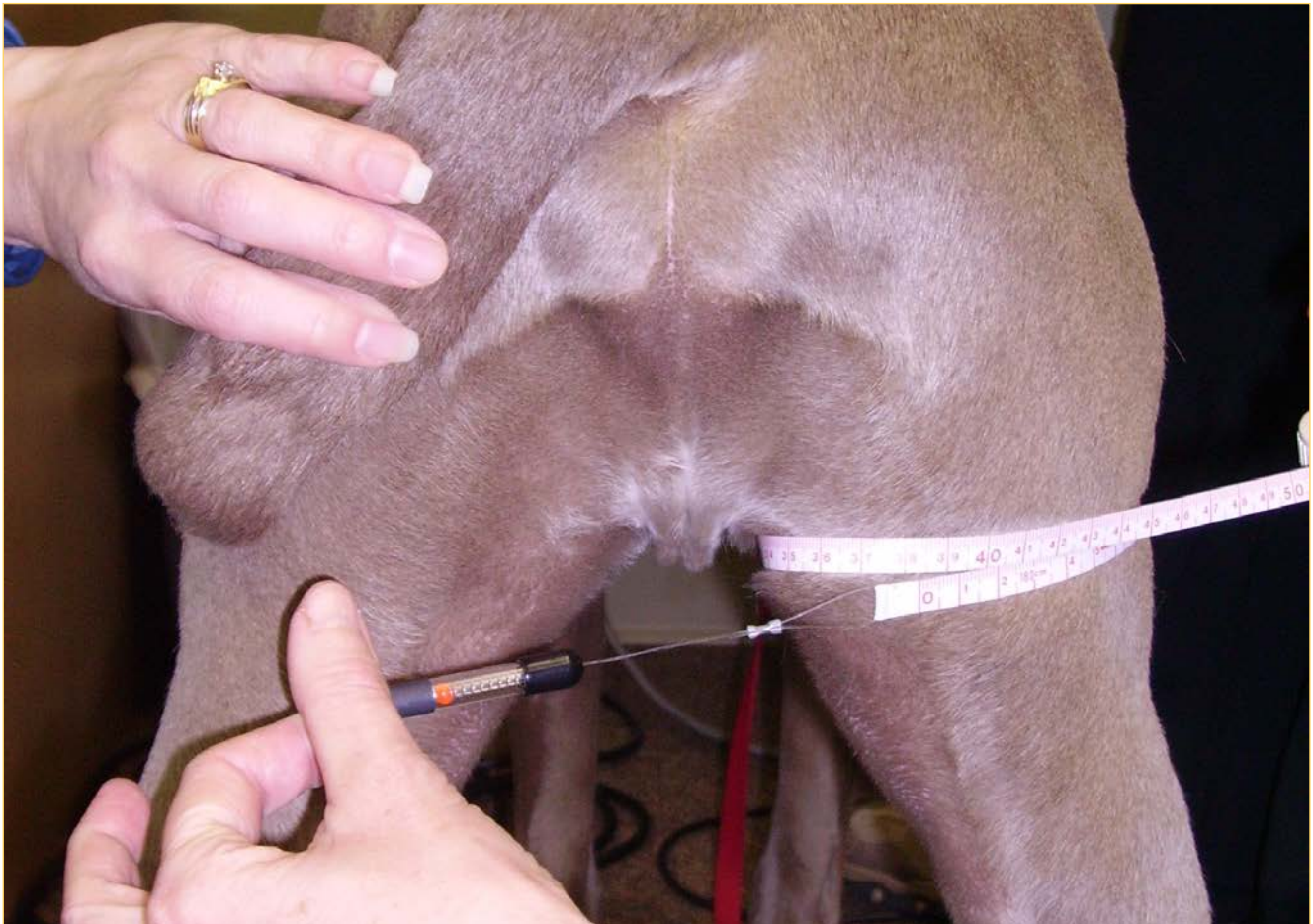

Four Leg News

Outcome Measures - LIMB CIRCUMFERENCE

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INTRODUCTION: Continuing on with the theme of Outcome Measures, in this issue, I'll be diving into Limb Circumference. I've kept this review to canine articles only (to save space really). Also, there are some unique challenges when it comes to canine application versus human application. So perhaps the human studies don't matter as much. Anyways, in this issue you'll learn about studies that use thigh circumference as an outcome measure, the reliability of limb circumference and factors and variables that might affect reliability, and an evaluation of four different types of measurement tapes. All in all, I think you'll enjoy the read, and of course my 2 cents at the end of each article! Cheers!

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CLINICAL STUDIES USING THIGH CIRCUMFERENCE

I've used this study a number of times, I know.... but we're just getting warmed up, and it fits!

Monk M, Preston C, McGowan C. Effects of early intensive postoperative physiotherapy on limb function after tibial plateau levelling osteotomy in dogs with deficiency of the cranial cruciate ligament. AJVR, Vol 67, No. 3, March 2006.

Here, they took 8 adult dogs with cruciate deficiency and subsequent TPLO surgery. Four went through a physiotherapy program, and four were put on a walking program.

The dogs were evaluated before surgery, 1 and 10 days after surgery, and 3 and 6 weeks after surgery. Thigh circumference (TC), stifle joint flexion and extension range of motion (ROM), lameness, and weight-bearing scores were recorded.

Before surgery, CCL-deficient limbs had significantly reduced TC and reduced flexion and extension ROMs, compared with values for the contralateral control limb. Six weeks after TPLO, the physiotherapy group had significantly larger TC than the home-exercise group, with the difference no longer evident between the affected and nonaffected limbs. Extension and flexion ROMs were significantly greater in the physiotherapy group, compared with values for the home-exercise group, 3 and 6 weeks after surgery. Six weeks after surgery, the difference in flexion and extension ROMs was no longer evident between the affected and nonaffected limbs in the physiotherapy group. Both groups had improvements for lameness and weight-bearing scores over time, but no difference was found between the 2 groups.

A wee bit about the physiotherapy: Physiotherapy included massage of the thigh muscles, passive ROM of the stifle joint, functional weight-bearing exercises, use of ice packs, and controlled leash walking. At each physiotherapy session, the physiotherapist performed one of the exercise sessions for that day, then demonstrated exercises for the following week to the owners. After suture removal, progressive UWTM exercise (water level at the greater trochanter and at 32°C) was completed at each physiotherapy session instead of leash walking on that day.

So early physiotherapy intervention improved thigh circumference (presumably muscle mass) as well as range of motion. However, both groups looked the same in regards to weight bearing and lameness.

Laurie's Thoughts: *I love this study, but I guess we're not sure what to make of it. Does thigh circumference equate to better function? Better long term outcome? We can't actually make those claims from this study. We only know that it is a measurement that is affected by the intervention (in this case post-operative physiotherapy).*



Clinical use of Thigh Circumference

As a Long Term Measurement of TPLO Outcomes

Moeller EM, Allen DA, Wilson ER, Lineberger JA, Lehenbauer T. Long-term outcomes of thigh circumference, stifle range-of-motion, and lameness after unilateral tibial plateau levelling osteotomy. Vet Comp Orthop Traumatol. 2010;23(1):37-42.

This study starts out by commenting that surgical techniques have been developed to try to stabilize cranial cruciate ligament (CCL) deficiency with a goal to minimize atrophy of the limb and promote limb use. Immediately following surgery, there is lameness of the post-operative limb. Assessing progress may be done by physical examination, gait analysis, force plate analysis, or *thigh circumference (TC)*. Long-term use of the affected limb can be assessed with a force plate by measuring changes in peak vertical force (PVF) and vertical impulse (VI), or by measuring Thigh Circumference as an indicator of muscle mass.

Materials & Methods: Twenty-nine dogs were assessed in this study with orthopaedic examination, visual gait assessment, TC measurement, and measurement of stifle ROM in extension and flexion; as well as radiographs of both stifles to evaluate the TPLO and to confirm no orthopaedic disease in the contralateral stifle.

About thigh circumference measurements: TC was taken with the dog in a normal standing posture by using a tape measure with a spring-tensioned device at midway between the greater trochanter and the lateral femoral condyle. Measurements were taken with the tension at the same level each time and made in triplicate, of which the mean was used for analysis.

Dogs were divided into groups: A was one to less than two years after surgery; B was two to less than three years; C was three to less than 4 years; and D was four to less than five years. Owners were asked if their dog had physical and/or NSAID therapies. Group A had ten dogs, B had 11 dogs, C had four dogs, and D had four dogs.

Results: (Specific to TC.) The mean TC of the TLPO limb (39.5 cm) was significantly different than the mean TC of the control limb (40.1 cm). The mean TC of the TLPO limb was 98.5% of the mean TC of the normal limb. 25 dogs did not have a clinically observed lameness in either limb despite the slight difference in TC; and there was no difference in TC between dogs with or without clinical lameness.

Conclusions: In dogs that were between one and five years postoperative from a unilateral TPLO, there was not a significant difference in TC, stifle flexion, and stifle extension when compared to dogs in the same group and within other groups. These findings support the conclusions that there is not likely any clinical significance of the statistical significance between TC between the operated limb and the normal limb.

Laurie's Thoughts: Well, this is an interesting study, and a kick in the teeth. I measure thigh circumference. Owners like to know. I like to know. I think it does give us some information about limb use and/or muscle hypertrophy (or atrophy), especially in the early stages, but here we are looking at long term. I would have to say that I don't think dogs are fully normal after a TPLO, I think they always favour that leg just a little (usually in stance)... which could account for the small difference in thigh circumference. It should be noted that THIS study used a visual evaluation of lameness to correlate with the thigh circumference, not anything more objective (such as a force plate or standing weight bearing measuring devices). Would there have been more of a correlation if objective measures for gait had been used? As I said, I usually see these dogs off load in stance, not gait. I think a lameness scale should include offloading in stance (we made up our own at my clinic... but we can chat about that another day!)

Other Studies Using Thigh Circumference as an Outcome Measure

Kalis, R. H. Liska, W. D. and Jankovits, D. A. Total hip replacement as a treatment option for capital physal fractures in dogs and cats. *Veterinary Surgery*. 2012, 41 (1): 148-55.

- These researchers used Thigh Circumference as one of the objective measures to show successful outcomes for total hip replacement in the cases presented.

Gordon-Evans, W. J. et al. Effect of the use of carprofen in dogs undergoing intense rehabilitation after lateral fabellar suture stabilization. *Journal of the American Veterinary Medical Association*. 2011, 239 (1): 75-80.

- These researched noted that carprofen did not improve the objective measures studied (including thigh circumference) following lateral fabellar stabilization and rehabilitation.

Pellegrino FJ, Risso A, Relling AE, Corranda Y. Physical response of dogs supplemented with fish oil during a treadmill training program. *J Anim Physiol Anim Nutr (Berl)*. 2019, 103 (2): 653 - 660.

- This study used thigh circumference as one of the measures to show that supplementing fish oil to dogs undergoing a 12-week treadmill training program was beneficial.



RELIABILITY OF LIMB CIRCUMFERENCE MEASUREMENT

Smith TJ, Baltzer WI, Jelinski SE, Salinardi BJ. Inter- and intratester reliability of anthropometric assessment of limb circumference in labrador retrievers. Vet Surg. 2013 Apr;42(3):316-21.

The ‘Why’ of it: In this study, the authors describe a simple method of anthropometric assessment of limb circumference at the level of the proximal antebrachium, mid brachium, proximal crus, and mid-thigh in dogs and to examine inter- and intratester reliability.

Materials and Methods: 20 field trial Labrador Retrievers were utilized. All were aware of the study purpose and had prior experience with the Gulick II measuring tape in a clinical setting. Dogs were examined by all 4 observers on 2 separate occasions on the same day. Dogs were not exercised between the 2 examination periods.



How the measurements were taken: Each dog was restrained by the owner in right lateral recumbency. Only the left thoracic limb and pelvic limb were measured. For each limb location 3 consecutive measurements were made. The measurement method was: (1) ascertain the location to place the tape perpendicular to the long axis of the limb, and (2) measure the circumference of the limb. The measurement method for all sessions and all observers was antebrachium, brachium, crus, and thigh. Measurements of the brachium (pABr) and crus (pCr) were made proximally at 25% the distance distally from elbow to carpus and stifle to tarsus, respectively; measurement of the brachium (mBr) and thigh (mTh) were made midway between the shoulder and elbow and hip and stifle, respectively. All 4 testers were experienced in use of the Gulick II.

Results: **Intratester** reliability was calculated for both the first measurements and mean of the triplicate measurements made by each observer in each measurement session. The pABr was measured reliably by all observers with ICC values ranging from 0.68–0.78 (1st measurement) and 0.67–0.78 (mean of triplicate measurements). Observer #4 reliably measured 2 additional areas (mCr and mTh) whereas the other observers were unreliable. Intratester reliability for measurement by observers of the mBr, pCr, and mTh was typically unreliable.

Assessment of **intertester** reliability was made for both the first measurements and mean (of the triplicate) measurements made by observers in the 1st and 2nd session. Intertester reliability was good for the pABr for all observers. Intertester reliability for measurements of the mBr, pCr, and mTh for both 1st and mean values were universally poor, although marginally better in the morning than afternoon, and using the mean compared with the first value

It should be noted that one observer was able to measure the locations reliably, showing the technique's potential for these anatomical regions but may require a training period or pre-selection of observers with good measurement reliability.

Conclusion: Consistent measurement of limb circumference of the proximal antebrachium in conscious dogs was repeatable using the Gulick II tape measure.

***Laurie's Thoughts:** So, I think this study goes to show that you need to develop your own consistent method of measurement. There is the potential to be reliable. However, I don't think you can expect to be reliable when making an estimate (i.e. 25% or Midway). For measurements at the proximal tibia / distal femur, or proximal radius / distal humerus, I measure a specific distance up or down from the joint line (stifle or elbow respectively). Otherwise, I measure at a horizontal circumferentially as high as I can get the tape measure into the axilla or groin... (I see a training video in the future).*

VARIABLES Affecting Thigh Girth Measurement

McCarthy DA, Millis DL, Levine D, Weigel JP. Variables Affecting Thigh Girth Measurement and Observer Reliability in Dogs. Front Vet Sci. 2018 Aug 30;5:203.

Introduction: Variables that may affect thigh girth include location of the measurement on the thigh, angle of limb in flexion or extension, whether the hair is clipped or not, determination of girth in awake or sedated dogs, and reproducibility between evaluators. The purpose of this study is to evaluate the effect of these variables on thigh girth measurements at two different locations before and 2 weeks after transection of a cranial cruciate ligament and immediate stabilization of the stifle.

Materials & Methods: Ten mixed breed hounds were used. They were concurrently being studied in regards to cruciate repair research.

How they measured: Measurements were made with dogs in lateral recumbency by two individuals. Both evaluators practiced the technique, including palpation of anatomic landmarks. The observer measured the thigh length and marked the site of measurement. An assistant placed the limb in position while the observer placed the tape around the limb and pulled until end tension was reached. The assistant recorded the value. A total of 18 measurements were made for each observer, with the limb repositioned each time. The means of each set of measurements (flexion, extension, and estimated standing angle) at both 50 and 70% thigh length were used for analysis. Thigh length (TL) was determined by measuring from the proximal tip of the greater trochanter to the distal aspect of the lateral fabella, with marks placed at 50 and 70% of the thigh length from the tip of the greater trochanter. The tape measure was placed at these points, perpendicular to the femur. Measurements were made on limbs of awake dogs prior to clipping and after clipping prior to surgery (and 2-weeks post-op) and with the stifle fully flexed, fully extended, and at an estimated functional standing angle while the tarsus was allowed to move passively during positioning. This also tested the effect of sedation.



FIGURE 1 | A Gulick II measuring tape was used to determine thigh girth. The tape was placed around the limb with a consistent amount of end-tension placed on the tissues minimizing differences in the amount of tension after the tape was pulled. The tape measure was pulled taut until one of the red balls was completely exposed (4 oz. of end tension).

Results: A total of 1,200 measurements were performed by both observers.

- Clipping the hair didn't significantly change measurements, however mean thigh girth was 7 and 3mm less in clipped limbs at the 50 and 70% TL locations, respectively, compared to the unclipped limbs.
- Although there was little difference between flexion of the stifle and placement of the limb in an estimated functional standing position, full extension of the stifle resulted in significantly less thigh girth.
- Sedation had little effect on thigh girth in the standing and extended positions for both thigh length sites. However, there was a trend for decreased thigh girth of sedated dogs with the limb in the flexed position.
- Significant decreases in thigh girth were seen 2-weeks after surgery in all stifle positions at both measurement sites, which ranged from 2.5 cm for the 70% thigh length with the limb extended to 3.8 cm for the 50% thigh length with the limb in a standing position.
- The best measurement correlations between observers was with measuring the 70% thigh length, with the stifle extended. Further more, it was suggested the the dog be positioned in lateral recumbency, relaxed or under sedation.
- There was significant reliability between observers following training at both the 50 and 70% TL in the extended stifle position groups.

Laurie's thoughts: So, unlike the previous study (or the one coming up), this study did find inter-rater reliability. Great! However sedated side lying dogs are not always what we see in clinical practice! That being said, what is important here is likely the position of the leg and consistency in where to measure. This study also highlights what I find clinically, that dogs lose muscle mass immediately after surgery.. which again highlights the use of Thigh Circumference as a useful short-term post-op outcome measurement.

FACTORS INFLUENCING THIGH CIRCUMFERENCE MEASUREMENTS

Bascuñán, A. L., Kieves, N., Goh, C., Hart, J., Regier, P., Rao, S., Foster, S., Palmer, R., & Duerr, F. M. Evaluation of Factors Influencing Thigh Circumference Measurement in Dogs. *Veterinary Evidence*, 1(2) 2016.

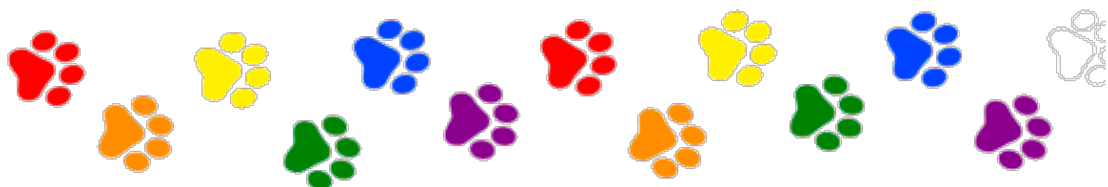
Introduction: Potential variables of hair coat length, variation in the site of measurement due to a lack of clearly identifiable landmarks on the limb, limb position, and dog movement, and their impacts on thigh circumference measurements are evaluated in this study. A laser device was used to guide placement of the measuring tape across the fixed thigh of cadaveric models that measured pre- and post-hair clipping.

Materials and Methods: This study was performed in two phases: First, to evaluate the effect of hair coat length across a range of muscle masses and to determine the inter- and intra-observer variability of thigh circumference (TC) measurement under constant conditions. Cadaver models were used in the first phase of the study. Second, to evaluate the effect of laser guidance on TC measurement, live dogs were measured with and without a device that projects a laser line across the canine limb.

Findings:

- The authors found there to be a significant difference in TC measurements of the same limb with and without hair coat, therefore evaluation of TC following therapeutic intervention should take into account clipping status of hair coat at the time of measurement. Inter-observer variability did not improve with clipping of the hair coat however.
- Inter-observer variability in TC measurement when all levels on the cadaver models were combined was 2.26 ± 1.18 cm. Intra-observer variability in TC measurement for all 4 observers when all levels were combined was 0.90 ± 0.61 cm.
- They also found that the use of a laser-guidance system nominally improves inter-observer variability for TC measurements. However, there was still significant differences between observer measurements both with or without the laser-guidance system.

Laurie's thoughts: Well, this study tells us that we might as well throw our tape measures in the garbage. I don't actually believe that however. So I would put a bit more faith into the previous studies that discuss how to position the leg for best reliability, and the need for consistent practice and technique in order to be reliable.



Measuring Limb Circumference with Different Devices

Baker SG, Roush JK, Unis MD, Wodiske T. Comparison of four commercial devices to measure limb circumference in dogs. Vet Comp Orthop Traumatol. 2010;23(6):406-10.

Purpose: The purpose of this study was to compare interobserver and intraobserver variability when measuring the circumference of canine limbs at four locations with four types of tape measures.

Materials & Methods: 5 intact male dogs from the humane society were used. The left and right forelimbs and hindlimbs were measured by three individuals at four locations: Circumference of mid-thigh (MT), tibial tuberosity (TT), hock (HO) and carpus (CA). The MT location was determined by estimating half of the distance between the greater trochanter and the lateral femoral condyle. The TT location was at the proximal aspect of the tibial crest. The HO location was at the plantar aspect of the calcaneus. All measurements were taken with the limb in functional standing position. The CA measurement was taken with the antebrachium in full extension at the level of the radiocarpal joint. Each observer with varying levels of experience performed the measurements in triplicate with each of the measuring devices at different times, independent of each other.

What did they use?

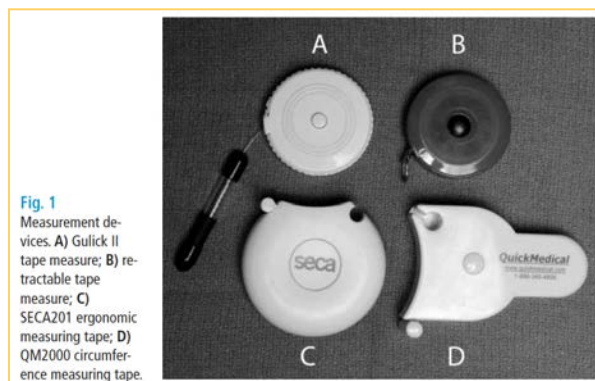
A Gulick II (GUL), The Retractable Tape Measure (RTM), The SECA201 ergonomic tape measure, and QM2000 circumference tape measure.

Results: Well, they reported all sorts of oddities between observers. (*Which we've come to expect*).

When observer measurements were combined, measurements with SECA and QM at all sites were significantly larger than with GUL and RTM. Intraobserver variation was greater for all devices at the MT and HO sites versus the TT and CA sites. The intraobserver variation of SECA was significantly greater than GUL at the TT site. Interobserver variation was greater for all devices at the MT, TT, and HO sites versus the CA site. The interobserver variation of QM was significantly greater than SECA at TT. The interobserver variation of QM was significantly greater than both GUL and RTM at HO, and the interobserver variation of SECA was significantly greater than RTM at HO.

Conclusion: Some interobserver variation was demonstrated, so we recommend that measurements be performed by the same individual for each patient if possible. Consistency can be achieved if the individual is familiar with the operation of the chosen measurement device, with the patient positioned similarly for each measurement session.

Laurie's thoughts: *Since you don't 'pull' on the SECA or QM, I'm not surprised that those measurement were larger. I think what should be most important is intrarater/observer reliability. Use what you have and what works in your hands. Practice to get consistent. I like that this study shows some degree of reliability for tools other than the Gulick II - it's so darned expensive for just a little tape measure!!*





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