FOUR LEG NEWS

Outcome Measures

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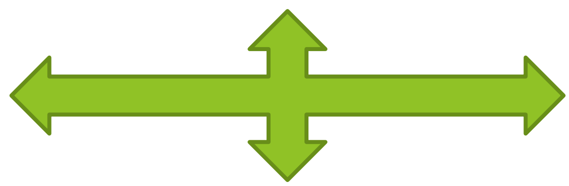
Weight Bearing Measurements



VOLUME 9 / ISSUE 3

May – June 2020

Hey Gang!

So, in continuing on along the Objective Measurements Theme, this issue is about Stance Analysis. I think you'll find the information useful and interesting. One thing I like about stance analysis is that it is an objective measure that can be utilized in clinical practice. Check out the article about the use of bathroom scales! That is a very 'do-able' weight bearing measure! The Stance Analyzer used in many of the research papers is a bit more 'high end' of a unit, but within reach of a clinician (especially as compared to force plate or gait analysis devices). I hope you enjoy the read!

Cheers! Laurie

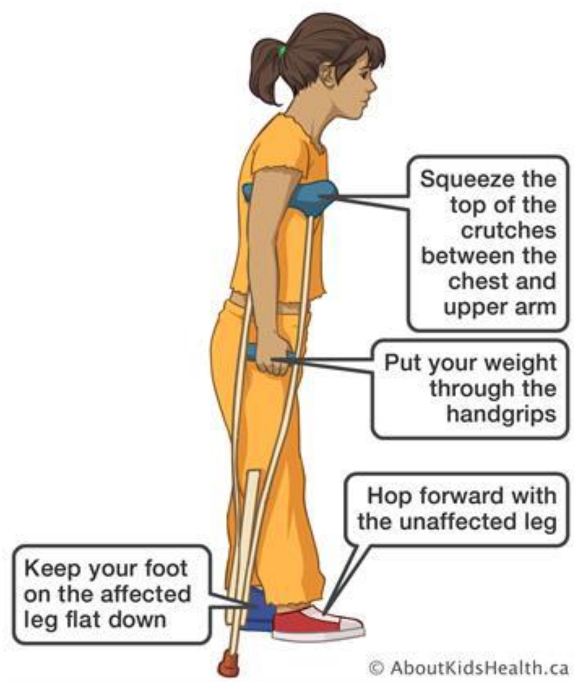
INTRODUCTION

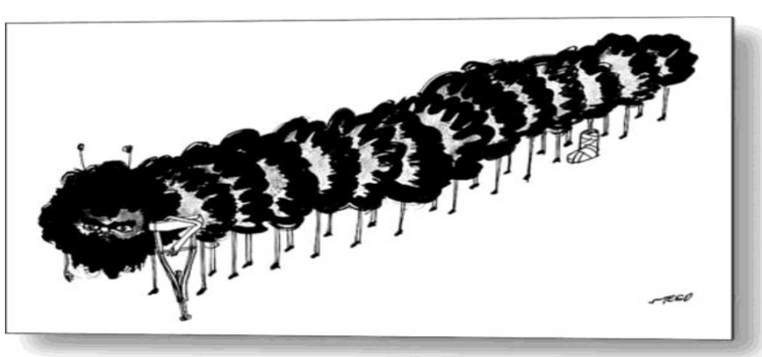
Thompson SG, Phillip R D, Roberts A. How do orthopaedic surgeons and rehabilitation professionals interpret and assess ‘toe touch’ weight bearing and ‘partial’ weight bearing status in the rehabilitation setting? BMJ Open Sport & Exercise Medicine 2018;4:e000326

Over time, limited mobility has a negative effect on healing of bone and soft tissues; so, a return to normal activity is ideal to avoid atrophy. There are various terms used by human orthopaedic surgeons as they prescribe an increase in weight-bearing status in increments; non-weight bearing, toe touch weight bearing (TTWB), flat foot feather touch weight bearing, egg shell weight bearing, partial weight bearing (PWB) and full weight bearing. Patient understanding of the terms also varies.

Different methods used to educate and assess the ability to repeat a weight-bearing status have included bathroom scales, force plates, insole measuring pressure devices, limb load monitors and biofeedback.

Two patients could have very different rehabilitation pathways if prescribed TTWB and PWB dependent on the interpretation of the healthcare professional prescribing the weight bearing status and the understanding of the professionals delivering the rehabilitation; as well as the understanding of the patient in the terms used. The findings of Thompson et al (2018) demonstrate that when static weighing scales were used to demonstrate weight-bearing status, the force applied was significantly lower than what was prescribed. The reason for the mismatch could be because static measures are very different to dynamic, or because people underestimate the weight. So, if scales are used, loading practice is encouraged to reassure and educate how much force can be put on the limb.





In the veterinary setting, the use of weight bearing (WB) measurement devices is usually utilized as an outcome measure as opposed to an educational measure (i.e. How much weight is the dog putting through the leg versus teach the dog to put 10% of its weight through its left hind leg.) The following research articles touch on the use of WB measurement devices in clinical research.

USE OF WB MEASUREMENT DEVICES IN VETERINARY RESEARCH:

Lascelles et al (2010) measured **standing body weight distribution** on a pressure sensitive walkway to determine that a cementless total hip replacement in dogs resulted in normal percentage body weight distribution to the operated limb by 3-months post-surgery.

Trisciuzzi et al (2019) assessed the Tibial Tuberosity Advancement (TTA) surgical technique with a series of outcome measurements including **baropodometric measurements** (Pet Safe Stance Analyzer). Using the analysis of load distribution on the pressure sensitive pad, body weight distribution was studied to identify a loss of load bearing. They were able to show that more than 80% of patients presented positive clinical results after 15 days of follow-up.

Wilson et al (2018) compared the effect of surgeon and tibial plateau levelling osteotomy (TPLO) procedure variations on the outcome of TPLO in naturally occurring cranial cruciate ligament disease by reviewing records from 142 dogs. The primary outcome measure was **static force** on the affected limb at re-evaluation on a PetSafe Stance Analyzer. The researchers were able to show improvement on the affected limb at 6- to 12-weeks re-evaluation.

Cole et al (2017) evaluated the effect of limb amputation on weight distribution to the remaining three limbs in 20 dogs. Ten dogs had a forelimb amputation and ten dogs had a hindlimb amputation; all had no history of orthopaedic or neural disease in the remaining three limbs. **Standing weight bearing** was evaluated with a commercial stance analyzer which showed that the dogs in both groups had the largest mean increase in weight bearing in the contralateral forelimb.

References:

- Lascelles BD, Freire M, Roe SC, DePuy V, Smith E, Marcellin-Little DJ. Evaluation of functional outcome after BFX total hip replacement using a pressure sensitive walkway. Vet Surg. 2010;39(1):71-77.
- Trisciuzzi R, Fracassi L, Martin HA, et al. 41 Cases of Treatment of Cranial Cruciate Ligament Rupture with Porous TTA: Three Years of Follow Up. Vet Sci. 2019;6(1):18.
- Wilson ML, Roush JK, Renberg WC. Comparison of the Effect of Dog, Surgeon and Surgical Procedure Variables on Improvement in Eight-Week Static Weight-Bearing following Tibial Plateau Levelling Osteotomy. Vet Comp Orthop Traumatol. 2018;31(6):396–404.
- Cole GL, Millis D. The effect of limb amputation on standing weight distribution in the remaining three limbs in dogs. Vet Comp Orthop Traumatol. 2017;30(1):59–61.

OUTCOME MEASURES OF CHOICE:

Hyytiäinen et al (2013) aimed to determine the most valid and sensitive physiotherapeutic evaluation methods for assessing functional capacity in hind limbs of dogs with stifle problems and to serve as a basis for developing an indexed test for this patient population.

The protocol consisted of 14 different evaluation methods: visual evaluation of lameness, visual evaluation of diagonal movement, visual evaluation of functional active range of motion and difference in thrust of hind limbs via functional tests, movement in stairs, evaluation of hind limb muscle atrophy, manual evaluation of hind limb static weight bearing, **quantitative measurement of static weight bearing of hind limbs with bathroom scales**, and passive range of motion of hind limb stifle and tarsal joints using a universal goniometer.

The results were compared with those from an orthopaedic examination, force plate analysis, radiographic evaluation, and a conclusive assessment. The results showed that evaluation of asymmetry in a sitting and lying position, assessment of muscle atrophy, manual **and measured static weight bearing**, and measurement of stifle passive range of motion were the most valid and sensitive physiotherapeutic evaluation methods.[6]

In 2018, the same researchers aimed at developing a quantitative testing battery for dogs' stifle functionality which summed up compensation in sitting and lying positions, symmetry of thrust in hindlimbs when rising from lying and sitting, **static weight bearing**, stifle flexion and extension and muscle mass symmetry, into the Finnish Canine Stifle Index (FCSI).

Sensitivities and specificities of the FCSI score were calculated against orthopaedic examination, radiological and force platform analysis and a conclusive assessment. In comparison to the conclusive assessment, the sensitivity and specificity of the FCSI were 90 per cent and 90.5 per cent, respectively. An estimate of the surgically treated and control dogs' FCSI scores were 105 and 20, respectively; showing a significant difference.[7]

- Hyytiäinen HK, Mölsä SH, Junnila JT, Laitinen-Vapaavuori OM, Hielm-Björkman AK. Ranking of physiotherapeutic evaluation methods as outcome measures of stifle functionality in dogs. Acta Vet Scand. 2013;55(1):29.
- Hyytiäinen HK, Mölsä SH, Junnila JJT, Laitinen-Vapaavuori OM, Hielm-Björkman AK. Developing a testing battery for measuring dogs' stifle functionality: the Finnish Canine Stifle Index (FCSI). Vet Rec. 2018;183(10):324.

VALIDITY / RELIABILITY:

Hyytiäinen HK, Mölsä SH, Junnila JT, Laitinen-Vapaavuori OM, Hielm-Björkman AK. Use of bathroom scales in measuring asymmetry of hindlimb static weight bearing in dogs with osteoarthritis. Vet Comp Orthop Traumatol. 2012;25(5):390–396.

Introduction: In this study, the research group evaluated the use of **bathroom scales** as a means to evaluate static weight bearing. Their rationale was that evaluation measures such as force plates analysis or pressure-sensitive walkway systems are expensive and take up too much time in clinical practice. This study aimed to assess the bathroom scale as a reliable and valid tool and develop guidelines on measuring static weight bearing in dogs with osteoarthritis (OA) in the hindlimbs.

Materials: The study used a control group of 21 healthy dogs with no known musculoskeletal problems, and a group of 43 dogs that had been surgically treated due to cranial cruciate ligament rupture within a
year and showed stifle OA with/without hip OA.

Methods: The *manual static weight bearing evaluation* was done by having the owner facing their dog and holding it in a square standing position while the examiner grasped each hindlimb around the metatarsal area and lifted one limb at a time to assess the resistance and weight bearing status.

The *quantitative measurement of static weight bearing* looked at distribution between hindlimbs by placing two calibrated bathroom scales under each hindlimb individually. The forelimbs were placed on a non-slippery platform at the same height as the scales. The owner of the dog held it in a straight standing position from the front. The examiner placed the hindlimbs onto the scales at the same time and recorded the measurements four times, with the scales reset each time.

Picture courtesy of Sabine Hárrer

A complete orthopaedic examination was also performed and dogs were grouped according to their findings. Gait analysis was done at the same time as the force platform analysis. Mediolateral and craniocaudal radiographs of both stifles and extended ventrodorsal radiographs from the hip joints bilaterally were taken of OA dogs under sedation. No radiographs were taken of the control group dogs. The conclusive assessment consisted of a veterinary surgeon's subjective final clinical assessment, based on signs of lameness and abnormalities from the orthopaedic examination, OA changes in the stifle and hip joints from radiographic examination, and hindlimb asymmetry from force plate datas.

The repeatability of the bathroom scale measurements was calculated by comparing a dog with its group, as well as calculated for affected and unaffected limbs within the OA group. The dogs were of different breeds and sizes so their weight was converted to percentages proportional to the total weight.

Results: The researchers used a set limit for normal difference in static weight bearing to be 3.3% +/- 2.7%.

The sensitivity of static weight bearing measurements using bathroom scales was 39% and specificity 85%. The repeatability of the static weight bearing measurements was 76% for all dogs, 61% for control group dogs, and 79% for OA dogs. The overall repeatability was 66% in the right, and 56% in the left hindlimb of the control dogs.

According to the conclusive assessment of OA dogs, the repeatability of the measurement was 74% and 83% for dogs with unilateral and bilateral hindlimb findings, respectively. Furthermore, with the OA dogs, the repeatability was 81% with the affected and 70% with the unaffected limbs.

As a side note, the manual evaluation of the hind limbs (i.e. subjective determination based on manually lifting the limb) didn't fair very well when compared against the objective data.

Conclusions: Manual assessment of the difference in static weight bearing between the hindlimbs can be evaluated, but not accurately enough for clinical evaluation. There was variable agreement between the bathroom scales (static weight bearing) and the force platform (dynamic weight bearing) and the authors concluded that both outcome measures are informative and of high interest to those evaluating functional outcome of the rehabilitation of dogs with OA. Furthermore, this study concluded that **bathroom scales can be used as a reliable, objective measurement tool** at minimal expense when measuring and evaluating the symmetry of static weight bearing in dogs with hindlimb OA.

Now you have a reason to love your bathroom scale!

VALIDITY / RELIABILITY:

Clough WT, Canapp SO. Assessing Clinical Relevance of Weight Distribution as Measured on a Stance Analyzer through Comparison with Lameness Determined on a Pressure Sensitive Walkway and Clinical Diagnosis. Vet Comp Orthop Traumatol 2018; 31(S 02): A1-A25

Introduction: In this study, Clough et al (2018) assessed the sensitivity of off-loading on a **stance analyzer (SA)** and its correlation with lameness as measured on a pressure sensitive walkway (PSW). The results were also compared with the clinical diagnosis determined at surgery.

Methods: 50 medium to large breed dogs were included in the study; 28 had hindlimb orthopaedic disease and 22 had forelimb orthopaedic disease. Orthopaedic diagnosis included physical examination, radiology, gait analysis of weight bearing and stride length, musculoskeletal ultrasound and operative findings. The total pressure index (TPI) was used to determine lameness on the PSW at a normal walking gait.

Following data collection on the PSW, each patient was encouraged to stand on the weight distribution platform. Normal weight distribution was considered 30/30/20/20 (forelimbs/hindlimbs) with a TPI standard deviation (SD) of 2% and a SA SD of 5%. Detection of limb off-loading was statistically compared with objective gait analysis and clinical diagnosis.

Results: The results of this study showed that the PSW identified 36 dogs as objectively lame (OL); 21 dogs with hindlimb orthopaedic disease and 15 dogs with forelimb orthopaedic disease. When compared with the OL group, the SA had an 85% sensitivity and 60% specificity. The positive predictive value (PPV) was 89%, and the negative predictive value was 50%. When compared with the entire study population, the SA had a sensitivity of 76%.

Conclusion: Studies utilizing the weight distribution platform to monitor response to treatment would be clinically valuable and useful for establishing research standards.

VALIDITY / RELIABILITY:

Wilson ML, Roush JK, Renberg WC. Single-day and multiday repeatability of stance analysis results for dogs with hind limb lameness. Am J Vet Res. 2019;80(4):403–409.

Introduction: Wilson et al (2019) aimed to assess single-day and multiday repeatability of data obtained with a **weight distribution analyzer** during stance in dogs with naturally occurring hind limb lameness. Body weight (BW) on each limb can be assessed at time points throughout the rehabilitation program. Static stance analysis eliminates the motion variables associated with force plate gait analysis; however, there is potential for limitations such as influence by the handler or other environmental factors.

Methods: In this study, two trials were performed; single-day trials with fifteen medium to large breed dogs, and multi-day trials with thirty-one small to large breed dogs. During each trial, five to 10 valid measurements/limb were collected over a 30-second period and the mean distribution of weight on each limb was calculated as well as the BW. The dog was then walked out of the room and returned immediately for 4 additional 30-second trials, each at 2-minute intervals, for a total of 5 trials/dog. The multi-day trial repeated the process on the following day. The data analysis was done by using symmetry indices (SI) to show weight load measured as percentage of BW on the affected limb and contralateral limb. A SI of 0 shows symmetry. This was compared with body weight and weight distribution on each limb among trials and between days. The repeatability of measurements was also assessed.

Results: The results of the single-day trial showed that there were no significant differences among trials for BW or for weight load distribution on any of the limbs. The forelimb SI did not differ significantly; however, the hind limb SI varied, with the mean hind limb SI of trial 2 and trial 4 lower than that of trial 3. In single-day trials, BW, weight distribution on the lame hind limb and contralateral hind limb, and hind limb SI were each significantly correlated. In multiday trials, BW results were similar; weight distribution on the lame hind limb and contralateral hind limb and hind limb SI were less but still significantly correlated between days. The LCCCs (agreement) were highest for BW, weight distribution on the contralateral hind limb, and hind limb SI in single-day trials and for BW and weight bearing on the contralateral and lame hind limbs in multiday trials. This is likely due to more day-to-day and moment-to-moment variations in redistribution of weight bearing and head position by individual dogs with hind limb lameness.

Dogs in the multiday trial had a slight but non-significant increase in weight distribution on the lame hind limb from days 1 to 2; most likely due to increased sensitivity in detection of these changes. Stance analysis also produced consistent measurements for weight distribution on the lame hind limb and contralateral hind limb during repeated trials on the same day.

Conclusions: The authors concluded that the analyzer used allowed for repeatable measurement of BW and weight distribution on the hind limbs of dogs with hind limb lameness. Measurement of forelimb stance variables was not repeatable in this group of dogs.

VALIDITY / RELIABILITY:

Phelps HA, Ramos V, Shires PK, Werre SR. The effect of measurement method on static weight distribution to all legs in dogs using the Quadruped Biofeedback System. Vet Comp Orthop Traumatol 2007; 20: 108-112.

Introduction: Phelps et al (2007) aimed to assess the effects of confinement, location, and local environment on the measurement of static quadruped load distribution as measured by **the Quadruped Biofeedback System (QBS)** in normal dogs. The QBS consists of four sensor pads and a laptop that allows for simultaneous measurement of load distribution in relation to total body weight.

Data collection in the form of mean load per extremity was recorded four times in five positions for a total of 20 measurements for each limb. Analysis of variance was used to test for effects of treatment and front or hind end location as well as their interactions. Right vs. Left for each end was also compared. The effects studied were enclosure, location, and position of the handler. Measurements were taken from 20 healthy adult dogs with no obvious lameness at the time of data collection; however, 5 dogs had history of lameness. A clear Plexiglas box was constructed in order to reduce stress from handler restraint and reduce movements during measurements. Partitions were added for smaller dogs.

The sequence of the treatments was assigned randomly and included five positions:
(A): Out of the box in the centre of the room with its head in a neutral position
(B): In the box on a scale with the left side against a wall with its head in a neutral position
(C): Same as B but with a treat held above the dog's head
(D): In the box in the centre of the room with its head in a neutral position without the scale
(E): Out of the box with the mat and pads near a wall on the left side with the dog's head in a neutral position
Note: The handler was at the dog's shoulder on the right side for B, C, and E; and on the left side for A and D.

Results: The results showed that for positions A and D, dogs tended to lean towards the handler in the front and away in the hind end; with a significant difference seen in the right and left measurements in the front but not in the hind end. In the other positions, the dogs tended to lean towards the wall in both ends. Positions B and C showed a significant difference between the right and left measurements in the hind but not the front end. Position E did not show a significant difference between front or hind ends, although it did show a tendency to lean towards the wall.

Treatment	End	Mean % Difference Between Sides	P-value	95% Confidence Limits	
				Lower	Upper
a	Front	6.17	<0.0001*	3.64	8.70
	Rear	–1.02	0.4286	–3.55	1.51
b	Front	1.89	0.1418	–0.64	4.42
	Rear	5.47	<0.0001*	2.94	8.02
c	Front	2.58	0.0458	0.05	5.10
	Rear	4.37	0.0007*	1.84	6.90
d	Front	4.09	0.0016*	1.57	6.62
	Rear	–2.82	0.0290	–5.37	–0.29
e	Front	2.58	0.0457	0.05	5.11
	Rear	2.76	0.0324	0.23	5.29

All P-values denoted with an asterisk *denote statistically significant data results.

Table 1
Effects of method by end with average percent difference between right and left sides, with negative values denoting a greater difference toward the right side of the dog. P-values were calculated for the effect of right versus left within each end with correction for random effects including session, period, dog and dog by end.

Discussion: The authors found the QBS simple to use and most of the dogs tolerated it with little handling for the twenty second duration of data collection. The study was held in a quiet room with only the handler and data collector present, which is recommended in a clinical setting. Analysis by front or hind end suggests that measurements were affected in similar manners; showing that enclosure, location, and handler position should be taken into consideration. Intra-treatment variation analysis showed that *Position A, no box in the centre of the room with the dog's head held neutrally, was the most consistent.* However, handler position does have an effect on the front end; with a low confidence interval. The authors noticed that position E, out of the box on the scale near a wall, had the least variation between right and left measurements, but had more variation between front and hind ends, with a low confidence interval. Since both positions A and E were outside of the box, this shows the lack of benefit of enclosures. Each method demonstrated consistency in measurement without any significant influence by day or session, suggesting that one standardized method be established for measurement throughout the treatment period.

Conclusion: The authors concluded that with standardization, the Quadruped Biofeedback System has potential use as a reliable instrument for the static measurement of quadruped load distribution in dogs.

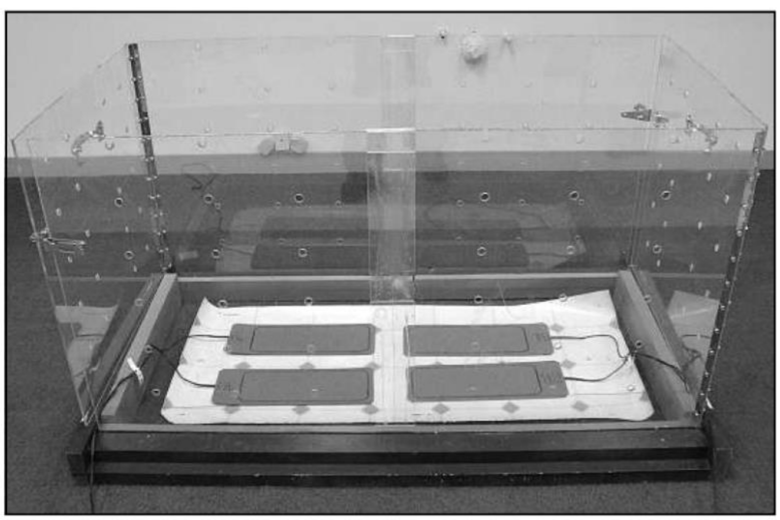


Fig. 1
Depiction of enclosure and pads used for data collection by the QBS.

Helpful Definitions:

SENSITIVITY versus **SPECIFICITY**
In medical diagnosis, test sensitivity is the ability of a test to correctly identify those with the disease (true positive rate), whereas test specificity is the ability of the test to correctly identify those without the disease (true negative rate).

https://en.wikipedia.org/wiki/Sensitivity_and_specificity

RELIABILITY
In simple terms, research reliability is the degree to which research method produces stable and consistent results. A specific measure is considered to be reliable if its application on the same object of measurement number of times produces the same results.

https://research-methodology.net/research-methodology/reliability-validity-and-repeatability/research-reliability/

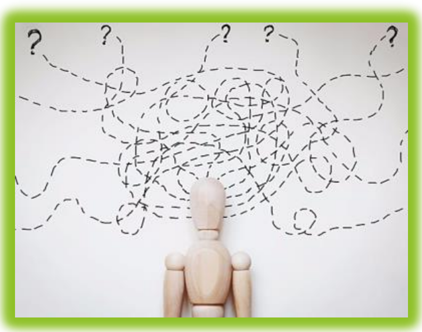
REPEATABILITY
repeatability measures the variation in measurements taken by a single instrument or person under the same conditions, while reproducibility measures whether an entire study or experiment can be reproduced in its entirety.

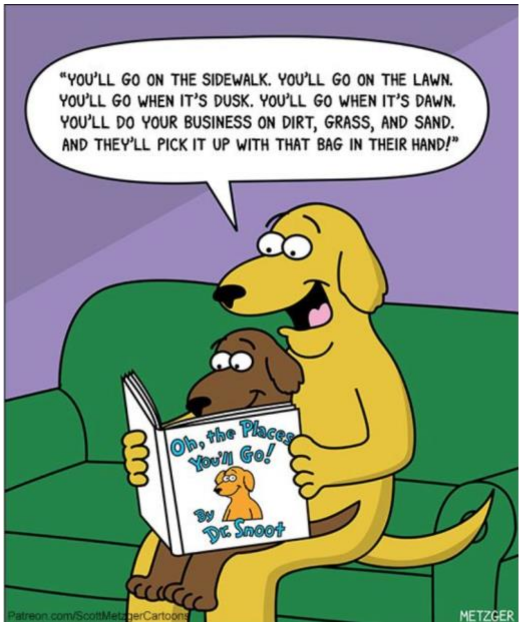
https://www.labmate-online.com/news/news-and-views/5/breaking-news/what-is-the-difference-between-repeatability-and-reproducibility/30638

VARIABILITY

Variability, almost by definition, is the extent to which data points in a statistical distribution or data set diverge—vary—from the average value, as well as the extent to which these data points differ from each other.

https://www.investopedia.com/terms/v/variability.asp





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