Date: 20-06-25

Final report

'As time goes by': movement symmetry in trotters and riding horses from rookie to athlete.
Från unghäst till atlet -förändringar över tid av rörelsesymmetrin hos trav- och ridhästar.

Project number: H-16-47-178

Project period: 2017-01-01—2019-12-31

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Part 1: Detailed summary

Det har visat sig att många hästar som tränar och tävlar rör sig med ett asymmetriskt rörelsemönster. Vi vet inte om dessa är smärtutlösta och orsakade av träningen eller om de kan vara en naturlig variation. Detta projekt syftade därför till att initiera tre kohortstudier där förändringar i rörelsemönstret över två års tid studeras hos rid- och travhästar. Prevalensen och grad av asymmetrier hos unghästar som inte tränats och ridhästar som tävlar på elitnivå har också studeras, likaså hur symmetrin påverkas av de olika faserna i skoningsperioden eftersom detta är viktig kunskap vid en hältutredning om man bör ta hänsyn till skoningsintervallet. Hur variationen i rörelseasymmetri kan se ut från vecka till vecka har också studerats. Projektet har givit oss viktig kunskap om rörelseasymmetrier i olika sporthästpopulationer. Vi har visat att asymmetrierna finns tidigt i hästarnas atletiska karriär och att de sannolikt kommer att varierar över tid inom samma individ. Även hos hästar på elit nivå inom rid-disciplinerna är rörelseasymmetrier vanliga och förhindrar inte hästarna från att prestera på hög nivå. Det är oerhört viktigt att som veterinär, vid hältutredningar och besiktningar, vara medveten om denna höga prevalens av asymmetrier. Den stora utmaningen är att identifiera när en asymmetri är orsakad av smärta och är ett tecken på ortopedisk sjukdom.

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Part 2: Main report

Introduction

Background

According to both insurance and clinical data, orthopaedic disorders are by far the most common health problems in the Swedish horse population. Swedish Warmblood horses have a median lifespan of only 15 years, which is in fact the age when a sport horse should be performing at its best, had it been healthy. The lifespan of trotters is probably even lower but no information is available. Tools that aid in early recognition of lameness and pain may assist both veterinarians and laypersons in preventing disease and hence suffering of the animals in our care.

Lameness

Accurate detection of the lame limb(s) and correct evaluation of the results of diagnostic analgesia in horses is a prerequisite for successful diagnosis, treatment and recovery. However, subjective scoring of mild to moderate lameness has been shown to be only 'moderately reliable'[1], leading to incorrect (or lack of) detection of early stage orthopaedic problems. The clinical examination of orthopaedic diseases is currently experiencing a shift of paradigm. While subjective visual evaluation of lameness has been the standard until now, the use of new objective symmetry measurements is emerging rapidly. These methods describe the degree of asymmetry of various aspects of the movement in a quantitative fashion.

The clinical use of these sensitive methods has however raised a number of research questions, which have been partly addressed by the applicants. In order to compare data derived from different systems we evaluated and compared different objective motion analysis systems [2–4]. To know how different ground surfaces and the circular movement on the lunge affects motion symmetry we also investigated how hard and soft surfaces [5] and movement on a circle affects the symmetry of the motion pattern in sound [6] and in lame horses [7]. A large population (n=222) of mature riding horses 'perceived as healthy by the owners' were examined and 73% showed motion asymmetries during straight-line trot [8]. It was not possible to explain to which extent these asymmetries were caused by pain/pathology and hence could pose a potential welfare issue. Since motion analyses of these horses were performed only once, we do not know when the asymmetries developed, for how long they have been present and if or how they change over time or are related to training.

To start addressing this question, we investigated if such asymmetries were caused by inflammatory pain and treated 66 asymmetrically moving horses with non-steroidal anti-inflammatory drugs in an owner-blinded randomized crossover study with symmetry of movement as outcome [9]. Interestingly, the horses did not respond to the analgesic treatment by increased symmetry of the movement. Either those horses should then be deemed sound and free from pain or there are other pain mechanisms, such as chronic pain, which show no response to NSAID-treatment.

However, the biological variation of individual symmetry of the movement has been investigated to a very limited extent until now, muddling the evaluation of the clinical significance of movement asymmetries during orthopaedic examinations.

The fundamental question that needs to be addressed is to which extent lameness and asymmetry represent synonymous conditions – or in other words; which animals presenting with motion asymmetries are in pain caused by pathology[10]?

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In order to increase our knowledge of the biological variation and the significance and clinical impact of motion asymmetries, longitudinal studies on large numbers of horses are required.

Objectives of the project

We have therefore performed a three-year collaborative project between the Swedish University of Agricultural Sciences and the Norwegian University of Life Sciences. The aims of the research project were to increase our knowledge of how motion asymmetry changes over time, and to determine the prevalence and magnitude of motion asymmetries in populations of young horses before training and in a group of high-performance horses. We also wanted to investigate how training and riding influence horses at different stages in their careers. Our results should be used as the basis for understanding the relationship between movement asymmetry, lameness and the risk of developing lameness.

The primary aim of the study was addressed in the first part of the project where we established cohorts for longitudinal monitoring of training and motion asymmetry in young trotters (I), young riding horses (II) and mature riding horses in training (III). After establishment of the cohorts, we performed a second part of the project where a number of short term studies were conducted in addition to the longitudinal studies. The aims of these were to investigate the prevalence and degree of motion asymmetries in three populations of horses that we have hitherto not studied: (1) young trotters before being trained; (2) young riding horses before being trained; and (3) high level performing riding horses.

Material and methods

Movement asymmetry measurement principles

Movement asymmetries were measured by inertial sensor technique (Lameness Locator ®) during straight line trot for all horses and also during lungeing/driving for riding and trotting horses respectively. The sensors were attached to the poll, withers, and pelvis where the vertical movement was recorded. A fourth sensor was attached to the right fore pastern in order to detect limb timing during the stride cycle. During trot the head and pelvis show sinusoidal movement patterns with two minima and two maxima per stride in sound horses. The minima occur during the two stance phases of the limbs and the two maxima in the suspension phases after push-off. In horses with an impact lameness, the head/pelvis show reduced vertical movement during the stance phase of the lame limb and thereby reaches a lower minimum position at mid-stance of the sound limb (HDmin/PDmin) (Fig 1.). A difference between the two maximum positions (HDmax/PDmax) is also commonly seen with a lower position reached after lame limb push off. Commonly used clinical lameness thresholds were used to define the presence of movement asymmetry, absolute values >6 mm for head movement asymmetries (HDmin, HDmax) and >3mm for hindlimb asymmetry, (PDmin and PDmax).

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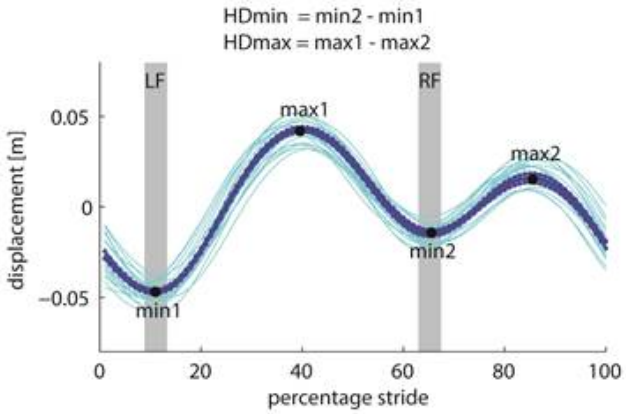

Fig 1. Vertical head movement in a horse with right forelimb (RF) lameness. The grey bars indicate left forelimb (LF) mid stance and right forelimb (RF) mid stance respectively. HDmin and HDmax are commonly used symmetry measures for lameness.

Project part 1: The three cohort studies of movement asymmetry development over time

Cohort I: Young riding horses.
Seventy-four privately owned Warmblood type riding horses aged 2-3 years were included in the study with the ambition to follow the movement asymmetry over time in at least 50 of these over a two-year period. The horses had been mounted and were used to lungeing but were not trained under saddle. The movement of the horses were measured every 3 months resulting in 9 visits per horse, if all were completed. At each visit, the vertical movement asymmetry was measured in straight line trot in hand and lungeing on a 10m circle in both directions. Each visit vas classified according to the horse's current training level: Unridden; Walk (ridden only in walk); Trot (ridden in walk and trot) and All (ridden in all gaits). A clinical examination focusing on the locomotor apparatus was performed at all visits and additionally, a questionnaire on training, lameness and disease during the 3 months preceding the visit was completed by the owner.

***Cohort II*:** 114 trotters, 1-2 years old, broken to harness but not yet in training were recruited with the ambition to follow at least 50 of these for a two-year period. At each visit, the vertical movement asymmetry was measured in straight line trot in hand and while driven. A clinical examination focusing on the locomotor apparatus was performed at all visits and additionally a questionnaire on training, lameness and disease during the 3 months preceding the visit was completed by the owner.

***Cohort III*:** Sixty riding horses of different ages in regular training, at low to intermediate level, were recruited and followed over three years. A subgroup of 49 horses were measured every week for 3 weeks to investigate the weekly variability of movement symmetry. Another subgroup of 15 horses were evaluated six times (before, during and after one shoeing cycle) to investigate the effect of trimming and shoeing on movement symmetry.

Project part 2: Prevalence studies of movement asymmetry in three sport horse populations

The prevalence of movement asymmetries were investigated in populations of Standardbred trotter yearlings, young riding horses (before training is initiated) and in high level riding horses (dressage, jumping and eventing). Stride-by-stride difference between the two

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displacement minima and maxima of the head (HDmin, HDmax) and pelvis (PDmin, PDmax) were calculated as trial means. The aim was to include 100 horses per groups and we recorded in total between 103 and 125 horses per group.

Results and discussion

Part 1. Longitudinal studies

Cohort I: Young riding horses

The 74 horses were examined during a total 526 visits, corresponding to an average of 7.1 visits per horse. Surprisingly, none of the horses had asymmetry parameters that were below the lameness thresholds during all visits. In 93.7% of the straight line measurements the values were above the thresholds for at least one of the four asymmetry parameters. For each asymmetry parameter the percentage of horses with at least one straight line measurement resulting in a value above the lameness threshold were as follows: HDmin: 96%; HDmax: 94%; PDmin: 100%; PDmax: 97%. The median (IQR) values for the asymmetry parameters above threshold were HDmin: median 12.7, IQR 10.8 mm; HDmax: median 10.6, IQR 5.9 mm; PDmin: median 6.9, IQR 5.3 mm and PDmax median 4.8, IQR 2.9 mm. Effect of training level and visit number on the different symmetry parameters are illustrated in fig 2-7. The most asymmetric horses at visit 1 are visualized in red and can be followed during next visits. It is not evident from the data that the individuals with high asymmetry values at visit 1 remain to be the most asymmetrical individuals over time.

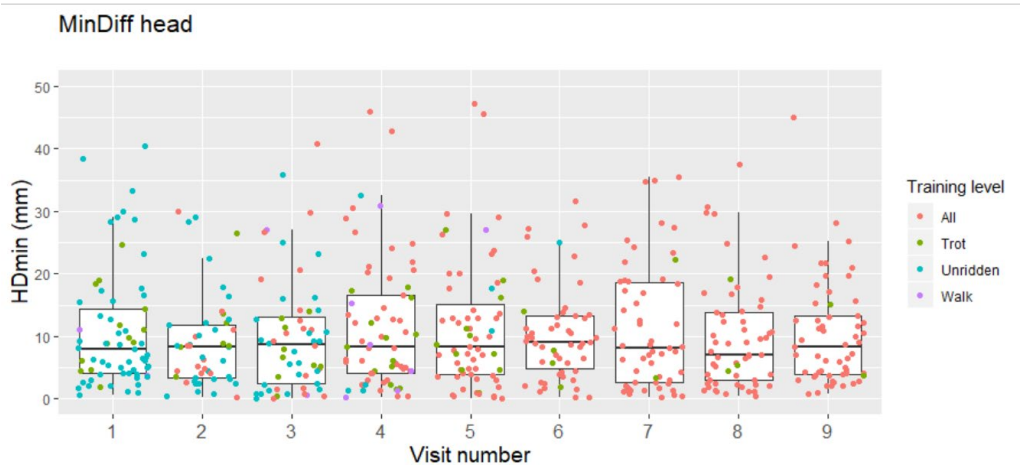

Fig 2. Effect of training level and visit number on mean HDmin (forelimb impact lameness). Each dot is a measurement from a horse per visit and colour indicate training level. Lameness thresholds are >6mm.

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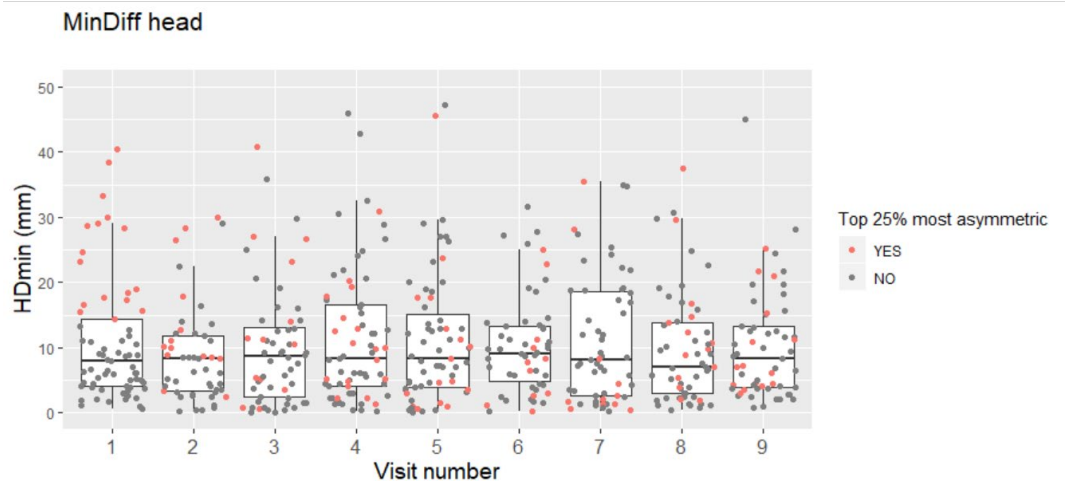

Fig 3. Top 25% of the horses with highest degree of HDmin (forelimb impact lameness) at Visit 1 are marked with red colour. These horses can then be followed during the coming visits (2-9) as they stay red.

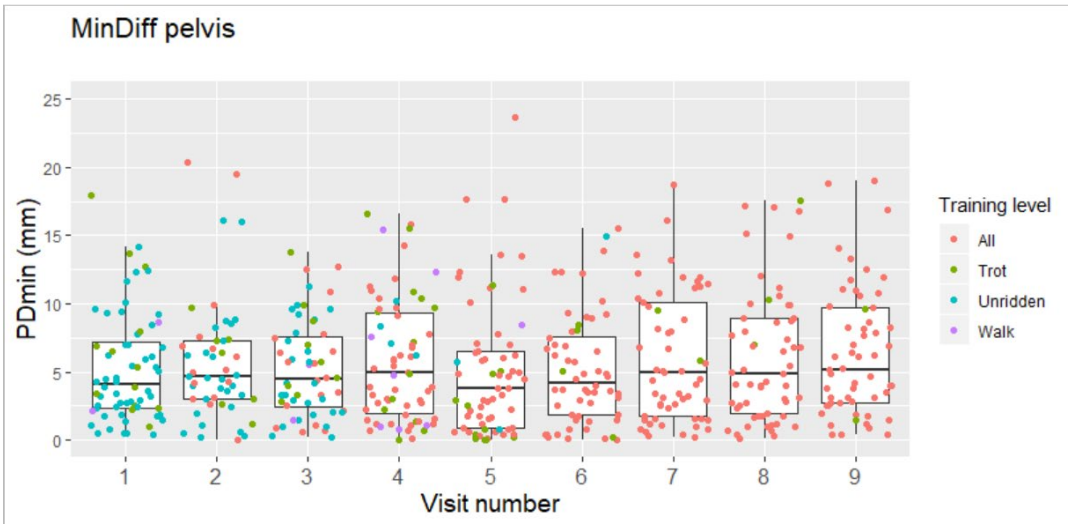

Fig 4. Effect of training level and visit number on PDmin (impact hindlimb lameness). Each dot represents a horse and the colour indicates the training status of the horse. Clinical lameness thresholds are >3 mm.

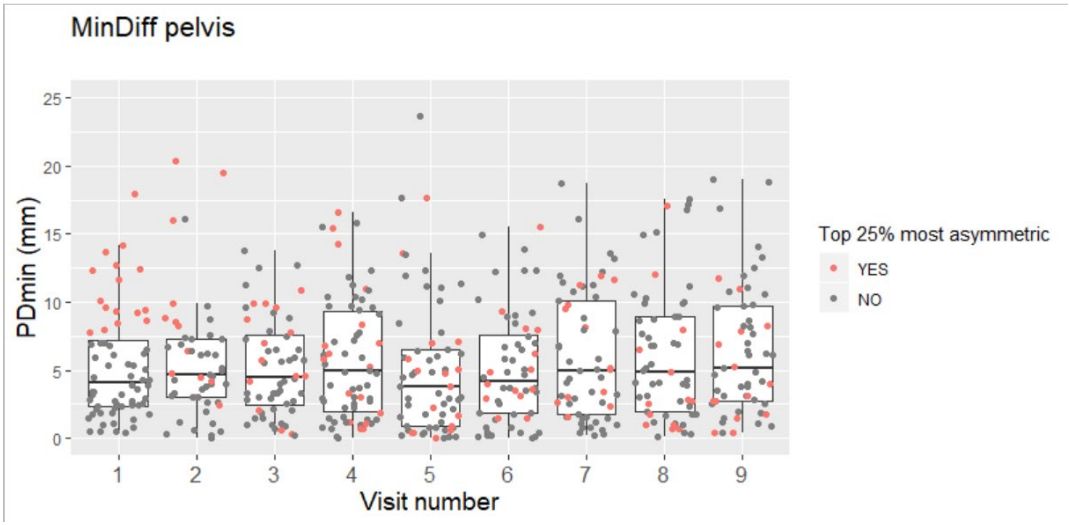

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Fig 5. Top 25% with highest degree of PDmin at Visit 1 in red. These horses can then be followed during the coming visits (2-9) as they stay red.

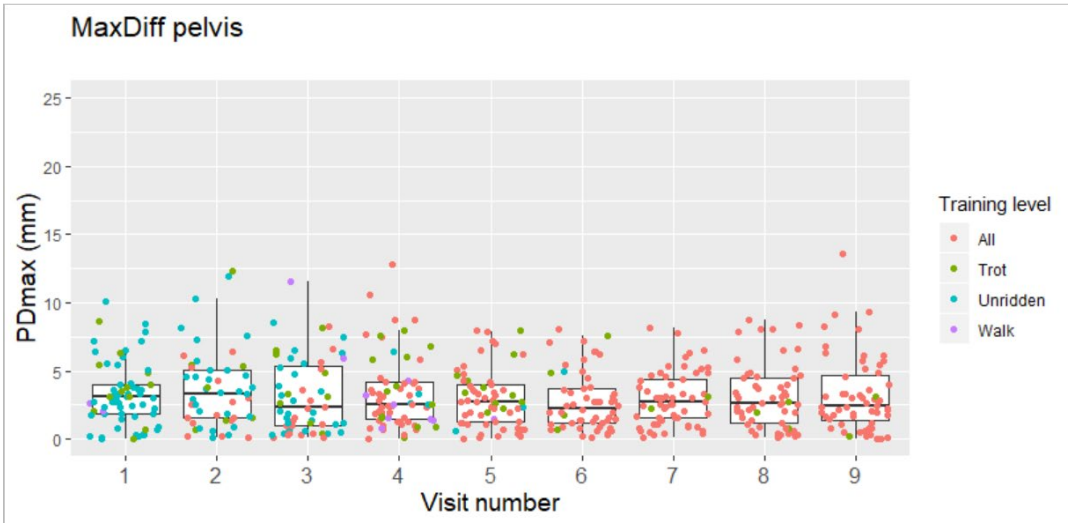

Fig 6. Effect of training level and visit number on mean pelvic maximum difference (push-off hindlimb lameness). Each dot represents a horse and the colour indicates the training status of the horse. Clinical lameness thresholds are > 3 mm.

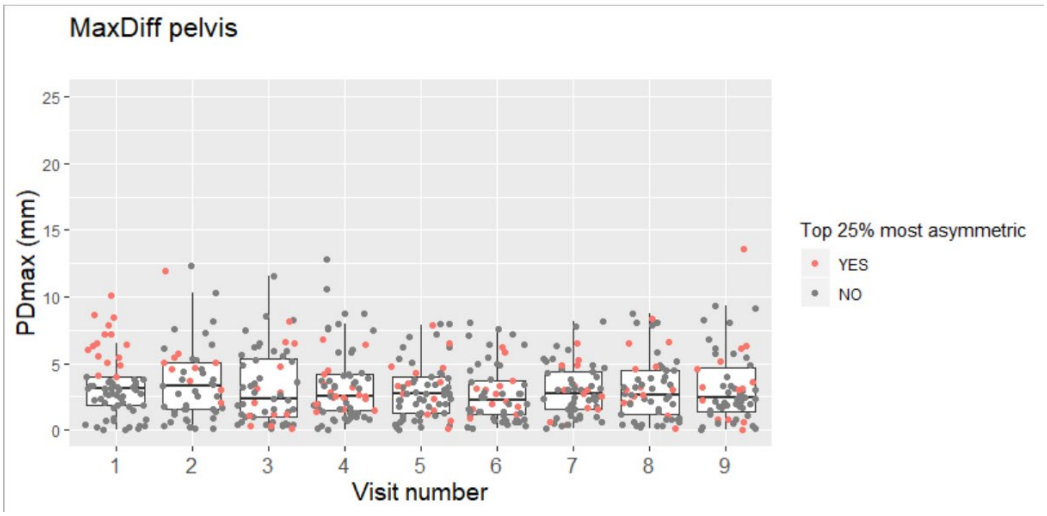

Fig 7. Top 25% with highest degree of PDmax at Visit 1 in red. These horses can then be followed during the coming visits (2-9).

Results show that vertical movement asymmetry has a high prevalence in young horses and when measured approximately every 3 months during a two year period, all horses presented with vertical movement asymmetry at some time point. There were no statistical significant effect of level of training or visit number. Large differences in the total training dose between horses of the same training level did however exist. The frequency of training between each visit were recorded and using this information calculation of a cumulative training dose should be feasible. Further analysis will therefore be performed to evaluate the effect of this cumulative training dose, rather than just the training level classification, on vertical movement asymmetry. The plan is also to evaluate other factors such as incidence of documented lameness, shoeing, surface and rider experience.

In addition, the results showed that the horses with the highest degree of asymmetry at the first visit were not more likely to show a high degree of asymmetry during later visits. These data should however be analyzed further, without focusing solely on asymmetries displayed at Visit 1. At a

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very young age the horses may be inexperienced at trot in hand, and this may be a confounder. A more true status may be obtained from analysis of asymmetries that persist over several visits with possible correlation to documented lameness both historically and during the study period.

Cohort II: **Young trotters**
In total 114 horses were recruited and of these 85 were included to be measured at nine occasions (every 3 months for two years). This cohort had the largest drop out percentage due to a number of reasons including horses being sold and transferred to other trainers, lameness or poor performance. Our results show that the majority of horses showed high degree of movement asymmetry and of the horses (n=30) that completed all measurements, 87% were treated for lameness by a veterinarian. Data analysis is still in progress and will be presented in a doctoral thesis at the end of 2020.

Cohort III: **Mature riding horses**
In total 106 mature horses were included and an average of 59 horses were measured at thirteen occasions (every third month). Of these, many showed movement asymmetries above clinically used thresholds at each visit (mean 83%). None of the horses were symmetrical during all measurements. The subgroup of 49 horses that were measured weekly over a three week period varied substantially in terms of magnitude and type of asymmetry/lameness (Table 1).

Table 1. Percentages and number of horses having no (0) asymmetries or asymmetries only during 1, 2 or for all 3 weeks is shown. Data are from 49 horses measured on straight line (hard surface) on 3 occasions during 3 weeks.

	weeks	n horses	%	95% CI	
HDmin	0	26	53.1	38.3	67.5
	1	10	20.4	10.2	34.3
	2	13	26.5	14.9	41.1
	3	5	10.2	3.4	22.2
PDmin	0	27	55.1	40.2	69.3
	1	10	20.4	10.2	34.3
	2	8	16.3	7.3	29.7
	3	4	8.2	2.3	19.6

In the 15 horses that were measured throughout the shoeing cycle no significant effect on movement asymmetry was seen of the different time points.

Part 2. Prevalence studies of movement asymmetries in different horse populations.

Prevalence of movement asymmetries in young trotters
Of 103 horses, 77 were measured both in-hand and on the track, 24 were measured only in-hand, and two were measured only on the track. Previously set symmetry thresholds for the measurement system were used for assessment of trials. The majority of horses (91, 88.3%) did not have any trials below threshold. Front and/or hind limb parameters were above the symmetry thresholds during in-hand trials for 94 (93.1%) horses, and during track trials for 74 (93.7%) horses. Asymmetry magnitude ranged from mild to severe, with the majority of horses showing mild asymmetry. A minority of horses (19.7%) switched side of asymmetry for one or more parameters between in-hand and track trials. Regression analysis showed significant association of female gender and decrease in one parameter of front limb asymmetry (HDmax), as well as between increased height at withers and decrease in one parameter of hind limb asymmetry (PDmax). Trial standard deviations

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were overall high, mainly due to horse behavior, and this variability should be considered when interpreting the results.

Prevalence of movement asymmetries in young riding horses

Thresholds used for clinical lameness detection were exceeded for 73% of the young horses for one or more variables: HDmin (n=45, mean 11.6 mm, SD 4.9 mm), PDmin (n=40, mean 5.7 mm, SD 2.3 mm), PDmax (n=37, mean 5.1 mm, SD 2.2 mm). These mean values are similar to those in 222 adult Warmblood horses measured in another study [8]. In conclusion, vertical movement asymmetries above clinically used thresholds are common in young unridden Warmblood horses without complaint of lameness from the rider.

Prevalence of movement asymmetries in elite riding horses

In total, 77% of the 125 elite horses showed one or several asymmetry parameters above the thresholds used for clinical lameness detection (Fig 8). Minimum position asymmetry of the pelvis was the most common asymmetry in the population (42%). This was the only parameter that differed between disciplines, with eventing horses being less asymmetrical (mean 1.6mm) compared to dressage horses (3.4mm) and show jumpers (3.1mm) (Wilcoxon rank-sum, p=0.02). Total asymmetry over disciplines is presented in Fig 9.

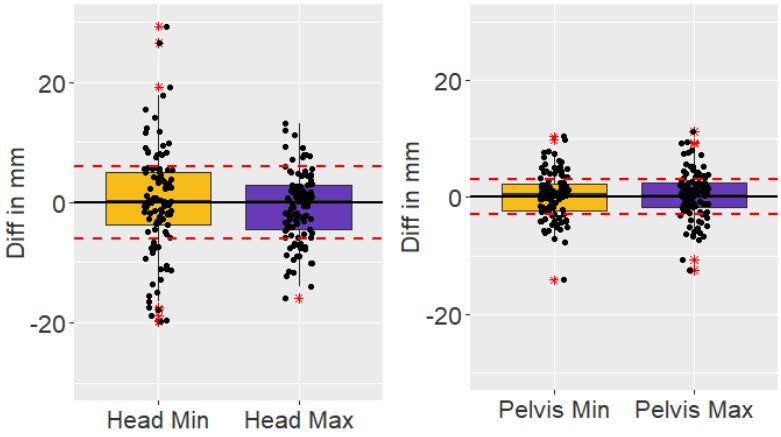

Fig 8. Asymmetry variables presented for all 125 elite horses. The clinically used thresholds are visualized by the stippled horizontal red lines, all dots above or below these lines are asymmetries that deemed to be relevant from a lameness perspective.

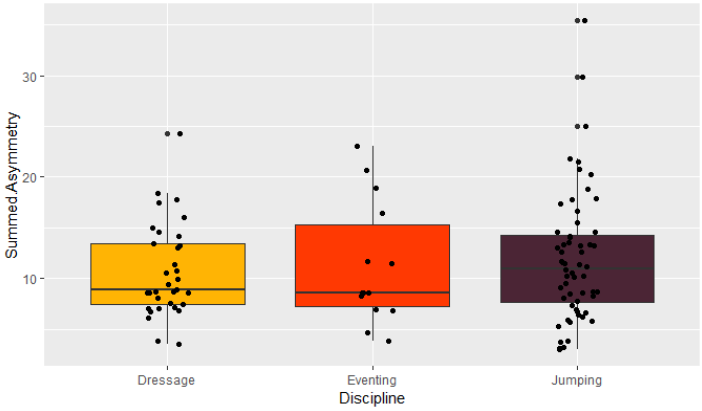

Fig 9. The asymmetry variables are summed for each of the 125 elite horses and presented by discipline. Statistical test (Wilcoxon rank-sum) revealed no significant difference between the disciplines for the total asymmetry.

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The aims of the research project were to increase our knowledge of how movement asymmetry changes over time, and to determine the prevalence and magnitude of movement asymmetries in populations of young horses before training and in a group of high-performance horses. We also wanted to investigate how training and riding influence horses at different stages in their careers. Our results should be used as the basis for understanding the relationship between movement asymmetry, lameness and the risk of developing lameness.

Conclusions

- In young riding horses, the horses with the highest degree of asymmetry at the visit 1 measurement were not more likely to show a high degree of asymmetry during later visits. This means that the training of rookies not necessarily induces characteristic changes in movement asymmetry.
- All horses will occasionally show increased movement asymmetry during a two year observation period.
- In young Standardbred trotters there were no significant effect of measuring horses in-hand versus driven on type and magnitude of asymmetry on a group level, even though 19% changed side of the asymmetry. Further studies on lame horses is needed to conclude if lameness examination can be performed by only trotting the horse in-hand.
- Vertical movement asymmetries above the clinically used thresholds are common in young Warmblood horses, in elite riding horses and in young Standardbred Trotters without complaint of lameness. This is important for the threshold used during assessment of lameness based solely on objective movement analysis.
- There is a large inter-week variability of movement asymmetry in riding horses in training which is important knowledge when lameness examination of horses is performed.
- The different time points in the shoeing cycle did not affect movement symmetry and may therefore not be crucial when lameness investigations are performed in horses.

Relevance for the practical horse sector incl. recommendations

This project has substantially increased our knowledge about movement asymmetry as a proxy for lameness and pointed to a very important issue: if movement asymmetry (lameness) is used as a proxy for orthopaedic pain, verification of pain should be done by use of analgesic nerve or joint blocks before any treatments or prognoses are installed. Otherwise many horses will continue to obtain medication of dubious relevance. It is also interesting to note, that the predictive value of the movement asymmetries in riding horses during young ages does not seem to predict the orthopedic health after the training, meaning that early screening for asymmetric movement is not a method to eliminate “future unhealthy horses”.

A recommendation is to get to know the movement of the individual horses when it is healthy, since sudden changes in movement asymmetry seems to more indicative of lameness, than the absolute value of an asymmetry.

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At the same time, our data indicates that the young trotters may be the most vulnerable of the populations investigated. Most young trotter were treated for lameness or disappeared during the study. This indicates that measures should be taken to observe this population closer during training, and to develop preventive measures.

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Part 3: Result dissemination

Scientific publications, *published*	A.S. Kallerud, C.T. Fjordbakk, E.H.S. Hendrickson, E. Persson-Sjodin, M. Hammarberg, M. Rhodin, E. Hernlund (2020) Prevalence of objectively measured movement asymmetry in yearling Standardbred trotters. Equine Veterinary Journal, DOI: 10.1111/evj.13302
Scientific publications, *manuscript*	E. Persson-Sjodin, E., C. Frisk, Hernlund, J. Lundblad, K. Ask and M. Rhodin. *Prevalence of vertical movement asymmetries in young unridden Warmblood horses.*
	E. Olsen, E. Persson-Sjödin, E. Hernlund, T. Pfau, A. Egenvall, C. Ekeberg and M. Rhodin. *Changes in movement symmetry and hoof angles in horses on the straight and lunge over two shoeing cycles.*
	M. Rhodin, E. Persson Sjodin, A. Byström, T. Pfau, E. Hernlund, A. Egenvall *Inter-week variation of movement symmetry at the trot in riding horses in training.*
	E. Hernlund, E. Persson-Sjodin, J. Lundblad, T. Pfau, Pia Haubro Andersen, M. Rhodin. *Vertical movement symmetry and rider perceived laterality in elite riding horses.*
	A.S. Kallerud, A. Byström, E. Persson-Sjodin, M. Rhodin, E. Hernlund, E.H.S. Hendrickson, C.T. Fjordbakk. *Effect of non-banked curved tracks on movement asymmetry in two-year-old Standardbred trotters.*
Conference publications/ presentations	E. Hernlund, E. Andersson, E. Persson-Sjodin och M. Rhodin. (2017) *Prevalens av rörelseasymmetrier hos ridhästar som tävlas på elitnivå. Veterinärkongressen, Uppsala 2017*
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	E. H. S. Hendrickson, A. S. Kallerud, E. Hernlund, E. Persson Sjödin, R. Krontveit, M. Rhodin (2018). *Comparison of movement asymmetries in young Standardbreds trotting in hand versus driven.* International Conference on Equine Exercise and Physiology, Australia nov 2018
	E. Hernlund, E. Persson-Sjodin, Britt Coles, T. Pfau, Pia Haubro Andersen, M. Rhodin (2018). *Vertical movement symmetry and rider perceived laterality in elite riding horses.* International Conference on Equine Exercise and Physiology, Australia nov 2018
	E. Persson-Sjodin, C Frisk, E. Hernlund, J. Lundblad, K. Ask, M. Rhodin (2020) Prevalence of vertical movement asymmetries in young unridden Warmblood horses. International Conference on Equine and Canine Locomotion. Abstract submitted.

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