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# Simple Video-Based Spatiotemporal Gait Analysis Is Not Better than Subjective Visual Assessment of Lameness in Dogs

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## Abstract

**Introduction** Visual gait analysis is prone to subjectivity, but objective analysis systems are not widely available to clinicians. Simple video analysis using high-definition recordings might enable identification of temporal or spatial variations that could permit objective and repeatable assessments of lameness in general practice.

**Methods** Cohorts of normal and mildly to moderately lame dogs were filmed using a standardized protocol. Using freely available software, measurements of stance, swing and stride time were obtained, along with measurements of pelvic, shoulder, and head height for each limb. Symmetry ratios were calculated, and distributions of normal and lame dogs compared using Mann–Whitney U test and Kruskal–Wallis test.

**Results** Recordings from 35 normal dogs were assessed along with 30 dogs with grade 1 to 3/5 lameness. While no consistent significant differences in temporal characteristics could be found, head height asymmetry was significantly different between lame and normal dogs ($p = 0.003$), with pairwise comparison showing this difference was restricted to forelimb-lame dogs ($p = 0.03$).

**Conclusion** While potentially useful for patient records, use of video recordings at walking speeds for simple spatiotemporal gait analysis does not appear to offer clinically significant advantages over visual gait analysis in a typical clinical population of lame dogs.

**Keywords**
► lameness evaluations
► kinematic
► osteoarthritis
► dogs

## Introduction

Lameness is a common clinical presentation in both general and specialized small animal veterinary practices. Apart from simple and/or self-limiting conditions, lameness due to osteoarthritis occurs frequently[1–3] and usually requires long-term management, such as analgesics and lifestyle changes.[4] The clinical diagnosis can be made and treatment response assessed with the aid of visual gait analysis using numerical rating scales.[5] However, these are subjective, vary between observers and time points, making accurate assessments of improvement or deterioration in lameness over time difficult: agreement with objective analyses is generally poor, especially for low-grade lameness.[6,7] Consistently grading lameness severity between clinic visits, and between veterinarians in larger clinics, is therefore challenging and potentially compromises assessment of response to treatment, particularly with lower grades of lameness for which visual cues are less dramatic.

While lameness severity can be assessed objectively using kinetic systems such as force-plates, pressure sensitive mats and treadmills,[8] these are not widely available outside research or referral settings. Kinematic gait analysis using marker-based motion capture systems can also be used to

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objectively evaluate body movement,[8] and measurements of head and pelvis movement can effectively identify gait asymmetry in induced-lameness models.[9,10] However, kinematic facilities also require dedicated space and equipment.

Most clinicians have access to high-quality video recording capabilities in the form of a smartphone: alternatively, dedicated video cameras can be purchased cheaply. Video recording enables comparisons across time points and video manipulation (looping, slow motion) can assist in visualizing subtle gait changes. However, these characterizations remain subjective. Standardization of recording protocols and use of simple, readily available programmes for video and image analysis might improve objectivity of video-based lameness evaluations. In particular, changes in spatial characteristics (such as head or pelvic movements between different limb stance phases) or temporal characteristics (to compare stance or swing times for paired limbs) might provide useful measures of severity for dogs with lameness.

The aim of this study was to assess the discrimination ability of simple spatial and temporal gait characteristics measured from video recordings in lameness-free dogs and a general population of lame dogs, as a low-cost tool for objective gait analysis and monitoring in practice.

## Methods

Approval for this study was obtained from the institutional ethics committee. Cohorts of lameness-free and lame dogs were recruited via social media appeals, local clinics and the university small animal hospital. Written owner consent was obtained for inclusion.

Dogs were classified into their groups (presence/absence of lameness, forelimb vs. hindlimb lameness) based on reported history, thorough clinical and orthopaedic examination and visual gait assessment by an experienced clinician.

All dogs were walked at a target walking speed of 1 metre/second by an experienced handler, using a loose leash, across a pressure sensitive walkway, following acclimatization to the procedure and walkway. Video footage was obtained in high definition ($1920 \times 1080$ pixels) using a video camera on a tripod, set to shoulder height of the dog. The distance from the camera to the centre-line of the walkway was 2.2 m. Multiple recordings were obtained for each direction of travel, with a valid recording being one in which the dog did not pull at the leash or make overt head movements in response to the surroundings. Video recordings were subsequently exported to a computer (►**Video 1**).

**Video 1**

Sample video recording from this study showing a patient being walked on a loose leash across the pressure sensitive walkway. Online content including video sequences viewable at: https://www.thieme-connect.com/products/ejournals/html/10.1055/s-0041-1731437.

**Table 1** Visual lameness scoring system used to grade dogs in this study

| | |
|---|---|
| 0 | Normal (sound) |
| 1 | Mild lameness with minimal head/pelvic movements |
| 2 | Moderate lameness with normal stride length and partial weight bearing |
| 3 | Moderate lameness with reduced stride length and partial weight bearing |
| 4 | Severe lameness with minimal use of limb |
| 5 | Non-weight bearing lameness |

Two video recordings, one for each direction of travel, were selected for further analysis for each dog.

For the lame cohort, subjective gait analysis was performed by two observers viewing the two video recordings together and using a numerical scale (►**Table 1**). If the lameness score differed between recordings, the highest score obtained was used.

### Temporal Analysis

Recordings were analysed using freely available software (Media Player Classic Home Cinema for Windows v.10.0). Frame-by-frame stepping was used to identify duration of the stance and swing phases for each paw as previously described,[11] using timestamps from the software. Recordings were analysed at 50 frames per second. Data were averaged across both directions of travel. Symmetry indices comparing left-right, fore-hind and diagonal limb pairs were calculated using spreadsheet software, using both a simple ratio (e.g. left/right) and an index based on the ratio of the absolute difference and sum of two limbs' values,[12] calculated as:

$$\left|\frac{\mathrm{Limb}_1 - \mathrm{Limb}_2}{\mathrm{Limb}_1 + \mathrm{Limb}_2}\right| \cdot 100$$

### Spatial Analysis

Mid-stance still images for each limb were exported from recordings in both directions of travel. Mid-stance for the forelimb was defined as that frame in which the midline of the antebrachium was aligned perpendicularly to the ground, and for the hindlimb as that frame in which the front border of the paw and the highest point in the pelvic region were aligned vertically.[10,13]

Using the rectangle tool in ImageJ,[14] vertical distances were obtained in pixels for various anatomic landmarks (►**Fig. 1**). Shoulder height was defined as the distance between the base of the paw and the backline along a line extended vertically through the midline of the antebrachium. Head height was defined as the distance between the base of the paw and the highest point on the head (excluding the ears). Pelvic height was defined as the distance between the base of the paw and the highest point in the pelvic region.

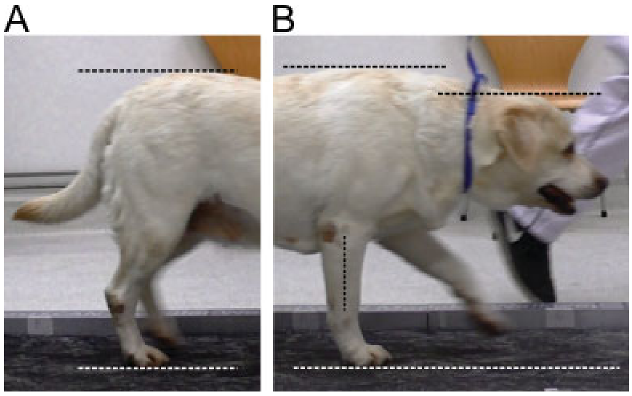


**Fig. 1** Spatial measurements. (**A**) Measurement of pelvic height at mid-stance. Pelvic height was defined as the distance between the dashed lines. (**B**) Measurement of head height and shoulder height relative to foot level at mid-stance, defined as vertical orientation of the antebrachium (dotted line). Measurements were made between the dashed lines. Measurements were averaged across both directions of travel to eliminate the effect of perspective on these values.

Data were averaged across both directions of travel. Symmetry indices comparing head height and pelvic height between left and right limbs were calculated using spreadsheet software, as before.

Measurements were repeated after 4 weeks for 20 randomly selected sound dogs and 13 lame dogs to assess measurement repeatability.

### Statistical Analysis

Statistical analysis was performed with commercial software (IBM SPSS Statistics for Windows, version 26, IBM Corp., Armonk, New York, United States). Index data were assessed for normality with the Shapiro–Wilk test and quantile-quantile plots. Indices for sound and all lame dogs were compared using the Mann–Whitney U test, and between sound and both forelimb and hindlimb lame dogs using the Kruskal–Wallis H-test with Bonferroni correction for multiple comparisons. When indicated, discriminant ability was tested using receiver operating characteristic curves. Significance was set at the 5% level.

Repeatability data were assessed for homoscedasticity graphically and with Koenker's test before evaluation using within-subject standard deviations (wsSD).[15]

## Results

Video recordings were obtained from 38 dogs clinically assessed to be sound. Pressure mat data for some of these dogs have been previously reported.[16] Data were excluded from three dogs due to missing/corrupted files (1 dog) and inability to extract hindlimb data (2 dogs). The mean age of the 35 dogs included in the analysis was 4 years, 1 month (SD: 15 months), mean weight was 27 kg (SD: 6.6 kg), and shoulder height was 54 cm (SD: 6.1 cm). Represented breeds included Labrador Retriever ($n = 10$), mixed breed ($n = 5$), Golden Retriever ($n = 4$), Border Collie ($n = 2$), Flat-Coated Retriever ($n = 2$), German Short-Haired Pointer ($n = 2$), and one each of Australian Kelpie, Australian Shepherd dog, Bernese Mountain dog, Cocker Spaniel, Dobermann, English Springer Spaniel, Gordon Setter, Staffordshire Bull Terrier, standard poodle, and Weimaraner.

Video recordings and pressure mat data were similarly obtained from 31 dogs with lameness. Pressure mat data for some of these dogs have been previously reported.[16] Data were excluded from one dog due to inability to extract hindlimb data. The mean age of the 30 dogs included in the analysis was 9 years, 1 month (SD: 32 months), mean weight was 34 kg (SD: 6.5 kg), and shoulder height was 55 cm (SD: 4.2 cm). Represented breeds included Labrador Retriever ($n = 13$), Golden Retriever ($n = 7$), German Shepherd Dog ($n = 3$), and one each of American Bulldog, American Staffordshire Bull Terrier, Rottweiler, Small Münsterländer, Whippet, Vizsla, and mixed breed.

The majority of the lame dogs had low-grade lameness (grade 1, $n = 18$; grade 2, $n = 8$; grade 3, $n = 4$). Sixteen had forelimb lameness, and 14 had hindlimb lameness. The majority of the lame dogs (23/30) were osteoarthritis patients (primarily elbow, hip, and/or phalangeal joints based on clinical history and previous radiography), along with two postoperative cruciate stabilization patients, and one each with bicipital tenosynovitis, medial glenohumeral ligament damage, and hindquarter myofascial pain.

Data for the indices based on absolute differences were not normally distributed and were reported as median values with interquartile ranges. Symmetry indices for the sound dogs are shown in ►**Table 2**. Minimal deviations from expected ideal values of 1 (simple ratios) or 0% (absolute differences) were observed. When lameness was present, simple ratio indices showed increased spread for temporal data and head height data, whereas for the absolute difference-based index only head height spread increased markedly (►**Figs. 2** and **3**, ►**Table 3**). More marked deviation from the reference intervals was noted for swing phase compared with stance phase. Visual analysis indicated that dogs falling outside the reference intervals generally had grade 2 or 3 lameness scores.

Apart from swing phase diagonals and the right-sided ipsilateral indices, no consistent pattern in significant differences between sound and lame dogs, either with or without exclusion of mild (grade 1) lameness, could be seen for the temporal indices (►**Table 4**).

For the spatial indices, only the distribution of the index based on absolute differences for head height had a significantly different distribution between sound and all lame dogs ($U = 749$, $p = 0.003$). Lameness grade significantly affected this index ($H(2) = 8.85$, $p = 0.012$). Forelimb lameness produced significantly greater index values compared with sound dogs ($z = -2.14$, adjusted $p = 0.027$) but hindlimb lameness index values did not differ significantly from either sound dogs or forelimb lameness values ($p = 0.1$, $p = 1$). The receiver-operating characteristic curve area for this index was 0.71 (95% confidence interval: 0.59; 0.84) indicating only fair performance. Using minimum distance to the left-upper corner for determining the optimum cut-off yielded a value of 0.63% (sensitivity 73%, specificity 60%).

Measurement repeatability for temporal indices was good, with wsSD in sound dogs for the stance phase ranging

**Table 2** Symmetry indices for spatial and temporal measures for the sound dogs in this study

| Index | | Simple ratio | Absolute differences |
|---|---|---|---|
| Spatial | Head L-R | 1.00 (SD: 0.02) | 0.45 (IQR: 0.20; 1.2) |
| | Shoulders L-R | 1.00 (SD: 0.01) | 0.31 (IQR: 0.14; 0.53) |
| | Pelvis L-R | 1.00 (SD: 0.01) | 0.33 (IQR: 0.12, 0.47) |
| Temporal (stance) | LF-RF | 1.00 (SD: 0.03) | 0.91 (IQR: 0.53; 1.36) |
| | LH-RH | 1.00 (SD: 0.03) | 0.90 (IQR: 0.55; 1.59) |
| | LF-LH | 1.01 (SD: 0.04) | 1.35 (IQR: 0.60; 2.32) |
| | RF-RH | 1.00 (SD: 0.03) | 1.06 (IQR: 0.46; 1.78) |
| | LF-RH | 1.00 (SD: 0.03) | 1.27 (IQR: 0.61; 2.00) |
| | RF-LH | 1.00 (SD: 0.04) | 1.15 (IQR: 0.29; 2.18 |
| Temporal (swing) | LF-RF | 0.99 (SD: 0.04) | 1.43 (IQR: 0.42; 2.21) |
| | LH-RH | 1.02 (SD: 0.06) | 1.80 (IQR: 0.80; 3.37) |
| | LF-LH | 0.95 (SD: 0.06) | 2.52 (IQR: 1.05; 4.22) |
| | RF-RH | 0.97 (SD: 0.06) | 2.28 (IQR: 1.02; 3.59) |
| | LF-RH | 0.97 (SD: 0.06) | 2.31 (IQR: 1.31; 4.06) |
| | RF-LH | 0.96 (SD: 0.07) | 3.14 (IQR: 2.11; 4.1) |

Note: Indices were calculated as simple ratios or based on absolute differences using the formula $\left|\frac{\mathrm{Limb}_1 - \mathrm{Limb}_2}{\mathrm{Limb}_1 + \mathrm{Limb}_2}\right| \cdot 100$ as previously described.[12] Spatial indices reference head or pelvic height, whereas temporal indices reference stance times. Data shown are means (SD—standard deviation) for simple ratio indices and medians (IQR—interquartile range) for absolute difference-based indices.
Abbreviations: F, forelimb; H, hindlimb; L, left; R, right.

**Table 3** Symmetry indices for spatial and temporal measures for the lame dogs in this study

| Index | | Simple ratios | Absolute differences |
|---|---|---|---|
| Spatial | Head L-R | 1.01 (SD: 0.06) | 1.20 (IQR: 0.61; 2.50) |
| | Shoulder L-R | 1.00 (SD: 0.01) | 0.30 (IQR: 0.09; 0.67) |
| | Pelvis L-R | 1.00 (SD: 0.01) | 0.27 (IQR: 0.09, 0.50) |
| Temporal (stance) | LF-RF | 1.00 (SD: 0.02) | 0.93 (IQR: 0.37; 1.17) |
| | LH-RH | 1.01 (SD: 0.04) | 0.69 (IQR: 0.50; 1.44) |
| | LF-LH | 0.99 (SD: 0.07) | 1.18 (IQR: 0.49; 2.24) |
| | RF-RH | 1.00 (SD: 0.07) | 1.01 (IQR: 0.65; 2.19) |
| | LF-RH | 1.00 (SD: 0.08) | 1.50 (IQR: 1.01; 2.49) |
| | RF-LH | 0.99 (SD: 0.07) | 1.26 (IQR: 0.57; 2.2) |
| Temporal (swing) | LF-RF | 1 (SD: 0.07) | 1.52 (IQR: 0.7; 3.32) |
| | LH-RH | 0.98 (SD: 0.07) | 1.98 (IQR: 0.97; 3.23) |
| | LF-LH | 0.96 (SD: 0.11) | 3.72 (IQR: 1.03; 6.65) |
| | RF-RH | 0.94 (SD: 0.08) | 4.42 (IQR: 2.3; 6.25) |
| | LF-RH | 0.94 (SD: 0.11) | 3.71 (IQR: 2.76; 8.21) |
| | RF-LH | 0.96 (SD: 0.11) | 4.41 (IQR: 1.91; 6.1) |

Note: Indices were calculated as simple ratios or based on absolute differences using the formula $\left|\frac{\mathrm{Limb}_1 - \mathrm{Limb}_2}{\mathrm{Limb}_1 + \mathrm{Limb}_2}\right| \cdot 100$ as previously described.[12] Spatial indices reference head or pelvic height, whereas temporal indices reference stance times. Data shown are means (SD—standard deviation) for simple ratio indices and medians (IQR—interquartile range) for absolute difference-based indices.
Abbreviations: F, forelimb; H, hindlimb; L, left; R, right.

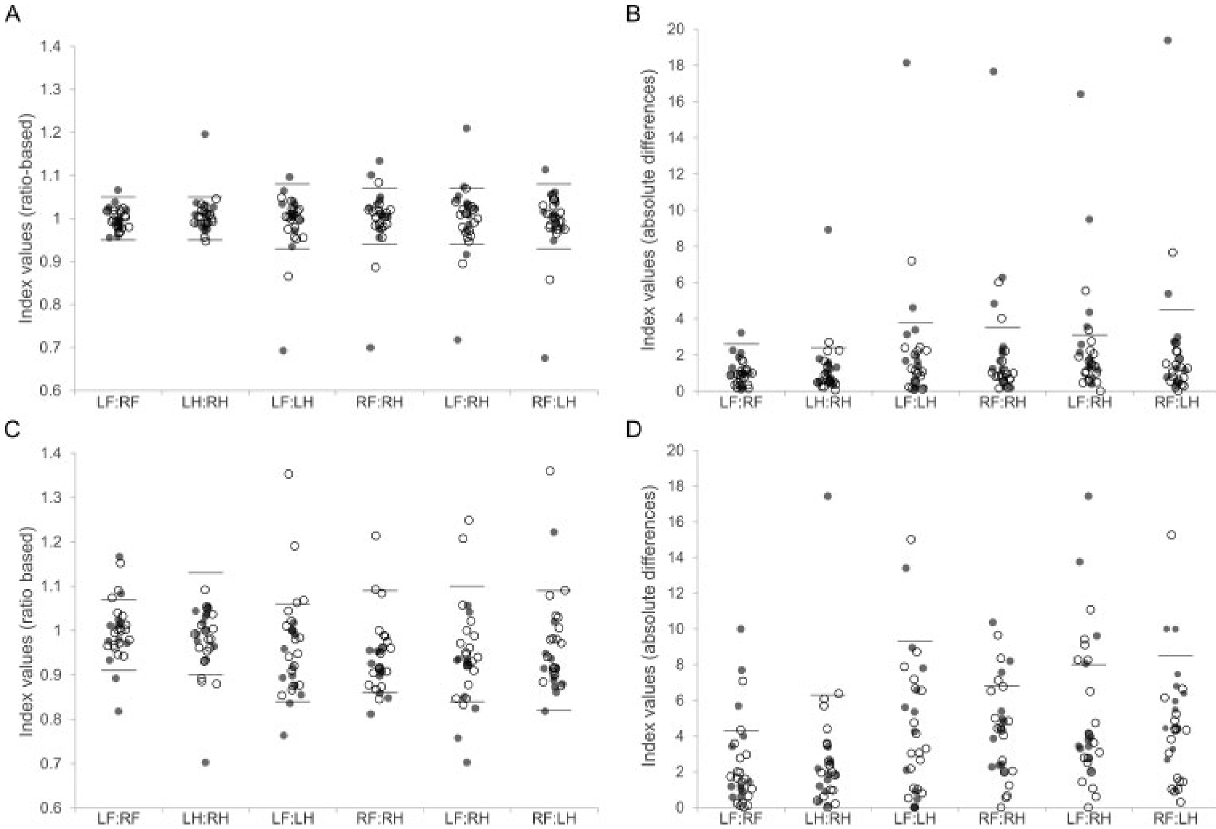


**Fig. 2** Temporal indices for 30 lame dogs. (**A**) Simple ratio indices based on stance time for limb pairs, calculated as limb1/limb2. (**B**) Ratios based on absolute differences of stance time, calculated as $\left|\frac{\mathrm{Limb}_1 - \mathrm{Limb}_2}{\mathrm{Limb}_1 + \mathrm{Limb}_2}\right| \cdot 100$ previously described.[12] (**C**) Simple ratio indices based on swing time limb pairs, calculated as limb1/limb2. (**D**) Ratios based on absolute differences of swing time, calculated as absolute value of $\left|\frac{\mathrm{Limb}_1 - \mathrm{Limb}_2}{\mathrm{Limb}_1 + \mathrm{Limb}_2}\right| \cdot 100$. F, forelimb; H, hindlimb; L, left; R, right. Horizontal bars represent two-sided (**A**, **C**) or one-sided (**B**, **D**) 95% confidence intervals, based on ratios calculated from 35 sound dogs. Empty markers indicate grade 1/5 lameness dogs, whereas shaded markers indicate dogs with grade 2 to 3/5 lameness, based on visual lameness assessments.

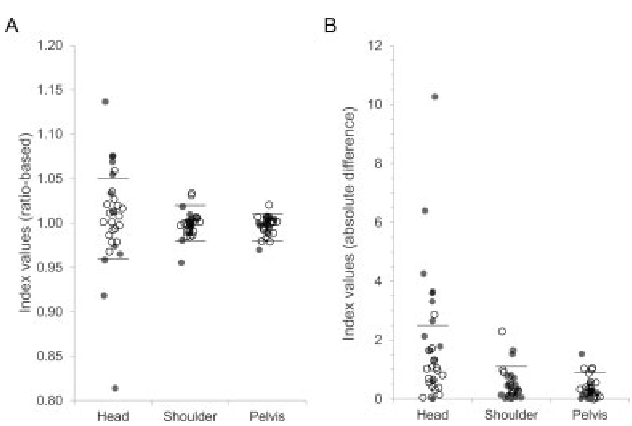


**Fig. 3** Spatial indices for 30 lame dogs. (**A**) Simple ratio indices based on limb pairs, calculated as limb1/limb2. (**B**) Ratios based on absolute differences, calculated as $\left|\frac{\mathrm{Limb}_1 - \mathrm{Limb}_2}{\mathrm{Limb}_1 + \mathrm{Limb}_2}\right| \cdot 100$ as previously described.[12] F, forelimb; H, hindlimb; L, left; R, right. Horizontal bars represent two-sided (**A**) or one-sided (**B**) 95% confidence intervals, based on ratios calculated from 35 sound dogs. Empty markers indicate grade 1/5 lameness dogs, whereas shaded markers indicate dogs with grade 2 to 3/5 lameness.

from 0.01 to 0.02 units for the ratio-based indices and from 0.3 to 0.7% for the absolute difference-based indices. Values for swing phase indices were higher at 0.03 to 0.04 units and 1.1 to 1.6% respectively. For lame dogs, wsSD values were similar, with stance phase repeatability of 0.01 units and 0.3 to 0.5% for ratio- and absolute difference–based indices, and swing phase repeatability of 0.01 to 0.03 units and 0.7 to 1.4% respectively. Measurement repeatability for spatial indices was also good with wsSD in sound dogs ranging from 0.005 to 0.01 units for the ratio-based indices and 0.1 to 0.4% for the absolute difference-based indices. In lame dogs, values ranged from 0.002 to 0.004 units and 0.1 to 0.2% respectively.

Mean time required for video recording of each dog was 7 minutes. Complete analysis of data took 29 minutes on average.

## Discussion

Simple video analysis of temporal gait parameters did not appear to be helpful in discrimination between sound and mildly to moderately lame dogs in this study population.

**Table 4** Overview of statistical testing of temporal symmetry indices in this study

| | | All lame dogs | | | Grade 1/5 lame excluded | | |
|---|---|---|---|---|---|---|---|
| | Index | Stride | Stance | Swing | Stride | Stance | Swing |
| Absolute difference-based indices | LF-RF | 0.58 | 0.91 | 0.42 | 0.63 | 0.34 | 0.25 |
| | LH-RH | 0.24 | 0.56 | 0.82 | 0.75 | 0.51 | 0.9 |
| | LF-LH | 0.6 | 0.71 | 0.16 | 0.53 | 0.57 | 0.34 |
| | RF-RH | 0.32 | 0.49 | **0.007** | 0.14 | 0.09 | **0.01** |
| | LF-RH | 0.54 | 0.15 | **0.01** | 0.68 | **0.04** | **0.009** |
| | RF-LH | 0.92 | 0.42 | 0.09 | **0.03** | 0.17 | **0.01** |
| Simple ratio-based indices | LF-RF | 0.81 | 0.49 | 0.56 | 0.94 | 0.94 | 0.85 |
| | LH-RH | 0.07 | 0.37 | 0.07 | 0.77 | 0.51 | 0.53 |
| | LF-LH | 0.94 | 0.7 | 0.97 | 0.81 | 0.78 | 0.19 |
| | RF-RH | 0.18 | 0.71 | **0.02** | 0.88 | 0.25 | **0.002** |
| | LF-RH | 0.26 | 0.92 | 0.09 | 0.86 | 0.29 | **0.03** |
| | RF-LH | 0.74 | 0.73 | 0.48 | 0.53 | 0.88 | **0.05** |

Note: Indices are sub-divided into stance, swing and stride phases and given as limb pairings under the index column. Simple ratio-based indices were calculated as $\text{limb}_1/\text{limb}_2$, whereas absolute difference-based indices were calculated as the absolute value of $\left|\frac{\text{Limb}_1 - \text{Limb}_2}{\text{Limb}_1 + \text{Limb}_2}\right|$ expressed as a percentage. *p*-Values are given for independent samples Mann–Whitney U tests comparing sound dogs with either all lame dogs or lame dogs with visual lameness scores greater than 1. Significant values (5% level) are highlighted in bold text.
Abbreviations: F, forelimb; H, hindlimb; L, left; R, right.

While forelimb lameness might be detectable using spatial measures from simple video recordings, sensitivity and specificity were poor.

Our normal population exhibited mild asymmetry, evidenced by the calculated reference intervals. Similar findings have been seen with both kinetic and kinematic studies, and may represent sub-clinical lameness, normal variation and mild shifts in weight bearing during ambulation. This inherent variability makes discrimination between normal and lame dogs with low-grade lameness difficult. Most grade 1/5 dogs were indistinguishable from the normal population, and there was considerable overlap even with the combined grade 2 to 3/5 group. Contributing factors could include that gait assessment was only performed for walking, or the known inaccuracy of visual gait analysis relative to objective methods of lameness assessment[6,7]; however, it seems that visual gait analysis incorporates more assessments (either consciously or subconsciously) than the limited objective measurements reported here.

Video-derived temporal parameters did not appear useful based on our results, with the possible exception of swing time indices. The short swing time relative to the stance time at the walking gait can result in relatively large changes in index values for similar absolute changes in duration.[17,18] Previous studies investigating temporal asymmetries with lameness due to hip and elbow osteoarthritis, hip dysplasia, and cranial cruciate ligament rupture have similarly failed to distinguish between lame and sound dogs,[19–22] although chronic cranial cruciate ligament rupture may result in significant stance time asymmetries.[23]

In contrast to previous studies using motion-capture or inertial sensors, we could not demonstrate clinically useful performance for lameness screening of symmetry indices related to head or pelvic height.[9,10,24] Superficially, both this study and the previous studies assessed similar grades of lameness. A key difference between this and the previous studies is that our patients had naturally occurring lameness, as opposed to induced swinging or supporting lameness in one limb at a time. Many of our patients were elderly, and likely had multiple joint problems, even if their lameness was worse in one limb. In addition, many of our patients could not reliably and repeatably be trotted for gait analysis, in contrast to the induced-lameness dogs. Trotting is generally recognized to produce more obvious signs of lameness than walking,[5] but for consistency between the normal and lame groups, we elected to examine the walking gait.

We cannot exclude that simple video analysis might be useful for monitoring of clinical patients with lameness confined to a known single joint or limb, and in which it is possible to obtain recordings at the trot, especially if the lameness is at least moderately severe. However, it would appear that the measurements described here are likely less useful for clinical screening or for longitudinal assessment of clinical patients with multiple osteoarthritic joints or complex lameness, especially if they struggle to trot. Compared with experimental situations or postoperative studies, many lame dogs presenting in general practice will have complex problems due to chronicity and compensatory responses within and outside the affected limb(s). Obtaining and processing the required video recordings were straightforward and the required in-clinic time was relatively short compared with other objective gait assessment tools.[8,25] While the actual analysis of the recordings may be considered time-consuming by clinicians, it could potentially be performed by non-veterinary staff with limited training requirements. Measurement repeatability appears to be good, even in lame dogs. Reproducibility and between visits variability were not assessed, due to the poor discriminant ability of the current measurements.

While we do not believe simple video gait analysis as described here is likely to be particularly useful in the clinical setting, longitudinal recordings of patients obtained in a standardized way (location, surface and speed) will probably represent a useful comparative tool in practice, given the ubiquity of recording equipment and the low cost of digital storage.

In conclusion, while potentially useful for patient records, use of video recordings at walking speeds for simple spatiotemporal gait analysis does not appear to offer advantages over visual gait analysis in a typical clinical population of lame dogs.

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Conflicts of Interest
The authors declare that they have no conflicts of interest.

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