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Comparison of a multi-functional fitness tracker with an inertial sensor system for locating and evaluating lameness in horses

Diploma Thesis

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submitted by
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I. Introduction

Gait

Horses have three basic gaits: walk, trot, and gallop, and some breeds additionally tolt and pass. (Over 2005, Posnikoff 2003) A gait is defined as "the repetitive limb coordination pattern in locomotion" whereas the stride is the continual movement of the individual limb which shows a stable cyclic pattern. The stride shows two phases: the stance phase, where the horse's hoof is set on the ground, and the swing phase, where the limb is moved forward. (Derman and Noakes 1994, Drevemo et al. 1980) During the swing phase, the leg performs a cycloid movement with its peak always occurring in the first third of the curve, regardless of gait, speed of movement, and front or hind limb. (Kofler and Edinger 2014) The stance phase itself again is divided into two parts: the restraint stage and the propulsion stage. (Derman and Noakes 1994) In between these two phases is the midstance, where the limb is in a rectangular position to the ground. (Derman and Noakes 1994, Keegan 2016) The restraint stage marks the duration of time when the hoof is on the ground, so from the contact of the heel until the end of mid-stance, whereas the propulsion stage describes the push-off, from the end of mid-stance until the toes leave the ground for the swing phase. (Drevemo et al. 1980, Posnikoff 2003)

Walk, being the slowest of the three basic gaits, shows a distinct four-beat rhythm. (Stodulka 2006, Burgschat 2003, Speirs 1997, Barrey 2013) The stride pattern is described as lateral as the two limbs of one side of the body are placed successively: 1. Hind left, 2. Front left, 3. Hind right, 4. Front right. (Stodulka 2006, Speirs 1997, Wilson and Keegan 2020) While the speed of walk can vary from collected walk to extended walk it is supposed to be rhythmical, even, and of a clear beat at all times. (Barrey 2013) As there are always at least two feet on the ground, it shows no period of suspension. (Stodulka 2006, Speirs 1997)

Like walk trot as is also considered a symmetrical gait meaning the movement of each pair of feet is evenly distributed over time. (Wilson and Keegan 2020, Derman and Noakes 1994, Barrey 2013) The diagonal pairs of feet touch the ground in turn in a two-beat rhythm. (Speirs 1997, Budd 2003, Derman and Noakes 1994, Stodulka 2006) This results in a short phase of suspension in between, when all four legs are in mid-air. (Speirs 1997, Stodulka 2006, Wilson and Keegan 2020) One gait cycle consists of each pair of feet being moved once, hence of two stance phases and two phases of suspension: 1. Hind right – Front left, 2. Phase of suspension, 3. Hind left – Front right, 4. Phase of suspension (Derman and Noakes 1994, Stodulka 2006) As a result head and pelvis reach minimum height around mid-stance and maximum height is reached as the horse's foot leaves the ground. There is a maximum and minimum position for each side of the horse. Therefore maximum/minimum position is reached twice each cycle. (Buchner 2013)

Gallop, the fastest of the three gaits (Stodulka 2006, Barrey 2013), in contrast to walk and trot, is asymmetrical, which means the footfall of each pair of feet is unevenly distributed over time. (Wilson and Keegan 2020) There are two types of gallop: one with an extended four-beat gait and the other canter, which may be considered a "three-beat gallop". (Derman and Noakes 1994, Speirs 1997, Budd 2003, Stodulka 2006) In both, the lead hind limb and the diagonally corresponding lead front limb carry the most weight. (Speirs 1997, Budd 2003) The gallop, as well as the canter, is titled according to the leading front limb. (Budd 2003, Stodulka 2006) Naturally, the horse changes the leading front limb when it fatigues or when turning. Turning right the right front leg will lead, turning left the left front leg is leading. (Speirs 1997, Ross 2011) In a right lead gallop, the stride pattern is described as following: 1. Hind left, 2. Hind right, 3. Front left, 4. Front right. Two strides are connected by a short phase of suspension. (Speirs 1997, Derman and Noakes 1994, Budd 2003) During canter, in contrast to gallop, not every limb is placed individually but one diagonal pair of limbs at the same time. So, based on the example of the right lead gallop in canter, it would be: 1. Hind left, 2. Hind right - Front left, 3. Front right. Again, followed by a phase of suspension. (Speirs 1997, Stodulka 2006, Budd 2003)

Types of Lameness

Lameness is defined as an abnormality of gait, (Speirs 1997) showing an irregular placement or movement of the horse's limb. (Pilliner and Davies 2004) It indicates a structural or functional disorder in one or more limbs or the axial skeleton (Baxter and Stashak 2020) and can have various causes including for example trauma, infection, congenital or acquired anomalies, and nervous disorders (Baxter and Stashak 2020, Hechler 2005). Being one of the most common medical conditions in horses, (USDA 2015) lameness can be classified according to the severity of the motion disorder (Hechler 2005) and the stride phase during which it occurs: supporting limb lameness, swinging limb lameness and mixed lameness. (Baxter and Stashak 2020, Hechler 2005) Furthermore, it is categorized depending on which limb is affected. It can be either a front or hind limb lameness or a bilateral or multi-limb lameness. (Buchner 2013)

Due to their symmetrical movement and even weight distribution walk and trot are more suitable to identify lameness (Kofler J and Edinger J. 2014) and hence the focus of this thesis. The main points we look at to evaluate lameness are the phase of stride, arc of foot flight, way of landing, weight bearing, extension of the fetlock joint, and the movement of head and pelvis. (Baxter and Stashak 2020, Speirs 1997, Kofler and Edinger 2014).

A stride consists of a cranial and a caudal phase. The cranial phase describes the part of the stride after the affected limb has passed the corresponding limb. Therefore, the caudal phase relates to the part of the stride before passing the opposite foot. (Speirs 1997, Baxter and Stashak 2020, Kofler and Edinger 2014) In a sound horse, both phases are of the same length. (Kofler and Edinger 2014, Ross 2011) Consequently, shortening one phase due to lameness results in the lengthening of the other to maintain similar stride length side to side. (Baxter and Stashak 2020, Ross 2011, Kofler and Edinger 2014) This is best evaluated by looking at the horse from the side comparing the phases of the stride of the paired hind/front limbs. (Kofler and Edinger 2014, Baxter and Stashak 2020) Most lame horses have a shortened cranial phase of the stride to reduce the time spent during the stance phase and to help during break-over. Other reasons are the loss of propulsion or an unwillingness to push off with the lame limb (Ross 2011).

Like the phases of stride, the arc of foot flight is again observed best by comparing it to the opposite foot from the side. (Speirs 1997, Baxter and Stashak 2020) A lowering of the arc may be indicative of lameness but does not reveal the type of lameness. Both, supporting limb and swinging limb lameness can prevent the horse from lifting its hoof as high as normal. In supporting limb lameness, it may decrease the pain at impact and in swinging limb lameness difficulties or pain in bending the extremity can influence the arc of flight. (Buchner 2013) Many horses showing an altered foot flight present a change in the phases of stride as well. (Baxter and Stashak 2020)

Another indication of lameness may be the way of landing. Usually, the hoof is placed flat and level on hard ground. (Ross 2011) A painful condition changes the loading pattern to avoid the painful region. More precisely, if the problem is located in the heel it places the toe region first and vice versa. Just as if the lateral or the medial portion of the hoof is hurting, more weight is carried on the sound or less hurting area of the sole. (Baxter and Stashak 2020, Speirs 1997, Buchner 2013)

Supporting limb lameness is usually a result of pain during stance phase and hence affected horses shift their weight to reduce load on the affected limb which results in distinct lameness associated gait patterns. (Buchner 2013) In a moving horse, the extension of the fetlock reflects the amount of weight the limb is bearing. (Baxter and Stashak 2020) Therefore, as the horse is transferring weight from the affected to the good extremity, the sound fetlock drops farther to the ground than the one of the troubled leg does. (Baxter and Stashak 2020, Kofler and Edinger 2014, Ross 2011) This may be visible, according to the degree of lameness, in the walk as well as in the trot. (Baxter and Stashak 2020)

In a sound horse, vertical head and *tuber sacrale* movement show a symmetrical, double-sinusoidal pattern and hence head and pelvic movement asymmetry are commonly used in lameness diagnosis. (Buchner et al. 1996) In forelimb lameness, to minimize load on a painful forelimb, head and neck elevate when the lame forelimb hits the ground and nod down when the sound forelimb begins the support or stance phase. (Ross 2011, Kofler and Edinger 2014) This observation is referred to as ‘vertical head movement pattern’. (Buchner 2013) In addition, horses with forelimb lameness shift weight in a caudal direction in a diagonal compensatory movement, which may appear as compensatory lameness in the contralateral (diagonal) hindlimb. To distinguish a real lameness from a compensatory “fake” one, provocation tests may be executed. (Kofler and Edinger 2014)

The distinctive characteristic of hindlimb lameness is vertical movement asymmetry of the pelvis (using the *os sacrum* as indicator of pelvic movement) and the hips (using the *tubera coxae* as indicator for the hip movement). (Kofler and Edinger 2014, Buchner 2013) While a sound horse presents with two symmetrical vertical *os sacrum* excursions per stride (symmetrical, double-sinusoidal pattern), the two excursions become asymmetric in lame horses. (Ross 2011)

Typically, in hindlimb lameness, in an attempt to minimize load on the affected hindlimb, the *os sacrum* and the ipsilateral *tuber coxae* (hip hike) of the lame limb show increased upward movement before the lame limb touches down (Buchner 1996, Ross 2011, Starke and May 2021). As a consequence of the reduced weight bearing on the lame limb the push-of is reduced and the pelvis and ipsilateral tuber coxae (hip drop) remain lower and drop during the swing phase of the affected limb. In contrast, the sound limb is fully loaded, allowing a powerful push-of at the end of the stance phase, which in turn causes the ipsilateral *tuber coxae* to only lower slightly during swing phase. The vertical displacement amplitude of the *tuber coxae* of the lame limb is therefore greater than the amplitude of the sound leg. In addition, hindlimb lameness may be associated with a change in the vertical head movement pattern. (Buchner et al. 1996, Buchner 2013) To reduce weight on the affected hind limb, the load is shifted to the front and the head is lowered when the diagonal front leg is moving forward. This sagittal compensatory movement may result in the erroneous diagnosis of an ipsilateral forelimb lameness.

Swinging limb lameness occurs when a horse’s leg is confined during swing phase without pain during stance phase. (Ross 2011, Buchner 2013) Causes of swinging limb lameness are mainly found in the upper part of the limb. (Speirs 1997, Kofler and Edinger 2014) Indicative of this may be the shortening of the cranial phase of stride. (Buchner 2013, Ross 2011) However, distinct swinging limb lameness is extremely rare. Most lameness conditions display a mixture of pain when weight-bearing in stance phase and some kind of problem while bringing the limb forward and are therefore considered as mixed lameness. (Ross 2011, Buchner 2013, Baxter and Stashak 2020, Kofler and Edinger 2014)

When painful conditions occur in paired extremities it is spoken of ‘bilateral lameness’. (Kofler and Edinger 2014) This might be hard to detect and is just referred to as poor performance when the lameness is of equal intensity in both limbs. (Keegan 2020, Ross 2011, Buchner 2013) The locomotion of the horse is often described as stiff, short, and shuffling. For a veterinarian who is not familiar with the normal movement patterns of that specific horse, this may be difficult to recognize. Therefore, to decide whether a bilateral lameness is present it can be helpful to lateralize the lameness. Methods for this are turning the horse in a cycle, longing in both directions, flexing or stressing the limb, or eliminating the pain in one leg. (Keegan 2020, Buchner 2013)

Subjective Lameness Exam

Lameness examination is one of the most common tasks of a veterinarian. Rarely, it is possible to set a diagnosis at first sight, but usually, a methodic procedure is necessary. (Hanbücken and Dahmen 2018, Hechler 2005) There are different factors predisposing to lameness such as age, breed, or purpose of use. Therefore, it is important to clarify the signalment and anamnesis before starting. (Kofler and Edinger 2014, Hanbücken and Dahmen 2018, Pilliner and Davies 2004) The anamnesis is followed by a visual examination at rest, palpation of the musculoskeletal system, and an examination during movement. (Pilliner and Davies 2004, Speirs 1997) The examination at rest should occur first from a distance with the horse, if possible, undisturbed and resting so it shows the position it is most comfortable in. (Pilliner and Davies 2004) The examiner assesses conformation, symmetry, and posture, incl. swellings, obvious wounds, and muscle atrophy. (Stodulka 2006, Speirs 1997) Observing one or more of these qualities may give a first hint of the site and source of pain. (Pilliner and Davies 2004) Thereafter a comprehensive palpation of all parts of the musculoskeletal system, incl. all 4 limbs, neck, back, and the pelvic regions, is performed, looking for signs of inflammation (heat, pain, redness, swelling) and assessing symmetry and function, including range of motion. Each limb should be assessed while bearing weight and with the limb elevated from the ground. (Rosser 2011).

The first visual examination during movement should take place on a level, hard and nonslip surface. (Hanbücken and Dahmen 2018, Kofler and Edinger 2014) The horse must be properly restrained but allowed to move its head and neck freely. (Pilliner and Davies 2004, Kofler and Edinger 2014) Initially, the horse is to be presented in walk. The handler leads the horse back and forth in a straight line giving the observer a chance to watch it from the front, back, side, and while turning. (Pilliner and Davies 2004, Kofler and Edinger 2014) Since not every lameness is visible in walk, or expressed differently in walk and trot, it is useful to compare the horse’s movement in both gaits. (Ross 2011, Hechler 2005, Kofler and Edinger 2014) For examination in trot, the same criteria apply as in walk. (Budd 2003, Stodulka 2006) Lameness may be more obvious in trot as the greater velocity causes a stronger impact on the limb during stance phase. (Kofler and Edinger 2014) If it is not clear which foot is affected it may help to trot (or walk) the horse in small circles in both directions. This puts more pressure on the inside legs increasing a present lameness. (Pilliner and Davies 2004, Kofler and Edinger 2014) Some lameness, mostly swinging limb lameness or lameness associated with ligaments or tendons, are more obvious when exercising on a soft or deep surface such as sand. (Speirs 1997, Hastie 2003, Ross 2011)

Another way to locate the source of lameness can be flexion (e.g. fore/rear limb lower/upper limb flexion test) or other provocation (e.g. heel elevation, toe elevation, shoulder extension) tests. During flexion tests, the limb is held in a specific position for 60 seconds and the horse is then led to trot immediately. (Pilliner and Davies 2004, Kofler and Edinger 2014, Hanbücken and Dahmen 2018) The flexion test is positive when the horse shows increased lameness as trotting away. (Speirs 1997)

To document lameness severity more accurately and to facilitate communication between veterinarians but also with the clients the use of a defined scale is essential. (Keegan 2007, Dyson 2011) As there is no universally accepted grading system yet (Dyson 2011), a few common ones are described in the following.

1999 the American Association of Equine Practitioners (AAEP) agreed on a grading scale ranging from zero to five, with zero showing no lameness at all and five being the most severe (Table 1). While *Grade 1* describes a lameness that is difficult and not consistently to observe, regardless of circumstances (e.g., under saddle, circling, hard surfaces, etc.) describes *Grade 2* a lameness which is also difficult and not consistently to observe in walk or when trotting in a straight line but is persistent under a certain circumstance. Is the lameness showing at all times and under all circumstances, therefore also when trotting a straight line, it is considered a *Grade 3* after AAEP and a *Grade 4* when it is also to be seen at walk. *Grade 5,* being the highest grade on the AAEP scale, is used when the horse is unable to take on more than minimal weight in motion and/or at rest or shows a complete inability to move (American Association of Equine Practitioners 1999). While this grading system has been in use since the late nineties over the years practitioners have adjusted or changed the system for their purpose. For instance, Dr. Mike Ross 2010 kept the grades from zero to five but specified the definitions for the single grades. He added the movement of head and pelvis to consideration (Table 1). Unlike the AAEP system, his scale is only to be applied to horses in trot. Sue Dyson also describes a numeric system she has worked out for herself throughout her career. The eight grades themselves have no further definition than mild, moderate, and severe, but are to be accompanied by verbal descriptions of the gait. This system is applicable independently under any circumstance (Table 1). (Dyson 2011)

In the German-speaking area, also a five (or six including *Grade 0* = sound) step scale is used. (Edinger 2010) In the Hanoverian system, the horses undergo a combined evaluation in walk and trot. *Grade 1* is considered a mild, inconsistent lameness, which is only visible in trot, but not at every step regardless of the circumstances. *Grade 2* on the other hand is visible at every step in trot, but not to hardly in walk. A moderate lameness is present in walk already and marks *Grade 3* on the Hanoverian scale. To be assigned *Grade 4* the lameness must be obvious in walk and trot under all circumstances and the lame limb bears the weight during walk as short as possible. At *Grade 5* the horse is reluctant to take any weight at all on the concerned limb. (Table 1)
While the general distribution of the grades is very similar, the Viennese scale in contrast to the Hanoverian grading system is to be used in walk and trot individually. The Viennese system, like the one from Dr. Ross, also includes the movement of head and pelvis. So, *Grade 1* describes a mild, inconsistent lameness that is barely noticeable and accompanied by a slight asymmetrical movement of head or pelvis visible in individual steps but not at all times. *Grade 2* shows a mild lameness but with constantly visible asymmetries in head or pelvic movement. If we see a moderate lameness with not only asymmetrical movement of the head or pelvis but also compensatory movement from front to back or vice versa the horse is assigned *Grade 3.* At *Grade 4* the horse shows only just a flat footing while at *Grade 5* the limb is only footed on the hoof tip or not at all. (Table 1)

A widely used scoring system in the UK uses a range from zero to ten, where zero determines ‘sound’ and ten a non-weight bearing lameness. (Table 1) A scale ranging from zero to ten is better to note small changes but also gives more room for variability and is less replicable. (Arkell et al. 2006).

This UK ten-step scale is comparable to a different approach used in a study in 1993 by Welsh et al. comparing a numeric grading system as described above with a visual analog scale. This visual grading system used a 100-mm straight line with perpendicular bars at either end. The bar at 0 mm was labeled ‘sound’ whereas the 100-mm bar was labeled ‘could not be lamer’. The observer evaluating the lameness was asked to mark the line at a point that he thinks represents the severeness of that lameness. Before, visual analog scales have already been successfully used in human pain evaluation and also this study showed a 95% correlation between the results of the numeric and the visual analog grading system. (Welsh et al. 1993)

Whichever grading system is used, it is important to recognize that not only every horse is different and shows an individual pattern of movement but also shows pain differently. No two horses with very similar radiological abnormalities show the same abnormalities of movement. Furthermore, none of the systems can take a symmetrical bilateral lameness into account which can be potentially misguiding. (Dyson 2011)

	American Association of Equine Practitioners	Dr. Mike Ross	Sue Dyson	Hanoverian	Viennese	UK
Grade 0	-	-	Sound.	-	-	Sound.
Grade 1	Lameness is difficult to observe and not consistently apparent regardless of circumstances (such as weight carrying, circling, inclines, hard surfaces).	Mild lameness observed while the horse is trotted in a straight line. When the lame forelimb strikes, a subtle head nod is observed; when the lame hindlimb strikes, a subtle pelvic hike occurs. The head nod and pelvic hike may be inconsistent at times.	-	**Mildly, indistinctly lame** – Inconsistent, mild lameness. The lameness is only visible at trot, but regardless of the circumstances of the examination (under saddle, lunge, hard/soft ground, etc.) not visible at every step at trot.	**Mildly, indistinctly lame** – Inconsistent, mild, hardly visible lameness, an asymmetric head movement or movement of the pelvis is only indistinctly recognizable with individual kicks.	The minimal degree of lameness detectable which may be inconsistent.
Grade 2	Lameness is difficult to observe at a walk or trotting a straight line but is consistently apparent under certain circumstances (such as weight carrying, circling, inclines, hard surfaces).	Obvious lameness is observed. The head nod and pelvic hike are seen consistently, and excursion is several cm.	Mild.	**Mildly, distinctly lame** – Mild lameness, constantly visible at trot. The lameness is not to hardly visible at a walk, but clearly visible at every trot.	**Mildly, distinctly lame** – Mild lameness, but constantly visible lameness with asymmetric head movement or movement of the pelvis.	A consistent, but mild, degree of lameness – detectable and consistent subtle head-nod.
Grade 3	Lameness is consistently observable at a trot under all circumstances.	Pronounced head nod and pelvic hike of several cm are noted. If the horse has unilateral singular hindlimb lameness, a head and neck nod is seen when the diagonal forelimb strikes the ground (mimicking ipsilateral forelimb lameness).	-	**Moderately lame** – The lameness is already visible at a walk.	**Moderately lame** – Moderate, clearly visible lameness, asymmetric head movement or hip-tuberosity movement with compensatory movement from front to back and vice versa.	Consistent and obvious head nod/pelvic asymmetry.
Grade 4	Lameness is obvious at a walk.	Severe lameness with extreme head nod and pelvic hike is present. The horse can still be trotted, however.	Moderate.	**Severely lame** – The lameness is clearly visible at walk and trot under all circumstances, the lame limb is only loaded briefly at walk.	**Severely lame** – High degree of lameness with just level footing.	Pronounced head nod/pelvic asymmetry.
Grade 5	Lameness produces minimal weight bearing in motion and/or at rest or a complete inability to move.	The horse does not bear weight on the limb. If trotted, the horse carries the limb (horses that are nonweightbearing at the walk or while standing should not be trotted).	-	**Nonweightbearing** – The horse does not take any load on the lame limb at a walk.	**Nonweightbearing** – No weight bearing or only toe-to-toe footing of the affected limb.	Marked head nod/pelvic asymmetry.
Grade 6	-	-	Severe.	-	-	Very marked head nod/pelvic asymmetry.
Grade 7	-	-	-	-	-	Difficulty trotting; only just able to place heels to the ground.
Grade 8	-	-	Nonweightbearing.	-	-	Minimal weight-bearing, heels not placed on the ground.
Grade 9	-	-	-	-	-	Only able to touch the limb to the ground.
Grade 10	-	-	-	-	-	Unable to put limb to the ground.

Tab. 1: Overview of the different grading systems.

Applicability of Subjective Lameness Exam

KG Keegan et al. in their study in 2013 compared the subjective evaluation of experienced equine veterinarians to the results of a body-mounted inertial sensor system. 106 horses, showing no, mild or moderate lameness have been classified by the veterinarians into three categories: right limb lameness scores greater than left limb lameness scores, left limb lameness scores greater than right limb lameness scores, or equal right and left limb lameness scores. Among themselves, the evaluators agreed for 58,5 % of the horses in the forehand and for 54,7 % in the hind hand. In comparison, agreements between the sensor system and the evaluators varied in the forelimb from fair ($0.20 \leq \kappa \leq 0.40$) to moderate ($0.41 \leq \kappa \leq 0.60$) and in the hindlimb only from slight ($0.0 \leq \kappa \leq 0.20$) to fair.[1] (Keegan et al. 2013)

In another study conducted by P Leemalankong et al. in 2019 twenty-six horses with hind-limb lameness have been simultaneously evaluated by equine clinicians and a body-mounted inertial sensor system. Further, the trials have been recorded and the videos assessed by thirteen additional veterinarians of different experience levels. Two clinicians in clinical conditions reached an agreement in 81 % of all trials, showing moderate ($\kappa = 0{,}289$) agreement. The veterinarians evaluating the recordings varied in their agreement from 61 to 63 % in all trials, considered fair ($0.241 \leq \kappa \leq 0.294$). Comparing the subjective lameness examinations with the results of the inertial sensor system again the clinicians being live on site showed a greater agreement ($\kappa = 0{,}546$) than the veterinarians relying on the videos ($0{,}162 \leq \kappa \leq 0{,}385$). Interesting to state here that the highly experienced veterinarians as well as the inexperienced ones both matched among themselves in 61 % of the cases while in comparison with the sensor system, the evaluators with higher experience reached a higher mean agreement (high experience 66 %, moderate 55 %, inexperienced 56 %). (Leemalankong et al. 2019). Both studies show that the variability in detecting and grading lameness is high, even among veterinary experts (Keegan et al. 2013), and that a higher level of experience does not equal a higher reliability. (Leemalankong et al. 2019) The latter is supported by another study from SD Starke and M Oosterlinck in which it is shown that neither the years of experience nor the caseload exposure had a significant effect

[1]Annotation: Kappa is a statistical measure for evaluating the reliability of agreement between two or more evaluators, results ≤ 0 being described as poor and $0{,}81 \leq \kappa \leq 1$ as almost perfect. (Sim and Wright 2005)

on the number of correct assessments at any level of asymmetry of forelimb and hindlimb lameness. Only asymmetries of 60 % or more in the forelimb have been significantly more often assessed correctly by the participants with a caseload of 11+ cases per month. (Starke and Oosterlinck 2019)

Furthermore, the repeatability of subjective lameness exams has been investigated. M Hewetson et al. had sixteen experienced veterinarians individually evaluate the same videos of twenty horses twice in an interval of four weeks. The observers used two different rating systems, one verbal rating system (VRS) consisting of several adjectives describing different levels of lameness and one numeric rating system (NRS) with a scale from zero (= sound) to five (= as lame as possible). The results showed that the intraobserver agreement with 58 % using the NRS and 60 % using the VRS was only slightly higher than the interobserver agreement with 56 % (NRS) and also 60 %. (Hewetson et al. 2006)

Another study operated in 2006 as well came to a similar result that the agreement between two numeric lameness scores (zero to ten) given by one observer based on a video recording on two occasions three months apart was good ($\kappa = 0{,}68$). Although comparing the evaluations of three different observers the agreement was just fair to moderate ($\kappa = 0{,}41$). (Fuller et al. 2006) With time of profession, veterinarians tend to define or develop their own scoring systems, regardless of training, which can be the cause for disagreement between different assessors. Further, the clinicians may differ in the weighting of different criteria coming to varying conclusions. (Hewetson et al. 2006, Fuller et al. 2006)

Although gait analysis techniques cannot replace a clinician, they can become a common tool increasing the accuracy and the repeatability of subjective lameness examination. (Van Weeren and Gómez Álvarez 2019)

Objective Lameness Exam

The human eye is limited when it comes to observing fast actions and detecting small asymmetries in the movement of horses. (Keegan 2020) This makes it especially hard to recognize mild lameness or lameness in several limbs. (Keegan 2011, 2020) Biomechanical analysis, more precisely the principles of kinematics and kinetics, can be used for objective assessment of lameness. (Keegan 2011) Kinematics refers to the geometric (e.g. height, displacement) and temporal (e.g. duration, rate) characteristics whereas kinetics measures the forces that produce, block or adjust motion. (Keegan 2007, Dalin and Jeffcott 1994)

There are several non-invasive and invasive methods of examining the kinetics. However invasive methods measuring internal forces, such as tendon forces or bone strains, are used less often. (Van den Bogert et al. 2013) Non-invasive methods for measuring kinetics include the force-measuring treadmill, stationary force plates, force shoes, and pressure-sensitive mats. (Keegan 2020, Dalin and Jeffcott 1994, Van den Bogert et al. 2013) These tools measure external forces, namely the forces produced between hoof and ground which can operate in all three directions: vertical, horizontal (forward backward), and transverse (mediolateral). (Keegan 2020, Weishaupt 2008, Dalin and Jeffcott 1994) As mentioned before, a supporting limb lameness causes the horse to put less weight on the affected limb resulting in a decrease of vertical ground reaction force (GRF). (Keegan 2020) This is the most prominent occurring change, although some conditions may also affect horizontal or transverse GRFs. (Keegan 2011) According to Keegan the most commonly used and cited tool for measuring GRF is the stationary force plate.

Kinematic measuring methods use the changes in the symmetry of the horse's movement and body occurring during lameness. While many different motion parameters can be used to detect and evaluate lameness, asymmetric vertical movement of the torso is the most sensitive kinematic measure. This is because it can be more directly associated with vertical ground reaction forces. (Keegan 2020) GRF in the first half of the stance phase is influenced by the downward movement of the torso, whereas reversely, upward movement in the second half is altered with altered GRFs. However, a horse may move its body parts consciously during a trial. Therefore, it is important to measure several contiguous strides to sustain the sensitivity. (Keegan 2011, Bell et al. 2016) For the veterinarian, results of the objective kinematic evaluation are often easier to understand and applied, as the measured criteria are found in the standard subjective examination as well.

Originally, methods based on videotaping have been used for evaluating a horse's kinematics. The horse is equipped with markers attached to the body and filmed while moving. The examination is performed on a treadmill. This makes sure that the horse is always in the camera's field of view with the highest spatial resolution. Computers track, record and evaluate the trajectories of the markers for signs of lameness. But a horse's motion on a treadmill slightly differs from its normal motion pattern. Therefore, lameness detected on a treadmill may not be identified overground and vice versa. There are newer and improved kinematic systems. However, they require space and multiple cameras and so are only of use in research centers and technologically advanced clinics.

An easier way of detecting asymmetries was found. (Keegan 2020) Adapted from the aerospace and automotive industries inertial sensors are used to quantify the movement of the horse. These small devices contain accelerometers or gyroscopes. As the name suggests, accelerometers measure the acceleration of the surface to which they are attached while gyroscopes measure direction and change of motion. (Keegan et al. 2013, Clayton and Schamhardt 2013) An accelerometer only measures acceleration in one direction. Therefore, to generate and two- or three-dimensional overview often two or three accelerometers are combined with their axes perpendicular to each other. However, this can also be a source of errors due to misalignment of the axes to the body axes or dislocation during movement. Gyroscopes used in combination with accelerometers can measure angular velocity in all three directions. To provide an absolute three-dimensional orientation a third sensor can be employed. A magnetometer uses the earth's magnetic field to evaluate the strength and/or direction of the magnetic field around it. (Clayton and Schamhardt 2013) An advantage of using these inertial sensor systems in the field is that they are small, can be attached to the horse's body and wirelessly transmit data. (Keegan et al. 2013)

Already in 1993, Weishaupt et al. described the usefulness of an accelerometer attached to a horse's head for detecting forehand lameness. (Weishaupt et al. 1993) In a similar manner concluded Pfau et al. in 2007 that one accelerometer attached to both *tuber coxae* can be used to distinguish between lame and sound horses with 100% sensitivity. (Pfau et al. 2007) Keegan et al. in 2004 used two accelerometers, one attached to the head halter near the horse's poll the other fixed at the midline in the pelvic region, and two additional gyroscopes, taped to the dorsal hoof wall of the right fore and hind limb. (Keegan et al. 2004) The system used then has been further developed and in following studies the gyroscope attached to the right hind limb was removed. (Keegan et al. 2011, Keegan et al. 2013, Rhodin et al. 2015)

By now there are several sensor systems on the market, claiming to help identify lameness. Hereby two approaches can be distinguished. Tracker systems such as *steed* or HoofStep® are designed for 24/7 use, measuring daily activity to quickly detect changes in behavior indicating lameness or other issues. While *steed* focuses on temperature, heart rate, respiration rate, and general movement and activity, HoofStep® recognizes when the horse is eating, resting, either standing or laying down, when it is minorly active, like walking or scratching, or when it is highly active, such as trotting, canter or rolling. (HoofStep 2021, Steed Equine Monitoring Solutions 2023) In comparison, inertial sensor systems such as CEEFIT by Seaver or EquiMoves are designed for aimed evaluation. For EquiMoves seven to nine wireless sensors are attached to the horse to measure 3D acceleration, rotation speed, and orientation generating data regarding the symmetry of gait, stride duration, rhythm, swing intensity, swing and stance duration, and more. It can be used for all gaits and surfaces. (EquiMoves 2023) CEEFIT in contrast, relies on only one inertial sensor which is easily clipped onto the strap. The sensor evaluates each gait for the percentage distribution to left and right, stride frequency, regularity, and elevation. Furthermore, it measures trot symmetry and can be used to judge jumps individually or for a full course. Unlike EquiMoves, it may also be helpful for trails as it includes GPS tracking and measurement of speed. (SEAVER 2021)

Equine veterinarians and engineers at the University of Missouri in the United States in collaboration with the Hiroshima Institute of Technology in Japan developed the Equinosis Q® lameness locator which is further used in this study. (Keegan 2020) The developers themselves refer to it as “the gold standard for field-based measurement of lameness”. (Equinosis, LLC 2020) It measures impact and push-off asymmetry in all four limbs, which makes it possible to detect compensatory or multiple-limb lameness. With Equinosis® baseline lameness can be detected when trotting a horse in a straight line, at the lunge, or under saddle. Furthermore, the response to flexion tests or blocking can be evaluated. (Keegan 2020)

In the last years, the British corporation Stride Innovations Ltd. developed the Estride™ trackers, a multi-functional fitness tracker system using a combination of 3-axis-magnetometers, -accelerometers, and -gyroscopes. Sensors are attached to the fetlock region of one or up to each limb. They evaluate a variety of parameters including frequency, regularity, and rhythm of stride, impact of foot fall, stride pattern, training time, and time spent in each gait as well as horse and rider calorie burn. Different sessions can be recorded and used to monitor the stability of the horse or compared to detect an improvement/worsening. (Stride Innovations Limited 2020)

One major difference between Equinosis® and Estride™ is in the purpose of use. While the Equinosis® is solely sold to licensed veterinarians to detect lameness in horses, the Estride™ is explicitly designed for use by the rider. In the "Estride™ Terms of Service" Stride Innovations Ltd. highlights that it is "[...] not intended to diagnose, treat, cure, or prevent any disease." (Keegan 2020, Stride Innovations Limited 2018) An advantage of the fitness tracker could be that it collects data in all gaits. Therefore, it may be used for longer periods of time or even for a whole training session. (Stride Innovations Limited 2020) In contrast, Equinosis® can only be used trotting the horse. (Keegan 2016)

Objectives and Hypothesis

The purpose of this study is to test and validate this new multi-functional fitness tracker developed by Stride Innovations Ltd. As this system is supposed to collect data in all gaits it has the potential to allow objective evaluation of gait characteristics even if horses are too lame to trot.

As first measure, a correlation between the results of the commonly used body-mounted inertial sensor system by Equinosis® and subjective lameness examination in trot was investigated. Afterwards the body-mounted inertial sensor system was set against the fitness tracker.

The following hypotheses were stated: Firstly, the results of Equinosis® and subjective assessment correlate significantly validating Equinosis® as an applicable standard. Secondly, data collected from both tracking systems correlate significantly approving Estride™ for use.

II. Materials and Methods

Horses

For the first part of the study 99 mature horses living at Gut Aiderbichl were chosen and 20 of these horses were assigned to the second part of the study. All horses come from very different backgrounds, including former riding school horses, broodmares, police, or carriage horses. The breeds varied from Percheron over Thoroughbred to Hanoverian. The oldest was born in 1988, the youngest in 2003, all of them showed different ranges of lameness in at least one limb at a first subjective examination.

The study was conducted with the approval of the Institutional Ethics Committee of the University of Veterinary Medicine Vienna (ETK-152/09/2019) in accordance with the guidelines in force at the University of Veterinary Medicine Vienna "Good scientific practice. Ethics in Science and Research" and national legislation.

Equipment

To fix the fitness tracker at the horses' legs four pastern wraps by Equinosis® designed especially for containing sensors were used. Securing the nodes into the little pockets of the brushing boots it was made sure that for each node the switch was facing up and the lights were facing outwards. One wrap was fastened on each fetlock joint, the pocket for the sensor facing lateral. For some horses it was important to support the brushing boots with tape to prevent them from slipping or falling off completely.

Additionally, the three sensors of the inertial sensor system have been attached at the same time as the ones for the fitness tracker. The head sensor was stored in a small pocket of a special bonnet, which was attached to the horse's stall halter. For the right front leg sensor, another one of the wraps by Equinosis® was used. It was fixed with the pocket facing front in the bend of the horse's right fetlock joint, right below the fitness tracker's brushing boot. Lastly, the pelvis sensor was attached with two clips to the midline between the *tuber sacrale* at the highest level of the pelvis. For all three sensors, it was made sure that the arrows printed on them pointed ahead.

Fig. 1: Sonata fully equipped

General Data Acquisition

As the sensors have been fixed and turned on, the horses were walked for three minutes up and down a straight line on hard and even ground. Following, they were trotted for three minutes, walking as they turned, and again three minutes of walk and three minutes trot. This total of twelve minutes of performance was completed without stopping. While the inertial sensor system collected data during the trotting periods, the fitness tracker started recording as the first three minutes walk began and stopped recording after the whole twelve minutes. Simultaneously, all horses have been subjectively evaluated by an experienced vet. All horses have been categorized following the Viennese Grading system. Additionally, the horses not even able to trot at all were assigned to a Grade 6.

The controller for the fitness tracker as well as the software receiving the inertial sensor system's data were kept at the same spot approximately halfway of the track. Matching the gait, the horse has not been restricted to a certain speed nor excessively hurried but was allowed to go forward at his natural pace. All trials took place in the same location and on the same surface.

Variations of setting only occurred as the rest of the herd was either left behind in the stable or in sight on the paddocks right next to the track, according to group and time of day. None of the horses have been influenced by a preceding nerve or joint block or flexion test.

Multi-functional fitness tracker data

The multi-functional fitness tracker consists of a radiofrequency (RF) module with an SD card and four 9-DOF sensor nodes, each containing a 3-axis magnetometer, a 3-axis accelerometer, and a 3-axis gyroscope. With a sampling frequency of 5Hz the fitness tracker is able to analyze gait in walk, trot, canter, and gallop. The nodes and the RF module connect via Bluetooth. It is also possible to connect a phone, which is capable of Bluetooth 4.0, with the module in order to collect the data or you can use a card reader to transfer the data from the SD card onto your computer. Either way, the data needs to be extracted after every run to prevent it from being overwritten. To evaluate the data the producer of the fitness tracker offers a dedicated website. Once you have an account set up for this website you create horses, you want to track, including for every horse the following information: name, breed, height, age, color, and gender. As you upload the data you can also state trial information. For example, on the one hand, activity instruction such as schooling or pre-purchase, on the other hand, the surface on which the trial was executed.

Front and hind legs being compared independently and diagonally for every single stride the tracker measures the elevation, landing curve, and the impact of foot fall. For the complete trial it measures the frequency, rhythm, and regularity of stride. Furthermore, it generates a stride pattern and recognizes deviation of strides. The results are shown in different graphs (Figure 2) You can either draw your own conclusion from the graphs or use the lameness indicator provided by the program. Here it states the observations of front and hind overall, in walk, trot and canter. It warns if there is an irregularity detected and informs which leg is short by how many percent due to how many and which irregular features. (Stride Innovations Limited 2020)

A

B

Fig. 2: (A) Stride Comparison: which limb is short and by how much (B) Feature Score: 100% on both legs means they are even

Inertial sensor system data

The inertial sensor system is made of two uni-axial accelerometers that sample at 200 Hz and one uni-axial gyroscope which samples at 200 Hz as well. Furthermore, the inertial sensor system comes with a tablet and a Bluetooth receiver to insert into the tablet's USB port, so the tablet receives data from the sensors during the trial. The accelerometers track the vertical head and pelvic acceleration while the gyroscope measures the angular velocity in the sagittal plane. It is not only used to detect the footing of the right forelimb but also calculates a median stride rate.

Before starting the data collection, the name of the horse, the name of the owner, and, where necessary, the organization are entered into the system. If the horse has been tracked before it is already in the database and new trials should be added to the existing data instead. After turning on and connecting the sensors the trial information is asked for. It is possible to choose from a list of trial versions, including lunge left/ride, straight line, straight uphill/downhill, or before and after flexions. For the trials conducted in this study, they were all labeled 'straight line'. Optional for straight-line trials and obligatory for lunging trials a surface can be chosen.

Generating the data, the inertial sensor system needs to collect at least 25 strides for straight-line trials. At least six continuous strides are required before the horse may be turned. These strides are selected for analysis based on the calculation of the median stride rate by the gyroscope on the right forelimb. Strides that fall out +/- 10 % of the median stride rate are excluded from the analysis. However, these strides can manually be included if desired. This study relies on the stride segments automatically chosen by the system. After ending the trial, the software generates a report with the collected data.

For each stride, the head and pelvic differences between right and left part of the stride are worked out and a mean value of all strides, as well as its standard deviation, is calculated (in mm). In a normal, saying symmetric, horse the mean value of all strides is +/- 6 mm for head movement and +/- 3 mm for pelvic movement. In the following, these results are referred to as Diff Max and Diff Min.

Additionally, to Diff Max and Diff Min a Total Diff Head (in mm) is calculated by the Pythagorean Theorem ($a^2 + b^2 = c^2$), where a is the value of Diff Max head, b the value of Diff Min head and c is the Total Diff Head. It is the vector sum of the Diff Max and Diff Min and can be used to estimate the overall level of forelimb lameness. The threshold for Total Diff Head revealing a lameness is 8.5 mm.

As the Diff Max Head is calculated by subtracting the maximum height of the head before left foot weight bearing from the maximum height of the head before right foot weight bearing, the value can either be positive or negative indicating side and timing of lameness. Same applies for Diff Min Head.

It is important to note that horses are animals not machines. Diff Max Head or Diff Min Head may show great peaks not due to actual strong lameness but because the horse is acting up or tossing the head. Therefore, if a mean is above threshold the standard deviation (SD) needs to be considered as well. The smaller the SD in relation to its mean, the more consistent the measurement. A greater SD shows an increased variability of the data and the trial should be repeated to ensure reliable results.

In the report generated by the system's software forelimb movement is displayed by a ray diagram plot (Figure 3). The y-axis shows Diff Min Head while Diff Max Head is plotted on the x-axis. Furthermore, it is divided into four quadrants: right foot push-off (left from y-axis, above x-axis), right foot impact (right from y-axis, above x-axis), left foot impact (left from y-axis, below x-axis), and left foot push-off (right from y-axis, below x-axis). Every step is represented by a blue ray. The length of the ray is proportionate to the amount of head movement asymmetry measured for that step. The side and timing of asymmetry is indicated by the direction the ray points. For a normal horse, a blue starburst pattern with the red ray falling within the threshold circle is typical. Blue rays falling out of the threshold circle are due to greater head movement but not unusual. The red ray shows the Total Diff Head and is representative of the mean of all forelimb strides. Does this fall outside the threshold circle, a forelimb lameness is indicated.

Similar to Diff Min/Max Head Diff Max Pelvis is calculated by subtracting the maximum height of the pelvis before left foot weight bearing from the maximum height of the pelvis before right foot weight bearing. The same applies to Diff Min Pelvis. For both, Diff Max and Diff Min Pelvis, right limb asymmetries are assigned positive (+) values and left limb asymmetries negative (-) values. Elevated Diff Max (+ or -) indicates a push-off lameness and elevated Diff Min (+ or -) an impact lameness. As Diff Max and Diff Min of the pelvis are independent variables it is possible to measure an impact lameness in one hind limb and a push-off lameness in the opposite hind limb at the same time.

In the report hind limb movement is also displayed by a ray diagram plot, but in contrast to the forelimb evaluation there is one diagram for each leg. (Figure 3) The number of strides is plotted on the x-axis. The plot for the left hind limb shows only negative digits on the y-axis, where Diff Max Pelvis and push-off is found above the x-axis and Diff Min Pelvis and impact below the x-axis. The second diagram shows the right hind limb, again, with the number of strides plotted on the x-axis and Diff Max Pelvis/push-off on y-axis above and Diff Min Pelvis/impact on y-axis below x-axis in only positive digits. Once more, same as for the forelimb movement, every ray represents one step and the length of the ray is proportionate to the length of this step.

This time, rays indicating push-off asymmetry are all red and rays suggesting impact lameness are green. For a normal horse, we would typically expect a fairly even distribution of rays with most of the rays falling into the grey threshold area.

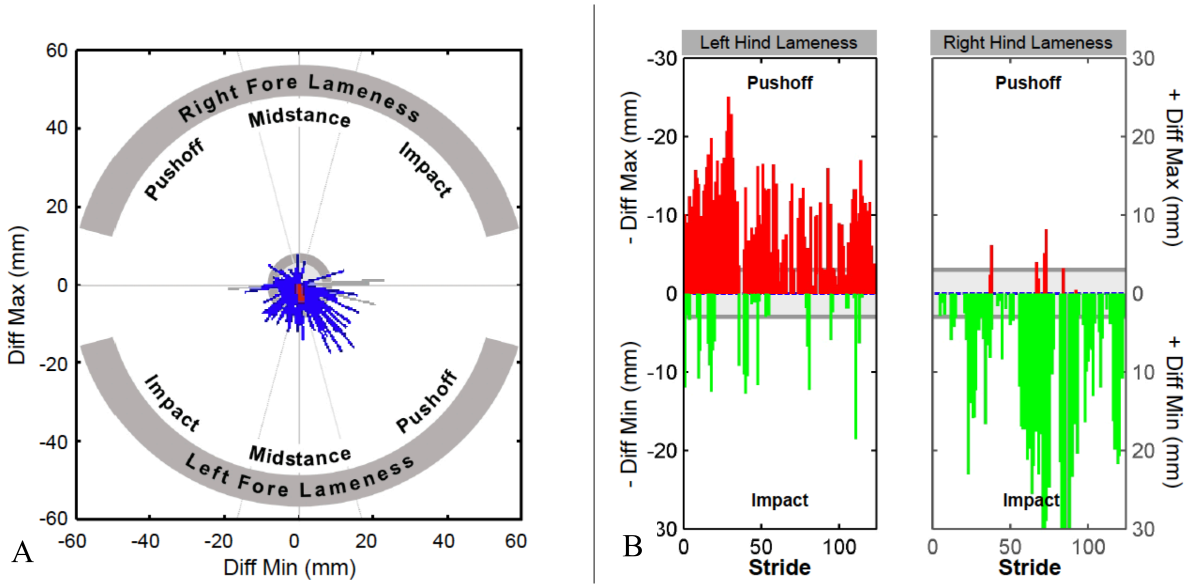

Fig. 3: (A) "no" evidence of fore lameness (B) "moderate" evidence of "mild/moderate" LH push-off lameness and "weak" evidence of "mild/moderate" RH impact lameness

Although the pelvis is less susceptible to excessive movement than the head, it is important to check the standard deviation and, where necessary, repeat the trial.

To summarize the asymmetry regarding side, timing, and amplitude the so-called Quantification Score (Q Score) is calculated. Q scores do not have a minus or plus sign since left or right and impact, midstance, or push-off are directly described in the value. There is one Q score for the forelimbs and a combined one with Push/Imp for the hind limbs.

The inertial sensor system offers an automated interpretation and degree of evidence (AIDE) in which it points out potential asymmetries and lameness. Here the strength of evidence is distinguished by “no”, “weak”, “moderate” and “strong” based on the extent of standard deviation. Strong evidence will be reported as the SD is less than 50% of the mean Diff Min head or the mean Diff Min/Max pelvis. Moderate evidence is announced when the SD is between 50 and 120 % of the means, whereas weak evidence is described when the SD exceeds 120 % of the mean. In addition to the strength of evidence, the severity of the lameness is stated. The levels range from “very mild” and “mild” to “mild/moderate”, “moderate” and “moderate/severe”.

Multiple limb lameness may be evident. In this case on straight-line reports a primary limb may be suggested in the AIDE based on known patterns of compensatory lameness.

Bilateral lameness may not be neglected by the results shown in the AIDE. (Keegan 2016)

Statistical Analysis

The lameness of 99 horses was evaluated subjectively in the gaits walk and trot and with the Equinosis® Lameness Locator and Estride™ in trot. Since both, subjective and machine methods, report data on an ordinal scale, the non-parametric Spearman correlation was used.

A symmetry sanity check was performed to validate the machine generated data. Horses are assumed to show lameness on both sides, right and left, equally. Therefore, the total distribution of lameness in the 20 horses for the tracker system comparison was analyzed for Equinosis® Lameness Locator and Estride™ respectively. Subsequently, a chi-squared test was performed to check the significance of the deviation from equality of sides. It turned out that the results with Estride™ differed strongly and significantly from the equality assumption. Thus, results from Estride™ were dropped from further analysis.

Results of the subjective evaluation in walk and trot were compared using Spearman correlations. Furthermore, the results of the subjective and Equinosis® Lameness Locator evaluations were compared in trot again using Spearman correlations. Additionally, the two trials for the same horse were compared. In particular, for all four legs lameness scores were compared for both Equinosis® trails and Equinosis® versus subjective evaluation.

All calculations were performed with the "R" statistical programming language (R Foundation for Statistical Computing, Vienna, Austria https://www.R-project.org/) (Team 2017).

III. Results

Horses

Of all 99 horses, only three did not show any lameness at all, neither walking nor trotting. Another 21 horses were not considered lame in walk but subjectively evaluated to different grades of lameness in at least one leg in trot. Based on the most severe degree of lameness displayed in walk eleven horses were graded 1/6, 37 horses 2/6, 21 3/6, five 4/6, none 5/6 and one horse was non-weightbearing in his right hind limb, thus graded 6/6. In trot, eight horses showed lameness in at least one limb assigned grade 1/6, 51 were evaluated with grade 2/6, 25 grade 3/6, three 4/6, none 5/6, and nine horses were not able to trot at all and therefore considered a 6/6 lameness in all four legs. The leg, or legs in plural, demonstrating lameness in walk was not necessarily the lame one(s) in trot. (Appendix A)

The 20 horses chosen for the second part of the study all showed lameness in at least one limb, scored 1/5 to 3-4/5 in trot on subjective lameness evaluation. Five horses showed lameness in one limb, twelve horses in two limbs, and three horses even in three limbs. 16 of them also showed lameness walking in at least one limb ranking from 1/5 to 3/5. Of these 16, six had one lame limb while the other ten were evaluated to be lame in two limbs. Although, speaking of the horses individually, the affected limb in walk was not necessarily the limb showing lameness in trot.

Classifying the horses based on the most severe grade of lameness in walk, four horses were 1/5, eight horses 2/5 and four 3/5 lame. In the trot, four horses were 1/5, eight horses 2/5, seven horses 3/5 and one horse 4/5 lame. No horse showed a lameness of grade 5/5. (Table 2)

	Walk	Trot		Walk	Trot		Walk	Trot		Walk	Trot
Aischa	LF 1/5	RH 2/5 Changing to LH (compensated)	**Esperanza**	RH 1/5	RF 2/5 LH 2/5	**Herby**	RF 1/5	RH 2/5 LH 2/5	**Pia**	RF 2/5 LH 2/5	LH 1/5
Kitty	LF 2/5 Does not bend fetlock joint RH	RH 2/5 LH 1/5 (severity increasing)	**Gitano**	RF 1/5 RH 1/5	LH 1/5	**Vera**	RF 3/5 RH 1/5	RF 3/5 RH 2/5 LH 2/5	**Sonata**	-	RF 2/5 LH 3/5
Sultan	-	RH 3/5 LH 2/5	**Gardist**	-	LH 3/5	**Avon**	RF 1/5 LH 2-3/5	RF 1/5 LH 2/5	**Subida**	RH 2/5 Occasionally switching to LH 2/5	RH 2/5 Occasionally switching to LH 2/5
Timon	-	RH 1/5 LH 1/5	**Chanel**	RH 3/5	RH 2/5 LH 2-3/5	**Belinda**	RF 1/5 RH 2/5	RF 2/5 RH 2/5	**Monera**	LF 2/5 LH 1/5	LF 1/5 LH 2/5 Switching to RH 1/5
Pandua	RF 2/5	RF 2/5 RH 3/5 LH 2/5	**Tiger**	LF 1/5 RH 3/5	RH 3/5	**Piri**	RF 2/5 RH 2/5	LH 1/5	**Halbmond**	RF 1/5 LH 2/5	RF 3-4/5 LH 2/5

Tab. 2: Subjective evaluation of the twenty horses additionally examined with the inertial sensor system and fitness tracker. Lameness grades after the Viennese grading system from one to five. LF = left front leg, RF = right front leg, LH = left hind leg, RH = right hind leg

System Results

For the 99 horses examined with Equinosis®, the Q score summarizing side, timing, and amplitude of the asymmetry displayed a total mean of 6.74 with values ranging from 0 to 104.7. (Appendix A)

The three horses showing no lameness had a total Q score of 2.27 with values ranging from 0 to 7.1. So, the sensor system recorded asymmetries, which were unnoticed or not considered relevant by the examiner. The lamer the horses, the higher the Q scores. For comparison, the Q score for the eight horses evaluated with a grade 1/6 lameness ranged from 0 to 10.3 with a mean of 3.12, whereas the three horses classified as 4/6 lame displayed a mean Q score total of 17.46 ranging from 0 to 104.7. For one of those three the lameness locator could not generate any data. While there were no horses in grade 5/6, the ones assigned to 6/6 were not able to trot at all and therefore could not be evaluated by the Equinosis®. (Table 3)

	n=99			n=3			n=8			n=51		
Trot	Overall			Grade 0 (subj. Lameness)			Grade 1 (subj. Lameness)			Grade 2 (subj. Lameness)		
Objektive Lameness	mean	s.d.	range	mean	s.d.	range	mean	s.d.	range	mean	s.d.	range
Q Score LF	9.17	15.57	0 - 104.7	2.13	3.70	0.00 - 6.40	2.43	4.01	0.00 - 10.30	8.36	9.22	0.00 - 32.90
Q Score RF	8.01	14.31	0 - 74.4	3.87	3.59	0.00 - 7.10	4.51	3.95	0.00 - 9.30	4.72	6.72	0.00 - 25.20
Q Score LH	5.20	5.87	0 - 24.6	0.27	0.46	0.00 - 0.80	3.50	2.02	0.00 - 5.90	4.43	4.36	0.00 - 13.10
Q Score RH	4.60	5.15	0 - 25.7	2.80	1.35	1.40 - 4.10	2.04	2.59	0.00 - 6.00	4.09	4.00	0.00 - 14.40
Q Score Total	6.74	11.38	0 - 104.7	2.27	2.66	0.00 - 7.10	3.12	3.25	0.00 - 10.30	5.40	6.61	0.00 - 32.90
	n=25			n=3			n=0			n=9		
	Grade 3 (subj. Lameness)			Grade 4 (subj. Lameness)			Grade 5 (subj. Lameness)			Grade 6 (subj. Lameness)		
Objektive Lameness	mean	s.d.	range	mean	s.d.	range	mean	s.d.	range	mean	s.d.	range
Q Score LF	10.36	17.25	0 - 54.3	52.35	74.03	0.00 - 104.70	-	-	-	-	-	-
Q Score RF	16.65	23.26	0 - 74.4	4.00	5.66	0.00 - 8.00	-	-	-	-	-	-
Q Score LH	7.90	8.40	0 - 24.6	5.20	6.79	0.40 - 10.00	-	-	-	-	-	-
Q Score RH	6.39	6.97	0 - 25.7	8.30	11.74	0.00 - 16.60	-	-	-	-	-	-
Q Score Total	10.32	15.74	0 - 74.4	17.46	35.78	0.00 - 104.70	-	-	-	-	-	-

Tab. 3: Mean, standard deviation (s.d.), and range of objective results of Equinosis® Lameness Locator for the total of 99 horses and the horses subjectively distributed to the different grades of Lameness

For the second part of the study, all results of both sensor systems are displayed in Appendix B. The fitness tracker features, in which corresponding legs are not equal, are marked red.

In the Equinosis® sensor system, assessed strides ranged from 35 to 180 for the forelimbs and 34 to 182 for the hind limbs, with a mean of 128 strides each. The mean for Total Diff Head is 12.61 mm ranging from 0.7 mm to 54.8 mm in all horses with SD = 13.39. Above a value of 8.5 mm, a horse was considered lame. Acceleration in the pelvis showed a mean of -1.49 mm for Diff Max indicating an average push-off lameness of the left hind limb. Whereas the mean of 3.82 mm for Diff Min Pelvis indicates an average impact lameness of the right hind limb. The Q score ranged from 0.7 to 54.8 total in the fore limb in all twenty horses (mean = 12.5, SD = 13.74) and from 0 Push/0.1 Imp to 27.7 Push/23.5 Imp in the hind limbs (mean = 6.56 Push/5.69 Imp, SD = 5.98/5.89). In the front limb, the Q score detected an impact lameness in thirteen horses (mean = 5.22, SD = 2.77), in six horses a forelimb midstance lameness (mean = 8.27, SD = 4.41), and in four horses a forelimb push-off lameness (mean = 16.51, SD = 16.78) in at least one of the two trials.

The two horses subjectively classified as grade 1/5 lame showed an average of 146.5/150 strides assessed, ranging from 105/103 to 180/182. The Total Diff Head displayed a mean of 7.43 mm not detecting lameness. Separated in the types of lameness, the mean Q score was 6.95 for push-off and 7.9 for impact lameness. On average, a tendency for a left hind push-off and right hind impact lameness are demonstrated, explained by the values Diff Max of the pelvis at mean = -5.55 mm and Diff Min at mean = 7.13. In the hindlimbs, the Q score ranges from 0.6 Push/0.7 Imp to 14.8 Push/15 Imp with a mean of 6.4 Push/6.93 Imp.

In comparison, the objective evaluation agreed with the subjective lameness evaluation for the nine horses subjectively identified as grade 2/5 lame. They showed a Total Diff Head of mean = 9.96 mm and a mean total Q score of 9.72, confirming lameness. Taking a closer look at the specific Q scores, it splits into mean = 3.75 Push/7.4 Mid/12.08 Imp. A mean of 0.24 mm for Diff Max Pelvis and of -0.05 mm for Diff Min Pelvis displayed a mild trend to right push-off and left impact asymmetry in the hind quarters. The hind Q score for push-off lameness ranged from 0 to 12.9 and 0.3 to 11.8 for impact lameness resulting in a mean of 4.03 Push/2.96 Imp. (Table 4)

	n=20			n=2			n=9		
	Overall			Grade 1 (subj. Lameness)			Grade 2 (subj. Lameness)		
Objektive Lameness	mean	s.d.	range	mean	s.d.	range	mean	s.d.	range
Equinosis									
Stride Rate	1.46	0.09	1.3 - 1.6	1.48	0.10	1.4 - 1.6	1.47	0.09	1.3 - 1.6
Strides Assessed (fore/hind)	128.3/128.53	36.23/36.91	35 - 180/34 - 182	146.5/150	38.73/36.62	105-180/103-182	128.18/129	36.32/37.14	38 - 176/38 - 173
Diff Max Head Mean in mm	4.42	9.25	-7.5 - 33	4.55	2.05	2.5 - 6.9	2.57	6.12	-7.5 - 14.7
Diff Max Head SD in mm	8.74	2.46	5.1 - 15	6.28	0.85	5.1 - 7	8.94	2.18	5.8 - 13.5
Diff Min Head Mean in mm	6.13	14.33	-12.4 - 43.8	0.73	6.57	-5.6 - 8.7	4.06	9.57	-9.6 - 22.9
Diff Min Head SD in mm	9.71	3.23	4.8 - 16.4	6.35	1.06	5.1 - 7.7	10.45	2.30	6.8 - 14.8
Total Diff Head (Vector Sum) in mm	12.61	13.69	0.7 - 54.8	7.43	1.38	6.1 - 9.2	9.96	7.16	0.7 - 27.2
Q Score Total (fore)	12.50	13.74	0.7 - 54.8	7.43	1.38	6.1 - 9.2	9.72	7.28	0.7 - 27.2
Q Score Push (fore)	5.22	2.77	0.7 - 7.8	6.95	1.20	6.1 - 7.8	3.75	4.31	0.7 - 6.8
Q Score Mid (fore)	8.27	4.41	3.8 - 18.5	-	-	-	7.40	1.40	6.3 - 9.8
Q Score Imp (fore)	16.51	16.78	1.1 - 54.8	7.90	1.84	6.6 - 9.2	12.08	8.62	3.7 - 27.2
Diff Max Pelvis Mean in mm	-1.49	6.86	-21.7 - 17.4	-5.55	1.32	-6.5 - -3.7	0.24	5.73	-8.4 - 12.9
Diff Max Pelvis SD in mm	4.63	2.16	1.8 - 10.2	6.50	3.25	3.5 - 9.6	3.52	0.97	1.8 - 5.6
Diff Min Pelvis Mean in mm	3.82	9.18	-15.5 - 27.7	7.13	8.98	-0.7 - 15	-0.05	3.74	-5.5 - 7.1
Diff Min Pelvis SD in mm	4.92	3.11	1.3 - 15.5	5.03	1.32	3.8 - 6.4	3.51	0.83	2.5 - 5
Q Score (hind)	6.56/5.69	5.98/5.89	0 - 27.7/0.1 - 23.5	6.4/6.93	6.1/5.95	0.6 - 14.8/0.7 - 15	4.03/2.96	2.98/3.31	0 - 12.9/0.3 - 11.8

Tab. 4: Mean, standard deviation (s.d.), and range of objective results of the Equinosis® Lameness Locator for the total of 20 horses and the horses subjectively assigned to Grade 1 and Grade 2

Eight horses were subjectively determined with a grade 3/5 lameness. These showed an average of 134.27/133.13 assessed strides. In detail, the assessed strides ranged from 80 to 175 in the fore limb and 79 to 176 in the hindlimb. The Total Diff Head displayed an increased mean of 11.59 mm. Mean forehand Q scores for the particular lameness types were 4.7 Push, 9.35 Mid, and 15.06 Imp. In the hind limb, they demonstrated an average left push-off lameness with a mean Diff Max of -2.55 mm and an average right impact lameness with mean Diff Min of 6.43 mm. The Q scores for the hind limbs, ranged from 0.6 to 27.7 for push-off lameness and 0.1 to 23.5 for impact lameness, with a mean of 9.62 Push/8.24 Imp.

Only one horse was assigned grade 4/5. The two trials resulted in an average of only 49/47 strides assessed. The total Diff Head with a mean of 53.05 mm and the mean Q score for impact lameness of 53.05 showed by far the highest elevation. The mean of -0.1 mm for Diff Max Pelvis was negligible as the mean of 10.55 mm for Diff Min Pelvis rather indicated an impact lameness for the right hind leg. In the hindlimbs, the mean Q score was 5.15 for push-off and 6.5 for impact lameness.

None of the horses was evaluated to show the highest grade of 5/5 lameness. (Table 5)

	n=8			n=1			n=0		
	Grade 3 (subj. Lameness)			Grade 4 (subj. Lameness)			Grade 5 (subj. Lameness)		
Objektive Lameness	mean	s.d.	range	mean	s.d.	range	mean	s.d.	range
Equinosis									
Stride Rate	1.44	0.08	1.3 - 1.6	1.50	0.00	1.5 - 1.5			
Strides Assessed (fore/hind)	134.27/133.13	24.12/24.76	80 - 175/79 - 176	49/47	19.8/18.38	35 - 63/34 - 60			
Diff Max Head Mean in mm	2.91	8.52	-5.9 - 22.8	31.25	2.47	29.5 - 33			
Diff Max Head SD in mm	8.94	2.83	6.2 - 15	10.60	0.99	9.9 - 11.3			
Diff Min Head Mean in mm	5.02	14.86	-12.4 - 37.5	42.90	1.27	42 - 43.8			
Diff Min Head SD in mm	8.93	3.33	4.8 - 15.5	15.95	0.64	15.5 - 16.4			
Total Diff Head (Vector Sum) in mm	11.59	13.61	1.1 - 43.8	53.05	2.47	51.3 - 54.8			
Q Score Total (fore)	11.59	13.61	1.1 - 43.8	53.05	2.47	51.3 - 54.8			
Q Score Push (fore)	4.70	0.00		-	-	-			
Q Score Mid (fore)	9.35	6.82	3.8 - 18.5	-	-	-			
Q Score Imp (fore)	15.06	17.75	1.1 - 43.8	53.05	2.47	51.3 - 54.8			
Diff Max Pelvis Mean in mm	-2.55	8.74	-21.7 - 17.4	-0.10	1.56	-1.2 - 1			
Diff Max Pelvis SD in mm	4.86	1.98	2.5 - 9.5	8.50	2.40	6.8 - 10.2			
Diff Min Pelvis Mean in mm	6.43	12.41	-15.5 - 27.7	10.55	1.77	9.3 - 11.8			
Diff Min Pelvis SD in mm	5.60	3.81	1.3 - 15.5	11.60	2.83	9.6 - 13.6			
Q Score (hind)	9.62/8.24	7.43/7.13	0.6 - 27.7/0.1 - 23.5	5.15/6.5	5.87/7.5	1 - 9.3/1.2 - 11.8			

Tab. 5: Mean, standard deviation (s.d.), and range of objective results of the Equinosis® Lameness Locator for the horses subjectively assigned to Grades 3 to 5

The Estride™ fitness tracker system recorded for a mean of 9.7 minutes out of the 12 min it was supposed to record for the 20 horses. For only one horse the total twelve minutes were documented, five made eleven minutes, and another five at least ten minutes. In general, more activity was recorded in the walk than in the trot, ranging from 80 % for the horse being 4/5 lame to 63.5 % for the two horses with 1/5. The 20 horses were on average 3.5 % short in the left front and 2.5 % short in the left hind limb. In detail, they overall ranged from being 7 % short in the left forelimb to 4 % short in the right front limb and from 6 % short left hind to 6 % short right hind. Taking a closer look at the particular groups, the two horses in 1/5 showed an average of 5.5 % shortness in the left front and 1 % in the right hind limb. In comparison, the results of the nine horses assigned to a grade 2/5 lameness displayed a mean lameness of 4.1 % in the left front and 2.6 % in the left hind limb. The eight horses evaluated to be grade 3/5 lame show the same trend with a mean of 2.3 % in the left front limb and a mean of 4 % in the left hind limb concerning shortness of stride. The only horse with a lameness grade of 4/5 was 4 % short in the left fore and 3 % short in the right hind limb. In total, the Estride™ reported eighteen out of twenty horses to be overall short in the left forelimb and sixteen out of twenty short in the left hind limb. (Appendix C)

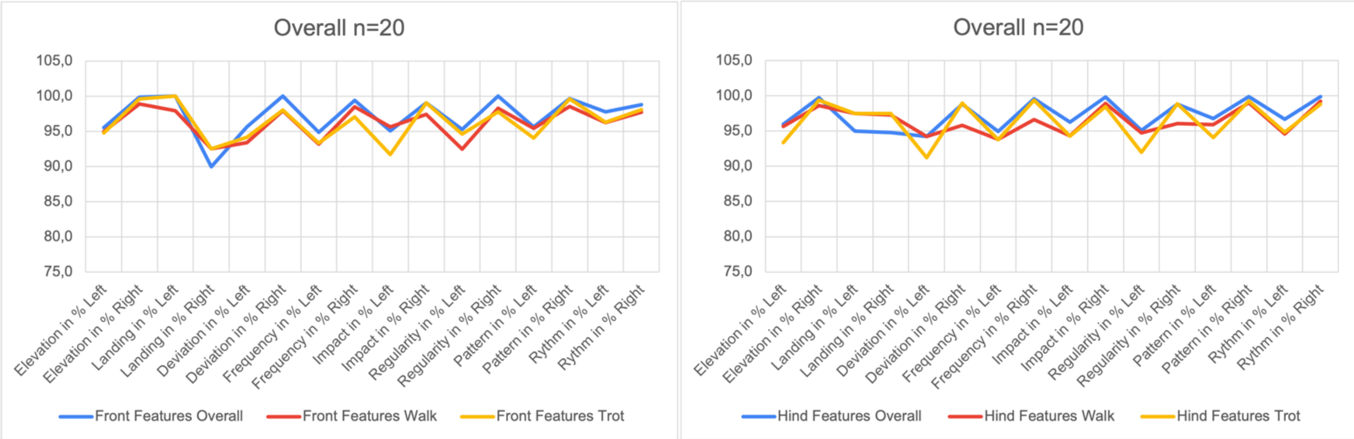

Fig. 4: Mean results of the Estride™ for the twenty horses overall. Left: forehand, right: hind quarters.

This is confirmed when looking more in detail at the Estride™ results. In an overview, it is seen that the horses overall show a shorter landing phase in the right front limb while elevation, deviation, frequency, impact, regularity, pattern, and rhythm is mainly decreased in the left forelimb. This concludes that there would be problems with the left forelimbs causing the right limbs to be brought down faster to decrease the weight. For the overall hind feature results, in mean, the horses show an altered landing phase in the left and the right hindlimb. Also, elevation, deviation, frequency, impact, and regularity are more shortened in the left hind leg. This indicates possible problems in the left hind limbs as well. (Figure 4)

Statistical Analysis

Checking the distribution of lameness between the left and right sides for both sensor systems used in this study (Table 6), it is found that Estride™ recognizes lameness of the left forelimb in 85 % (17 on the left and three on the right side) and of the left hind limb in 90 % of the cases (18 on the left and two on the right side). A chi-square test showed a significant deviation from the expected 1:1 ratio in both cases (p = 0.00 and p = 0.00, respectively) On the other hand, none of the comparisons between left and right limbs are significant for Equinosis®. Thus, while Equinosis® passes the sanity check for left-right symmetry, Estride™ fails. We will therefore not consider Estride™ anymore and concentrate on Equinosis®.

	Lameness Locator 1	Lameness Locator 2	Estride trot	same
Aischa	L	L	L	TRUE
Kitty	R	R	L	FALSE
Sultan	L	L	L	TRUE
Esperanza	R	NA	L	NA
Gardist	L	R	R	FALSE
Subida	L	L	L	TRUE
Tiger	R	R	L	FALSE
Vera	R	R	L	FALSE
Chanel	R	NA	L	NA
Sonata	L	L	L	TRUE
Pandua	L	R	L	FALSE
Gitano	R	R	L	FALSE
Timon	L	L	L	TRUE
Avon	L	L	L	TRUE
Belinda	R	R	L	FALSE
Monera	L	L	R	FALSE
Herby	R	R	L	FALSE
Piri	R	R	L	FALSE
Pia	R	R	R	TRUE
Halbmond	R	R	L	FALSE

	Lameness Locator 1	Lameness Locator 2	Estride trot	same2
Aischa	R	R	L	FALSE
Kitty	R	R	L	FALSE
Sultan	L	L	L	TRUE
Esperanza	L	NA	L	NA
Gardist	L	L	R	FALSE
Subida	L	L	L	TRUE
Tiger	R	R	L	FALSE
Vera	R	L	L	FALSE
Chanel	L	NA	L	NA
Sonata	R	L	L	FALSE
Pandua	R	L	L	FALSE
Gitano	L	L	L	TRUE
Timon	R	L	L	FALSE
Avon	R	L	L	FALSE
Belinda	L	R	L	FALSE
Monera	L	L	L	TRUE
Herby	R	L	L	FALSE
Piri	L	L	R	FALSE
Pia	R	R	L	FALSE
Halbmond	R	L	L	FALSE

Tab. 6: Table showing which leg was considered lame in the two Equinosis trails (= Lameness Locator 1/2) and by the Estride in trot (= Estride trot) and whether the three outcomes match (= same). The table on the left presents results for the forehand, and the right for the hindquarters.
L = left leg, R = right leg, NA = no result available, TRUE = results agree, FALSE = results disagree

Comparing the results of all 99 horses for the Equinosis® with subjective evaluation in trot, they show a strong and significant correlation with values ranging from $\rho = 0.62$ to $\rho = 0.74$ ($p = 0.00$) in all four legs. This means the lameness locator and examiner often agree on leg and severity of lameness. (Table 7) Note that for both front and hind legs a strong negative correlation for the Equinosis® is observed: if lameness is recognized in one leg almost never lameness is located in the contralateral limb. A similar trend is also observed in the subjective evaluation of trot, where the negative correlation is less strong compared to the Equinosis®, and also of walk, where the negative correlation is only mild. Furthermore, the Q scores show a mild positive correlation between lameness in the left front and right hind leg. This correlation is not seen in the results of the subjective evaluation. (Figure 6)

		Spearman corr ρ	p
LF Q Score	LF Subj Trot	0.58	0.00
RF Q Score	RF Subj Trot	0.73	0.00
LH Q Score	LH Subj Trot	0.65	0.00
RH Q Score	RH Subj Trot	0.65	0.00

Tab. 7: Results of Spearman correlation Equinosis® vs. subjective evaluation in trot

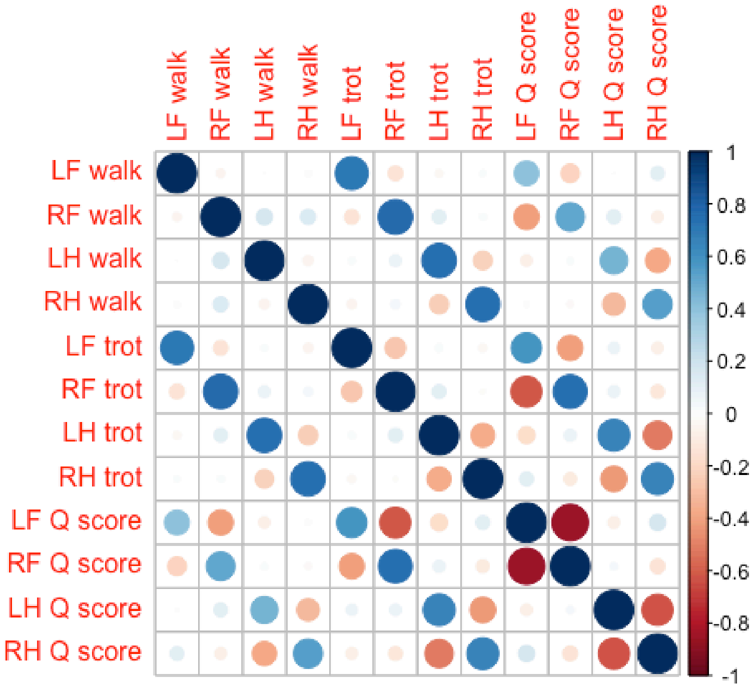

Fig. 6: Graph displaying Spearman correlation between Equinosis® and subjective results. blue = positive correlation, red = negative correlation. The darker and bigger the dot, the greater the correlation.

IV. Discussion

In this study, the results of the inertial sensor system by Equinosis® were firstly set in comparison with subjective lameness assessment and secondly contrasted with the results of the fitness tracker by Estride™.

Previous studies suggested a significant fair correlation between the former. (Keegan 2013, Leemalankong 2019) This trend was confirmed by the results of our study. The agreement between the inertial sensor system and subjective evaluation was statistically strong and significant in all four legs. The Equinosis® and examiner also agreed on seeing a negative correlation between the contralateral legs, although the negative correlation detected by the examiner was less strong than the one identified by the tracker system. Furthermore, the subjective evaluation assessed a mild negative correlation in walk as well. The latter can be justified with the general stride pattern. In walk, every leg is moved individually. In trot on the other hand, as the movement of each side is connected by a short phase of suspension, they are rather dependent on each other. Because of the strong negative correlation of the Q scores, it can be discussed whether the sensor system is not able to evaluate both limbs independently. Here the subjective examiner might be better skilled to differentiate. Moreover, the stride pattern explains the mild positive correlation between Q scores for left front and right hind leg, which was not listed by the examiner. As the left forelimb moves simultaneously with the contralateral hind limb one naturally influences the other. But it may be harder to distinguish for the sensor system which leg is the original cause for the asymmetry in movement.

Then again, the sensor system recognizes irregularities where the examiner assigns a grade 0 for lameness. Here a subsequent study could be interesting to evaluate whether horses, showing no subjective lameness but an elevated Q score, stay sound in follow-ups or develop lameness later on. In other words, whether the lameness locator is overly sensitive or detects smaller signs of lameness before the bare eye does so. According to the increasing severity of lameness grades, the Q scores increase for the 99 horses.

For that first part of the study, it can be concluded that the Equinosis® inertial sensor system obtains good results in lameness examination. Although for a holistic result, they should be combined with a subjective exam and analyzed in context. Nevertheless, it is a good tool to give to hand for grading lameness if horses are examined repeatedly by different vets or for follow-ups.

As the Equinosis® system is only to be operated by veterinarians there are several systems, such as CEEFIT or Estride™, developed to be handled by horse owners themselves to track the training and to detect lameness at an early stage. (SEAVER 2021, Stride Innovations Limited 2020)
Usually, when examining a larger number of horses, they are expected to show lameness distributed evenly to both sides. Therefore, the results of the Estride™ fitness tracker system stand out as they identify the left limb to 85 % in the front and to 90 % in the back. Consequently, the Estride™ fails the sanity check and is not considered to provide reliable information.
Further development of these fitness tracker systems would be desirable to support the recognition of disposition. As owners see their horses every day, small or gradual degradations are generally hard to detect. Moreover, the Estride™ measures a number of parameters including elevation, landing, deviation, and impact which could be helpful for veterinarians to distinguish between the different types of lameness. With sensors attached to all four legs these parameters are assessed for each leg individually. In contrast to the inertial sensor system attached to the head, pelvis, and one leg, this could give the opportunity to detect bilateral lameness seperately. In conclusion, the idea of the fitness tracker system is good, and the system itself, if it was properly working, certainly helpful but still needs further improvement.
However, it must be added that a sample size of 20 horses is rather small and a second trial with a remarkably larger pool might deliver different results. Also, as the Estride™ is more a fitness tracker than an actual lameness locator it would be interesting to compare it to another fitness system over a longer period and see if they generate correlating data.

V. Summary English

Lameness examination is one of the most common tasks of a veterinarian. Different grading systems have been developed to classify the severity of lameness. With time of profession, veterinarians tend to define their own scoring systems, which can be the cause for disagreement between different assessors. Further, the clinicians may come to different conclusions varying in the weighting of the criteria. Gait analysis techniques can become a common tool increasing the accuracy and the repeatability of subjective lameness examination. This study investigated the correlation between the results of the commonly used body-mounted inertial sensor system by Equinosis® and subjective lameness examination in trot for 99 horses. Afterwards, the body-mounted inertial sensor system was set against a fitness tracker system for 20 of these horses. Results show that Equinosis® and the veterinarian agree strongly and significantly. In addition, the sensor system sometimes identifies irregularities where the examiner does not, hence they should always be combined with a clinical examination and analyzed in context. The fitness tracker system used in this study did not even pass the sanity check for an equal side distribution of lameness. Therefore, as it would be an interesting tool for training and horse owners, it requires further improvement. It must be mentioned that a sample size of 20 horses for the fitness tracker test is rather small and a higher number of trials could conduct better results.

VI. Summary German

Die Lahmheitsdiagnostik ist eine der häufigsten Aufgaben von Tierärzt:innen. Um den Schweregrad von Lahmheiten einheitlich zu klassifizieren wurden verschiedene Bewertungssysteme entwickelt. Mit der Zeit individualisieren Tierärzt:innen diese Bewertungssysteme, was zu Unstimmigkeiten zwischen verschiedenen Untersucher:innen führen kann. Außerdem unterscheidet sich die Gewichtung der Kriterien verschiedener Kliniker:innen, wodurch sie zu unterschiedlichen Schlussfolgerungen kommen. Technische Ganganalyseverfahren können zu einem gängigen Instrument werden, das die Genauigkeit und Wiederholbarkeit der subjektiven Lahmheitsuntersuchung erhöhen soll. In dieser Studie wurde die Korrelation zwischen den Ergebnissen des am Körper getragenen Trägheitssensorsystems von Equinosis® und der subjektiven Lahmheitsuntersuchung im Trab bei 99 Pferden untersucht. Anschließend wurde bei 20 dieser Pferde dieses Trägheitssensor-System mit einem Fitness-Tracker-System verglichen. Die Ergebnisse zeigen, dass Equinosis® und die Tierärztinnen stark und signifikant übereinstimmen. Darüber hinaus erkennt das Sensorsystem manchmal Unregelmäßigkeiten, die die Untersucherin nicht erkennt. Aus diesem Grund sollte die Untersuchung mittels Sensorsystem immer mit einer subjektiven Untersuchung kombiniert und im Zusammenhang analysiert werden. Das in dieser Studie verwendete Fitness-Tracker-System bestand nicht einmal die Plausibilitätsprüfung für eine gleichmäßige Verteilung von Lahmheiten. Da es ein interessantes Hilfsmittel für das Training und für die Pferdebesitzer:innen selbst wäre, wäre es wünschenswert es weiter zu entwickeln. Es muss aber auch erwähnt werden, dass eine Stichprobengröße von 20 Pferden für den Fitness-Tracker-Test eher klein ist und eine höhere Anzahl zu besseren Ergebnissen führen könnte.

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IX. List of Abbreviations

AIDE – Automated interpretation and degree of evidence

Diff Max – Difference in Maximum Head/Pelvis Height

Diff Min – Difference in Minimum Head/Pelvis Height

Dipl. ACVS – Diplomate of the American College of Veterinary Surgeons

Dipl. ECVS – Diplomate of the European College of Veterinary Surgeons

DOF – Degrees of Freedom

GRF – Ground Reaction Force

Hz – Hertz

Imp – Impact Lameness

Mid – Midstance Lameness

mm – Millimeter

NRS – Numeric Rating System

Push – Push-off Lameness

RF - Radiofrequency

SD – Standard Deviation

Total Diff Head – Vector Sum of Mean Diff Min and Mean Diff Max values

Univ.-Prof. – Professor of University

USDA – U.S. Department of Agriculture

VRS – Verbal Rating System

X. Appendix

Appendix A

	LF walk	RF walk	LH walk	RH walk	LF trot	RF trot	LH trot	RH trot	LF Q score	RF Q score	LH Q score	RH Q score
Aischa	0	1	0	2	0	0	0	2	1,7	0,0	0,0	7,0
Alboro del Maro	0	2	3	0	0	2	3	0	0,0	13,5	12,7	0,0
Annabell	1	1	0	0	0	0	0	2	5,1	0,0	0,6	10,2
Aperio	0	0	0	0	0	0	0	0	0,0	4,5	0,0	4,1
Arie	1	0	0	0	1	0	2	0	14,9	0,0	10,3	2,2
Arthos	4	0	0	2	4	0	0	2	104,7	0,0	0,4	16,6
Assim	0	0	0	2	0	3	0	4	C	C	C	C
Avon	2	0	0	0	2	0	0	2	10,6	0,0	3,3	8,7
Babsi	0	0	0	1	0	1	0	2	0,0	13,6	0,0	6,1
Baby Bella	0	0	0	2	0	0	0	3	12,0	0,0	0,7	14,1
Belinda	0	2	0	2	0	2	0	2	0,0	7,5	5,9	14,4
Bella	0	0	0	0	0	0	0	2	7,2	0,0	0,0	8,4
Bimbo	1	0	0	0	3	0	0	1	53,9	0,0	3,6	8,4
Blitz	2	0	0	0	3	0	0	2	26,5	0,0	0,0	12,0
Burli	3	4	0	0	6	6	6	6	C	C	C	C
Calvin	0	0	3	3	6	6	6	6	C	C	C	C
Carlos	0	0	2	1	0	0	2	0	11,7	0,0	11,3	5,5
Cassandra	0	0	2	0	1	0	0	2	18,8	0,0	7,4	0,0
Chanel	0	0	2	0	3	0	3	0	0,0	5,3	21,7	0,0
Chari	0	0	0	0	2	0	2	0	9,0	0,0	12,4	0,0
Charlotte	0	0	0	0	1	0	2	2	15,5	0,0	1,7	0
Cheran	0	0	0	2	0	1	0	2	0,0	12,7	0,0	6,6
Dorita	0	0	0	0	2	0	2	0	18,8	0,0	11,1	0,0
Ella	3	3	0	0	6	6	6	6	C	C	C	C
Esperanza	0	0	0	0	0	1	2	2	0,0	3,7	11,0	0,0
Fee	0	0	0	0	2	0	0	2	32,9	0,0	0,0	3,9
Felix	2	3	0	0	2	3	0	0	0,0	20,6	11,2	0,0
Fidelio	0	0	0	0	0	0	0	0	6,4	0,0	0,8	1,4
Flambert	2	2	3	2	4	4	4	4	0,0	8,0	10,0	0,0
Franzi	0	2	0	0	0	3	2	0	0,0	66,3	23,8	0,0
Gaby	0	1	0	2	0	1	0	2	0,0	8,4	7,4	6,9
Gandhi(Andi)	2	0	0	0	2	0	0	0	30,5	0,0	3,0	5,3
Gardist	1	0	2	0	1	0	3	0	1,6	0,0	7,8	0,0

	LF walk	RF walk	LH walk	RH walk	LF trot	RF trot	LH trot	RH trot	LF Q score	RF Q score	LH Q score	RH Q score
Gerold	0	0	0	0	0	0	1	1	0,0	8,2	4,8	6,0
Gert	0	1	0	0	0	2	0	0	0,0	14,0	1,0	0,0
Gigant	0	3	2	6	6	6	6	6	C	C	C	C
Gitano	0	0	0	0	0	0	1	0	0,0	6,6	3,7	0,0
Gloomy	0	1	0	2	0	1	0	2	0,0	10,7	0,0	3,3
Halfmoon	0	0	0	0	0	0	0	2	12,4	0,0	0,0	8,6
Hanne	0	2	3	2	0	2	3	2	0,0	10,4	0,0	10,8
Herby	0	0	0	0	0	0	2	2	0,0	13,0	6,2	7,1
Herzog	0	0	0	0	0	1	0	2	0,0	10,2	5,3	7,5
Hilde	0	2	3	0	0	2	3	0	0,0	25,1	15,5	0,0
Joe	0	0	0	0	0	2	0	2	0,0	21,3	0,0	4,4
Karim	0	1	0	0	0	2	0	1	0,0	25,2	0,0	4,4
Katharina	0	2	2	0	2	2	2	0	10,8	0,0	0,0	7,2
Lakota	0	3	0	3	0	3	0	3	0,0	53,6	0,0	12,1
Larry	2	0	2	2	2	0	2	2	15,3	0,0	4,5	3,4
Lena	0	0	0	3	0	0	0	3	0,0	74,4	0,0	12,2
Lennox	0	0	2	0	0	0	2	0	0,0	12,6	12,9	0,0
Lorena	0	0	0	0	0	0	1	1	2,1	0,0	3,7	3,7
Lory	2	0	0	0	2	0	0	2	21,2	0,0	0,2	11,0
Lotto Vulkan	3	4	0	0	6	6	6	6	C	C	C	C
Marco	2	0	0	0	2	0	0	0	24,2	0,0	1,6	0,5
Martin	0	0	0	0	0	0	0	0	0,0	7,1	0,0	2,9
Martina	0	0	0	0	0	2	0	0	0,0	12,8	5,3	1,7
Mary Lou	0	0	0	0	1	0	0	0	10,3	0,0	1,9	1,2
Massimo	3	4	0	0	6	6	6	6	C	C	C	C
Michi von Rhein	0	0	0	0	0	2	2	0	0,0	9,9	9,1	0,0
Mistral	0	4	0	0	6	6	6	6	C	C	C	C
Misty	0	0	2	2	1	0	2	2	11,1	0,0	10,6	0,0
Monera	0	0	0	1	1	0	0	2	7,1	0,0	0,7	2,6
Monte Video	3	3	3	3	6	6	6	6	C	C	C	C
Nelle	0	2	0	2	3	0	0	3	54,3	0,0	17,5	0,0
Nino	0	0	0	2	0	0	0	2	6,4	0,0	8,0	2,2
Pan-Zahra	0	0	0	0	0	0	1	0	0,0	9,3	5,7	0,0

	LF walk	RF walk	LH walk	RH walk	LF trot	RF trot	LH trot	RH trot	LF Q score	RF Q score	LH Q score	RH Q score
Pandua	2	0	0	3	2	0	0	3	6,4	0,0	1,9	10,8
Paula_Haflinger	0	2	0	0	0	2	0	0	0,0	10,7	0,7	0,0
Paula_RumänischesWarr	0	0	0	2	0	0	0	2	5,9	0,0	0,0	7,3
Paula-B-Stall	1	0	1	0	2	0	2	0	0,0	16,0	5,4	1,8
Paula-Koellersberg	0	1	0	2	0	1	0	2	0,0	11,2	0,0	7,8
Pauline	3	0	0	2	3	0	0	2	40,6	0,0	0,0	25,7
Pia	0	0	0	1	0	0	0	1	0,0	7,2	0,0	5,4
Pioneer	0	0	0	0	2	0	0	0	6,7	0,0	5,8	6,5
Piri	1	0	0	0	2	0	0	0	0,0	15,0	0,5	0,8
Queen of the Roses 2nd	0	0	2	0	1	0	2	0	9,5	0,0	7,5	0,0
Reny	0	0	2	0	0	0	2	0	0,0	9,1	10,5	0,9
Rita	2	3	1	0	2	3	2	0	0,0	57,8	9,8	0,0
Rocky	1	0	2	0	1	0	2	0	10,0	0,0	8,1	0,0
Safir	0	0	0	0	1	0	0	0	7,0	0,0	2,3	0,0
Savanna	0	0	0	2	0	0	0	2	13,7	0,0	4,4	9,9
Sonata	0	0	2	0	0	0	3	0	7,0	0,0	24,6	0,0
Sophie	0	2	3	0	0	2	3	0	0,0	12,0	16,7	0,0
Steffi	0	0	0	0	2	0	1	0	21,6	0,0	0,0	2,5
Stella	2	0	0	2	2	0	1	2	3,9	0,0	4,3	14,3
Sternschnuppe	2	0	2	0	2	0	2	0	28,5	0,0	8,9	0,0
Subida	3	0	0	2	3	0	0	2	19,4	0,0	0,0	3,3
Sultan	0	0	2	0	0	0	2	0	5,7	0,0	13,1	0,0
Sunny-Sunshine Feeling	2	0	1	0	2	0	1	0	22,8	0,0	5,0	0,0
Ted	0	0	2	2	1	0	2	2	0,0	3,2	0,0	1,5
Tiger	2	0	0	3	2	0	0	3	31,1	0,0	0,0	13,6
Timon	0	0	1	2	0	0	2	3	6,1	0,0	6,5	14,8
Tina	3	3	0	0	3	3	2	0	0,0	17,3	13,6	0,0
Titus	3	3	0	0	6	6	6	6	C	C	C	C
Topsi	0	0	0	2	0	1	0	3	0,0	8,8	0,0	8,9
Tosca	0	2	3	2	0	2	3	2	0,0	8,6	9,8	5,2
Ulrich	0	0	0	1	2	0	0	2	12,9	0,0	1,0	6,1
Vera	0	3	0	2	0	3	0	2	0,0	42,5	0,0	7,9
Vulkan	0	0	0	0	1	1	1	0	0,0	4,8	5,9	0,0

Appendix B

	Aischa	Kitty	Sultan	Esperanza	Gardist	Subida	Tiger	Vera	Chanel	Sonata
Equinosis 1										
Stride Rate	1,3	1,5	1,5	1,5	1,4	1,5	1,6	1,5	1,4	1,4
Strides Assessed (fore/hind)	126/125	175/173	122/122	83/79	80/79	165/170	115/114	175/176	147/149	119/121
Diff Max Head Mean in mm	-2,4	-0,7	0,6	3,2	-1,9	1,9	-3,4	21,8	4,6	-0,8
Diff Max Head SD in mm	11,5	8,6	6,2	8,4	9,8	9,2	12,9	10,5	7,4	6,3
Diff Min Head Mean in mm	-3,6	6,2	-4,5	1,8	-0,2	-9,6	0,3	36,5	2,6	-0,8
Diff Min Head SD in mm	12,9	12,4	4,9	7,7	8,8	12,8	15,5	9,2	6,7	5,4
Total Diff Head (Vector Sum) in	8,5	6,3	4,5	3,7	1,9	9,8	3,4	42,5	5,3	1,1
Q Score (fore)	L 4,4 Imp	R 6,3 Mid	L 4,5 Mid	R 3,7 Imp	L 1,9 Imp	L 9,8 Mid	R 3,4 Push	R 42,5 Imp	R 5,3 Imp	L 1,1 Imp
Diff Max Pelvis Mean in mm	1,4	12,9	-8,7	-6,4	-6,7	-2,5	17,4	0,6	-21,7	-1,2
Diff Max Pelvis SD in mm	2	4,9	6,1	3,3	5,9	3,8	6,8	4,5	9,5	3,8
Diff Min Pelvis Mean in mm	4,2	-5	7,4	-3,9	-9,2	0	27,7	7,9	-13	8,1
Diff Min Pelvis SD in mm	3,2	3,7	11,8	3,7	7,9	3,1	4,9	3,9	7,6	2,6
Q Score (hind)	R 1,4 Push/ R 4,2 Imp	R 12,9 Push/L 5,0 Imp	L 8,7 Push/ R 7,4 Imp	L 6,4 Push/ L 3,9 Imp	L 6,7 Push/ L 9,2 Imp	L 2,5 Push/ R 0,0 Imp	R 17,4 Push/ R 27,7 Imp	R 0,6 Push/ R 7,9 Imp	L 21,7 Push/ L 13 Imp	L 1,2 Push/ R 8,1 Imp
Trial AIDE	"moderate" evidence of "mild" RH impact lameness	"moderate" evidence of "mild" LH impact lameness. "strong" evidence of "moderate/severe" RH pushoff lameness.	"moderate" evidence of "mild/moderate" LH pushoff lameness. "weak" evidence of "mild/moderate" RH impact lameness.	"moderate" evidence of "mild" LH impact lameness. "moderate" evidence of "mild/moderate" LH pushoff lameness.	"moderate" evidence of "moderate" LH impact lameness. "moderate" evidence of "mild/moderate" LH pushoff lameness	"weak" evidence of "mild" LF midstance lameness	"strong" evidence of "moderate/severe" RH impact lameness. "strong" evidence of "moderate/severe" RH pushoff lameness	"strong" evidence of "moderate/severe" RF impact lameness "strong" evidence of "mild/moderate" RH impact lameness	"moderate" evidence of "moderate/severe" LH impact lameness. "strong" evidence of "moderate/severe" LH pushoff lameness	"strong" evidence of "mild/moderate" RH impact lameness
Equinosis 2										
Stride Rate	1,3	1,5	1,5	-	1,5	1,5	1,5	1,5	-	1,4
Strides Assessed (fore/hind)	114/112	176/173	140/138	-	131/129	129/128	168/165	145/149	-	131/131
Diff Max Head Mean in mm	-2,1	-0,5	0	-	2,3	1,8	-4,7	22,8	-	-5,9
Diff Max Head SD in mm	11	8,1	6,2	-	6,5	9	15	7,6	-	6,6
Diff Min Head Mean in mm	-3,7	0,5	-3,8	-	6,7	-6,6	6,2	37,5	-	-12,4
Diff Min Head SD in mm	14,8	9,1	4,8	-	8,8	10,7	14,9	10,4	-	7,4
Total Diff Head (Vector Sum) in	4,3	0,7	3,8	-	7	6,8	7,8	43,8	-	13,7
Q Score (fore)	L 4,3 Imp	R 0,7 Push	L 3,8 Mid	-	R 7,0 Imp	L 6,8 Push	R 7,8 Push	R 43,8 Imp	-	L 13,7 Imp
Diff Max Pelvis Mean in mm	3	11,8	-8,5	-	-8	-0,8	10,2	-1,9	-	-1,4
Diff Max Pelvis SD in mm	1,8	3,4	7,3	-	4,3	3,1	4,7	4,1	-	5,1
Diff Min Pelvis Mean in mm	5,5	-5,5	19	-	-15,5	-0,8	23,5	2,9	-	8,1
Diff Min Pelvis SD in mm	2,9	2,6	15,5	-	6,4	2,8	4,3	4,8	-	4,1
Q Score (hind)	R 3,0 Push/ R 5,5 Imp	R 11,8 Push / L 5,5 Imp	L 8,5 Push/ R 19 Imp	-	L 8,0 Push/ L 15,5 Imp	L 0,8 Push/ L 0,8 Imp	R 10,2 Push/ R 23,5 Imp	L 1,9 Push/ R 2,9 Imp	-	L 1,4 Push/ R 8,1 Imp
Trial AIDE	"moderate" evidence of "mild" RH impact lameness. "moderate" evidence of "mild" RH pushoff lameness	"strong" evidence of "mild" LH impact lameness. "strong" evidence of "moderate" RH pushoff lameness.	"moderate" evidence of "mild/moderate" LH pushoff lameness. "moderate" evidence of "moderate/severe" RH impact lameness.		"strong" evidence of "moderate/severe" LH impact lameness. "moderate" evidence of "mild/moderate" LH pushoff lameness	No evidence of lameness	"strong" evidence of "moderate/severe" RH impact lameness. "strong" evidence of "moderate" RH pushoff lameness	"strong" evidence of "moderate/severe" RF impact lameness		"moderate" evidence of "mild" LF impact lameness "moderate" evidence of "mild/moderate" RH impact lameness
Estride										
Activity Walk in %	63	63	50	66	71	55	63	71	66	63
Activity Trot in %	36	36	50	33	28	44	36	28	33	36
Total Minutes	11	11	10	9	7	9	11	7	9	11
Overall										
Front Observations	No irregularity detected	no irregularity detected	no irregularity detected	no irregularity detected	No irregularity detected	no irregularity detected	no irregularity detected	no irregularity detected	no irregularity detected	no irregularity detected
	FL short by 4%	FL short by 6%	FL short by 3%	FL short by 5%	FR short by 2%	FL short by 3%	FL short by 3%	FL short by 4%	FL short by 3%	FL short by 6%
Hind Observations	No irregularity detected	no irregularity detected	No irregularity detected	no irregularity detected	No irregularity detected	No irregularity detected	no irregularity detected	no irregularity detected	no irregularity detected	no irregularity detected
	HR short by 3%	HL short by 4%	HL short by 3%	HL short by 4%	HL short by 5%	HL short by 6%	HL short by 3%	HL short by 3%	HL short by 5%	HL short by 6%
Stride Comparison										
Front Left Stride in %	46	44	47	45	52	47	47	46	47	44
Front Right Stride in %	54	56	53	55	48	53	53	54	53	56
Hind Left Stride in %	53	46	47	46	45	44	47	47	45	44
Hind Right Stride in %	47	54	53	54	55	56	53	53	55	56

	Aischa	Kitty	Sultan	Esperanza	Gardist	Subida	Tiger	Vera	Chanel	Sonata
Stride Comparison										
Front Left Stride in %	46	44	47	45	52	47	47	46	47	44
Front Right Stride in %	54	56	53	55	48	53	53	54	53	56
Hind Left Stride in %	53	46	47	46	45	44	47	47	45	44
Hind Right Stride in %	47	54	53	54	55	56	53	53	55	56
Front Features										
Elevation in % Left	93,3	90	93	96,9	100	95	93,3	95,1	100	89,9
Elevation in % Right	100	100	100	100	97,4	100	100	100	100	100
Landing in % Left	100	100	100	100	100	100	100	100	100	100
Landing in % Right	100	50	100	100	100	100	100	100	100	100
Deviation in % Left	100	87,4	100	94,4	98	91,7	92,9	100	100	80,1
Deviation in % Right	100	100	100	100	100	100	100	100	100	100
Frequency in % Left	100	84,9	96,3	100	97,8	91,6	88	85	100	81,7
Frequency in % Right	100	100	100	100	100	100	100	100	100	100
Impact in % Left	88,8	100	85	100	100	100	100	100	100	100
Impact in % Right	100	100	100	100	91,9	100	100	100	100	100
Regularity in % Left	100	85,2	100	100	96,1	93,1	90,2	100	100	81,5
Regularity in % Right	100	100	100	100	100	100	100	100	100	100
Pattern in % Left	93,1	92,8	89	95	100	100	97,5	100	100	93,7
Pattern in % Right	100	100	100	100	96	100	100	100	100	100
Rythm in % Left	89,2	93,2	100	100	100	95,9	100	100	97,4	100
Rythm in % Right	100	100	100	100	93,3	100	100	100	100	100
Hind Features										
Elevation in % Left	100	90,8	97	93	100	87,4	100	99,1	92,8	92,3
Elevation in % Right	100	100	100	100	100	100	100	100	100	100
Landing in % Left	100	100	100	100	100	100	100	100	50	100
Landing in % Right	50	100	50	100	100	100	100	100	100	100
Deviation in % Left	100	90	94,2	90,1	100	85,1	100	100	90,1	82,7
Deviation in % Right	98,7	100	100	100	100	100	100	91,7	100	100
Frequency in % Left	100	95	96	90,5	100	87	100	100	91,9	84,4
Frequency in % Right	98,4	100	100	100	100	100	100	100	100	100
Impact in % Left	100	90,8	98,9	97,9	98,2	90,9	91	88	100	100
Impact in % Right	100	100	100	100	100	100	100	100	100	100
Regularity in % Left	100	91,2	100	89,1	100	83	100	100	95	80,6
Regularity in % Right	100	100	100	100	100	100	100	91,1	100	100
Pattern in % Left	95,2	90,7	100	95,8	100	90,3	92,1	95,8	100	100
Pattern in % Right	100	100	100	100	100	100	100	100	100	100
Rythm in % Left	100	100	100	92,6	100	94	92,7	94,9	100	86,9
Rythm in % Right	100	100	100	100	100	100	100	100	100	100
Walk										
Front Observations	No irregularity detected	no irregularity detected	no irregularity detected	no irregularity detected	No irregularity detected	no irregularity detected	no irregularity detected	no irregularity detected	no irregularity detected	no irregularity detected
	FL Short by 4%	FL short by 7%	FL short by 2%	FL short by 5%	Fr short by 2%	FL short by 3%	FL short by 3%	FL short by 3%	FL short by 3%	FL short by 8%
Hind Observations	No irregularity detected	No irregularity detected	No irregularity detected	no irregularity detected	No irregularity detected	no irregularity detected	no irregularity detected	no irregularity detected	no irregularity detected	no irregularity detected
	HR short by 1%	HL short by 6%	HL short by 4%	HL short by 3%	HL short by 5%	HL short by 7%	HR short by 4%	HL short by 5%	HL short by 5%	HL short by 8%
Stride Comparison										
Front Left Stride in %	46	43	48	45	52	47	47	47	47	42
Front Right Stride in %	54	57	52	55	48	53	53	53	53	58
Hind Left Stride in %	51	44	46	47	45	43	54	45	45	42
Hind Right Stride in %	49	56	54	53	55	57	46	55	55	58
Front Features										
Elevation in % Left	92,3	92,8	95,9	95,7	100	95,8	94	95,6	100	85,7
Elevation in % Right	100	100	100	100	97	100	100	100	99,4	100
Landing in % Left	100	100	100	58,9	100	100	100	100	100	100
Landing in % Right	100	50	100	100	100	100	100	100	100	100
Deviation in % Left	90,1	89,7	100	89	98,6	90,9	91,7	100	93,2	70,1
Deviation in % Right	100	100	97,8	100	100	100	100	93,7	100	100
Frequency in % Left	89,3	82,8	99,6	91,8	97,2	92,7	90,7	99,3	89,2	75,2
Frequency in % Right	100	100	100	100	100	100	100	100	100	100
Impact in % Left	97,7	100	85,4	100	100	100	100	86,5	100	100
Impact in % Right	100	96,7	100	98,5	91	96,9	98,7	100	91,6	94,5
Regularity in % Left	87,7	84,8	100	91,5	98,1	90,6	90,3	100	91	70,7
Regularity in % Right	100	100	96,1	100	100	100	100	98,1	100	100
Pattern in % Left	95,4	93,7	91,3	96	100	100	96,6	89,8	100	92,4
Pattern in % Right	100	100	100	100	94,4	98,5	100	100	96,6	100
Rythm in % Left	92,4	97,6	100	100	100	98,6	100	100	98,3	92,9
Rythm in % Right	100	100	99,5	98,6	95,3	100	90,6	92,3	100	100

	Aischa	Kitty	Sultan	Esperanza	Gardist	Subida	Tiger	Vera	Chanel	Sonata
Hind Features										
Elevation in % Left	100	86,1	99,5	94,5	94,4	84,2	100	99,1	98,1	86,4
Elevation in % Right	99,2	100	100	100	100	100	99,3	100	100	100
Landing in % Left	100	100	100	100	100	100	100	100	50	100
Landing in % Right	100	100	50	100	100	100	100	100	100	100
Deviation in % Left	100	85	97,3	90,7	90,7	80,9	100	100	89,5	78,6
Deviation in % Right	99	100	100	100	100	100	88,6	83,8	100	100
Frequency in % Left	100	91,6	94,4	91,1	87,7	82,8	100	100	92,6	79,1
Frequency in % Right	98,9	100	100	100	100	100	93,3	84,6	100	100
Impact in % Left	100	88,2	99,2	96,5	98,5	88,5	87,7	82,2	100	99,2
Impact in % Right	98,9	100	100	100	100	100	100	100	96,6	100
Regularity in % Left	100	86,5	100	94,9	91,3	78,6	100	100	94,9	75,3
Regularity in % Right	99,1	100	99,6	100	100	100	89,2	84,9	100	100
Pattern in % Left	98,5	86,8	97,9	95,3	90,2	90,8	94,1	93	100	93,3
Pattern in % Right	100	100	100	100	100	100	100	100	97,8	100
Rythm in % Left	100	95	95,5	91,5	75,7	96,5	94,4	95,6	100	80,1
Rythm in % Right	98	100	100	100	100	100	100	100	96,1	100
Trot										
Front Observations	no irregularity detected	no irregularity detected	no irregularity detected	no irregularity detected	no irregularity detected	no irregularity detected	no irregularity detected	no irregularity detected	no irregularity detected	no irregularity detected
	FL Short by 4%	FL short by 6%	FL short by 4%	FL short by 5%	FR short by 2%	FL short by 3%	FL short by 3%	FL short by 6%	FL short by 3%	FL short by 3%
Hind Observations	no irregularity detected	no irregularity detected	no irregularity detected	No irregularity detected	no irregularity detected	no irregularity detected	no irregularity detected	no irregularity detected	no irregularity detected	no irregularity detected
	HL short by 5%	HL short by 2%	HL short by 2%	HL short by 4%	HR short by 4%	HL short by 5%	HL short by 3%	HL short by 1%	HL short by 5%	HL short by 4%
Stride Comparison										
Front Left Stride in %	46	44	46	45	52	47	47	44	47	47
Front Right Stride in %	54	56	54	55	48	53	53	56	53	53
Hind Left Stride in %	45	48	48	46	54	45	47	49	45	46
Hind Right Stride in %	55	52	52	54	46	55	53	51	55	54
Front Features										
Elevation in % Left	94,4	87,2	90	98,1	100	94,2	92,7	94,6	97,2	94,1
Elevation in % Right	100	100	100	100	97,7	100	100	100	100	100
Landing in % Left	100	100	100	100	100	100	100	100	100	100
Landing in % Right	100	100	100	50	100	100	100	100	100	100
Deviation in % Left	100	85,2	92	99,8	97,4	92,5	94	78,5	100	90
Deviation in % Right	96,3	100	100	100	100	100	100	100	95,3	100
Frequency in % Left	100	87	93	100	98,4	90,5	85,2	70,7	100	88,3
Frequency in % Right	97,5	100	100	97,3	100	100	100	100	92,6	100
Impact in % Left	79,9	90,7	84,7	91,5	200	94,5	96,2	100	93,5	97,7
Impact in % Right	100	100	100	100	92,7	100	100	96,4	100	100
Regularity in % Left	100	85,6	95,1	100	94	95,6	90	87,5	100	92,4
Regularity in % Right	92,8	100	100	96,9	100	100	100	100	96,5	100
Pattern in % Left	90,8	91,9	86,6	94,1	100	95,5	98,3	100	93	95,1
Pattern in % Right	100	100	100	100	97,6	100	100	98,1	100	100
Rythm in % Left	86	88,8	97	96,1	100	93,2	99,5	94	96,6	100
Rythm in % Right	100	100	100	100	91,2	100	100	100	100	98,8
Hind Features										
Elevation in % Left	95,8	95,6	94,5	91,4	100	90,7	94,4	99,1	87,5	98,2
Elevation in % Right	100	100	100	100	92,8	100	100	100	100	100
Landing in % Left	100	100	100	100	100	100	100	100	100	100
Landing in % Right	50	100	100	100	100	100	100	100	100	100
Deviation in % Left	100	94,9	91,1	89,5	100	89,2	95,3	100	90,7	86,8
Deviation in % Right	98,4	100	100	100	88,7	100	100	99,6	100	100
Frequency in % Left	100	98,5	97,7	90	100	91,1	96,1	97,1	91,1	89,7
Frequency in % Right	97,9	100	100	100	91,9	100	100	100	100	100
Impact in % Left	93,9	93,5	98,5	99,3	97,9	93,2	94,2	93,8	85,6	100
Impact in % Right	100	100	100	100	100	100	100	100	100	89,8
Regularity in % Left	98,2	96	93,1	83,3	100	87,4	95,5	100	95,1	85,8
Regularity in % Right	100	100	100	100	88,7	100	100	97,4	100	100
Pattern in % Left	92	94,7	100	96,4	100	89,8	90,1	98,5	84,7	100
Pattern in % Right	100	100	99,5	100	92,5	100	100	100	100	98,2
Rythm in % Left	94,6	100	100	93,7	100	91,4	91,1	94,1	88,7	93,7
Rythm in % Right	100	98,9	98	100	86,7	100	100	100	100	100
Subjective										
Walk	LF 1/5 (not visible in Trot)	LF 2/5 , doesn't bend ankle joint RH	-	RH 1/5	-	RH 2/5 sometimes changing to LH 2/5	LF 1/5, RH 3/5	RF 3/5, RH 1/5	RH 3/5	-
Trot	RH 2/5 changing to LH	RH 2/5, LH 1/5 (increasing)	RH 3/5, LH 2/5	LH 2/5, RF 2/5	LH 3/5	RH 2/5 sometimes changing to LH 2/5	RH 3/5	RF 3/5, RH 2/5, LH 2/5	RH 2/5, LH 2/5 --> 3/5	RF 2/5, LH 3/5

	Pandua	Gitano	Timon	Avon	Belinda	Monera	Herby	Piri	Pia	Halbmond
Equinosis 1										
Stride Rate	1,3	1,6	1,4	1,4	1,4	1,4	1,5	1,6	1,6	1,5
Strides Assessed (fore/hind)	109/107	179/175	105/103	128/117	138/146	143/146	133/139	38/38	103/98	35/34
Diff Max Head Mean in mm	4,5	5,6	2,5	0,1	-0,3	-3	11	11,7	-0,6	29,5
Diff Max Head SD in mm	7	6,8	7	12,6	7,4	6	6	13,5	10,1	11,3
Diff Min Head Mean in mm	-1,2	3,4	-5,6	-10,6	6,5	-3,9	7	22,2	7,2	42
Diff Min Head SD in mm	7,5	7,7	6,3	11,1	6,8	8,4	10,2	10,4	11,7	15,5
Total Diff Head (Vector Sum) in	4,7	6,6	6,1	10,6	6,5	4,9	13	25,1	7,2	51,3
Q Score (fore)	L 4,7 Push	R 6,6 Imp	L 6,1 Push	L 10,6 Mid	R 6,5 Mid	L 4,9 Imp	R 13 Imp	R 25,1 Imp	R 7,2 Mid	R 51,3 Imp
Diff Max Pelvis Mean in mm	-1,3	-3,7	-6,5	-3,3	-1,2	-1,7	-6,2	-2,3	5,4	1
Diff Max Pelvis SD in mm	2,6	3,5	9,6	3,1	2,4	3,7	3,8	3,7	5,6	10,2
Diff Min Pelvis Mean in mm	11	-0,6	14,8	8,7	-2,8	-3	7,1	1,8	4,8	9,3
Diff Min Pelvis SD in mm	1,3	4	5,9	3,7	2,5	3	4	4,5	4,6	13,6
Q Score (hind)	L 1,3 Push/ R 11 Imp	L 3,7 Push/ L 0,6 Imp	L 6,5 Push/ R 14,8 Imp	L 3,3 Push/ R 8,7 Imp	L 1,2 Push/ L 2,8 Imp	L 1,7 Push/ L 3 Imp	L 6,2 Push/ R 7,1 Imp	L 2,3 Push/ R 1,8 Imp	R 5,4 Push/ R 4,8 Imp	R 1,0 Push/ R 9,3 Imp
Trial AIDE	"strong" evidence of "moderate" RH impact lameness.	"moderate" evidence of "mild" LH pushoff lameness.	"weak" evidence of "mild/moderate" LH pushoff lameness. "strong" evidence of "moderate/severe" RH impact lameness.	"moderate" evidence of "mild" LF midstance lameness "moderate" evidence of "mild" LH pushoff lameness "strong" evidence of "mild/moderate" RH impact	"weak" evidence of "very mild" RF midstance asymmetry "weak" evidence of "very mild" LH impact asymmetry	"weak" evidence of "very mild" LH impact asymmetry	"moderate" evidence of "mild" RF impact lameness. "moderate" evidence of "mild/moderate" LH pushoff lameness. "moderate" evidence of "mild/moderate" RH impact lameness.	"strong" evidence of "mild/moderate" RF impact lameness	"moderate" evidence of "mild" RH impact lameness. "moderate" evidence of "mild" RH pushoff lameness	"strong" evidence of "moderate/severe" RF impact lameness
Equinosis 2										
Stride Rate	1,3	1,5	1,4	1,4	1,6	1,4	1,4	1,5	1,5	1,5
Strides Assessed (fore/hind)	150/143	180/182	122/140	154/157	168/167	149/157	138/134	89/92	112/116	63/60
Diff Max Head Mean in mm	5,1	3,2	6,9	-1,5	4,8	-7,5	11	14,7	0,7	33
Diff Max Head SD in mm	9,2	6,2	5,1	10,3	9,6	6,6	5,8	11,3	9,8	9,9
Diff Min Head Mean in mm	0,6	8,7	-3,6	18,4	16	-5,9	4,9	22,9	7,2	43,8
Diff Min Head SD in mm	6,6	6,3	5,1	11,9	12,2	7,4	10,5	11,9	7,8	16,4
Total Diff Head (Vector Sum) in	5,2	9,2	7,8	18,5	16,7	9,5	12	27,2	7,2	54,8
Q Score (fore)	R 5,2 Imp	R 9,2 Imp	L 7,8 Push	L 18,5 Mid	R 16,7 Imp	L 9,5 Imp	R 12 Imp	R 27,2 Imp	R 7,2 Mid	R 54,8
Diff Max Pelvis Mean in mm	-0,1	-5,5	-6,5	-3,6	1,4	-0,9	-8,4	-3	1,5	-1,2
Diff Max Pelvis SD in mm	2,5	3,9	9	2,6	3,4	3,5	2,9	4	4,6	6,8
Diff Min Pelvis Mean in mm	12	-0,7	15	-2,1	-0,5	-3,2	0,3	-0,4	0,5	11,8
Diff Min Pelvis SD in mm	2,6	3,8	6,4	2,6	3,7	3	2,5	4,8	5	9,6
Q Score (hind)	L 0,1 Push / R 12 Imp	L 5,5 Push/1,5 L 0,7 Imp	L 6,5 Push / R 15 Imp	L 3,6 Push/ L 2,1 Imp	R 1,4 Push/ L 0,5 Imp	L 0,9 Push/ L 3,1 Imp	L 8,4 Push/ R 0,3 Imp	L 3,0 Push/ L 0,4 Imp	R 1,5 Push/ R 0,5 Imp	L 1,2 Push/ R 11,8 Imp
Trial AIDE	"strong" evidence of "moderate/severe" RH impact lameness.	"moderate" evidence of "mild" RF impact lameness. "moderate" evidence of "mild" LH pushoff lameness.	"weak" evidence of "very mild" LF pushoff asymmetry. "weak" evidence of "mild/moderate" LH pushoff lameness. "strong" evidence of "moderate/severe" RH impact lameness.	"moderate" evidence of "mild/moderate" LF midstance lameness "moderate" evidence of "mild" LH pushoff lameness	"moderate" evidence of "mild" RF impact lameness	"moderate" evidence of "mild" LF impact lameness "moderate" evidence of "mild" LH impact lameness	"moderate" evidence of "mild" RF impact lameness. “strong" evidence of "mild/moderate" LH pushoff lameness.	"moderate" evidence of "moderate" RF impact lameness	"weak" evidence of "very mild" RF midstance asymmetry	"strong" evidence of "moderate/severe" RF impact lameness "moderate" evidence of "moderate" RH impact lameness
Estride										
Activity Walk in %	80	50	77	77	66	70	66	75	63	80
Activity Trot in %	20	50	22	22	33	30	33	25	36	20
Total Minutes	10	10	9	9	9	10	9	12	11	10
Overall										
Front Observations	no irregularity detected	no irregularity detected	no irregularity detected	no irregularity detected	no irregularity detected	no irregularity detected	no irregularity detected	no irregularity detected	no irregularity detected	no irregularity detected
	FL short by 5%	FL short by 4%	FL short by 7%	FR short by 4%	FL short by 3%	FL short by 1%	FL short by 3%	FL short by 5%	FL short by 7%	FL short by 4%
Hind Observations	no irregularity detected	no irregularity detected	no irregularity detected	no irregularity detected	no irregularity detected	no irregularity detected	no irregularity detected	no irregularity detected	no irregularity detected	no irregularity detected
	HL short by 3%	HL short by 4%	HR short by 6%	HL short by 4%	HL short by 6%	HL short by 3%	HL short by 3%	HR short by 3%	HL short by 3%	HR short by 3%
Stride Comparison										
Front Left Stride in %	45	46	43	54	47	49	47	45	43	46
Front Right Stride in %	55	54	57	46	53	51	53	55	57	54
Hind Left Stride in %	47	46	56	46	44	47	47	53	47	53
Hind Right Stride in %	53	54	44	54	56	53	53	47	53	47

	Pandua	Gitano	Timon	Avon	Belinda	Monera	Herby	Piri	Pia	Halbmond
Stride Comparison										
Front Left Stride in %	45	46	43	54	47	49	47	45	43	46
Front Right Stride in %	55	54	57	46	53	51	53	55	57	54
Hind Left Stride in %	47	46	56	46	44	47	47	53	47	53
Hind Right Stride in %	53	54	44	54	56	53	53	47	53	47
Front Features										
Elevation in % Left	97,7	94	89,5	100	96,9	100	94	92,3	100	100
Elevation in % Right	100	100	100	100	100	100	100	100	100	100
Landing in % Left	100	100	100	100	100	100	100	100	100	100
Landing in % Right	50	100	50	100	100	100	100	50	100	100
Deviation in % Left	93,9	88,6	91,9	100	93,3	100	100	100	100	100
Deviation in % Right	100	100	100	100	100	99,9	100	100	100	100
Frequency in % Left	100	86,8	94,3	100	94,2	100	97,1	100	100	100
Frequency in % Right	100	100	100	100	100	100	100	100	100	87,9
Impact in % Left	97,7	100	83,6	100	100	100	92,2	82,7	81,9	89,4
Impact in % Right	100	100	100	94,9	93,9	100	100	100	100	100
Regularity in % Left	93,7	89,7	93,9	100	92,6	96,5	92,7	100	100	100
Regularity in % Right	100	100	100	100	100	100	100	100	100	100
Pattern in % Left	93,5	100	85,7	100	100	99,5	91,4	90,8	91	100
Pattern in % Right	100	100	100	100	97	100	100	100	100	100
Rythm in % Left	97,1	100	84	100	100	100	100	98,1	100	100
Rythm in % Right	100	100	100	91,6	94,9	96,3	100	100	100	100
Hind Features										
Elevation in % Left	100	91,9	100	90,8	88,4	100	95,7	100	100	100
Elevation in % Right	100	100	100	100	100	100	100	94,9	100	100
Landing in % Left	100	100	50	100	100	100	100	100	100	100
Landing in % Right	100	100	100	100	100	100	100	95,1	100	100
Deviation in % Left	97,4	84,3	100	92	78,7	100	100	100	100	100
Deviation in % Right	100	100	100	100	100	95,1	100	91	100	100
Frequency in % Left	96,9	83,6	100	94	79,3	100	100	100	100	100
Frequency in % Right	100	100	100	100	100	100	100	93,4	100	100
Impact in % Left	100	100	100	84,9	100	88,9	100	100	96	100
Impact in % Right	100	100	100	100	100	100	100	100	100	96,9
Regularity in % Left	97,6	86,5	100	98,2	80,7	100	100	100	100	100
Regularity in % Right	100	100	100	100	100	93	100	92,5	100	100
Pattern in % Left	100	100	100	93,1	94,1	95,1	95,5	100	97,3	100
Pattern in % Right	100	100	100	100	100	100	100	97,6	100	100
Rythm in % Left	93,2	100	100	91,9	100	95,8	91,1	100	100	100
Rythm in % Right	100	99,2	98,1	100	100	100	100	100	100	100
Walk										
Front Observations	no irregularity detected	no irregularity detected	no irregularity detected	no irregularity detected	no irregularity detected	no irregularity detected	no irregularity detected	no irregularity detected	no irregularity detected	no irregularity detected
	FL short by 5%	FL short by 3%	FL short by 8%	FR short by 6%	FL short by 3%	FL short by 1%	FL short by 3%	FL short by 2%	FL short by 7%	FR short by 5%
Hind Observations	no irregularity detected	no irregularity detected	no irregularity detected	no irregularity detected	no irregularity detected	no irregularity detected	no irregularity detected	no irregularity detected	no irregularity detected	no irregularity detected
	HL short by 2%	HL short by 4%	HR short by 5%	HL short by 4%	HL short by 4%	HR short by 3%	HL short by 2%	HR short by 4%	HR short by 3%	HR short by 2%
Stride Comparison										
Front Left Stride in %	45	47	42	56	47	49	47	48	43	55
Front Right Stride in %	55	53	58	44	53	51	53	52	57	45
Hind Left Stride in %	48	46	55	46	46	53	48	54	53	52
Hind Right Stride in %	52	54	45	54	54	47	52	46	47	48
Front Features										
Elevation in % Left	97,4	96,3	89,3	100	96,5	99,6	92,9	93,5	86,1	100
Elevation in % Right	100	100	100	89,3	100	100	100	100	100	92,1
Landing in % Left	100	100	100	100	100	100	100	100	100	100
Landing in % Right	50	100	50	100	100	100	100	100	100	100
Deviation in % Left	91,4	91,3	94,4	100	93,8	100	100	98,3	85,2	100
Deviation in % Right	100	100	100	85,1	100	98,6	96,3	100	100	86,9
Frequency in % Left	98,1	86,2	96,4	100	94,7	99,8	95,9	98,2	86,2	100
Frequency in % Right	100	100	100	86,3	100	100	100	100	100	83,8
Impact in % Left	99,3	100	83	100	100	100	88,2	88,2	88,7	95,9
Impact in % Right	100	94,5	100	91,7	93,7	100	100	100	100	100
Regularity in % Left	92,1	89,6	95,3	100	91,9	96,9	96	98,4	85	100
Regularity in % Right	100	100	100	87,5	100	100	100	100	100	84
Pattern in % Left	95,4	100	86,6	100	100	99,9	90	93,3	87,8	100
Pattern in % Right	100	97,4	100	88,9	97,2	100	100	100	100	97,2
Rythm in % Left	97,7	100	80,4	100	100	100	93,2	97,5	80,4	95,5
Rythm in % Right	100	97,4	100	89,2	94,3	96,7	100	100	100	100

	Pandua	Gitano	Timon	Avon	Belinda	Monera	Herby	Piri	Pia	Halbmond
Hind Features										
Elevation in % Left	100	90,9	100	90,6	91,6	100	97,2	100	100	100
Elevation in % Right	97,2	100	89,2	100	100	98,4	100	95	97,8	95,8
Landing in % Left	100	100	100	100	100	100	100	100	100	100
Landing in % Right	100	100	100	100	100	100	100	95,1	100	100
Deviation in % Left	98	87,3	100	93,2	92,8	100	100	100	100	100
Deviation in % Right	100	100	81,7	100	100	91,5	97,8	88,4	88,6	96,8
Frequency in % Left	95,6	84,2	100	91,3	86,1	100	100	100	100	100
Frequency in % Right	100	100	83,3	100	100	94,9	96,9	89,3	91,8	98,8
Impact in % Left	100	95,3	100	85,3	92,9	92,7	87,4	99,3	93,9	100
Impact in % Right	92,8	100	95	100	100	100	100	100	100	94,7
Regularity in % Left	97,8	88,4	100	96,7	89,8	100	100	100	100	100
Regularity in % Right	100	100	84,7	100	100	88,5	94,6	91,5	91,6	96,9
Pattern in % Left	100	97,5	100	93,6	92,5	98,3	96,2	100	99,9	100
Pattern in % Right	95,9	100	93,6	100	100	100	100	99,4	100	93,7
Rythm in % Left	97,5	100	100	95,8	97,8	95	97,3	84	100	100
Rythm in % Right	100	98,5	98,4	100	100	100	100	100	98,2	94,7
Trot										
Front Observations	no irregularity detected	no irregularity detected	no irregularity detected	no irregularity detected	no irregularity detected	no irregularity detected	no irregularity detected	no irregularity detected	no irregularity detected	no irregularity detected
	FL short by 5%	FL short by 5%	FL short by 6%	FL short by 3%	FL short by 3%	FR short by 1%	FL short by 2%	FL short by 7%	FR short by 7%	FL short by 4%
Hind Observations	no irregularity detected	no irregularity detected	no irregularity detected	no irregularity detected	no irregularity detected	no irregularity detected	no irregularity detected	no irregularity detected	no irregularity detected	no irregularity detected
	HL short by 5%	HL short by 5%	HL short by 6%	HL short by 4%	HL short by 8%	HL short by 3%	HL short by 4%	HR short by 2%	HL short by 3%	HL short by 5%
Stride Comparison										
Front Left Stride in %	45	45	44	47	47	51	48	43	57	46
Front Right Stride in %	55	55	56	53	53	49	52	57	43	54
Hind Left Stride in %	45	45	44	46	42	47	46	52	47	45
Hind Right Stride in %	55	55	56	54	58	53	54	48	53	55
Front Features										
Elevation in % Left	98,1	91,8	89,7	98,3	97,3	100	95	91	100	91,6
Elevation in % Right	100	100	100	100	100	98,6	100	100	96,2	100
Landing in % Left	100	100	100	100	100	100	100	100	100	100
Landing in % Right	50	100	100	100	100	100	100	50	100	100
Deviation in % Left	96,4	85,8	89,5	94,7	92,8	100	95,6	100	100	99
Deviation in % Right	100	100	100	100	100	99,3	100	93,6	76,4	100
Frequency in % Left	100	87,4	92,2	82,4	93,7	100	98,3	100	100	100
Frequency in % Right	88,2	100	100	100	100	94,8	100	98,6	80,1	91,9
Impact in % Left	96,2	93,9	84,2	100	100	100	96,2	77,2	75,1	83
Impact in % Right	100	100	100	98,2	94,1	99,2	100	100	100	100
Regularity in % Left	95,4	89,7	92,5	97	93,2	96,2	89,5	100	100	98,4
Regularity in % Right	100	100	100	100	100	100	100	91,5	77,2	100
Pattern in % Left	91,6	93,7	84,9	99,5	100	99,1	92,8	88,4	94,2	92
Pattern in % Right	100	100	100	100	96,8	100	100	100	100	100
Rythm in % Left	96,4	92,3	87,6	100	100	100	100	98,7	100	100
Rythm in % Right	100	100	100	94	95,6	95,9	97,9	100	97	90,9
Hind Features										
Elevation in % Left	86,2	92,9	91,9	90,9	85,3	94,6	94,3	100	94,3	89,7
Elevation in % Right	100	100	100	100	100	100	100	94,7	100	100
Landing in % Left	100	100	50	100	100	100	100	100	100	100
Landing in % Right	100	100	100	100	100	100	100	100	100	100
Deviation in % Left	96,9	81,2	97,7	90,8	64,5	100	84,2	100	90,4	81,6
Deviation in % Right	100	100	100	100	100	98,8	100	93,7	100	100
Frequency in % Left	98,3	83	98,6	96,7	72,5	94,8	99,9	100	91,2	88,7
Frequency in % Right	100	100	100	100	100	100	100	97,5	100	100
Impact in % Left	77,6	100	90,3	84,5	100	85	100	100	98	100
Impact in % Right	100	94,2	100	100	94,2	100	95,2	96,3	100	99
Regularity in % Left	97,5	84,5	93	99,8	71,6	100	85,9	100	92,9	79,6
Regularity in % Right	100	100	100	100	100	97,4	100	93,5	100	100
Pattern in % Left	84,8	100	85,7	92,5	95,8	91,9	94,9	100	94,8	94,6
Pattern in % Right	100	99,3	100	100	100	100	100	95,8	100	100
Rythm in % Left	89	100	100	87,9	100	96,6	85	100	92,7	98,6
Rythm in % Right	100	99,8	97,8	100	98	100	100	97,2	100	100
Subjective										
Walk	RF 2/5	RF 1/5, RH 1/5	-	RF 1/5, LH 2-3/5	RH 2/5, RF 1/5	LH 1/5, LF 2/5	RF 1/5	RF 2/5, RH 2/5	LH 2/5, RF 2/5	RF 1/5, LH 2/5
Trot	RF 2/5, RH 3/5, LH 2/5	LH 1/5	RH 1/5, LH 1/5	LH 2/5, RF 1/5	RF 2/5, RH 2/5	LF 1/5, LH 2/5 changing to RH 1/5	RH 2/5, LH 2/5	LH 1/5	LH 1/5	RF 3-4/5, LH 2/5

Appendix C

	n=20			n=2			n=9		
	Overall			Grade 1 (subj. Lameness)			Grade 2 (subj. Lameness)		
Objektive Lameness	mean	s.d.	range	mean	s.d.	range	mean	s.d.	range
Equinosis									
Stride Rate	1,46	0,09	1.3 - 1.6	1,48	0,10	1.4 - 1.6	1,47	0,09	1.3 - 1.6
Strides Assessed (fore/hind)	128.3/128.53	36.23/36.91	35 - 180/34 - 182	146.5/150	38.73/36.62	105-180/103-182	128.18/129	36.32/37.14	38 - 176/38 - 173
Diff Max Head Mean in mm	4,42	9,25	-7.5 - 33	4,55	2,05	2.5 - 6.9	2,57	6,12	-7.5 - 14.7
Diff Max Head SD in mm	8,74	2,46	5.1 - 15	6,28	0,85	5.1 - 7	8,94	2,18	5.8 - 13.5
Diff Min Head Mean in mm	6,13	14,33	-12.4 - 43.8	0,73	6,57	-5.6 - 8.7	4,06	9,57	-9.6 - 22.9
Diff Min Head SD in mm	9,71	3,23	4.8 - 16.4	6,35	1,06	5.1 - 7.7	10,45	2,30	6.8 - 14.8
Total Diff Head (Vector Sum) in mm	12,61	13,69	0.7 - 54.8	7,43	1,38	6.1 - 9.2	9,96	7,16	0.7 - 27.2
Q Score Total (fore)	12,50	13,74	0.7 - 54.8	7,43	1,38	6.1 - 9.2	9,72	7,28	0.7 - 27.2
Q Score Push (fore)	5,22	2,77	0.7 - 7.8	6,95	1,20	6.1 - 7.8	3,75	4,31	0.7 - 6.8
Q Score Mid (fore)	8,27	4,41	3.8 - 18.5	-	-	-	7,40	1,40	6.3 - 9.8
Q Score Imp (fore)	16,51	16,78	1.1 - 54.8	7,90	1,84	6.6 - 9.2	12,08	8,62	3.7 - 27.2
Diff Max Pelvis Mean in mm	-1,49	6,86	-21.7 - 17.4	-5,55	1,32	-6.5 - -3.7	0,24	5,73	-8.4 - 12.9
Diff Max Pelvis SD in mm	4,63	2,16	1.8 - 10.2	6,50	3,25	3.5 - 9.6	3,52	0,97	1.8 - 5.6
Diff Min Pelvis Mean in mm	3,82	9,18	-15.5 - 27.7	7,13	8,98	-0.7 - 15	-0,05	3,74	-5.5 - 7.1
Diff Min Pelvis SD in mm	4,92	3,11	1.3 - 15.5	5,03	1,32	3.8 - 6.4	3,51	0,83	2.5 - 5
Q Score (hind)	6.56/5.69	5.98/5.89	0 - 27.7/0.1 - 23.5	6.4/6.93	6.1/5.95	0.6 - 14.8/0.7 - 15	4.03/2.96	2.98/3.31	0 - 12.9/0.3 - 11.8
Estride									
Activity Walk in %	66,8	8,7	50 - 80	63,5	19,1	50 - 77	65,2	5,5	55 - 75
Activity Trot in %	32,6	8,7	20 - 50	36,0	19,8	22 - 50	34,0	5,1	25 - 44
Total Minutes	9,7	1,3	7 - 12	9,5	0,7	9 - 10	10,1	1,2	9 - 12
Overall									
Front Observations	4,1	1,6	1 - 7	5,5	2,1	4 - 7	4,1	1,8	1 - 7
Hind Observations	4,0	1,2	3 - 6	4,0	1,4	4 - 6	3,9	1,3	3 - 6
Stride Comparison									
Front Left Stride in %	46,5	2,7	43 - 54	44,5	2,1	43 - 46	45,9	1,8	43 - 49
Front Right Stride in %	53,5	2,7	46 - 57	55,5	2,1	54 - 57	54,1	1,8	51 - 57
Hind Left Stride in %	47,5	3,4	44 - 56	51,0	7,1	46 - 56	47,4	3,4	44 - 53
Hind Right Stride in %	52,5	3,4	44 - 56	49,0	7,1	44 - 54	52,6	3,4	47 - 56

	n=20			n=2			n=9		
	Overall			Grade 1 (subj. Lameness)			Grade 2 (subj. Lameness)		
Objektive Lameness	mean	s.d.	range	mean	s.d.	range	mean	s.d.	range
Front Features									
Elevation in % Left	95,5	3,7	89.5 - 100	91,75	3,18	89.5 - 94	95,38	3,39	90 - 100
Elevation in % Right	99,9	0,6	97.4 - 100	100,00	0,00	100 - 100	100,00	0,00	100 - 100
Landing in % Left	100,0	0,0	100 - 100	100,00	0,00	100 - 100	100,00	0,00	100 - 100
Landing in % Right	90,0	20,5	50 - 100	75,00	35,36	50 - 100	88,89	22,05	50 - 100
Deviation in % Left	95,6	5,6	80.1 - 100	90,25	2,33	88.6 - 91.9	96,31	4,76	87.4 - 100
Deviation in % Right	100,0	0,0	99.9 - 100	100,00	0,00	100 - 100	99,99	0,03	99.9 - 100
Frequency in % Left	94,9	6,3	81.7 - 100	90,55	5,30	86.8 - 94.3	96,42	5,31	84.9 - 100
Frequency in % Right	99,4	2,7	87.9 - 100	100,00	0,00	100 - 100	100,00	0,00	100 - 100
Impact in % Left	95,1	7,0	81.9 - 100	91,80	11,60	83.6 - 100	93,96	7,78	81.9 - 100
Impact in % Right	99,0	2,4	91.9 - 100	100,00	0,00	100 - 100	99,32	2,03	93.9 - 100
Regularity in % Left	95,3	5,5	81.5 - 100	91,80	2,97	89.7 - 93.9	95,57	5,12	85.2 - 100
Regularity in % Right	100,0	0,0	100 - 100	100,00	0,00	100 - 100	100,00	0,00	100 - 100
Pattern in % Left	95,7	4,6	85.7 - 100	92,85	10,11	85.7 - 100	94,84	3,95	90.8 - 100
Pattern in % Right	99,7	1,1	96 - 100	100,00	0,00	100 - 100	99,67	1,00	97 - 100
Rythm in % Left	97,7	4,3	84 - 100	92,00	11,31	84 - 100	97,38	3,90	89.2 - 100
Rythm in % Right	98,8	2,6	91.6 - 100	100,00	0,00	100 - 100	99,02	1,97	94.9 - 100
Hind Features									
Elevation in % Left	96,0	4,5	87.4 - 100	95,95	5,73	91.9 - 100	95,03	5,28	87.4 - 100
Elevation in % Right	99,7	1,1	94.9 - 100	100,00	0,00	100 - 100	99,43	1,70	94.9 - 100
Landing in % Left	95,0	15,4	50 - 100	75,00	35,36	50 - 100	100,00	0,00	100 - 100
Landing in % Right	94,8	15,3	50 - 100	100,00	0,00	100 - 100	93,90	16,54	50 - 100
Deviation in % Left	94,2	7,1	78.7 - 100	92,15	11,10	84.3 - 100	93,77	8,09	78.7 - 100
Deviation in % Right	98,8	2,8	91 - 100	100,00	0,00	100 - 100	98,31	3,18	91 - 100
Frequency in % Left	94,9	6,6	79.3 - 100	91,80	11,60	83.6 - 100	94,64	7,54	79.3 - 100
Frequency in % Right	99,6	1,5	93.4 - 100	100,00	0,00	100 - 100	99,09	2,20	93.4 - 100
Impact in % Left	96,3	5,1	84.9 - 100	100,00	0,00	100 - 100	96,06	4,62	88.9 - 100
Impact in % Right	99,8	0,7	96.9 - 100	100,00	0,00	100 - 100	100,00	0,00	100 - 100
Regularity in % Left	95,1	7,1	80.6 - 100	93,25	9,55	86.5 - 100	93,78	7,98	80.7 - 100
Regularity in % Right	98,8	2,9	91.1 - 100	100,00	0,00	100 - 100	98,39	3,20	92.5 - 100
Pattern in % Left	96,8	3,4	90.3 - 100	100,00	0,00	100 - 100	94,89	3,01	90.3 - 100
Pattern in % Right	99,9	0,5	97.6 - 100	100,00	0,00	100 - 100	99,73	0,80	97.6 - 100
Rythm in % Left	96,7	4,1	86.9 - 100	100,00	0,00	100 - 100	97,06	3,70	91.1 - 100
Rythm in % Right	99,9	0,5	98.1 - 100	98,65	0,78	98.1 - 99.2	100,00	0,00	100 - 100

	n=20			n=2			n=9		
	Overall			Grade 1 (subj. Lameness)			Grade 2 (subj. Lameness)		
Objektive Lameness	mean	s.d.	range	mean	s.d.	range	mean	s.d.	range
Walk									
Front Observations	4,2	2,1	1 - 8	5,5	3,5	3 - 8	3,9	2,1	1 - 7
Hind Observations	4,1	1,7	1 - 8	4,5	0,7	4 - 5	3,7	1,9	1 - 7
Stride Comparison									
Front Left Stride in %	47,2	3,7	42 - 56	44,5	3,5	42 - 47	46,1	2,1	43 - 49
Front Right Stride in %	52,9	3,7	44 - 58	55,5	3,5	53 - 58	53,9	2,1	51 - 57
Hind Left Stride in %	48,2	4,1	42 - 55	50,5	6,4	46 - 55	48,8	4,1	43 - 54
Hind Right Stride in %	51,9	4,1	45 - 58	49,5	6,4	45 - 54	51,2	4,1	46 - 57
Front Features									
Elevation in % Left	95,0	4,3	85.7 - 100	92,80	4,95	89.3 - 96.3	93,91	3,74	86.1 - 99.6
Elevation in % Right	98,9	2,9	89.3 - 100	100,00	0,00	100 - 100	100,00	0,00	100 - 100
Landing in % Left	97,9	9,2	58.9 - 100	100,00	0,00	100 - 100	95,43	13,70	58.9 - 100
Landing in % Right	92,5	18,3	50 - 100	75,00	35,36	50 - 100	94,44	16,67	50 - 100
Deviation in % Left	93,4	7,2	70.1 - 100	92,85	2,19	91.3 - 94.4	93,00	5,33	85.2 - 100
Deviation in % Right	97,9	4,4	85.1 - 100	100,00	0,00	100 - 100	99,43	1,26	96.3 - 100
Frequency in % Left	93,2	6,8	75.2 - 100	91,30	7,21	86.2 - 96.4	92,38	5,55	82.8 - 99.8
Frequency in % Right	98,5	4,6	83.8 - 100	100,00	0,00	100 - 100	100,00	0,00	100 - 100
Impact in % Left	95,6	6,2	83 - 100	91,50	12,02	83 - 100	95,87	5,68	88.2 - 100
Impact in % Right	97,4	3,3	91 - 100	97,25	3,89	94.5 - 100	98,42	2,24	93.7 - 100
Regularity in % Left	92,5	7,1	70.7 - 100	92,45	4,03	89.6 - 95.3	91,42	4,99	84.8 - 98.4
Regularity in % Right	98,3	4,4	84 - 100	100,00	0,00	100 - 100	100,00	0,00	100 - 100
Pattern in % Left	95,4	4,6	86.6 - 100	93,30	9,48	86.6 - 100	95,12	4,42	87.8 - 100
Pattern in % Right	98,5	2,8	88.9 - 100	98,70	1,84	97.4 - 100	99,52	1,00	97.2 - 100
Rythm in % Left	96,2	6,0	80.4 - 100	90,20	13,86	80.4 - 100	95,52	6,34	80.4 - 100
Rythm in % Right	97,7	3,5	89.2 - 100	98,70	1,84	97.4 - 100	98,84	2,04	94.3 - 100
Hind Features									
Elevation in % Left	95,6	5,4	84.2 - 100	95,45	6,43	90.9 - 100	94,84	6,25	84.2 - 100
Elevation in % Right	98,6	2,7	89.2 - 100	94,60	7,64	89.2 - 100	98,93	1,69	95 - 100
Landing in % Left	97,5	11,2	50 - 100	100,00	0,00	100 - 100	100,00	0,00	100 - 100
Landing in % Right	97,3	11,2	50 - 100	100,00	0,00	100 - 100	99,46	1,63	95.1 - 100
Deviation in % Left	94,2	7,0	78.6 - 100	93,65	8,98	87.3 - 100	94,38	7,45	80.9 - 100
Deviation in % Right	95,8	6,2	81.7 - 100	90,85	12,94	81.7 - 100	96,14	5,11	88.4 - 100
Frequency in % Left	93,8	6,9	79.1 - 100	92,10	11,17	84.2 - 100	94,62	6,88	82.8 - 100
Frequency in % Right	96,6	5,4	83.3 - 100	91,65	11,81	83.3 - 100	96,87	4,03	89.3 - 100
Impact in % Left	94,3	5,9	82.2 - 100	97,65	3,32	95.3 - 100	93,27	4,69	87.4 - 100
Impact in % Right	98,9	2,2	92.8 - 100	97,50	3,54	95 - 100	99,88	0,37	98.9 - 100
Regularity in % Left	94,7	7,5	75.3 - 100	94,20	8,20	88.4 - 100	94,42	7,83	78.6 - 100
Regularity in % Right	96,0	5,5	84.7 - 100	92,35	10,82	84.7 - 100	96,14	4,63	88.5 - 100
Pattern in % Left	95,9	3,9	86.8 - 100	98,75	1,77	97.5 - 100	95,37	4,52	86.8 - 100
Pattern in % Right	99,0	2,1	93.6 - 100	96,80	4,53	93.6 - 100	99,93	0,20	99.4 - 100
Rythm in % Left	94,6	6,9	75.7 - 100	100,00	0,00	100 - 100	95,23	4,98	84 - 100
Rythm in % Right	99,2	1,5	94.7 - 100	98,45	0,07	98.4 - 98.5	99,58	0,84	98 - 100

	n=20			n=2			n=9		
	Overall			Grade 1 (subj. Lameness)			Grade 2 (subj. Lameness)		
Objektive Lameness	mean	s.d.	range	mean	s.d.	range	mean	s.d.	range
Trot									
Front Observations	4,1	1,7	1 - 7	5,5	0,7	5 - 6	4,2	2,2	1 - 7
Hind Observations	4,0	1,6	1 - 8	5,5	0,7	5 - 6	4,0	1,9	2 - 8
Stride Comparison									
Front Left Stride in %	46,9	3,2	43 - 57	44,5	0,7	44 - 45	47,6	4,2	43 - 57
Front Right Stride in %	53,1	3,2	43 - 57	55,5	0,7	55 - 56	52,4	4,2	43 - 57
Hind Left Stride in %	46,6	2,7	42 - 54	44,5	0,7	44 - 45	46,4	2,7	42 - 52
Hind Right Stride in %	53,4	2,7	46 - 58	55,5	0,7	55 - 56	53,6	2,7	48 - 58
Front Features									
Elevation in % Left	94,77	3,79	87.2 - 100	90,75	1,48	89.7 - 91.8	95,24	4,22	87.2 - 100
Elevation in % Right	99,63	1,00	96.2 - 100	100,00	0,00	100 - 100	99,42	1,29	96.2 - 100
Landing in % Left	100,00	0,00	100 - 100	100,00	0,00	100 - 100	100,00	0,00	100 - 100
Landing in % Right	92,50	18,32	50 - 100	100,00	0,00	100 - 100	88,89	22,05	50 - 100
Deviation in % Left	94,16	6,01	78.5 - 100	93,83	2,62	85.8 - 89.5	96,21	5,21	85.2 - 100
Deviation in % Right	98,05	5,42	76.4 - 100	100,00	0,00	100 - 100	96,18	7,75	76.4 - 100
Frequency in % Left	93,36	7,99	70.7 - 100	89,80	3,39	87.4 - 92.2	96,61	4,98	87 - 100
Frequency in % Right	97,05	5,25	80.1 - 100	100,00	0,00	100 - 100	96,48	6,39	80.1 - 100
Impact in % Left	91,73	8,16	75.1 - 100	89,05	6,86	84.2 - 93.9	89,46	9,66	75.1 - 100
Impact in % Right	99,03	2,13	92.7 - 100	100,00	0,00	100 - 100	99,26	1,95	94.1 - 100
Regularity in % Left	94,61	4,50	85.6 - 100	91,10	1,98	89.7 - 92.5	95,57	5,25	85.6 - 100
Regularity in % Right	97,75	5,45	77.2 - 100	100,00	0,00	100 - 100	95,38	7,59	77.2 - 100
Pattern in % Left	94,08	4,48	84.9 - 100	89,30	6,22	84.9 - 93.7	94,09	3,74	88.4 - 100
Pattern in % Right	99,63	0,94	96.8 - 100	100,00	0,00	100 - 100	99,64	1,07	96.8 - 100
Rythm in % Left	96,31	4,56	86 - 100	89,95	3,32	87.6 - 92.3	95,87	5,37	86 - 100
Rythm in % Right	98,07	3,01	90.9 - 100	100,00	0,00	100 - 100	98,49	1,90	95.6 - 100
Hind Features									
Elevation in % Left	93,37	4,26	85.3 - 100	92,40	0,71	91.9 - 92.9	93,56	4,09	85.3 - 100
Elevation in % Right	99,38	1,95	92.8 - 100	100,00	0,00	100 - 100	99,41	1,77	94.7 - 100
Landing in % Left	97,50	11,18	50 - 100	75,00	35,36	50 - 100	100,00	0,00	100 - 100
Landing in % Right	97,50	11,18	50 - 100	100,00	0,00	100 - 100	94,44	16,67	50 - 100
Deviation in % Left	91,24	8,81	64.5 - 100	89,45	11,67	81.2 - 97.7	90,30	11,23	64.5 - 100
Deviation in % Right	98,96	2,81	88.7 - 100	100,00	0,00	100 - 100	98,99	2,08	93.7 - 100
Frequency in % Left	93,75	6,91	72.5 - 100	90,80	11,03	83 - 98.6	93,11	8,77	72.5 - 100
Frequency in % Right	99,37	1,89	91.9 - 100	100,00	0,00	100 - 100	99,49	1,02	97.5 - 100
Impact in % Left	94,27	6,57	77.6 - 100	95,15	6,86	90.3 - 100	95,88	5,03	85 - 100
Impact in % Right	98,44	2,90	89.8 - 100	97,10	4,10	94.2 - 100	98,41	2,44	94.2 - 100
Regularity in % Left	91,96	8,03	71.6 - 100	88,75	6,01	84.5 - 93	90,59	9,46	71.6 - 100
Regularity in % Right	98,85	2,87	88.7 - 100	100,00	0,00	100 - 100	98,99	2,23	93.5 - 100
Pattern in % Left	94,06	5,10	84.7 - 100	92,85	10,11	85.7 - 100	94,48	2,98	89.8 - 100
Pattern in % Right	99,27	1,88	92.5 - 100	99,65	0,49	99.3 - 100	99,53	1,40	95.8 - 100
Rythm in % Left	94,86	4,89	85 - 100	100,00	0,00	100 - 100	94,89	4,97	85 - 100
Rythm in % Right	98,82	3,00	86.7 - 100	98,80	1,41	97.8 - 99.8	99,34	1,07	97.2 - 100

	n=8			n=1			n=0		
	Grade 3 (subj. Lameness)			Grade 4 (subj. Lameness)			Grade 5 (subj. Lameness)		
Objektive Lameness	mean	s.d.	range	mean	s.d.	range	mean	s.d.	range
Equinosis									
Stride Rate	1,44	0,08	1.3 - 1.6	1,50	0,00	1.5 - 1.5			
Strides Assessed (fore/hind)	134.27/133.13	24.12/24.76	80 - 175/79 - 176	49/47	19.8/18.38	35 - 63/34 - 60			
Diff Max Head Mean in mm	2,91	8,52	-5.9 - 22.8	31,25	2,47	29.5 - 33			
Diff Max Head SD in mm	8,94	2,83	6.2 - 15	10,60	0,99	9.9 - 11.3			
Diff Min Head Mean in mm	5,02	14,86	-12.4 - 37.5	42,90	1,27	42 - 43.8			
Diff Min Head SD in mm	8,93	3,33	4.8 - 15.5	15,95	0,64	15.5 - 16.4			
Total Diff Head (Vector Sum) in mm	11,59	13,61	1.1 - 43.8	53,05	2,47	51.3 - 54.8			
Q Score Total (fore)	11,59	13,61	1.1 - 43.8	53,05	2,47	51.3 - 54.8			
Q Score Push (fore)	4,70	0,00		-	-	-			
Q Score Mid (fore)	9,35	6,82	3.8 - 18.5	-	-	-			
Q Score Imp (fore)	15,06	17,75	1.1 - 43.8	53,05	2,47	51.3 - 54.8			
Diff Max Pelvis Mean in mm	-2,55	8,74	-21.7 - 17.4	-0,10	1,56	-1.2 - 1			
Diff Max Pelvis SD in mm	4,86	1,98	2.5 - 9.5	8,50	2,40	6.8 - 10.2			
Diff Min Pelvis Mean in mm	6,43	12,41	-15.5 - 27.7	10,55	1,77	9.3 - 11.8			
Diff Min Pelvis SD in mm	5,60	3,81	1.3 - 15.5	11,60	2,83	9.6 - 13.6			
Q Score (hind)	9.62/8.24	7.43/7.13	0.6 - 27.7/0.1 - 23.5	5.15/6.5	5.87/7.5	1 - 9.3/1.2 - 11.8			
Estride									
Activity Walk in %	67,6	9,4	50 - 80	80	0	80			
Activity Trot in %	31,6	9,5	20 - 50	20	0	20			
Total Minutes	9,3	1,6	7 - 11	10	0	10			
Overall									
Front Observations	3,8	1,3	2 - 6	4	0	4			
Hind Observations	4,0	1,2	3 - 6	3	0	3			
Stride Comparison									
Front Left Stride in %	47,8	3,5	44 - 54	46	0	46			
Front Right Stride in %	52,3	3,5	46 - 56	54	0	54			
Hind Left Stride in %	46,0	1,2	44 - 47	53	0	53			
Hind Right Stride in %	54,0	1,2	53 - 56	47	0	47			

	n=8			n=1			n=0		
	Grade 3 (subj. Lameness)			Grade 4 (subj. Lameness)			Grade 5 (subj. Lameness)		
Objektive Lameness	mean	s.d.	range	mean	s.d.	range	mean	s.d.	range
Front Features									
Elevation in % Left	96,13	3,87	89.9 - 100	100	0	100			
Elevation in % Right	99,68	0,92	97.4 - 100	100	0	100			
Landing in % Left	100,00	0,00	100 - 100	100	0	100			
Landing in % Right	93,75	17,68	50 - 100	100	0	100			
Deviation in % Left	95,61	6,90	80.1 - 100	100	0	100			
Deviation in % Right	100,00	0,00	100 - 100	100	0	100			
Frequency in % Left	93,60	7,51	81.7 - 100	100	0	100			
Frequency in % Right	100,00	0,00	100 - 100	87,9	0	87,9			
Impact in % Left	97,84	5,25	85 - 100	89,4	0	89,4			
Impact in % Right	98,35	3,16	91.9 - 100	100	0	100			
Regularity in % Left	95,19	6,63	81.5 - 100	100	0	100			
Regularity in % Right	100,00	0,00	100 - 100	100	0	100			
Pattern in % Left	96,71	4,19	89 - 100	100	0	100			
Pattern in % Right	99,50	1,41	96 - 100	100	0	100			
Rythm in % Left	99,31	1,28	97.1 - 100	100	0	100			
Rythm in % Right	98,11	3,52	91.6 - 100	100	0	100			
Hind Features									
Elevation in % Left	96,50	3,92	90.8 - 100	100	0	100			
Elevation in % Right	100,00	0,00	100 - 100	100	0	100			
Landing in % Left	93,75	17,68	50 - 100	100	0	100			
Landing in % Right	93,75	17,68	50 - 100	100	0	100			
Deviation in % Left	94,55	6,14	82.7 - 100	100	0	100			
Deviation in % Right	98,96	2,93	91.7 - 100	100	0	100			
Frequency in % Left	95,40	5,36	84.4 - 100	100	0	100			
Frequency in % Right	100,00	0,00	100 - 100	100	0	100			
Impact in % Left	95,13	6,18	84.9 - 100	100	0	100			
Impact in % Right	100,00	0,00	100 - 100	96,9	0	96,9			
Regularity in % Left	96,43	6,63	80.6 - 100	100	0	100			
Regularity in % Right	98,89	3,15	91.1 - 100	100	0	100			
Pattern in % Left	97,63	3,43	92.1 - 100	100	0	100			
Pattern in % Right	100,00	0,00	100 - 100	100	0	100			
Rythm in % Left	94,95	4,76	86.9 - 100	100	0	100			
Rythm in % Right	100,00	0,00	100 - 100	100	0	100			

	n=8			n=1			n=0		
	Grade 3 (subj. Lameness)			Grade 4 (subj. Lameness)			Grade 5 (subj. Lameness)		
Objektive Lameness	mean	s.d.	range	mean	s.d.	range	mean	s.d.	range
Walk									
Front Observations	4,0	2,1	2 - 8	5		5			
Hind Observations	4,6	1,7	2 - 8	2		2			
Stride Comparison									
Front Left Stride in %	48,0	4,3	42 - 56	55	0	55			
Front Right Stride in %	52,0	4,3	44 - 58	45	0	45			
Hind Left Stride in %	46,4	3,5	42 - 54	52	0	52			
Hind Right Stride in %	53,6	3,5	46 - 58	48	0	48			
Front Features									
Elevation in % Left	96,08	4,78	85.7 - 100	100	0	100			
Elevation in % Right	98,21	3,75	89.3 - 100	92,1	0	92,1			
Landing in % Left	100,00	0,00	100 - 100	100	0	100			
Landing in % Right	93,75	17,68	50 - 100	100	0	100			
Deviation in % Left	93,13	10,05	70.1 - 100	100	0	100			
Deviation in % Right	97,08	5,32	85.1 - 100	86,9	0	86,9			
Frequency in % Left	93,66	8,53	75.2 - 100	100	0	100			
Frequency in % Right	98,29	4,84	86.3 - 100	83,8	0	83,8			
Impact in % Left	96,40	6,46	85.4 - 100	95,9	0	95,9			
Impact in % Right	95,94	4,15	91 - 100	100	0	100			
Regularity in % Left	92,78	9,87	70.7 - 100	100	0	100			
Regularity in % Right	97,71	4,36	87.5 - 100	84	0	84			
Pattern in % Left	95,69	4,16	89.8 - 100	100	0	100			
Pattern in % Right	97,49	4,06	88.9 - 100	97,2	0	97,2			
Rythm in % Left	98,61	2,48	92.9 - 100	95,5	0	95,5			
Rythm in % Right	95,86	4,62	89.2 - 100	100	0	100			
Hind Features									
Elevation in % Left	96,01	5,10	86.4 - 100	100	0	100			
Elevation in % Right	99,56	0,99	97.2 - 100	95,8	0	95,8			
Landing in % Left	93,75	17,68	50 - 100	100	0	100			
Landing in % Right	93,75	17,68	50 - 100	100	0	100			
Deviation in % Left	93,41	7,22	78.6 - 100	100	0	100			
Deviation in % Right	96,55	6,52	83.8 - 100	96,8	0	96,8			
Frequency in % Left	92,59	6,86	79.1 - 100	100	0	100			
Frequency in % Right	97,24	5,62	84.6 - 100	98,8	0	98,8			
Impact in % Left	94,01	7,57	82.2 - 100	100	0	100			
Impact in % Right	98,68	2,66	92.8 - 100	94,7	0	94,7			
Regularity in % Left	94,50	8,33	75.3 - 100	100	0	100			
Regularity in % Right	96,71	6,08	84.9 - 100	96,9	0	96,9			
Pattern in % Left	95,26	3,60	90.2 - 100	100	0	100			
Pattern in % Right	99,21	1,54	95.9 - 100	93,7	0	93,7			
Rythm in % Left	91,83	8,84	75.7 - 100	100	0	100			
Rythm in % Right	99,51	1,38	96.1 - 100	94,7	0	94,7			

	n=8			n=1			n=0		
	Grade 3 (subj. Lameness)			Grade 4 (subj. Lameness)			Grade 5 (subj. Lameness)		
Objektive Lameness	mean	s.d.	range	mean	s.d.	range	mean	s.d.	range
Trot									
Front Observations	3,6	1,3	2 - 6	4		4			
Hind Observations	3,5	1,4	1 - 5	5		5			
Stride Comparison									
Front Left Stride in %	46,9	2,4	44 - 52	46	0	46			
Front Right Stride in %	53,1	2,4	48 - 56	54	0	54			
Hind Left Stride in %	47,5	3,0	45 - 54	45	0	45			
Hind Right Stride in %	52,5	3,0	46 - 55	55	0	55			
Front Features									
Elevation in % Left	95,63	3,35	90 - 100	91,6	0	91,6			
Elevation in % Right	99,71	0,81	97.7 - 100	100	0	100			
Landing in % Left	100,00	0,00	100 - 100	100	0	100			
Landing in % Right	93,75	17,68	50 - 100	100	0	100			
Deviation in % Left	92,88	6,59	78.5 - 100	99	0	99			
Deviation in % Right	99,41	1,66	95.3 - 100	100	0	100			
Frequency in % Left	89,75	10,25	70.7 - 100	100	0	100			
Frequency in % Right	97,60	4,60	88.2 - 100	91,9	0	91,9			
Impact in % Left	96,04	5,14	84.7 - 100	83	0	83			
Impact in % Right	98,41	2,65	92.7 - 100	100	0	100			
Regularity in % Left	93,93	3,94	87.5 - 100	98,4	0	98,4			
Regularity in % Right	99,56	1,24	96.5 - 100	100	0	100			
Pattern in % Left	95,51	4,86	86.6 - 100	92	0	92			
Pattern in % Right	99,46	1,00	97.6 - 100	100	0	100			
Rythm in % Left	97,94	2,26	94 - 100	100	0	100			
Rythm in % Right	98,00	3,44	91.2 - 100	90,9	0	90,9			
Hind Features									
Elevation in % Left	93,85	5,25	86.2 - 100	89,7	0	89,7			
Elevation in % Right	99,10	2,55	92.8 - 100	100	0	100			
Landing in % Left	100,00	0,00	100 - 100	100	0	100			
Landing in % Right	100,00	0,00	100 - 100	100	0	100			
Deviation in % Left	93,95	4,83	86.8 - 100	81,6	0	81,6			
Deviation in % Right	98,54	3,98	88.7 - 100	100	0	100			
Frequency in % Left	95,84	3,57	89.7 - 100	88,7	0	88,7			
Frequency in % Right	98,99	2,86	91.9 - 100	100	0	100			
Impact in % Left	91,51	8,03	77.6 - 100	100	0	100			
Impact in % Right	98,73	3,61	89.8 - 100	99	0	99			
Regularity in % Left	95,85	4,81	85.8 - 100	79,6	0	79,6			
Regularity in % Right	98,26	3,97	88.7 - 100	100	0	100			
Pattern in % Left	93,83	6,73	84.7 - 100	94,6	0	94,6			
Pattern in % Right	98,78	2,61	92.5 - 100	100	0	100			
Rythm in % Left	93,06	4,84	87.9 - 100	98,6	0	98,6			
Rythm in % Right	98,09	4,65	86.7 - 100	100	0	100			