Original Article

A first exploration of perceived pros and cons of quantitative gait analysis in equine clinical practice

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Summary

Background: Quantitative gait analysis is rapidly gaining ground in equine practice, and pros and cons are regularly discussed within the scientific literature. However, no data exist on the appreciation of the technique by equine clinicians, their motivation to use it or not, and their perception of its value in daily practice.
Objectives: To make a first inventory of opinions, expectances and experiences of equine veterinarians concerning the use of quantitative gait analysis in their daily general practice.
Study design: Survey.
Methods: A questionnaire was sent out to a group of equine orthopaedic clinicians working in an equine clinic or practice. Respondents were classified as users (having clinical experience with quantitative gait analysis) or not (nonusers). Data were analysed using descriptive statistics.
Results: Within the sample population, users were more positive about the usefulness of quantitative gait analysis than nonusers. Veterinarians who purchased a system were motivated by better objectivity, transparency, documentation and client service. Main reasons not to purchase a system were costs and complexity of data interpretation. A minority of both users and nonusers deemed quantitative gait analysis also suitable for equine professionals other than veterinarians.
Main limitations: Users (n = 40) outnumbered nonusers (n = 32), sample size was limited (n = 72) and insufficient to allow for generalisation of results.
Conclusions: Users of quantitative gait analysis were more positive about the technology than nonusers. More data are needed to allow for generalisation of the results. Regularly repeating this survey may help in monitoring, and eventually guiding the process of integration of gait analysis technology within equine clinical practice by providing valuable information for individual clinics, educational institutions and the industry producing this technology.

Introduction

Quantitative gait analysis is becoming more and more routine in equine orthopaedic practice (van Weeren *et al*. 2017). Several systems are currently commercially available (e.g. Lameness Locator[1], QHorse[2], Equimoves[3], Equigait[4]) and the number of users is increasing steadily. At the same time, clinicians are questioning the technology (Dyson 2014, 2019;

Clinical relevance

- Quantitative gait analysis technology has become available for routine clinical use and is currently being used in an increasing number of places.
- This study is a first inventory survey of current users and nonusers of quantitative gait analysis in equine clinical practice.
- Results provide the reader with perceptions and experiences of equine veterinarians concerning the use of quantitative gait analysis in the daily situation. These perceptions and experiences may be valuable for clinicians to help them in their decision-making on whether or not to apply equine gait analysis technology in their clinic or practice.

Bathe *et al*. 2018). The main concerns mentioned are an over-reliance on technology (Bathe *et al*. 2018), the much larger quantity of parameters taken into account by an experienced clinician compared with the currently used systems for lameness assessment, which are mostly based on sagittal plane asymmetry parameters only (Bathe *et al*. 2018), and the less than straightforward relationship of measured asymmetries with what we clinically call lameness (Dyson 2019). Protagonists of quantitative gait analysis mention the poor inter-observer agreement among clinicians when visually assessing lameness (Fuller *et al*. 2006; Hewetson *et al*. 2006; Keegan *et al*. 2010; Hammarberg *et al*. 2016), expectation bias when performing diagnostic analgesia (Arkell *et al*. 2006), and the limited spatial resolution of the human eye in asymmetric motion perception (Parkes *et al*. 2009). An extensive review of these factors has been done previously (Keegan 2007; Serra Bragança *et al*. 2018).

Systems to objectively quantify equine locomotion can be divided into either force measuring (kinetics) or motion measuring (kinematics). Kinetic systems (e.g. force plates, pressure plates, force measuring treadmill, force shoes) have been developed and used for many years but for practical reasons or limited availability, to date, none of these systems is yet suited for routine clinical use (Serra Bragança *et al*.

2018). Of the kinematic systems, optical motion capture is considered the 'gold standard' because of its accuracy and precision. This technique optically tracks the 3D position of skin markers in a calibrated space. A second kinematic approach uses body-mounted inertial measurement units (IMUs). The technique is very user-friendly, as it does not need a calibrated space and can be used everywhere and under many conditions. IMU sensors are composed of a gyroscope, accelerometer and magnetometer, measuring acceleration, angular velocity and the earth's magnetic field in all three dimensions. Using attitude estimation algorithms, specific data processing routines such as double-integration of acceleration and assumptions of cyclicity in the movement (Pfau *et al.* 2005; Bosch *et al.* 2018), relevant parameters can be calculated, for example displacement and body segments angles. IMU sensors are often assumed to be less accurate in calculating a position estimate (Serra Bragança *et al.* 2018). Nevertheless, modern IMU sensors can reach high levels of accuracy in the quantification of equine kinematics (Pfau *et al.* 2005; Bosch *et al.* 2018).

The discussion on the value of quantitative gait analysis systems for equine practice is thus far based on single personal experiences and opinions. No more structurally acquired data exist yet on the appreciation of quantitative gait analysis by equine orthopaedic clinicians, their motivation to use or not use this technology and their perception of its usability for daily practice. This study, to the authors' best knowledge, is a first inventory survey of current users and nonusers of quantitative gait analysis to explore perceptions with respect to the use of quantitative gait analysis in a clinical setting. The information, though preliminary, might be valuable for equine clinicians to help in the decision-making process on whether or not to apply gait analysis technology in their daily routine.

Materials and methods

Experimental setup
The online survey platform Qualtrics[5] was used to design and distribute the questionnaire. The study focused on equine practitioners and excluded researchers in the field of equine gait analysis. Participants were recruited via social media (Facebook, LinkedIn), using both public and private groups of equine veterinarians, as well as through an announcement on the website of the European College of Veterinary Sports Medicine and Rehabilitation (ECVSMR). The same link was used on all media. Thereby, it was unknown how many participants were recruited via which medium. Written informed consent was obtained from all participants. Participation was anonymous, but participants were given the opportunity to provide their name and email address at the end of the survey for potential participation in further research. Estimated time to complete the questionnaire was eight minutes.

The questionnaire
The questionnaire (**Supplementary Item 1**) contained 28 unique questions. Questions 1 to 10 covered demographic information, professional situation (practice owner versus employee, ambulatory versus stationary work), clientele and orthopaedic experience (with and/or without quantitative gait analysis). Afterwards, the questionnaire was different for users and nonusers. Nonusers were defined as: no practical

experience or only observation of use during continuing education events and/or with colleagues; users were defined as personal experience with equine quantitative gait analysis. Nonusers had to answer five additional questions on their general opinion and perception of the usefulness of the technology. Users answered 15 additional questions, the five posed to the nonusers and ten more questions on the original expectations they had of the system, their experiences with its use and their overall satisfaction with the system. Practice owners, both users and nonusers of quantitative gait analysis answered two more questions regarding their considerations to (not) purchase a system.

Data analysis
Data were analysed with the automated Qualtrics[5] software. Results are presented using descriptive statistics (percentages and frequencies). Statistical testing was not performed.

Results

Respondents
In total 152 veterinarians responded between 17 February 2020 and 12 March 2020, of which 96 completed the questionnaire. Of these, 24 were involved in research related to quantitative gait analysis and were excluded, resulting in 72 respondents.

Thirty-two respondents (44.4%) were classified as nonusers, and 40 respondents (55.6%) were classified as users of equine quantitative gait analysis.

Descriptive information of the population
Female equine veterinarians outnumbered their male colleagues (**Table 1**). Most respondents fell within the age category of 35–45 years. Employers and employees were equally represented (48.6% vs. 51.4%). The level of experience was high, with 59.7% having >10 years of equine orthopaedic experience. This category comprised 72.5% of the users and 44.8% of the nonusers. The category with the highest caseload category (>50 cases per month) contained 42% of the users and 28.1% of the nonusers. Most veterinarians worked both stationary and ambulatory (50%). The predominant clientele for both users and nonusers were amateur and professional equestrian competitors with 41.7% and 38.9% respectively.

Users
Users about their use of quantitative gait analysis
Within the sample population, the Lameness Locator[1] was the most commonly used system (55%), followed by QHorse[2] (50%). Both Equimoves[3] and Equigait[4] were each mentioned by 5% of the users. At some sites, more than one system was in use. Both mean and median of the satisfaction with the system(s) the respondent was clinically working with, were 7.0 on a scale from 1 (not at all satisfied) to 10 (perfectly satisfied). Scores ranged from 2 to 10. Most users (50%) performed quantitative analyses on 0–25% of their orthopaedic patients, for the categories 25–50%, 50–75% and 75–100% of patients this figure was 22.5%, 12.5% and 15% respectively.

Users were asked to indicate the types of orthopaedic patients they assessed with quantitative gait analysis (multiple choices allowed). Lameness examinations were mentioned mostly (85%), followed by neck/back/pelvic complaints

TABLE 1: Descriptive statistics (in percentages) of the respondents, divided into nonusers (no personal experience with quantitative gait analysis), and users (personal clinical experience with quantitative gait analysis). The last column gives the mean percentage of all respondents (users and nonusers) for that row. Countries mentioned as 'other' are (in decreasing order): France, Australia, Italy, Spain, Canada, Norway, Austria, Denmark, Hong Kong, Ireland, Mexico, New Zealand, Paraguay, Poland, Russia, Switzerland, and the United Arab Emirates

	Nonusers n = 32	Users n = 40	Total n = 72
Percentage respondents	44.4	55.6	
Gender			
Male	40.6	42.5	41.7
Female	59.4	57.5	58.3
Age			
<25 years	0	0	0
25-35 years	40.6	20	29.2
35-45 years	34.4	40	37.5
>45 years	25	40	33.3
Employer or employee			
Employer	53.1	45	48.6
Employee	46.9	55	51.4
Experience in orthopaedics			
<1 year	0	0	0
1-5 years	28.1	12.5	19.4
5-10 years	28.1	15	20.8
>10 years	44.8	72.5	59.7
Location clinic/practice			
Belgium	0	5	2.8
Germany	12.5	30	22.2
The Netherlands	46.9	12.5	27.8
United Kingdom	3.1	15	9.7
United States of America	9.4	12.5	11.1
Sweden	3.1	5	4.2
Other	25	20	22.2
Orthopaedic caseload per month			
<10	15.6	2.5	8.3
11-30	40.6	37.5	38.9
31-50	15.6	17.5	16.7
>50	28.1	42.5	36.1
Working stationary or ambulatory			
Stationary	6.3	40	25
Ambulatory	41.6	12.5	25
Both	53.1	47.5	50
Clientele			
Leisure/hobby	18.9	5	11.1
Amateur competitive sport	37.5	45	41.7
Professional competitive sport	31.3	45	38.9
Thoroughbred/trotter	9.4	2.5	5.6
Other	3.1	2.5	2.8

(32.5%), regular sport horse monitoring (30%), prepurchase examinations (27.5%) and 'other' (17.5%). Circumstances under which the systems were used (multiple choices allowed) included: hard ground (65%), soft ground (75%), straight line (92.5%), circle (85%), after flexion tests (25%), after local analgesia (85.5%), under tack (25%) and in 'other circumstances' (7.5%).

Self-appraisal of own subjective judgement and assessment of the effect of quantitative gait analysis on the way of looking at lameness
Users were asked if they ever questioned their observations during subjective orthopaedic assessments and whether their experience with quantitative gait analysis had changed the
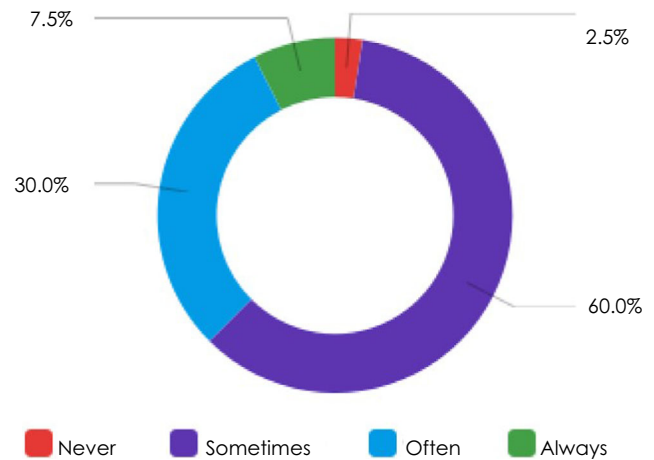

Fig 1: Frequencies of veterinarians questioning their own observation during subjective orthopaedic assessment. Answered by the users of quantitative gait analysis within the sample population.

way they looked at lameness. The majority of the veterinarians sometimes questioned their own observations (60%, **Fig 1**) and stated that their experience with quantitative gait analysis had indeed changed their way of looking at lameness (55%, **Fig 2**).

Users about their expectations
Within the sample population, expectations of users before they had started using equine gait analysis technology were mostly related to the supposed added value for specific cases, for example subtle hindlimb lameness and interpretation after diagnostic analgesia, and to the perceived objectivity and usability of the system. With respect to usability, expectations ranged from 'instantly interpretable and a high usability' to 'complicated and time-consuming'. As expectations that had been met, respondents mentioned added value in case of subtle lameness and after blocking, and in poor-performance cases. The possibility to work more preventively was mentioned as well. Expectations that had not been met were related to practical issues (uncooperative horses, time-consuming), the lack of differentiation between sources of asymmetry (i.e. anatomical variation, pain-related lameness, compensatory asymmetry and mechanical restrictions), and the limited scope of the outcome parameters (e.g. only measuring vertical asymmetry, no possibility to measure neck and back motion). Concerning usability, numerous respondents mentioned difficulties in the interpretation of the outcome parameters and a lack of service and training. A complete overview of responses is available in **Supplementary Item 2**.

Users and nonusers
General opinion on quantitative gait analysis
Of the users within the sample population, 82.5% were positive or very positive about the use of quantitative gait analysis in equine practice. For nonusers, this was 62.6%. In the nonuser group, 12.5% had a negative or very negative opinion, in the user group no such opinions were mentioned. A neutral opinion was given by 17.5% of the users versus 25.0% of the nonusers (**Fig 3**).
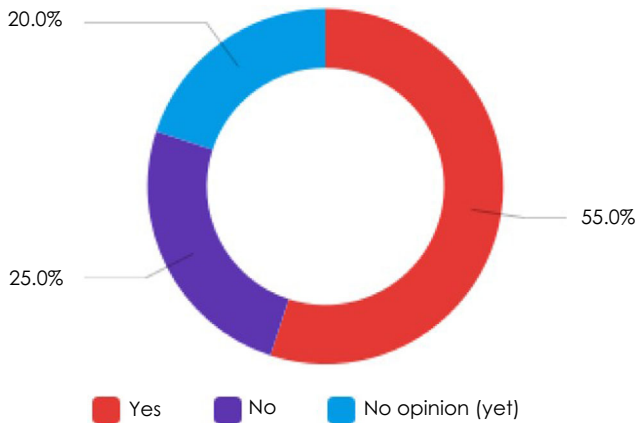
Fig 2: *Answers to the question if experience with quantitative gait analysis had changed the way of looking at lameness. Answered by the users of quantitative gait analysis within the sample population.*

Argumentation of users and nonusers to justify their general opinion on quantitative gait analysis in the veterinary field can be found in **Supplementary Item 3**. Negative argumentation included an over-reliance on technology, the lack of usability in bilateral lameness, and costs. Positive argumentation included the usability for regular sport horse monitoring, standardisation of orthopaedic examinations, objectivity and the outcome being a source of reliable documentation.

Influence of quantitative gait analysis on veterinary skills
Of the users within our sample, 67.5% believed that quantitative gait analysis had made them better veterinarians. Of the nonusers, 50% thought it could potentially make them better veterinarians. Of the users, 12.5% disagreed and of the nonusers 18.8% disagreed on the statement that quantitative gait analysis had made, or could potentially make them better veterinarians. The remaining respondents had no opinion.

Appreciation of quantitative gait analysis by clients
Of the users, 80% assumed their clients to be positive or very positive regarding the use of quantitative gait analysis. Of the nonusers, 62.6% assumed a positive or very positive

appreciation of their clients, when they would use quantitative gait analysis in their daily practice (**Fig 4**).

For the justification of their assumption about their clients' opinion on quantitative gait analysis, practitioners gave both positive and negative arguments. Positive arguments included clients' appreciation of lameness evaluation supported by objective data, the recognisability of lameness for clients, and the documentation during training and rehabilitation. On the negative side, the difficulty of interpretation by owners and the tendency of clients to think that the machine cannot be wrong were mentioned. The traditional racing disciplines (e.g. Thoroughbreds and trotters) were thought to be less open to new developments like quantitative gait analysis. An overview of all remarks can be found in **Supplementary Item 4**.

Use of quantitative gait analysis by others than veterinarians, for example studbooks, sports organisations, judges and/or trainers
Users and nonusers within the sample population agreed on the potential suitability of quantitative gait analysis by others than veterinarians (e.g. by studbooks, judges, trainers and sport authorities); only 17.5% (users) and 12.5% (nonusers) thought this to be a good idea and 47.5% (users) vs. 50% (nonusers) disagreed. The remaining respondents had no opinion. Remarks supporting such use mentioned the help in early lameness detection, a reliance on objective data rather than different people's opinions and the expectation that lame horses would no longer pass the vet check. People not agreeing mentioned concerns about potential loss of business and the need of a skilled veterinarian for the interpretation of data. For an overview of remarks see **Supplementary Item 5**.

Considerations for practice owners to purchase quantitative gait analysis systems or not
Supplementary Item 6 presents all considerations upon which practice owners included in the sample population decided to purchase or not quantitative gait analysis equipment. Purchasers mentioned objectivity and transparency, a better service for clients, their will to improve their own skills and the possibility of being part of ongoing (novel) developments. Nonpurchasers mentioned costs, time, limited applicability in the field and complexity of the systems as considerations to not acquire a system.
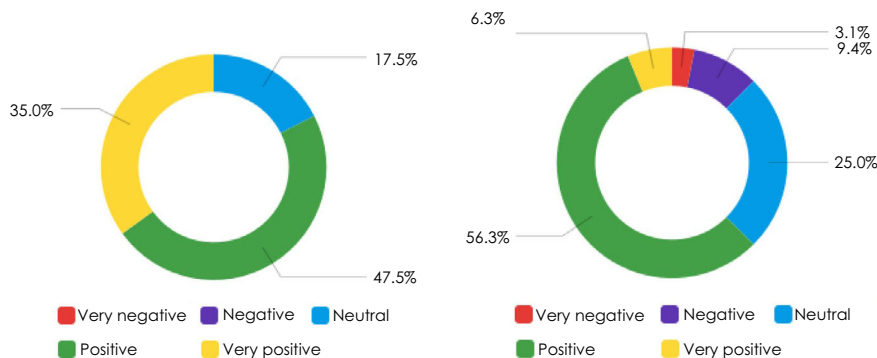

Fig 3: *The general opinion regarding the usefulness of quantitative gait analysis in equine practice, for users (left) and nonusers (right) within the sample population.*
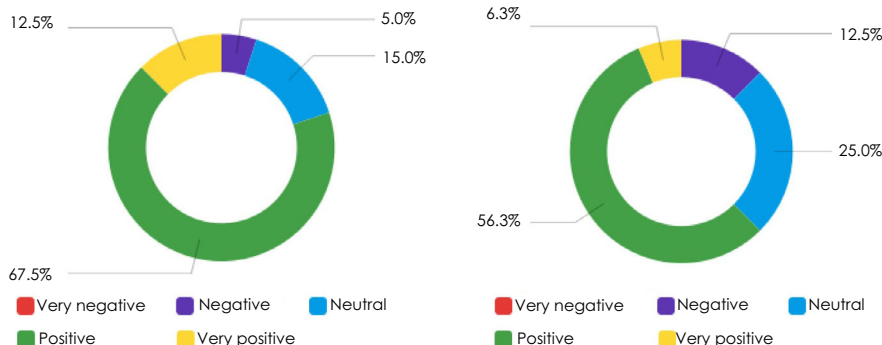
Fig 4: The assumed appreciation of quantitative gait analysis by clients, on the left for users, on the right for nonusers within the sample population.

Discussion

This study is a first inventory of the opinions about, expectances of, and (where applicable) experiences with quantitative gait analysis in equine practice in a restricted population of both users and nonusers of the technology. The purpose was to provide the equine practitioner with more than anecdotal evidence and single opinions in determining their position with regard to this upcoming technology, i.e. these perceptions and experiences could provide valuable information for clinicians in the decision-making process on whether or not to use quantitative gait analysis.

About 30% of the respondents did not complete the survey. The reason for this, and whether it might create a possible bias of our results, is unknown. The demographics of the population of respondents in the study showed a higher experienced level in the group of users. This may be related to financial possibilities (of more experienced clinicians) to invest in a system for quantitative gait analysis, another point of view of senior clinicians on how to serve clients best, or on their perception of the necessity of innovation. The aim to continuously improve skills is explicitly mentioned by many users within the sample population, both less and more experienced clinicians.

Most users used the Lameness Locator[1] or QHorse[2] systems and graded their system on average with a 7 on a scale from 0-10. However, despite this satisfaction with the system, most clinicians use the system for only 0-25% of their orthopaedic cases. The reasons for this relatively low rate are not entirely clear, but factors such as complexity of the interpretation, time needed to do an analysis, lack of technical support and unsuitable patients were mentioned. Interestingly, at some places nearly 100% of orthopaedic cases were measured.

The majority of users questioned their observations often or sometimes. Because most users confirmed that quantitative gait analysis had changed the way they look at a lameness, an educational effect seems to happen in daily practice. Reflections like: *'The system helps us to think more, question ourselves, quantify and document gaits. In cases where we 'disagree' with the quantified data, it stimulates us to think further'* and *'It is the future; more objectivity and transparency bring better diagnoses and documentation of lameness and prepurchase examinations'* illustrate this perceived educational effect for the cohort of veterinarians using gait analysis technology in this sample population.

Other expectations that had been met, were the opportunity of applying quantitative gait analysis for preventive medicine instead of treatment afterwards, remote monitoring of patients providing possibilities for multidisciplinary teamwork (e.g. consisting of veterinarian, chiropractor, farrier, rehabilitation centres, etc.), and tele-assessment of data interpretation. The expectations that were not met, were all related to the practical usability and possibilities of the system, like a lack of parameters other than vertical motion asymmetry and the inability to differentiate between pain-related lameness and other asymmetries, shortcomings that have been criticised in literature as well (Bathe *et al.* 2018; Dyson 2019). Other points of concern are the complexity of interpretation, technical problems that cannot always be dealt with by the clinician, and insufficient after-sales support and training.

Considerations inciting clinic/practice owners to invest in a system relate to personal development and improvement of clinical service, for example increased objectivity and transparency, better diagnoses, and improved documentation of cases. Furthermore, keeping up to date with technological developments was mentioned within this sample of clinicians. Concerns that prevent practice owners from purchasing equipment were mainly related to financial aspects, and to the complexity of both the system itself and the data interpretation. Of these, complexity of interpretation was mentioned several times. It is unclear whether this is due to created expectations by the industry selling the devices, or based on personal assumptions about the straightforwardness of the clinical translation of the outcome. There is some contrast between the widespread recognition of the difficulty of learning to (subjectively) assess lameness properly, and of the complexity of the biomechanical research behind quantitative gait analysis (Serra Bragança *et al.* 2018) on the one hand and, on the other, the stance of some respondents describing the technology with terms like 'gadget' or 'tool'. These respondents might have expected a ready-to-use outcome and did not count on a substantial time investment needed to get to master correct interpretation. In fact, one of the respondents remarked: *'I expected black-and-white answers'*.

Recent scientific discussions have made clear that the implementation of quantitative gait analysis in clinical practice is a process that requires clear definitions of the terminology that is used, in order to prevent wrong

perceptions, either amongst veterinarians, clientele or the lay public (van Weeren *et al.* 2017). An example is the distinction between 'lameness' and 'asymmetry'. 'Lameness' in equine orthopaedics is a clinical sign (Ross 2011) associated with unfitness to compete, which is in the vast majority of cases accompanied by an asymmetric gait. *Vice versa,* 'asymmetry' in quantitative gait analysis is a simple quantitative parameter that describes deviation from perfect symmetric motion, without identification of the cause (pain-induced, mechanical restriction, neurological [Ishihara *et al.* 2009], handedness [Starke *et al.* 2012; Byström *et al.* 2018, 2020] or biological variation within or between horses (Rhodin *et al.* 2015; Hardeman *et al.* 2019]), and hence without *a priori* qualification of clinical relevance. Education of (future) users on terminology and backgrounds of quantitative gait analysis could possibly lead to more awareness of the knowledge necessary to use this technology in daily practice, thereby leading to an increase in the quality of both data collection and interpretation.

Responses from the users within the sample population on the usefulness of quantitative gait analysis were more positive than those of the nonusers. Here, it should be realised that users base their opinion on their (factual) experience and nonusers – forcibly – on their perception. Within the respondents of this study, hands-on experience seemed to positively influence the opinion of veterinarians. The comments on assumed client appreciation illustrated that users perceive that their clients appreciate quantitative gait analysis as an addition to the clinical examination, and even ask for it. Concerns are mostly cost-related and associated with client education. Client education and communication by a skilled veterinarian remain important, as mentioned by several respondents. This was mentioned as well in earlier research that focused on the use of quantitative gait analysis during prepurchase examinations (Hardeman *et al.* 2021).

Half of both users and nonusers within this sample of equine orthopaedic clinicians were of the opinion that quantitative gait analysis should not be available for others than veterinarians (e.g. studbooks, sports organisations, judges and/or trainers). Protagonists of use by others mentioned improvement of welfare during competitions with help of quantitative gait analysis: '*unsound horses would not pass the vet check anymore*' and '*lameness during competitions is unacceptable*', but others were concerned about the correct interpretation of the data, stating that veterinary expertise is mandatory. One veterinarian warned for too early implementation of the technique, which could possibly cause wrong expectations. Nevertheless, multiple clinicians, including those initially not in favour of use by others than vets, agreed on the potential value of use by others, but with the condition that an expert (veterinarian) should be involved in data interpretation. The authors concluded from the opinion of many respondents that clear communication and a good level of expertise should accompany the application of quantitative gait analysis in the equine sector. If those conditions are met, quantitative gait analysis may have benefits for trainers, breeders, or judges, through improving their skills and thereby positively influencing equine (sports) level and welfare, provided veterinary expertise in data interpretation is guaranteed. The usage of quantitative gait analysis during vet-checks has recently been advocated by some researchers, raising awareness about the low observer agreement between veterinarians in assessing horses as fit or unfit to compete (Lopes *et al.* 2018; Serra Bragança *et al.* 2020).

Limitations

Limitations of this study are the small number of respondents (n = 72), and the number of users (n = 40) compared with nonusers (n = 32) of quantitative gait analysis in the daily equine clinical situation, which is not a representative sample of the current population of equine orthopaedic clinicians worldwide. The recruitment process (through social media and the ECVSMR website) may have led to a bias in sample population. For these reasons, the outcome of this first exploratory study should be seen as an indication, but cannot be generalised.

Conclusion

This study is a first inventory of opinions, expectances, and experiences around the clinical use of quantitative gait analysis. Users in the sample population are more positive compared with nonusers about the use of the technology in the equine veterinary field. Further technical developments are necessary to meet the demands as mentioned by respondents, such as an increase of the number of analysed parameters, the ability to analyse back and neck motion, analysing under tack, increased functionality for bi- or multi limb lameness and an increase of user-friendliness.

Repeating studies like the current one, with a larger sample of equine veterinarians, at regular intervals, may help in monitoring this process and can generate important information to detect tendencies and clinical needs, help clinicians in their decision-making, and improve the technology by the industry.

Manufacturers' addresses

[1]Lameness Locator, Equinos Q, Columbia, USA, www.equinosis.com
[2]QHorse, Qualisys AB, Gothenburg, Sweden, www.qualisys.com/applications/equine-animal
[3]Equimoves, The Netherlands, www.equimoves.nl
[4]Equigait, United Kingdom, www.equigait.co.uk
[5]Qualtrics [XM] Experience Management Software, USA, www.qualtrics.com

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Supporting information

Additional Supporting Information may be found in the online version of this article at the publisher's website:

Supplementary Item 1: The questionnaire.

Supplementary Item 2: Categorisation of the expectations from users of quantitative gait analysis on forehand, expectations that have been met, and expectations that have not been met.

Supplementary Item 3: Categorisation of positive and negative argumentation of users and nonusers of quantitative gait analysis, used to justify their general opinion on the usefulness of the technique for equine practice.

Supplementary Item 4: Categorisation of positive and negative remarks of users and nonusers of quantitative gait analysis on their assumption of the (potential) appreciation of the technique by their clients.

Supplementary Item 5: Categorisation of arguments why nonveterinarian use of quantitative gait analysis was thought to be a good idea or not.

Supplementary Item 6: Considerations upon which practice owners base their decision to (not) purchase a quantitative gait analysis system.