The application of objective gait analysis in the commercial equine clinic

Identifying current users and non-users and gaining in-depth information about opinions and experiences

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Abstract

Background and objective: Objective gait analysis (OGA) is gradually becoming a standard procedure in equine clinics. It is not fully clear why veterinarians decide to work or not to work with OGA. The main objective of this study was to identify and describe current users and non-users of OGA and gain in-depth information about their opinions and experiences with OGA. With this it was aimed to determine what properties of OGA make that a clinic does or does not choose to use this technique and why.

Method: Data from current users and non-users of OGA in the clinical situation (n=72) was obtained through the performance of a combined qualitative and quantitative questionnaire using Qualtrics® spread among veterinarians via Facebook and LinkedIn.

Results: The results of the questionnaire suggested there were typical characteristics for both users and non-users. Furthermore, the overall opinion of users was in general more positive than of non-users. Moreover, both users and non-users respectively positively experienced and recognized the added value and increased objectivity. Most often negatively experienced were cost, practicability and usability.

Conclusions and clinical significance: This study shows that the main positive properties of OGA are added value and increased objectivity and negative properties are cost, practicability and usability. These properties of OGA make that a clinic decides either to use OGA or not. Both quantitative and qualitative research aiming to identify and describe current users and non-users of OGA are still in its infancy. Our current study seems promising and can potentially improve equine health and performance in the future with the use of techniques for OGA

Introduction

Nowadays horses are used primarily as sport and leisure animals, for which a good functioning locomotor apparatus is required. Dysfunctioning of one or multiple of the components of the equine locomotory apparatus can cause the problem of lameness in horses. For equine veterinarians, musculoskeletal conditions (i.e. showing lameness) are the most frequently seen patients (Nielsen, Dean et al. 2014). In order to start adequate therapy and (re)optimization of the performance of a horse the cause of the lameness must be tracked down.

Lameness was once defined as abnormal stance or gait caused by structural or functional abnormality of the locomotor system (Davidson 2018). Clinical and observational skills are essential for equine gait evaluation and interpretation (Dyson, S. 2011). Right now most veterinarians are dependent on subjective visual examination of gait for their lameness examinations. However, human eye assessment has its limitations, and may be unreliable (Parkes, Weller et al. 2009). This can therefore lead to limited indifferences between veterinarians and disagreement (Keegan, K. G., Dent et al. 2010). The objective measurement of a horses' gait has been a subject of investigation for various years now (Serra Bragança, Rhodin et al. 2018).

Throughout the last 150 years a lot has happened in the development of techniques for the objective detection and analysis of lameness in horses and some of these techniques recently became available for the clinical practice (Serra Bragança, Rhodin et al. 2018, Bosch, Serra Bragança et al. 2018, Hardeman, Serra Bragança et al.

2019). In these papers it is proposed that gait analysis will possibly start to play a great role in performance evaluation in the near future, for example for pre-purchase examinations and regular sport horse monitoring.

Objective gait analysis (OGA) may be of considerable supportive value for solving orthopaedic cases (Keegan, 2007). Systems for OGA measuring equine locomotion can be divided into either force measuring (kinetics) or motion measuring (kinematics) (Serra Bragança, Rhodin et al. 2018). With the kinematics based techniques of OGA either inertial measurement units (IMU's) sensors are placed on a horses' body and measure acceleration, and these measured data is converted into position, or optical motion capture (OMC) is used which operates with infrared cameras (markers) and thereby calculates 3D position directly (Serra Bragança, Rhodin et al. 2018). OGA is gradually becoming a standard procedure in commercial equine clinics and various veterinarians work routinely with OGA (users). On the other hand, there are also veterinarians who (consciously or unconsciously) do not work with OGA (non-users).

It is not fully clear why veterinarians choose to work or not to work with OGA. Therefore, mapping the arguments and experiences of both users and non-users can be of great interest, possibly in order to improve techniques for OGA. The use of OGA in commercial equine clinics is still in its infancy and evaluation of the usage of OGA may be of great utility and profitability to improve equine health and performance in the future. This leads to the main research question of this study which will be; what properties of OGA make that a clinic does or does not choose to use this technique and why?

Objective

The aim of this (quantitative and qualitative) explorative study is to (1) identify and describe current users and non-users of OGA, (2) gain in-depth information about the opinion and experience of users with OGA, (3) gain information about the opinion and experience of non-users with OGA and (4) suggest aspects for improvement of OGA application in commercial equine clinics. This research was set up very comprehensively in order to gather a wide variety of information, thus no hypotheses were formulated beforehand.

Background

Terms and definitions

As stated by van Weeren et al., the use of quantitative gait analysis in clinical practice is a process which requires very clear definitions of the used terminology. This in order to avoid confusion and to prevent the formation of wrong perceptions, either amongst professionals or by the lay public (van Weeren, Pfau et al. 2017).

To prevent confusion a list of frequently used terms in the orthopaedic field are depicted in the table below with their abbreviation and definition:

Term	Definition
Objective gait analysis (OGA)	Technology to quantitatively measure gait through either kinetics or kinematics Synonym: Quantitative gait analysis (QGA)

Kinetics	Kinetics is the study of internal and external forces resulting from musculoskeletal work
Kinematics	"Kinematics is the study of the movement of body segments during locomotion"
Lameness	(1) "Lameness is an indication of a structural or functional disorder in one or more limbs or the back that is evident when the horse is standing or in movement" (2) Lameness is simply a clinical sign – a manifestation of the signs of inflammation, including pain, or a mechanical defect – that results in a gait abnormality characterized by limping" (3) "An alteration of the normal gait due to a functional or structural disorder in the locomotor system"
Asymmetry	"A technical term describing a larger or smaller deviation of perfectly symmetric motion"

Table 1: Table with an overview of terms with definitions (van Weeren, Pfau et al. 2017, Serra Bragança, Rhodin et al. 2018, Sharp 2019).

Important to point out is that asymmetry and pain may be, and frequently are hallmarks of lameness, but by no means ever-present (van Weeren, Pfau et al. 2017). Therefore, the term 'lameness' should be cautiously used and should not be used interchangeably with the term 'asymmetry'.

Kinetics versus kinematics

Nowadays, systems for objectively measuring equine locomotion can be divided into either force measuring (kinetics) or motion measuring (kinematics) (Serra Bragança, Rhodin et al. 2018).

Force measuring platforms are often used for kinetic gait analysis and are considered the 'gold standard'. Force platforms very precisely and accurately measure the three components which compose the ground reaction force (GRF). Lameness can be detected through finding differences in weight bearing, for example between legs. However, collection of data is time-intensive and difficult. Newer developed pressure plates are more practicable, but less accurate and precise and cannot measure the separate components of the GRF. Lastly, force measuring horseshoes and a force measuring treadmill were developed as equipment for kinetic studies. Unfortunately, these had several factors that critically limited their clinical applicability. All in all, Bragança et al. conclude that there is currently no equipment measuring kinetics clinically applicable for lameness assessment.

For kinematic gait analysis, optical motion capture (OMC) plays the key role. Current techniques track 3D position of reflective markers directly with infrared cameras. In kinematic gait analysis 3D OMC systems are considered to be the 'gold standard' because of their high accuracy and precision. A second technique within kinematics uses inertial measurement units (IMU's). IMU sensors are attached to body parts of a horses and measure acceleration at the time of locomotory examination. The data are converted into speed and afterwards into position which makes the IMU system less accurate. Comparing both techniques, OMC is dependent on stationary cameras, while the IMU system can be practicably used on different locations in the clinic or during ambulatory work.

Example placement of accelerometer sensors of the commercially available system of The Lameness Locator system of Equinosis® is depicted in figure 1 below. The sensors were placed on the head, pelvis and the pastern of the right front limb. Each sensor consisted of an accelerometer, radio, antennae, battery, microcontroller, and circuitry for wireless transmission of data.

Fig. 1: A horse instrumented with the Lameness Locator system of Equinosis®, whereby accelerometers are placed on the head, pelvis and the pastern of the right front leg (McCracken, Kramer et al. 2012)

An example graphical presentation of the results of computer converted data from a sensor or OMC placed on the pelvis is shown in figure 2 on the next page (Serra Bragança, Rhodin et al. 2018).

Most commonly changes measured in a lame limb with a unilateral lameness are a reduction of peak vertical force and vertical impulse and a decreased swing duration. The top picture shows the vertical displacement of the pelvis during a stride of the horse measured by a sensor placed on the tuber sacrale. Asymmetry of the vertical displacement of the pelvis can indicate that the action of the limb with the smallest vertical displacement is affected in a horse with a unilateral lameness. In this picture for the left hind stance of the stride the smallest vertical displacement is measured and therefore this may be indicative for left hind lameness. The bottom picture shows the vertical and horizontal ground reaction forces and impulses that are generated by the horse throughout the stride. It can be seen that both the peak vertical force (PVF_{LH}) and vertical impulse of the left hind leg are smaller than those of the right hind leg. This also may suggest the left hind leg is affected.

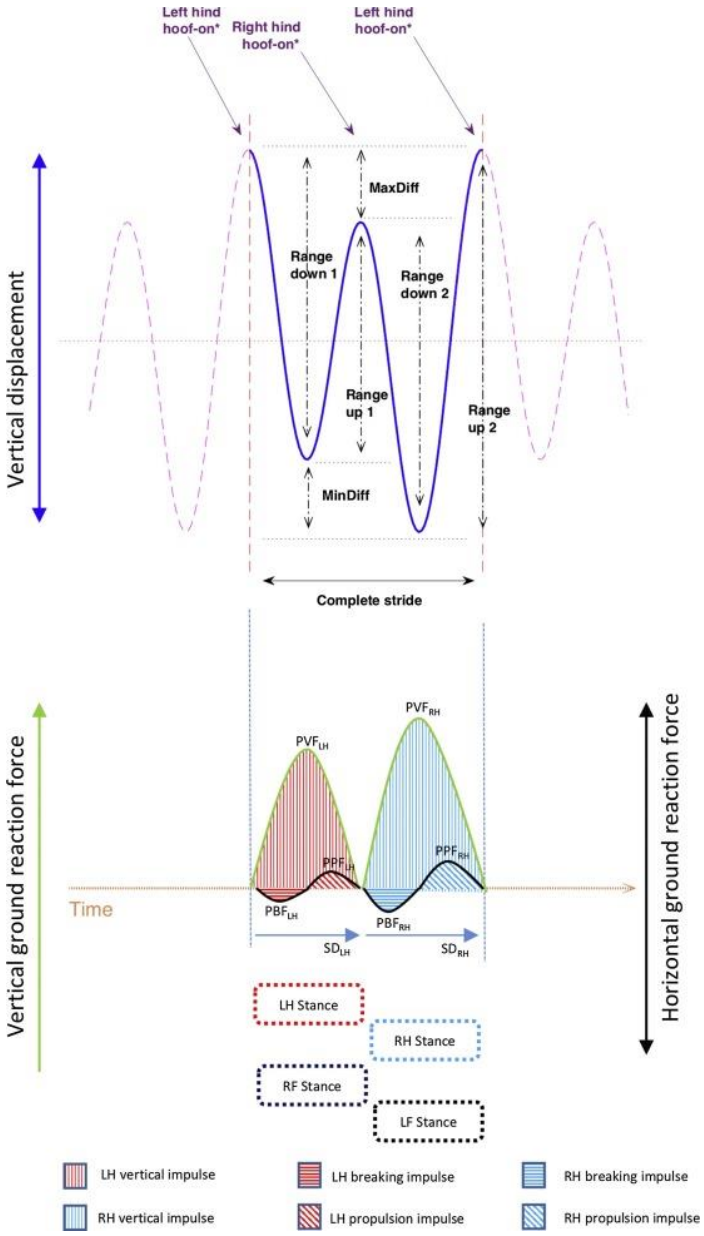

Fig. 2: Graphical presentation of the results of computer converted data from OGA sensors (Serra Bragança, Rhodin et al. 2018).

Quantitative gait analysis

Quantitative gait analysis is becoming more and more a routine in the commercial orthopedic equine clinic (van Weeren, Pfau et al. 2017). There has been a long existing interest in horse locomotion, with papers originating from 17th and 18th century, passing by the first use of computer technology in research (Fredricson, Drevemo 1971) and offering multiple systems for the clinical situation nowadays (Serra Bragança, Rhodin et al. 2018). These passed developments may characterize the strong demand for quantitative systems, which possibly correlates with the marginal interobserver agreement during a subjective (visual) lameness assessment (Fuller, Bladon et al. 2006, Hammarberg, Egenvall et al. 2016, Hewetson, Christley et al. 2006, Keegan, K. G., Dent et al. 2010), the limitations of the human eye to detect asymmetry (and thereby lameness) (Parkes, Weller et al. 2009) and the current discussion in our society around ethics and welfare of horse sports (Bouter 2019).

Gómez Álvarez and Van Weeren accurately summarized the practical uses of QGA (Gómez Álvarez, van Weeren 2019). Current main use of QGA is for investigation of gait disturbances in horses with musculoskeletal conditions, for example during a lameness examination. Furthermore, QGA has shown potential in diagnosis and assessment of ataxia in horses in several studies on neurological conditions. In addition, it can be used for the evaluation of training and exercise programs and sport-specific biomechanics, for example for early detection of injuries. Moreover, new potentials of QGA lie in the investigation of behavioral problems and welfare issues and facilitating training and rehabilitation programs following injury.
They conclude that the use of QGA is currently not limited anymore to the investigation of lameness and is increasingly being used for many other horse-related aspects. Yet, Gómez Álvarez and Van Weeren do indicate the continuous demand for development of devices for more accuracy, performance and practicability.

Current discussion between advocates and sceptics
Van Weeren et al. also importantly noted that the use of OGA can lead to difficult situations and that there are lots of grey areas in terms of how to use the results of OGA (van Weeren, Pfau et al. 2017). Horses that are so called 'owner-sound' can appear asymmetric when gait analysis is performed. Gait asymmetry can be a sign of affected welfare, but to what extend is still uncertain. To use the term of lameness for a horse that shows a certain amount of asymmetry using OGA can cause confusion for the owner. In addition, different veterinarians call different amounts of asymmetry lame or not. This is one of the points of discussion concerning OGA.

Furthermore, Bathe et al. express their concern about clinicians blindly following what the systems for objective gait analysis say and lose overview (Bathe, Judy et al. 2018). They are afraid that when OGA techniques are used by insufficiently skilled clinicians they will use it to replace proper clinical evaluation and thinking. This way mistakes are made faster and more efficiently.

However, as response to the letter to the editor of Bathe et al., Adair et al. responded and said among other things that the sensor systems of OGA techniques surpass the qualities of the human eye and that both with and without the use of OGA techniques incorrect conclusions can be drawn by clinicians working up orthopedic cases (Adair, Baus et al. 2018).

Moreover, Dyson reported about several limitation of OGA techniques (Dyson, Sue 2014). She notes doubt about the use of OGA techniques to analyze lameness in multiple limbs and lameness that is only shown by a horse on a circle or when ridden.

Methods

Study design and procedure
A carefully composed qualitative and quantitative questionnaire was performed to (1) identify and describe the current users and non-users (population) of objective gait analysis in the clinical situation and (2) map their opinion on (topics related to) and experiences with the use of OGA and motives to use OGA or not. This was done through inclusion of multiple choice, open and clarification questions into the questionnaire. The draft questionnaire was pilot-tested and checked by supervisors and interested.. Approximately fifteen remarks on grammar and formulation were taken into the development of the final questionnaire.

The final version consisted of in total 43 questions divided into five blocks. Respondents got questions presented depending on their experience with OGA and working relationship. All respondents firstly received the same block with ten general demographic questions. Depending on their experience with OGA, a respondent after that received either a block with questions for 'users' or a block with questions for 'non-users'. Next, 'users' which also indicated they were employer received a block of questions concerning the purchase of their system for OGA. Lastly, all respondents got a block with ending questions, in which they could share anything remaining about OGA and optionally leave their name and email address. An example of the complete questionnaire can be found in Appendix A.

The questionnaire was distributed online using the survey tool Qualtrics®. Respondents were invited to participate via various media, namely via Facebook, LinkedIn and through the researchers personal networks. Furthermore, a small news item was placed on the website of the European College of Veterinary Sports Medicine and Rehabilitation (ECVSMR). To encourage participation, respondents were able to fill out the questionnaire anonymous with the option to leave their name and email address for an explorative, elaborative interview for a future investigation. Privacy and confidentiality were respected through the following aspects; Qualtrics® meets the UU GDPR guidelines, participants could stop at all times and anonymization of the data for the analyzation in the results.

Data management and statistical analysis

The analysis of the results of the multiple choice questions was performed in Qualtrics®. The dataset was transferred to a Microsoft Excel document for the analysis of open and clarification questions. Graphical illustrations shown in the results section were made using Qualtrics®. Incomplete questionnaires were excluded using filters in Qualtrics® and Microsoft Excel. For giving quotes, the numbering of the respondents according to the date of completion was used from Excel, i.e. P15 refers to participant 15.

Statistical analysis for the comparison of apparent differing variables between the groups 'users' and 'non-users' was done with the use of a chi squared test performed by hand and the level of statistical significance was set at $p<0.05$.

Results

In total 152 veterinarians responded to the questionnaire between February 17th and March 12th, 2020. Ninety-six questionnaires were fully completed and included in the analysis. Twenty-four respondents who indicated their job mainly consists or consisted of research related to OGA were excluded from the analysis. Therefore, further analysis of the results included 72 respondents.

Identification of respondent population and of current users and non-users of objective gait analysis in the clinical situation

Table 1 provides an overview of all 72 responses included in this study, 42 per cent of the respondents (30/72) indicated they had used a technique for OGA for at least 25 cases or more, of which 14 respondents indicated a practical experience with OGA in more than 100 cases.

Practical experience with OGA	Number	%
None or only observed during continuing education or with colleagues	32	44.4
< 25 cases	10	13.9
25-100 cases	16	22.2
> 100 cases	14	19.4
Total	72	100

Table 1: Distribution of practical experience of respondents with OGA, with exclusion of researchers (n=72)
Abbreviations: n=number of respondents, %=percentage, <=less than, >=more than

General respondent demographics

Personal background data from respondents of the questionnaire per group of experience with OGA is summarized in table 2 on the next page. The last row provides an overview of general respondent information in total.

With regard to the entire respondent population several matters were possible to highlight. A slight majority of all respondents were female (58%). The age group of 35-45 years included the most respondents (38%). There was an almost equal division between employers (49%) and employees (51%). The general work experience in equine orthopaedics was more than 10 years (60%). For the orthopaedic case load there was a clear distinction in two major groups of veterinarians; a group with a caseload of 11-30 cases per month (39%) and a group with a caseload of more than 50 cases per month (36%).

Fifty per cent of the respondents have worked both stationary and ambulatory. Twenty-five per cent have worked only stationary and the remaining 25% worked only ambulatory.

Approximately 76% (55/72) of the respondents have worked in a European equine clinic. Twenty-four per cent (17/72) have worked in a non-European clinic. Within the European group of respondents, the main fraction of the respondents have worked in an equine clinic located in the Netherlands (20/55, 36%). Of the non-European located veterinarians, the largest groups have worked in the United States of America (10/17, 59%) and Australia (4/17, 24%).

Most respondents indicated that the majority of their patient population consisted of amateur competitive sport (42%) and professional competitive sport (39%). Two respondents filled out another group of horses as the main part of their patient population namely, breeding and 50/50 professional sport and racehorses.

	None or only observed during continuing education or with colleagues (%) (n=32)	< 25 cases (%) (n=10)	25-100 cases (%) (n=16)	> 100 cases (%) (n=14)	Total (%) (n=72)
Percentage of respondents	44.4	13.9	22.2	19.4	100
Gender					
Male	40.6	30.0	43.8	50.0	41.7
Female	59.4	70.0	56.3	50.0	58.3
Age					
<25 years	0	0	0	0	0
25-35 years	40.6	30.0	31.3	0	29.2
35-45 years	34.4	60.0	25	42.9	37.5
> 45 years	25.0	10.0	44.8	57.1	33.3
Employer or employee					
Employer	53.1	40.0	43.8	50.0	48.6
Employee	46.9	60.0	56.3	50.0	51.4
Years of work experience in equine orthopaedics					
< 1 year	0	0	0	0	0
1-5 years	28.1	20.0	18.8	0	19.4
5-10 years	28.1	20.0	18.8	7.1	20.8
> 10 years	44.8	60.0	62.5	92.9	59.7
Location clinic/practice					
Belgium	0	0	0	14.3	2.8
Germany	12.5	40.0	31.3	21.4	22.2
Netherlands	46.9	20.0	18.8	0	27.8
United Kingdom	3.1	10.0	18.8	14.3	9.7
United States of America	9.4	10.0	6.3	21.4	11.1
Sweden	3.1	0	6.3	7.1	4.2
Other	25.0	20.0	18.8	21.4	22.2
Orthopedic caseload per month					
< 10	15.6	10.0	0	0	8.3
11-30	40.6	40.0	50.0	21.4	38.9
31-50	15.6	10.0	12.5	28.6	16.7
> 50	28.1	40.0	37.5	50.0	36.1
Working stationary or ambulatory					
Stationary	6.3	20.0	43.8	50.0	25.0
Ambulatory	41.6	20.0	12.5	7.1	25.0
Both	53.1	60.0	43.8	42.9	50.0
Composition of patient population					
Leisure/hobby	18.9	0	6.3	7.1	11.1
Amateur competitive sport	37.5	50.0	50.0	35.7	41.7
Professional competitive sport	31.3	50.0	43.8	42.9	38.9
Thoroughbred/trotter	9.4	0	0	7.1	5.6
Other	3.1	0	0	7.1	2.8

Table 2: General respondent information (demographic data) of the questionnaire respondents, expressed as percentages of respondents for each group of practical experience with OGA and for the total (n=72)
Abbreviations: n=number of respondents, %=percentage, <=less than, >=more than

To be able to identify and describe current users and non-users a division was made. Respondents who filled out they had no practical experience with OGA or only observed during continuing education or with colleagues were seen as non-users (n=32).

Respondents with a practical experience of more than 25 cases (25-100 and > 100) were directly seen as users (subtotal of 30). A decision was made that respondents with a practical experience of less than 25 cases were also seen as users despite their less practical experience with OGA. Therefore, in total 40 respondents were classified as user.

General respondent demographics of users versus non-users

Characteristics of users versus non-users can be found in table 3. The total population is given as comparison.

Of all users, 58% were female. General age was > 35 years and there was a slight majority (55%) of employees. A great majority (73%) has had a work experience in equine orthopaedics of more than 10 years. For the orthopaedic caseload per month there was, as for the entire group of respondents, a distinction in two groups. A group of veterinarians with a caseload of 11-30 cases (38%) and a group of veterinarians with a caseload of more than 50 cases (43%). Eighty-eight per cent of users have worked either stationary or both stationary and ambulatory and their patient population mainly consisted of amateur and professional competitive sport horses (90%). Most users were employed in a clinic located in Germany.

Of all non-users, 59% were female. The age group 25-45 years comprised most non-users (75%) and there was a slight minority (47%) of employees. Both the years of work experience in equine orthopaedics and the orthopaedic caseload had varied results. Forty-five per cent of non-users had a working experience of more than 10 years. And a caseload of 11-30 cases per month included the biggest (41%) group of non-users. A great majority (94%) of non-users have worked ambulatory or both ambulatory or stationary and their patient population mainly consisted of leisure/hobby, amateur and professional competitive sport horses (88%). Almost half of non-users have worked in a Dutch clinic.

There were some notable differences between the two groups, users and non-users visible from the table. Firstly, the group of users in general had a higher average age than non-users. Secondly, it could be marked that the years of work experience and the orthopaedic caseload per month of users was clearly higher than that of non-users. Furthermore, it stood out that users primarily have worked stationary or both stationary and ambulatory, while non-users predominantly have worked ambulatory or both ambulatory and stationary. Lastly, non-users more often indicated that leisure or hobby horses were the main part of their patient population than users (19% versus 5%).

The above-named notable differences were further statistically analysed using a Chi-squared test performed by hand for the comparison of differences in proportions. This demonstrated a significant difference in proportions between the group of users and non-users for the variables years of work experience ($p<0.050$) and working stationary or ambulatory or both ($p<0.001$). No significant difference in proportions was found between users and non-users for the variables age, orthopaedic caseload per month and composition of patient population. The execution of the Chi-squared tests can be found

in appendix B. Thus, the clear association seen in our sample between the variables years of work experience and working stationary or ambulatory, and practical experience with OGA were likely to be true for the entire population. The tendency for association seen in our sample between the variables age, orthopaedic caseload and composition of patient population, and practical experience with OGA were not likely to be true for the entire population.

To summarize, there were some typical characteristics of both users and non-users.
For users these characteristics were; a general age of > 35 years and work experience of > 10 years. In addition, they have operated principally stationary or both stationary and ambulatory. Moreover, they have worked in general with amateur and professional competitive sport horses.
For non-users these were; a general age of 25-45 years, have operated primarily ambulatory or both ambulatory and stationary and have worked with leisure/hobby, amateur and professional competitive sport horses.

	Non-user (%)	User (%)	Total (%)
Number of respondents and percentage	32 44.4	40 55.6	72 100
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	20.0	29.2
35-45 years	34.4	40.0	37.5
> 45 years	25.0	40.0	33.3
Employer or employee			
Employer	53.1	45.0	48.6
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Years of work experience in equine orthopaedics			
< 1 year	0	0	0
1-5 years	28.1	12.5	19.4
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Belgium	0	5.0	2.8
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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	6.3	40.0	25.0
Stationary	41.6	12.5	25.0
Ambulatory	53.1	47.5	50.0
Both			
Composition of patient population	18.9	5.0	11.1
Leisure/hobby	37.5	45.0	41.7
Amateur competitive sport	31.3	45.0	38.9
Professional competitive sport	9.4	2.5	5.6
Thoroughbred/trotter	3.1	2.5	2.8
Other			

Table 3: General respondent information (demographic data) of the questionnaire respondents, expressed as percentages of respondents for users, non-users and for the total (n=72)
Abbreviations: n=number of respondents, %=percentage, <=less than, >=more than

Use of OGA

Users answered several questions concerning their use of (techniques for) OGA. These were questions about the system they use for OGA, how they use their system, the percentage and type of orthopaedic patients they asses with OGA, and under what circumstances they use OGA.

Figure 3 shows that the most commonly used systems were Equinosis Q/Lameness Locator and Qualisys/Qhorse. Respectively 55% (22/40) and 50% (20/40) of the users indicated to have used one or both of these systems for OGA. Equimoves and Equigait were indicated to been used both by only 2 respondents. One other system named in the bar chart used by a respondent was Xsens.

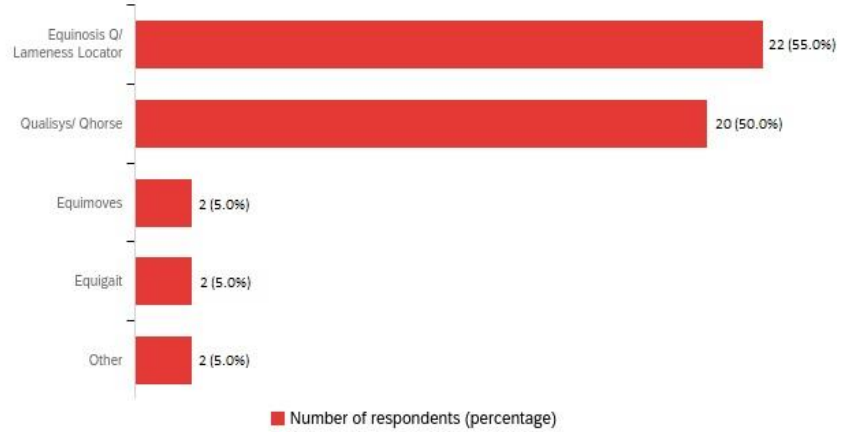


Figure 3: Bar chart of systems for OGA used by users (multiple choice)

Figures 4 and 5 show that users predominantly used systems for OGA stationary (72.5%), some have used them both ambulatory and stationary and only a few just ambulatory and that half of the users indicated to have assessed less than 25% of their own orthopaedic patients with systems for OGA. Fifteen per cent marked to have used OGA for more than 75% of their patients.

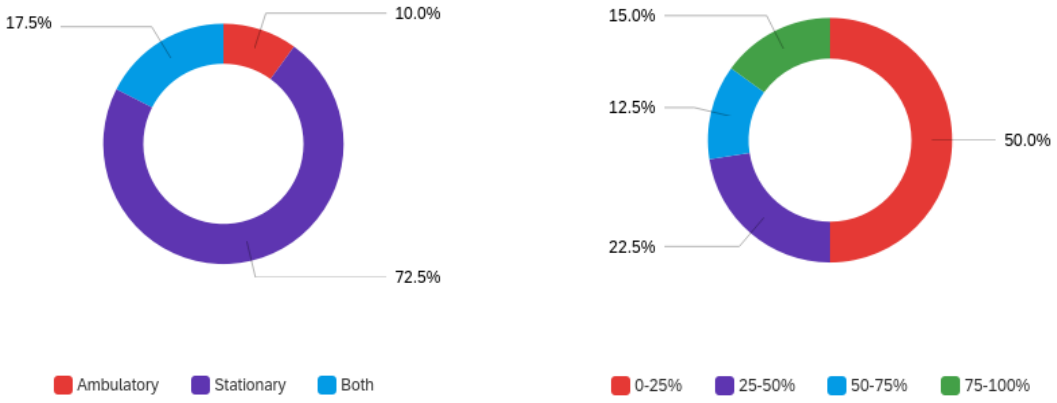


Figure 4 and 5: Pie charts of how techniques for OGA were used and the percentage of orthopaedic patients to which OGA was applied

Patients that come for lameness examination were pointed out by 85% of the users as a group of patients they assess with OGA. Figure 6 also shows that about equal amounts of users indicated to (also) have used OGA for the patient groups that come for pre-purchase examination, neck, back, or pelvic complaints and regular check-up or regular sport horse monitoring systems. Other groups of patients that respondents indicated to

have assessed with systems for OGA were only for horses that show loss of performance, during clinical trials or research and as an independent witness expert in legal proceedings.

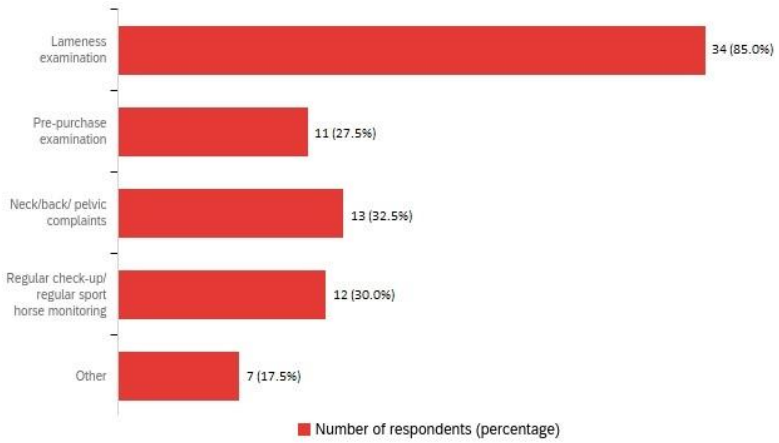


Figure 6: Bar chart of the type of patients for which OGA was indicated to be used (multiple choice)

Figure 7 shows that 93.5% of the users indicated to have used systems for OGA on the straight line and before and after regional and/or joint anaesthesia. Eighty-five and a half per cent stated to (also) have used OGA on the circle. After that 75, 65, 25 and 25% said they have used OGA (too) on soft ground, hard ground, under tack and during flexion tests. Other circumstances specified under which respondents have used OGA were farriery, video comparison and before and after treatment.

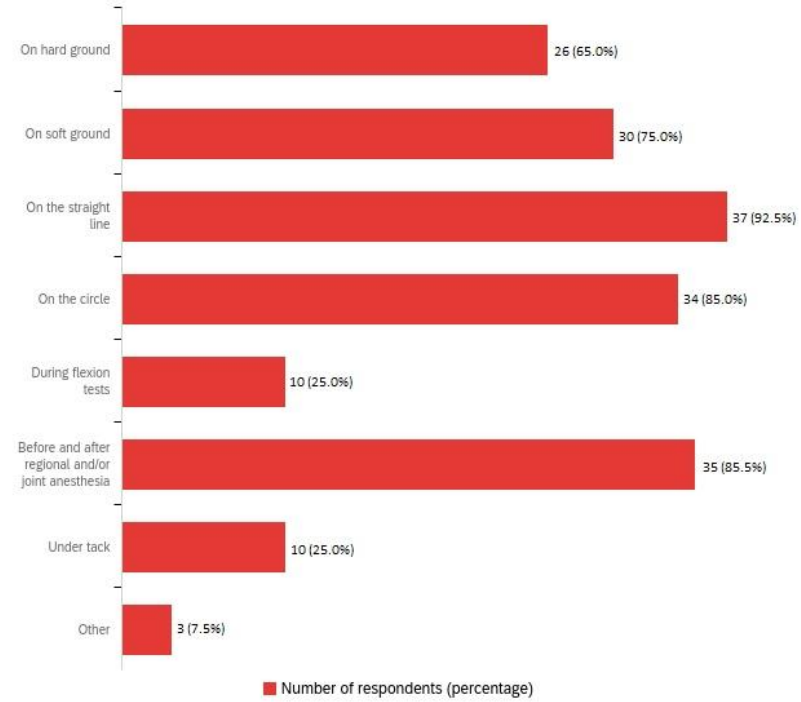
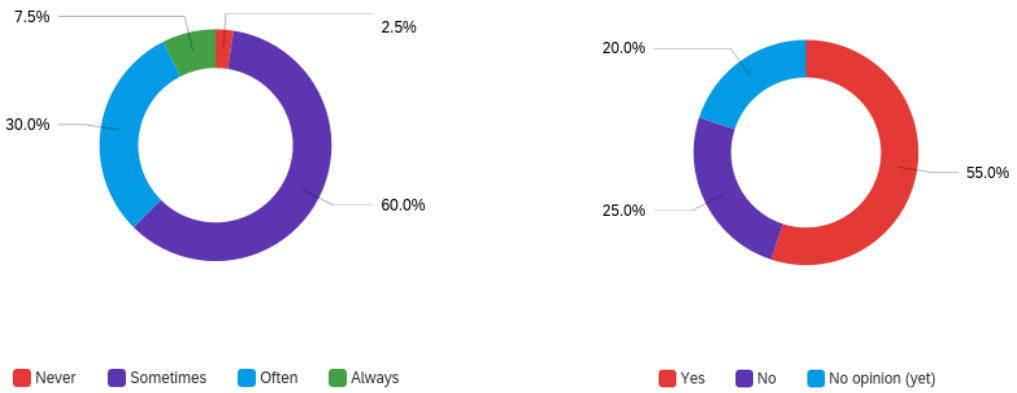


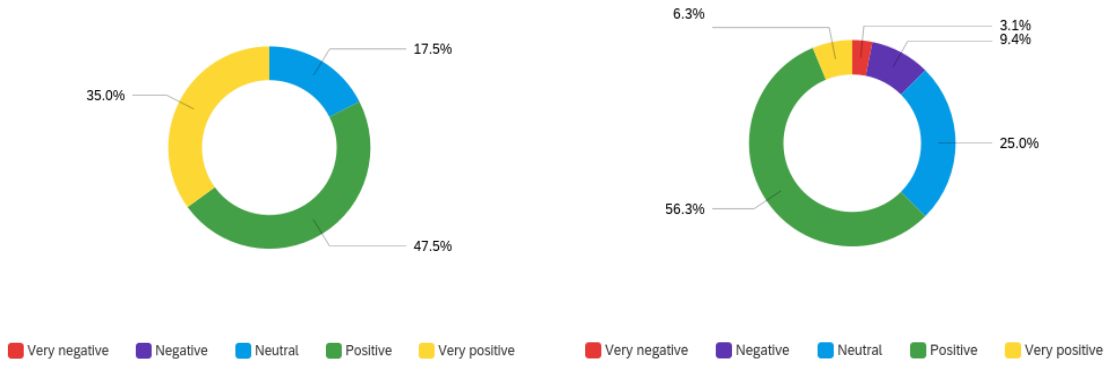
Figure 7: Bar chart of the circumstances under which OGA was indicated to be used (multiple choice)

In figure 8 it can be seen that a great majority (90%) of the users indicated to sometimes or often question their observation during orthopaedic assessments without the use of OGA. Eight per cent of users indicates to always doubt their observation.
Furthermore, figure 9 shows that for more than half of the users (55%) their experience with OGA had changed their way they look at lameness.



Figures 8 and 9: Pie charts of questioning observations during orthopaedic assessments without the use of OGA and whether their experience with OGA had changed the way they look at lameness

Opinion and experience of users and non-users with OGA
Figures 10 and 11 show the overall opinion of users and non-users regarding the development of OGA in the equine clinic. It can be seen that a larger proportion of the users were positive or very positive (82.5%) than of the non-users (62.6%).



Figures 10 and 11: Pie charts of the overall opinion of users (left) and non-users (right) regarding the development of OGA in the equine clinic

Both users and non-users were asked to clarify their answer on how their overall opinion was regarding the development of OGA in the equine clinic. Within the clarifications of users a distinction could be made between positive and negative remarks. Furthermore, within the positive remarks of users four categories could be classified; (1) general positive remarks, (2) remarks on the added value of OGA for specific or difficult cases or certain circumstances, (3) remarks on objectivity and (4) remarks on how OGA can improve veterinarians.

Firstly, and with the largest share, general positive remarks, such as *"useful"* (P61), *"helpful"* (P73) and *"additional patient info"* (P56). Secondly, remarks on the

added value of OGA for specific or difficult cases or certain circumstances, such as *"helps in difficult cases"* (P45), *".. very helpful for rechecks and for more severe lameness.."* (P118) and *"very useful for blocks"* (P145). Thirdly, remarks on objectivity, such as *"brings objectivity into a very subjective field.."* (P48) and *"contributes to objectifying lameness"* (P148). And lastly, a few remarks on how OGA can improve veterinarians, such as *".. development of own view"* (P56) and *"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"* (P58).

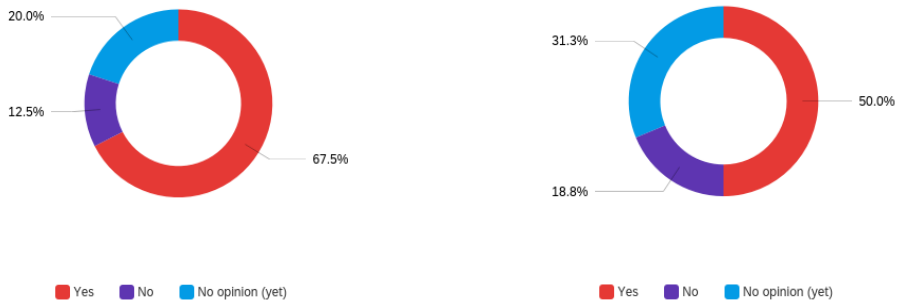
Within the negative responses of users two categories could be classified; these remarks related to (1) (the functioning of) the system and (2) time and cost. Remarks on (the functioning of) the system for example were *"more accurate systems need to be developed"* (P66), *"confusing with multilimb lameness"* (P75) and *"the system is cumbersome.."* (P9). Regarding cost and time respondents remarked *".. often time consuming"* (P12) and *".. the best systems are still extremely expensive so out of reach for most vets"* (P39).

The clarification comments made by non-users could be grouped into three general categories, related to (1) positive comments on OGA, (2) drawbacks of OGA and (3) how OGA has no added value.

Firstly, positive comments on OGA and noting the benefits and added values of OGA, such as *"helps with standardisation of the lameness examination.."* (P 10). Within the comments on the added value more frequently recurring clarifications were on the added value of OGA in specific cases; *"potential for further support in difficult cases"*. (P79) and on how OGA offers objectivity; *"gives an objective image of lameness"* (P74). Secondly, remarks by non-users that pointed out the drawbacks of OGA; *"doesn't work well on all orthopaedic cases and risk the vet of being blinded to this"* (P57) and *"still needs more evidence/work particularly surrounding bilateral limb lameness.."* (P151). And thirdly, remarks on how OGA has no added value compared to regular clinical lameness examination, such as *"clinical examination gives more information"* (P6) and *"unnecessary, doesn't add information. A good sport vet is faster and more accurate"* (P127).

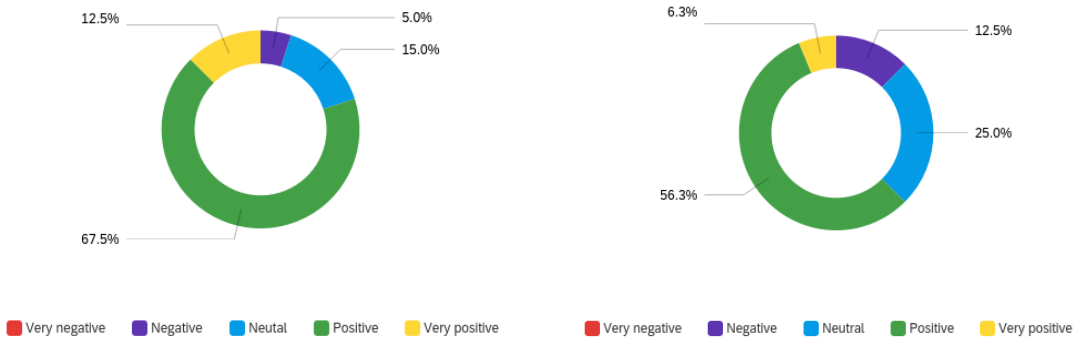
Comparing the clarifications of the users and non-users, both groups mentioned alike positive remarks on the added value of OGA and negative remarks on flaws of OGA. Only non-users also commented how OGA has no added value.

Furthermore, figures 12 and 13 show whether users felt that the use of OGA has made them a better veterinarian (by providing support in their decision-making) and whether non-users thought that the use of OGA could make them a better veterinarian. A larger proportion of the users thought it did than non-users thought it could (67.5% versus 50%).



Figures 12 and 13: Pie charts of whether users (left) and non-users (right) thought that the use of OGA has made or could make them a better veterinarian.

Next, figures 14 and 15 show how users and non-users thought their clients would appreciate the use of OGA within their clinic. Notable was that a greater proportion of the users (80%) thought clients would positively or very positively appreciate the use of OGA within their practice, compared to non-users (62.6%). Moreover, users indicated smaller proportion of their clients would negatively appreciate the use of OGA (5%) than non-users (13%).



Figures 14 and 15: Pie charts of how users (left) and non-users (right) thought their clients would appreciate the use of OGA within their practice

Within the clarifying comments of users on this question a division could be made into positive comments and negative comments. The positive comments could be categorised into two groups, related to (1) how clients like the additional information obtained from OGA that support the veterinarian and (2) feedback perceived from clients.

Firstly, most responses were on how clients like the additional information obtained from OGA that support the veterinarian (i.e. objectivity wise) and give a visualisation of the lameness examination for them. Users for example responded: *"Clients are becoming increasingly critical and like the vet's allegations to be supported by measurements"* (P36) and *"they can see something objectively .."* (P145). And secondly, a group of comments were on general positive feedback perceived from clients, such as *"clients like it"* (P35 and P126), *"very positive feedback"* (P24) and *"they ask for it"* (P73).

On the other hand, the negative comments could also be grouped into two categories, related to (1) negative experiences or opinions perceived by clients and (2) negative experiences of veterinarians about clients.

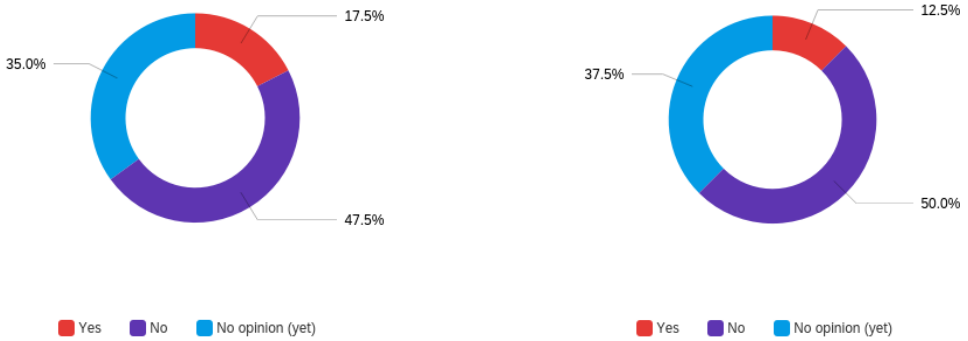
Remarks that could be categorised as responses on negative experiences or opinions perceived by clients were for example; *"the data are hard to interpret for owners.."* (P9) and *"I think most professional riders want the experience of a vet rather than completely rely on in their opinion gadgets"* (P39). Furthermore, a group of negative responses were on negative experiences of veterinarians about clients, such as *"clients have a tendency to think that the machine can't be wrong…"* (P62).

The responses of non-users in the clarifications could be classified in three categories, related to (1) experiences with clients, (2) estimations or predictions of the opinion of clients and (3) pros and cons of OGA for owners.

Firstly, responses of non-users in which they described their experiences with clients, for example; *"some like it, others think new things are exaggerated"*(P3) and *"requires client education"* (P59). Next, responses in which they gave an estimation or prediction of the opinion of clients, such as *".. TB race trainers are not likely to appreciate the tool"* (P151) and *"thoroughbred and trotting sport probably are probably less open to new developments .."* (P15). And lastly, clarifications in which they named the pros or cons of OGA for owners, i.e. *"maybe too expensive"* (P26) and *"time demanding and cumbersome.."* (P125) versus *"makes lameness clearer and more recognizable for owner"* (P38) and *".. help in documenting rehabilitation progress.."* (P23).

When comparing the clarifications of the users and non-users, quotes mentioned by both groups were classified under the categories experiences with clients and estimations or predictions of the opinion of clients.

Lastly, figures 16 and 17 show whether users and non-users thought OGA should or should not be used by studbooks, sports organisations, judges and/or trainers.



Figures 16 and 17: Pie charts of whether users (left) and non-users (right) thought OGA should or should not be used by studbooks, sports organisations, judges and/or trainers

Users that thought OGA should not be used by studbooks, sports organisations, judges and/or trainers stress snags in the clarifications, for example that OGA is *"it's a tool that needs to be thoroughly understood and interpreted .."* (P126) and *".. a dangerous tool to use in isolation"* (P75) and *"needs to be used with formal training by those experienced in lameness examination"* (P61). Whereas, users that were for the use of OGA by studbooks, sports organisations, judges and/or trainers implicate added value, such as there is *"no reason any more to rely on subjective .. "data" "* (P78) and *".. it can help in early lameness detection"* (P77).

Non-users that were for the use of OGA by studbooks, sports organisations, judges and/or trainers alike as users noted the added value of OGA in the clarifications, for example *"more objective than the opinion of different people"* (P72) and that this way *".. horses that are unsound, would not pass vet check.."* (P23). On the contrary, non-users that thought OGA should not be used by studbooks, sports organisations, judges and/or trainers similarly like users stressed snags, such as *"should stay an instrument for lameness examination"* (P18), *"a trained eye of a veterinarian remains necessary for the interpretation"* (P38) and *"errors in interpretation lurk"* (P29).

Satisfaction of users with respect to the system they use for OGA
The bar chart in figure 18 below shows how users expressed their satisfaction with the system they have applied for OGA on a scale from 1 (not at all satisfied) to 10 (could not be better). Users gave their system an average mark of 6.97.

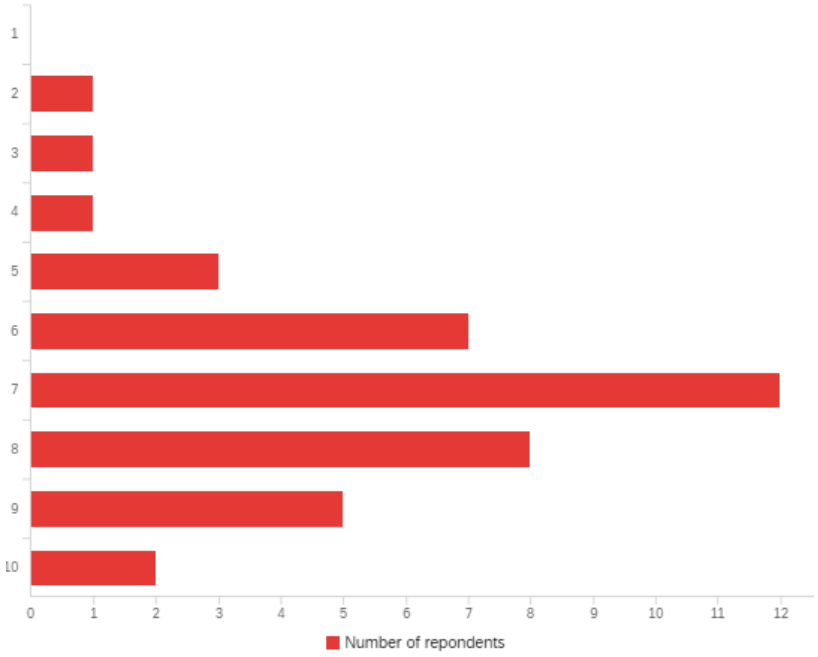


Figure 18: Bar chart of how satisfied users were with their system for OGA used on a scale from 1 (not at all satisfied) to 10 (could not be better)

Furthermore, users were asked what their expectations of the system for OGA they have worked with beforehand were. Their expectations beforehand could be classified into five categories.
The categories are shown in the table below with examples for each category.

Category	Examples
No or unspecified expectations	*"no expectation.."* (P76) *"was not sure what to expect"* (P44)
General positive and negative expectations	*"positive"* (P7) *".. optimistic.."* (P66) *"open minded"* (P75) *"high expectations"* (P65) *"apprehensive"* (P35)

Expectations for aid in specific or difficult cases	*"to get a support in diagnosing difficult subtle irregularities"* (P12) *".. support for hind limb lameness decision making and interpretation of partial improvements during blocking"* (P52) *"to help me with complex lameness cases"* (P68)
Expectation to gain more accuracy and objectivity	*"it would provide more precise measurements than I am able"* (P28) *".. it would get round the limitations of human perception when it comes to lameness recognition and get rit of expectation bias and hence overall human error"* (P78) *".. quantitative measuring.."* (P37)
Expectations about user friendliness and comprehensibility	*"complicated"* (P45) *".. instant interpretable results and ease in use.."* (P36) *".. straightforward to use"* (P61)

Table 4: Categories with beforehand expectations of users on the system of OGA they have worked with.

Next, users were asked which expectations had been met. Expectations that had been met could be classified into five groups of responses. (1) confirmation of met expectations in general, (2) confirmation of negative expectations met, (3) met expectations on the aid of OGA for specific or difficult cases or certain circumstances, (4) met expectations to gain more accuracy and objectivity and (5) responses on how OGA has a general (positive) contribution.

Firstly, confirmation of met expectations in general, such as *"yes, they were met"* (P28), *"all"* (P73) and *"everything"* (P77). Secondly, three confirmations of negative expectations met, these were *"analysis complicated"* (P45), *"time consuming"* (P46) and *"no - guarded value perceived"* (P66). The third, and largest, group of responses were related to expectations on the aid of OGA for specific or difficult cases or certain circumstances. Examples of this group were; *"improvement of understanding cause-effect and multi-limb-lameness"* (P30) and *"improved assessment of nerve and joint blocks. Clearer identification of site affected in subtle cases"* (P33). The fourth group of expectations met were related to gaining more accuracy and objectivity, such as *"clear objective findings and subtle changes.."* (P48) and *"it is a support in subtle differences after local anaesthesia.."* (P12). And lastly, responses related to how OGA has a general (positive) contribution, for example *"has a positive contribution.."* (P148) and *".. it has made us better veterinarians"* (P58).

Moreover, users were also asked which expectations had not been met. Responses on expectations that had not been met could be grouped into two main categories; (1) responses indicating lacking practicability and comprehensibility and (2) responses about how the system had less added value or gave a different outcome than expected. Additionally, some respondents indicated there were *"none"* (P28&73&78) expectations not met. Some examples of responses related to lacking practicability and comprehensibility were; *"interpretation of findings can be difficult"* (P44), *"execution difficult"* (P45) and *"a little complicated for evaluation in the circle and during riding"* (P145). Respondents indicated how the system had less added value or gave a different outcome than expected could be seen in responses such as; *"we only measure vertical*

asymmetry; not rotation .." (P58) and *".. the helpfulness for difficult (hind leg) lameness is disappointing"* (P9).

Reasons veterinary practice owners had or had not purchased a system for OGA

Reasons veterinary practice owners purchased a system for OGA

Users that also were employer/entrepreneur/veterinary practice owner (n=18) were asked about the considerations that played a role in the purchase of a system with the possibility of OGA. The considerations they mentioned could be grouped into two main groups, namely (1) related to the added value a system for OGA brings and (2) related to progressiveness and being able to offer more to clients and patients. For the first group, respondents mentioned things such as *".. more objectivity and transparency brings better diagnosis and documentation of lameness.."* (P48) and *"more visible judgement of a dynamic problem"* (P126). Related to progressiveness and being able to offer more to clients and patients, respondents spoke for example of *"wanting to become better, wanting to serve our clients and our patients better"* (P58) and *"continuous development.."* (P121).

In total 10 out of the 18 veterinary practice owners indicated to have had concerns around the purchase of a system for OGA. Concerns and misgivings around the purchase were related to (1) cost-benefit analysis, (2) practicability and usability of the system and (3) the acceptance of the system by clients. Seven entrepreneurs indicated to have concerns about costs and benefits of the system for OGA considered to purchase. Concerns they mentioned were, for example; *"the cost and would we use it enough to pay for it"* (P68) and *"the value (income) to my practice"* (P27). Also, five entrepreneurs mentioned to have objections related to the practicability and usability of the system they considered to purchase. They pointed out objections, such as *".. how good does the system work in my hands"* (P13) and *"very complicated system. Not easy to understand the technical issues"* (P73). Lastly, one respondent named the acceptance of the system by clients as concern around the purchase of a system for OGA, namely *".. would the clients accept it?"* (P58).

Reasons veterinary practice owners had not purchased a system for OGA

Seventeen non-users that also were employers and entrepreneurs were posed the question why they until now had decided not to buy a system (with the possibility of OGA) and what considerations had played a role in their decision.

Reasons and considerations they gave could be classified in three categories, related to (1) flaws or drawbacks of OGA, (2) lacking added value of OGA and (3) the incorporation of OGA into the practice.

Firstly and principally, respondents who stated flaws or drawbacks of OGA were a reason they had not purchased a system for OGA. This category could be divided into two general groups; remarks on costs; *"costs"* (P4&22), *"price!.."* (P23) and *"financial.."* (P51) and other remarks on practicability and applicability; *"applicability in the field and availability of easier gadgets"* (P29) and *"complexity of the systems"* (P10). Secondly, respondents named not to seeing added value in the use of OGA as reason to refrain from purchase; *"in my experience it has not provided any information that could not have been gathered by an experienced sport veterinarian.."* (P127), *"do not need it.."* (P125) and *"still a big believer in the nuances of a thorough clinical examination"* (P59). And thirdly, the incorporation of OGA into the practice of respondents was a consideration that had played a role in their decision; *"not sure how*

exactly to integrate it into my practice at this time" (P117) and *"only ambulatory practice"* (P11).

When comparing the concerns and misgivings around the purchase of a system for OGA named by users and the reasons and considerations that made non-users decide not to buy a system with the possibility for OGA, both groups mentioned costs and practicability and usability of OGA. Non-users also remarked to doubt the added value of OGA, which was not mentioned by users.

Suggestions or aspects for improvement of (techniques for) OGA
Some respondents mentioned aspects or suggestions for improvement of (techniques for) OGA. A few examples of these comments were;

- *"improve easy-to-use back exam"* (P30)
- *"difficult to use in ambulance, maybe there will be a possibility to use there in the future"* (P72)
- *"still needs more evidence/work particularly surrounding bilateral limb lameness.."* (P151)
- *"more accurate system needs to be developed"* (P66)
- *"may be faster"* (P121)
- *"more possibilities with rider under saddle.."* (P46)

Discussion

The objective of this study was to (1) identify and describe current users and non-users of OGA, (2) gain in-depth information about the opinion and experience with OGA of both users and non-users and (3) possibly be able to suggest aspects for the improvement of OGA application in commercial equine clinics. This was done in order to be able to formulate an answer to the main question of this study; what properties of OGA make that a clinic does or does not choose to use this technique and why? The results of this research were obtained through the performance of a carefully composed combined qualitative and quantitative questionnaire using Qualtrics®.

Firstly, the results of the questionnaire suggest there were some typical characteristics of both users and non-users. Users had statistically significantly more years of work experience than non-users and operated principally stationary or both stationary and ambulatory.

Secondly, it can be remarked that the overall opinion of users was generally more positive than that of non-users. Users mentioned more positive aspects and fewer negative aspects of OGA than non-users. For the experience of users and non-users with OGA it stood out from the questionnaire that both users as non-users most repeatedly mentioned remarks or comments grouped to the categories added value and increased objectivity. Cost, practicability and usability were most prominent and recurring themes of negative comments or clarifications by both users and non-users. Only non-users in general also mentioned to doubt the added value of OGA.

Thirdly, suggestions for aspects for the improvement of OGA application in commercial equine clinics definitely can be made. These will be discussed later on in the paper.

Lastly, to formulate an answer to the main question of this study mentioned in the introduction; essential properties of OGA which make that a clinic does (1) choose to use OGA are the added value that techniques for OGA bring for veterinarians, clients and patients and (2) does not choose to use OGA are cost, practicability and usability.

As noticed above, users had statistically significantly more years of work experience than non-users. However, as first thought it might have been more probable that younger veterinarians (with less working experience) would be more open to the inclusion of 'newer' techniques such as OGA. On the contrary, it could be explained by the fact that more experienced veterinarians might have more confidence than less experienced veterinarians and decide to include the relatively new techniques for OGA into their practice. Furthermore, cost was an often mentioned drawback of OGA. Cost could possibly explain that mainly veterinarians with more years work experience (and therefore older of age) use OGA more often since they might have built up a larger financial buffer. As a consequence, they may be able to invest in the purchase of a system with the possibility of OGA more often than the maybe less financially stable younger veterinarians with fewer years of work experience.
Next, the observation that users operated principally stationary or both stationary and ambulatory could be explained as techniques for OGA might in general be easier to use stationary than ambulatory. This can be supported by the observation that several respondents mentioned that in their opinion the techniques for OGA were less easy to use in an ambulatory situation. Veterinarians working ambulatory would need to take the system with them and install it each time they want to use it for a patient.
Moreover, it stood out that the overall opinion of users was in general more positive than of non-users. This could rather logically be explained as working with (techniques for) OGA may cause veterinarians to be more positive since they could experience the positive aspects and added value of OGA more than non-users that do not work with OGA.

In earlier mentioned papers on the current discussion between users and non-users of OGA, researchers have given their opinion on the topic of the use of OGA (van Weeren, Pfau et al. 2017, Bathe, Judy et al. 2018, Adair, Baus et al. 2018, Dyson, Sue 2014). However, there have not previously been done similar studies aiming to map the arguments and experiences with the application of techniques for OGA in the commercial equine clinic. Consequently, comparison to other papers on alike investigations was not possible. Thus, all above made assumptions are based on the authors thoughts and opinions and further research is therefore stressed to be of great importance.

Clarification for selection of respondents and work-out of results
For the elaboration of the results two main decisions were made on the inclusion and exclusion of certain respondents which are desirable to explain.
Firstly, respondents who filled out their job mainly consists or consisted of research related to OGA were directly left out for the analysis of the results. When looking at the group of researchers left out, several general differences with regular practicing veterinarians stood out. These were the following: they were in general of older age, they had a work experience in orthopaedics of more than 10 years more often and they indicated they had more practical experience with OGA. If the researchers would have been included in the analysis of the results it would have caused distorted image. Their

higher practical experience with OGA does not align with the experience of a typical user in the clinical practice who was aimed to identify and describe. Therefore, researchers were excluded from the analysis of the results before the display of table 1.

Secondly, respondents who filled out they have had a practical experience with OGA of less than 25 cases were classified as users. Beforehand, the results of the multiple choice, open and clarification questions of users were scanned through. This showed no trend was or major differences were apparent between the group of respondents with a practical experience of less than 25 cases and respondents with a practical experience of more than 25 cases. In the opinion of the author no trend indicating a major difference between the groups was visible. In particular, no clear difference was visible during the comparison of respondents with a practical experience of less than 25 cases and respondents with a practical experience of 25-100 cases. There were some differences visible during the comparison of respondents with a practical experience of less than 25 cases with respondents with a practical experience of more than 100 cases, being the last group was in general more positive about OGA. Yet, this difference was also visible between respondents with a practical experience of 25-100 cases and respondents with a practical experience of more than 100 cases. Therefore, despite the present (minor) differences respondents with a practical experience of less than 25 cases were classified as users.

Strengths

A great strength of this study is that this is the first investigation done on this subject set up this way in order to be able to identify and describe current users and non-users of OGA and gain in-depth information about their opinions and experiences with OGA. We have gained insights into this matter that were previously only supported by opinions of researchers.

Meanwhile, this was a very comprehensive research, so we gathered a lot of information, which in turn can provide a lot of starting points, interesting leads and questions for further follow-up studies. Data collection through the use of a questionnaire was rather straight-forward and simple for both researchers and respondents.

Study limitations

One of the limitations of this study was the limited number of questionnaires fully completed out of the total amount of questionnaires started by respondents. Only 96 out of the in total 152 started questionnaires (63.2%) were entirely filled out. Partially completed questionnaires contained too much missing data and were therefore not usable. The amount of results could have been larger, which would have given a greater strength to the study. It could be noticed that almost all not fully completed questionnaires were ceased after the first block of questions. This might be an indication that respondents were discouraged after seeing the second block of questions and decided to quit. To encourage respondents to fill out the entire questionnaire, the questionnaire could either be built up differently or a more accurate estimation of the duration and description of the structure and build-up of the questionnaire could be given in advance. It could also be stressed that full completion of the questionnaire is of great importance.

In addition, due to the exclusion of partially completed questionnaires from the study the amount of employers/veterinary practice owners was limited to only eighteen

(users) and seventeen (non-users). Of this number a proportion entered non-usable answers. Therefore, the reasons veterinary practice owners had or had not purchased a system for OGA mentioned in the results came from two rather small groups of respondents. Thus, it may be doubted whether the answers of these small groups of respondents cab represent the entire population.

The representability for the entire population of this relatively small sample might in general be questioned. This thus also accounts for the description of users versus non-users, the use of OGA by users and the opinions and experiences of users and non-users with OGA. Moreover, since this study obtained results mainly from respondents from Europe it may be discussed whether they could represent the global population of equine veterinarians in which systems they use for OGA, the circumstances and groups of patients they apply OGA to. The execution of investigations with alike study designs could show whether similar results can be found. Especially a larger sample would be useful to strengthen affirmations about the transferability of the findings to the entire population.

Furthermore, for this study there were no inclusion criteria for equine clinics set beforehand. To obtain the best results it would have been desired that commercial clinics approached were of approximately the same size (i.e. number of veterinarians, clients, patients) with as only difference whether or not they use OGA within their practice. The use of OGA should have been the only variable differing between the clinics, and (all) other variables should have been relatively similar. Due to the distribution method applied, it was not feasible to keep other variables alike, thus veterinarians from possibly completely different clinics may have responded. This may also explain certain results obtained, namely for example above discussed clear distinction in the results into two groups of veterinarians that indicated to have an orthopedic caseload of either 11-30 cases per month or a group with a caseload of >50 cases per month. It could be argued that the respondents who indicated they had a caseload of 11-30 cases per month might be veterinarians working in a general or common fist line clinic. Whereas, the respondents who indicated they had a caseload of more than 50 cases per month might be veterinarians working at a specialist orthopaedic practice. However, since there was no question included into the questionnaire regarding the type of clinic respondents have worked at, it could not be determined if this was true.

Moreover, as previously noted above, in this study the respondents who indicated to have a practical experience with OGA of <25 cases were classified as users. It could have been doubted whether this group of users were equal enough to users that indicated to have a greater practical experience. If the quantity of the results would have been bigger, this group of respondents could have been taken as a separate category in the description of the results and discussion. On the other hand it could also have been decided to exclude this group of respondents from the results to create a clearer distinction between users and non-users. However, due to the lacking quantity of the results of this study this was not decided.

Suggestions for aspects for the improvement of OGA application in commercial equine clinics

Firstly, an aspect for the improvement of OGA application could be to make systems more time efficient. Respondents often indicated that the use of OGA is time demanding

and lengthens the clinical examination too much. If systems could be developed that work quicker and more efficient this threshold for the use of OGA could be taken away.

Secondly, respondents often commented on the functioning of systems of OGA and mentioned that in their opinion systems for OGA can be complicated to use and therefore not easy in use. Increasing practicability could also remove this barrier for the use of OGA.

Thirdly, the analysis of the findings and results of systems for OGA were remarked as difficult to interpret, analyze or comprehend. This could also be an aspect for improvement. If the outcome given by a system for OGA is easy to use, it is more attractive to use a system. Simultaneously, the results may be easier to explain and show to clients. A role may also lay in the updating and refining education on how to apply, use and interpret systems for OGA. In addition, if the companies behind systems for OGA might work together, inter-system differences may be reduced, which might make it more appealing for veterinarians to use systems for OGA since data from different systems may then also be easier to exchange. If companies work together they may also decide together to lower the price for systems and with that promote the purchase of a system by commercial clinics. This may lift away the often mentioned barrier of price.

Application of the findings of this study to the clinical field

The bottlenecks found in this research are relevant and essential for the development of current and new systems for OGA to increase aspects such as practicability and usability. Problems indicated in this study around the topic of interpretation of the results of systems for OGA could be used to develop and optimize the education on the use (of systems for) OGA. This could possibly lead to an increase in the application of OGA in commercial equine clinics and with that potentially increase equine health and performance. Furthermore, an increase in the application of OGA may be of great contribution to the development of veterinarians themselves since the use of OGA may keep them questioning and checking their observations and their minds flexible and progressive.

Conclusion

This study shows that the main properties that make a clinic choose to use OGA are the added value techniques for OGA bring for veterinarians, clients and patients. Central properties that make a clinic choose not to use OGA are cost, practicability and usability.

Both quantitative and qualitative research aiming to identify and describe current users and non-users of OGA are still in its infancy. Our current study seems promising and can potentially improve equine health and performance in the future with the use of techniques for OGA. The potential of current techniques for OGA are right now seen and utilised by a rather limited number of equine veterinarians, even though they may be of great utility and profitability for all veterinarians, patients and clients. Undoubtedly, elaborate research on the opinions and experiences of veterinarians working in commercial equine clinics is essential for the confirmation and validation of the results found in this study.

Future perspectives

Further and elaborative investigations on the application of OGA in the commercial equine clinic seem of great significance in order to be able to give a more accurate display of the population, their opinions and experiences with the use of OGA.

For future researches the limitations of this study could be taken into account for the development of a further elaborative and in-depth investigation. It should be aimed to obtain a greater quantity of results in order to give more power to the study. In addition, inclusion criteria for equine clinics should be established beforehand to minimize variables contrasting and isolate the use of OGA as single variable that differs between clinics.

Besides that, from the results of this/a questionnaire a sample of users and non-users could be selected for explorative, qualitative interviews in order to gain in-depth information concerning the medical and commercial arguments to use OGA or not (motivation), their experiences with the use of OGA and whether it had caused changes in their clinical work up of patients.

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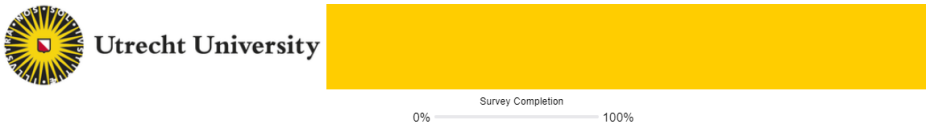
Appendix A

Example complete questionnaire for a user



English - United Kingdom

Thank you for participating in this scientific study about the use of 'objective gait analysis' in clinical practice. Your contribution will help bringing research closer to the equine practice.
We look forward to reading your opinion!
All collected data will be anonymised. The completion of this survey will approximately take 6 minutes of your time.

Gender

- ○ Male
- ○ Female

Age

- ○ < 25 years
- ○ 25-35 years
- ○ 35-45 years
- ○ > 45 years

Employer/entrepreneur or employee?

- ○ Employer/entrepeneur
- ○ Employee

Years of work experience in orthopedics

- ○ < 1 year
- ○ 1-5 years
- ○ 5-10 years
- ○ > 10 years

Location clinic/practice

- ◯ Belgium
- ◯ Germany
- ◯ Netherlands
- ◯ United Kingdom
- ◯ United States of America
- ◯ Sweden
- ◯ Other, namely..

Orthopedic caseload per month

- ◯ < 10
- ◯ 11-30
- ◯ 31-50
- ◯ > 50

Do you work stationary or ambulatory?

- ◯ Stationary
- ◯ Ambulatory
- ◯ Both

The majority of your patient population consists of:

- ◯ Leisure/hobby
- ◯ Amateur competitive sport
- ◯ Professional competitive sport
- ◯ Thoroughbred/trotter
- ◯ Other, namely...

How much practical experience do you have with 'objective gait analysis'?

- ◯ None or only observed during continuing education/with colleagues
- ◯ < 25 cases
- ◯ 25-100 cases
- ◯ > 100 cases

Does/did your job mainly consist(s) of research related to 'objective gait analysis'?

- ◯ Yes
- ◯ No

English - United Kingdom ▼

Which system for 'objective gait analysis' do you use (multiple choice)?

- ☐ Qualisys/Qhorse
- ☐ Equimoves
- ☐ Equigait
- ☐ Equinosis Q/Lameness Locator
- ☐ Other, namely...

How do you use 'objective gait analysis'?

- ○ Ambulatory
- ○ Stationary
- ○ Both

What percentage of your own orthopedic patients do you assess with 'objective gait analysis'?

- ○ 0-25%
- ○ 25-50%
- ○ 50-75%
- ○ 75-100%

What type of patient do you assess with 'objective gait analysis' (multiple choice)?

- [ ] Lameness examination
- [ ] Pre-purchase examination
- [ ] Neck/back/pelvic complaints
- [ ] Regular check-up/regular sport horse monitoring
- [ ] Other, namely...

Under what circumstances do you use 'objective gait analysis' (multiple choice)?

- [ ] On hard ground
- [ ] On soft ground
- [ ] On the straight line
- [ ] On the circle
- [ ] During flexion tests
- [ ] Before and after regional and/or joint anesthesia
- [ ] Under tack
- [ ] Other, namely...

Do you ever question your observation during orthopedic assessments (without the use of 'objective gait analysis')?

- ◯ Never
- ◯ Sometimes
- ◯ Often
- ◯ Always

Has your experience with objective gait analysis changed the way you look at lameness?

- ◯ Yes
- ◯ No
- ◯ No opinion (yet)

Do you feel that the use of 'objective gait analysis' makes/has made you a better veterinarian (by providing support in your decision-making)?

- ◯ Yes
- ◯ No
- ◯ No opinion (yet)

How satisfied are you with your system on a scale from 1 (not at all satisfied) to 10 (couldn't be better)?

1	2	3	4	5	6	7	8	9	10
○	○	○	○	○	○	○	○	○	○

How is your overall opinion regarding the development of 'objective gait analysis' in the equine clinic/practice?

- ○ Very negative
- ○ Negative
- ○ Neutral
- ○ Positive
- ○ Very positive

Clarification

How do you think your clients appreciate the use of 'objective gait analysis' within your clinic/practice?

- ◯ Very negative
- ◯ Negative
- ◯ Neutral
- ◯ Positive
- ◯ Very positive

Clarification

What were your expectations of your system for 'objective gait analysis' before you worked with it?

What expectations have been met?

What expectations have not been met?

Should 'objective gait analysis' also be used by studbooks, sports organisations, judges and/or trainers?

- ◯ Yes
- ◯ No
- ◯ No opinion (yet)

Clarification

English - United Kingdom ▼

Why did you decide to buy a system with the possibility of 'objective gait analysis'/what considerations played a role in this decision?

Were there any concerns/misgivings around your purchase? And if so, which ones?

English - United Kingdom ▼

Is there anything else you would like to share with us about 'objective gait analysis'?

We would like to select a few veterinarians for a short interview. Therefore, please fill in your name and email address below. If you don't want to participate, please leave the next two fields open.

Name

Email adress

Appendix B

Work-up of statistical analysis

User/non-user & age

Contingency table of age by practical experience with OGA (frequency distribution of age for the practical experience with OGA)

	User	Non-user	Total
< 25 years	0	0	0
25-35 years	8	13	21
35-45 years	16	11	27
> 45 years	16	8	24
Total	40	32	72

Expected frequencies for perfectly independent variables

	User	Non-user	Total
< 25 years	0	0	0
25-35 years	11.7	9.3	21
35-45 years	15	12	27
> 45 years	13.3	10.7	24
Total	40	32	72

$Test_8 = ((8-11.7)^2/11.7)+((16-15)^2/15)+((16-13.3)^2/13.3)+((13-9.2)^2/9.3)+((11-12)^2/12)+((8-11.7)^2/10.7$

$= 0.756+0.067+0.548+1.553+0.083+0.681 = 3.688$

With df = 2 → $0.1<p<0.25$

Conclusion: there is no statistically significant relationship between age and practical experience with OGA

User/non-user & years of work experience

Contingency table of years of work experience by practical experience with OGA (frequency distribution of years of work experience for the practical experience with OGA)

	User	Non-user	Total
< 1 year	0	0	0
1-5 years	5	9	14
5-10 years	6	9	15
> 10 years	29	14	43
Total	40	32	72

Expected frequencies for perfectly independent variables

	User	Non-user	Total
< 1 year	0	0	0
1-5 years	7.8	6.2	14
5-10 years	8.3	6.7	15
> 10 years	23.9	19.1	43
Total	40	32	72

$Test_8$ = $((5-7.8)^2/7.8)+((6-8.3)^2/8.3)+((29-23.9)^2/23.9)+((9-6.2)^2/6.2)+((9-6.7)^2/6.7)+((14-19.1)^2/19.1)$

= 1.005+0.637+1.088+1.265+0.7896+1.362 = 6.147

With df = 2 → $0.025<p<0.050$

Conclusion: there is a statistically significant relationship between years of work experience and practical experience with OGA

User/non-user & orthopaedic caseload/month

Contingency table of orthopaedic caseload/month by practical experience with OGA (frequency distribution of orthopaedic caseload/month for the practical experience with OGA)

	User	Non-user	Total
< 10	1	5	6
10-30	15	13	28
31-50	7	5	12
> 50	17	9	26
Total	40	32	72

Expected frequencies for perfectly independent variables

	User	Non-user	Total
< 10	3.3	2.7	6
10-30	15.6	12.4	28
31-50	6.7	5.3	12
> 50	14.4	11.6	26
Total	40	32	72

$Test_8$ = $((1-3.3)^2/3.3)+((15-15.6)^2/15.6)+((7-6.7)^2/6.7)+((17-14.4)^2/14.4)+((5-2.7)^2/2.7)+((13-12.4)^2/12.4)+((5-5.3)^2/5.3)+((9-11.6)^2/11.6)$ =

1.603+0.023+0.0134+0.4694+1.959+0.029+0.017+0.583 = 4.6968

With df = 3 → $0.100<p<0.250$

Conclusion: there is no statistically significant relationship between orthopaedic caseload/month and practical experience with OGA.

User/non-user & working stationary or ambulatory

Contingency table of working stationary or ambulatory by practical experience with OGA (frequency distribution of working stationary or ambulatory for the practical experience with OGA)

	User	Non-user	Total
Stationary	16	2	18
Ambulatory	5	13	18
Both	19	17	36
Total	40	32	72

Expected frequencies for perfectly independent variables

	User	Non-user	Total

Stationary	10	8	18
Ambulatory	10	8	18
Both	20	16	36
Total	40	32	72

$Test_8 = ((16-10)^{2)}/10)+((5-10)^2/10)+((19-20)^2/20)+((2-8)^2/8)+((13-8)^2/8)+((17-16)^2/16)$
$= 3.6+2.5+0.05+4.5+3.125+0.0625 = 13.8375$

With df = 2 → $p<0.001$

Conclusion: there is a statistically significant relationship between working stationary or ambulatory and practical experience with OGA.

User/non-user & composition of patient population

Contingency table of composition of patient population by practical experience with OGA (frequency distribution of composition of patient population for the practical experience with OGA)

	User	Non-user	Total
Leisure/hobby	2	6	8
Amateur comp sport	18	12	30
Prof comp sport	18	10	28
Thoroughbred/trotter	1	3	4
Other	1	1	2
Total	40	32	72

Expected frequencies for perfectly independent variables

	User	Non-user	Total
Leisure/hobby	4.4	3.6	8
Amateur comp sport	16.7	13.3	30
Prof comp sport	15.6	12.4	28
Thoroughbred/trotter	2.2	1.8	4
Other	1.1	0.9	2
Total	40	32	72

$Test_8 = ((2-4.4)^2/4.4)+((18-16.7)^2/16.7)+((18-15.6)^2/15.6)+((1-2.2)^2/2.2)+((1-1.1)^2/1.1)$
$+((6-3.6)^2/3.6)+((12-13.3)^2/13.3)+((10-12.3)^2/12.4)+((3-1.8)^2/1.8)+((1-0.9)^2/0.9)$
$= 1.309+0.101+0.369+0.655+0.009+1.6+0.127+0.465+0.8+0.11 = 5.446$

With df = 4 → $0.1<p<0.25$

Conclusion: there is no statistically significant relationship between the composition of the patient population and practical experience with OGA.