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Weighting the relative importance of behaviors affecting gait score

Barbara Jones[1,2], I. Ching Tsai[3], Yu-Mei Chang[4] and Jeffrey Bewley[5]

[1]Tarleton State University, Animal Sciences and Veterinary Technology, Stephenville, Texas, USA; [2]Texas A&M AgriLife Research, Stephenville, Texas, USA; [3]DeLaval, Lansing, MI, USA; [4]Research Support Office, The Royal Veterinary College, London, UK and [5]CowFocused Solutions, Elizabethtown, KY, USA

Research Article

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Author for correspondence:
Barbara Jones, Email: bwjones@tarleton.edu

Abstract

This research communication evaluates experts' opinions on the importance and weights of six gait aspects. In 2016, a Qualtrics (Qualtrics LLC., Provo, Utah) survey was distributed to lameness experts. Six gait aspects – general symmetry, tracking, spine curvature, head bobbing, speed and abduction as well as adduction were included. Respondents were asked to rank the gait aspects from 1 (most important) to 6 (least important), and to indicate which weight each gait aspect should receive when assessing lameness. For each gait aspect, frequency (percentage %) was used to describe the distribution of rank, and medians as well as 25th and 75th percentiles were used to summarize assigned weights. Thirty-nine percent of respondents ranked general symmetry first, followed by 32% for tracking, and 19% ranked spine curvature third. Head bobbing ranked fourth with 10% whereas, speed, abduction and adduction were not ranked. The median, 25th and 75th percentiles weight for each gait aspect were: general symmetry (25, 15, and 30), tracking (20, 10, and 30), spine curvature (20, 10, and 21), head bobbing (15, 10, and 20), speed (10, 5, and 20), and abduction and adduction (10, 5, and 10). General symmetry and tracking were deemed the most important gait aspects. A composite gait score can be calculated based on weighted importance of different gait aspects to indicate possible lameness.

Lameness is recognized as an abnormal gait resulting from efforts to minimize pain. Lameness is the one of the greatest concerns regarding animal welfare in the dairy industry. Currently, the most common way to detect lameness is visual observation. However, the reliability of such observation is low (Eriksson *et al*., 2020) and cattle often mask their pain as they are prey animals, which leads to a delay in detection (O'Callaghan *et al*., 2003). Therefore, consistent gait scoring is important as gait scoring is used to assess the quality of cattle movement (Schlageter-Tello *et al*., 2014).

The first group to describe gait scoring was Manson and Leaver (1988). The authors used a 1−5 scoring system, in 0.5 increments, with score five denoting the poorest gait score. However, many different gait scoring systems exist making scoring difficult (Manson and Leaver, 1988; Sprecher *et al*., 1997; Flower and Weary, 2009). Schlageter-Tello *et al*. (2014) identified 25 different scoring systems in a review of 244 journal articles, further highlighting that the scientific community has no consensus for which scoring system to use. The same study reported that general symmetry was used as a gait scoring method in 17 different manuscripts of the 244 articles assessed, the greatest of any gait aspect. Similarly, the gait scoring system described by Sprecher *et al*. (1997) was mentioned in 69 papers, the greatest of any scoring system. This scoring system uses asymmetric gait, or more formally known, general symmetry, as an evaluated aspect. Tracking was used in five of the papers. The same study reported that 25 total gait aspects were determined in all articles assessed, implying many aspects are available to score lameness in cattle. Additionally, because many different systems exist, concern and confusion has arisen from so many different systems. Therefore, having a consistent scoring system would prove useful.

Many systems that use multiple gait aspects assign equal importance to all gait aspects when calculating final gait score (O'Callaghan *et al*., 2003; Olmos *et al*., 2009). How much weight should be assigned to each aspect is unclear (Eriksson *et al*., 2020). Therefore, the objective of this study was to first identify which gait aspects respondents deem most important and second to identify weights applied to individual gait aspects to calculate an overall final gait score from data collected in an expert opinion survey.

Materials and methods

Survey design

A two-question survey was developed using Qualtrics software (Qualtrics LLC., Provo, Utah; online Supplementary material). Online distribution was chosen for respondent convenience

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Table 1. The percentage of survey respondents ($n = 31$) ranking of each gait aspect 1 (most important) to 6 (least important)

	Importance (1 = most important, 6 = least important) Response (%)					
Gait aspect[a]	1	2	3	4	5	6
General symmetry	38.71	22.58	16.13	3.23	16.13	3.23
Speed	0	16.13	6.45	22.58	19.35	35.48
Head bobbing	9.68	12.90	35.48	12.90	22.58	6.45
Spine curvature	19.35	29.03	16.13	16.13	9.68	9.68
Tracking	32.26	19.35	16.13	19.35	6.45	6.45
Abduction/adduction	0	0	9.68	25.81	25.81	38.71

[a]Gait aspects were determined from Olmos *et al.* (2009).

and wide-reaching distribution. The survey was distributed *via* email on 22 February 2016 and again on 7 March 2016 to individuals deemed lameness experts by the first author ($n = 46$). The experts were selected based on (1) being a prominent figure with a lameness research program and having published research in scientific journal articles or (2) having presented research at the 2015 international scientific meeting '18th International Symposium and 10th International Conference on Lameness in Ruminants' conference held in Valdivia, Chile. The survey was closed on 21 March 2016.

The survey was developed to maintain respondent anonymity and the survey was purposefully short to enhance the response rate. Six different gait aspect scores to evaluate lameness (1 = sound cow, 5 = severely lame cow) described in Olmos *et al.* (2009) were used in this survey. Each individual gait aspect was defined in the survey correspondence when the survey was sent to respondents. This multiple gait aspect scoring system was purposefully chosen as this system encompasses a diverse range of gait aspects and not just one as other systems describe. The six individual gait aspects were general symmetry, tracking, spine curvature, head bobbing, speed, and abduction and adduction (online Supplementary Figure S1). General symmetry, or also known as asymmetric gait, is how evenly cows place weight on each leg as they walk. Tracking is the length between the anterior and posterior legs during the stride phase of walking. Spine curvature is the degree to which the spine arches during walking. Head bobbing is the pattern of the vertical head movement during walking. Speed is how freely and easily the cow walks. Abduction and adduction are the amount of left and right stride during the swing phase of walking (Olmos *et al.*, 2009). Respondents were asked to indicate relative rank (1 = most important, 6 = least important) and their weights of these six gait aspects when determining lameness. For determining weights, respondents were asked to assign a certain percentage for each aspect based on their expert opinion, the percentage summed for all gait aspects had to equal 100%.

Statistical analysis

For each gait aspect, frequency listed as a % was used to describe the distribution of rank. Medians, 25th and 75th percentiles were used to summarize assigned weights. Medians were chosen to summarize weights, because the distribution of the weights for each gait aspect was skewed, therefore, descriptive statistics such as medians, 25th and 75th percentiles were the most appropriate analytics. Statistical analyses to determine frequency and median, 25th and 75th percentiles were completed using SAS (Version 9.4, SAS Institute, Inc., Cary, NC).

Table 2. Median, 25th, and 75th percentile of weights applied to each gait aspect as determined *via* a lameness expert survey

Gait aspect[a]	Median	25th	75th
General symmetry	25	15	30
Speed	10	5	20
Head bobbing	15	10	20
Spine curvature	20	10	21
Tracking	20	10	30
Abduction/adduction	10	5	10

[a]Gait aspects were determined from Olmos *et al.* (2009).

Results and discussion

A response rate of 67% was observed ($n = 32$ individuals responded). One survey was discarded for incompleteness making the total response $n = 31$. Percentage rankings of gait aspects from 1 (most important) to 6 (least important) is displayed in Table 1. As a highlight, general symmetry was ranked first most frequently. The weights that 31 experts assigned to each of the 6 gait aspects are depicted in Figure S2, and the median, 25th, and 75th percentiles for each gait aspect that the experts assigned are displayed in Table 2. As a highlight, general symmetry was assigned the most weight.

Most notably, general symmetry and tracking were ranked first most frequently and received the greatest weights, emphasizing that experts deemed these two aspects as the most important. In contrast, abduction and adduction and speed received the lowest weight, respectively. Also, both were never ranked first, stressing that experts deemed these two aspects as the least important. These two aspects may be ranked lowest due to their being less objectively scored. Also, depending on when the two are scored during the day could change their score, as Flower *et al.* (2006) found differences in gait score when scoring before and after milking. Furthermore, abuction and adduction should be scored from behind the cow whereas the other gait attributes may be scored from the side of the cow. This makes abduction and adduction more problematic to score and thus viewed as being of least importance by survey respondents. Spine curvature was ranked third and head bobbing was ranked fourth. Both of

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these aspects are also less objectively scored and cows that have a curved spine may not be lame, but have abdominal pain (Thomsen, 2009). Chapinal *et al.* (2009) reported moderate to strong positive correlations among general symmetry, tracking and head bobbing, and weak to moderate negative correlations between speed and all other aspects. The inter-correlations among these gait characteristics may have contributed to the slight discrepancies among experts' opinions regarding the most important gait aspects and their weights. Respondents were located worldwide. One of the pitfalls of this survey is that country of origin was not asked of respondents. Country-by-country opinions of lameness may differ. However, because country of origin was not asked, this survey is not able to distinguish the difference.

There is a lack of consensus in the literature regarding the best choices of visual locomotion scoring systems, and a review carried out by Schlageter-Tello *et al.* (2014) suggested that observers often assign importance based on their own beliefs and values. A composite gait score that accommodates these experts weighted importance to reflect lameness is potentially a better system than treating these gait aspects equally. General symmetry, tracking, and spine curvature, received the greatest percentage of weight, and recall that general symmetry and tracking were ranked the two highest in importance, respectively. A composite gait score can be calculated based on weighted importance of different gait aspects to indicate possible lameness. Although the composite score can now be used to indicate lameness, no further research has yet been conducted to evaluate if the aggregate score improves diagnosis of lameness.

Supplementary material. The supplementary material for this article can be found at https://doi.org/10.1017/S0022029922000206.

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