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Completion Report for BSAS Scholarships and other awards

Steve Bishop Early Career Award

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Pilot Study on electomyographic and kinematic evaluation of movement and muscle activity in lame horses

Lameness is one of the most common problems in equine veterinary practice and the most common cause of euthanasia and mortality in horses. The prevalence and impact of lameness on equine welfare has led to extensive research, which has biomechanically analysed lameness-related alterations in movement. Locomotion is ultimately facilitated by the actions of muscles. However, limited information is available about adaptive muscle activity, which facilitates movement during lameness. The Steve Bishop Early Career Scholarship was therefore awarded to undertake an original pilot study, which aimed to compare movement and muscle activity patterns in horses during non-lame (control) and induced lameness conditions using three-dimensional (3D) kinematic and surface electromyography (sEMG) data, respectively. The study was conducted at Utrecht University's Faculty of Equine Veterinary Medicine alongside Dr. Tijn Spoormakers and Dr. Filipe Serra Bragança. Data were successfully collected from eight horses and, although the data are still undergoing analysis, it is envisaged that this information will further our understanding of locomotor adaptations during lameness. This may inform the development of objective lameness-detection methods for early diagnosis and treatment of lameness, which will ultimately serve to reduce pain and incapacity in lame horses.

Receiving this scholarship from BSAS has been highly valuable to my career, as it provided the opportunity to work with, and learn from established, reputable researchers and veterinarians at Utrecht University. The University's equine clinic has access to state-of-the-art technology/software for objective lameness-detection, from which I learnt new data acquisition and analysis skills. It is envisaged that this study will lead to high-quality research outputs and surely, further collaborative work with Utrecht University. This will have long-term benefits for my career progression as an equine biomechanics researcher.

What was done?

Ethical approval for this study was obtained from Utrecht University (CCD: AVD108002015307) and the University of Central Lancashire (Reference number: RE/17/08a_b).

Surface electromyography (sEMG) and three-dimensional (3D) kinematic data were non-invasively collected from eight clinically non-lame horses during non-lame (control) and induced lameness conditions. Temporary, mild forelimb and hindlimb lameness (2-3/5 AAEP Lameness Scale) were induced using mechanical screw pressure, which was applied and monitored by qualified veterinarians (T.S., F.S.B.) using a modified horseshoe (1). This lameness induction method offered a unique opportunity to observe neuromuscular adaptations from lame and non-lame conditions, with horses acting as their own control. This has not previously been done.

Horses were prepared for data collection by first removing all hair from bilateral locations over the following superficial muscles: Triceps Brachii, Latissimus Dorsi, Longissimus Dorsi (at location of T12 and L2 vertebrae), Superficial Gluteal, Biceps Femoris and Semitendinosus. Sensor locations were determined using ultrasonography and previously described anatomical locations for each muscle. Locations were thoroughly cleaned using isopropyl alcohol and sEMG sensors (Delsys Trigno, Delsys Inc., USA) were bilaterally placed over prepared locations using adhesive strips (Figure 1). To collect 3D kinematic data, retro-reflective markers and inertial measurement units (IMUs) (EquiMoves, Inertia Technology, The Netherlands) were placed over anatomical landmarks using adhesive tape and bandages (Figure 2). Once sEMG sensors and markers were applied, horses underwent gait analysis protocols to synchronously collect sEMG and 3D kinematic data during non-lame (control) and induced lameness conditions. Data were synchronously collected using an external trigger (Delsys Trigger Module, Delsys Inc., USA).

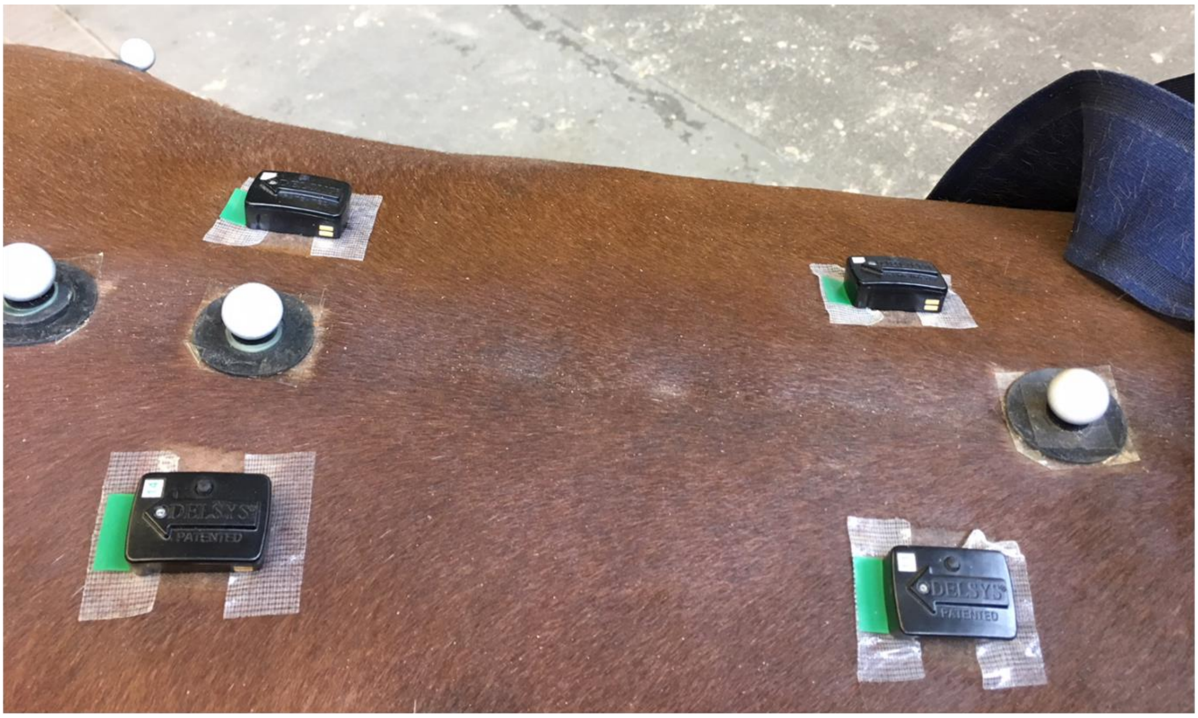


Figure 1. sEMG sensors attached to the prepared skin of one horse using adhesive strips. Sensors are bilaterally located above the Longissimus Dorsi muscle at T12 and L2 vertebrae locations.

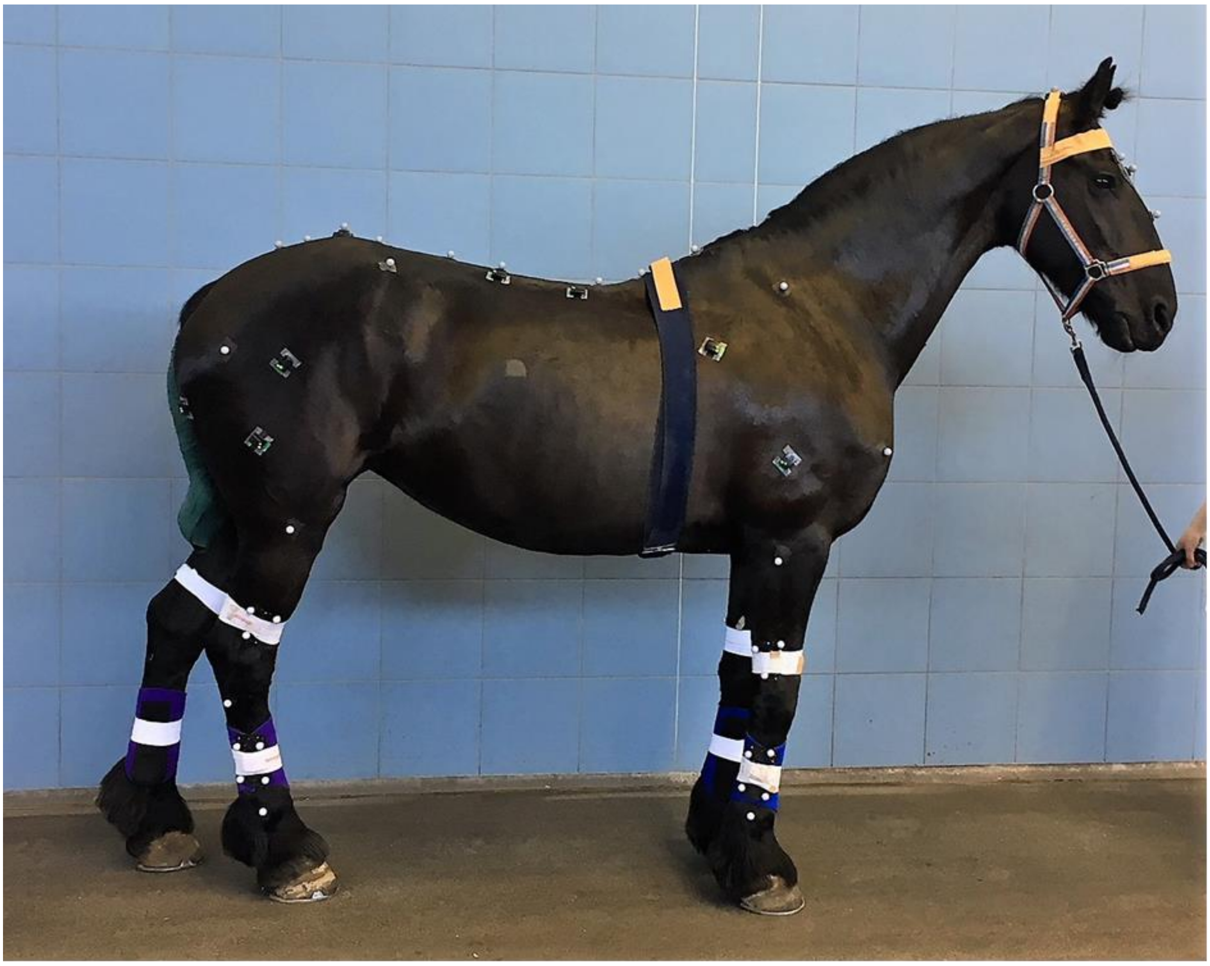


Figure 2. A horse prepared for gait analysis, showing the anatomical locations for retro-reflective markers, sEMG sensors and IMU sensors.

Three-dimensional kinematic data were collected using eighteen Qualisys Oqus (Qualisys AB, Sweden) cameras, which were secured to the walls surrounding an indoor hall where lameness evaluations are conducted (Figure 3). 3D kinematic and sEMG data were initially collected from the non-lame (control) condition to determine the non-lame gait pattern of each horse. Data were collected during in-hand (straight-line) trials at walk and trot on a hard surface (Figure 4a). Data were also collected during lunging (circle) trials on the left and right rein at walk and trot on a hard surface (Figure 4b). Following non-lame (control) data collection, forelimb lameness was induced using mechanical screw pressure to produce reversible lameness, graded by two veterinarians (T.S., F.S.B.) as 2-3/5 on the AAEP lameness scale. Horses were randomly divided into two groups (n=4) for right and left forelimb lameness induction, in a cross-over design. Following lameness induction, straight-line and lunging trials were repeated for lameness conditions. After each data collection session, the screw/ sole pressure was removed, and two veterinarians observed the horse trot to determine whether there was any residual lameness. None of the horses showed adverse reactions to the mild, temporary lameness that was induced for the purposes of this study and all horses were deemed sound after removing the screw. All markers and sensors were then removed, and each horse was returned to its stable. After a washout period of at least 24 hours, the data collection process was repeated for non-lame (control) and lameness conditions, where hindlimb lameness was randomly induced in the right (n=4) or left (n=4) hindlimb.

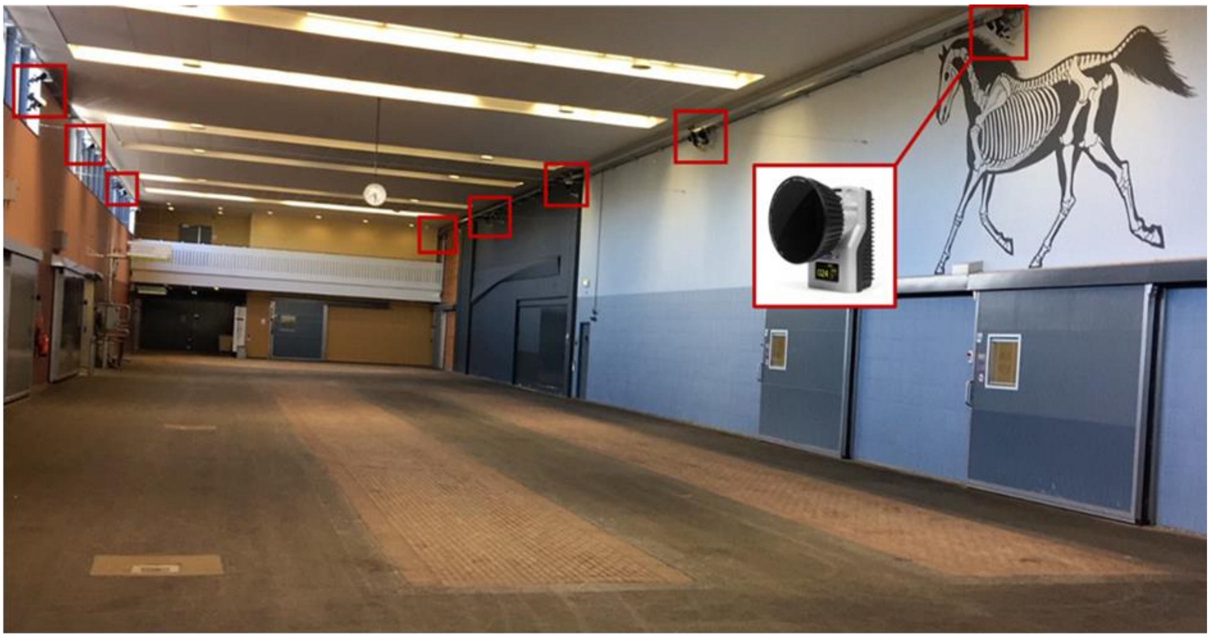
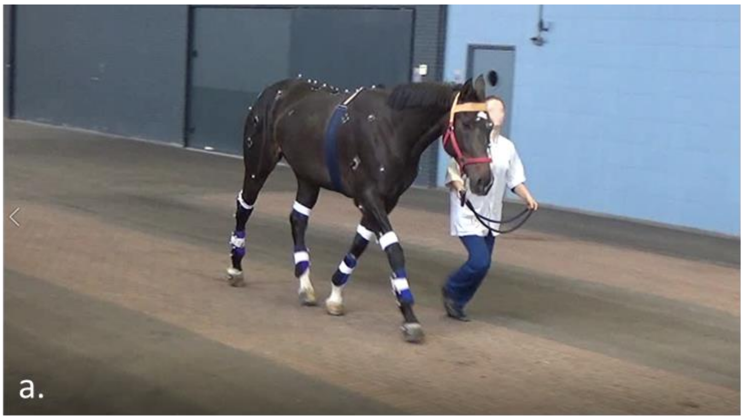


Figure 3. The indoor hall where data collection occurred, showing the locations of Qualisys cameras.



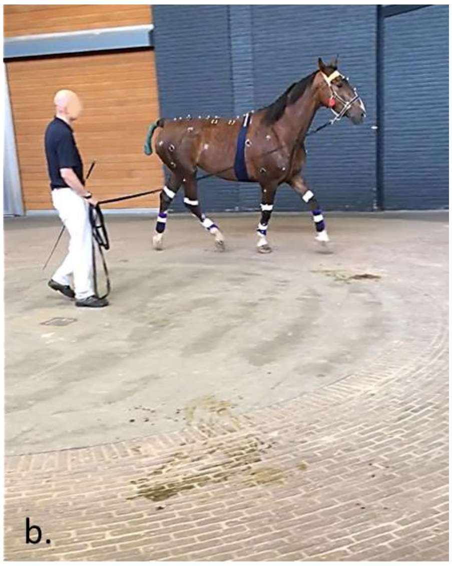


Figure 4. Horses undergoing a). in-hand, straight and b.) lunge trials during data collection

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Benefits of the Award:

1. Are there any significant outcomes / follow up activities as a result of the activity you undertook?

Data processing and analysis are currently underway, but not are yet completed. It is therefore not possible to report any significant outcomes at this stage. Kinematic data are currently being tracked in Qualisys Track Manager (Qualisys AB, Sweden). Following this, data will be imported into Visual 3D (C-Motion Inc., USA) for analysis of kinematic and sEMG data. Findings from this study will be published in peer-reviewed journals and presented at conference presentations. The researchers involved in this study and I will attend at the International Conference for Equine Exercise Physiology, which is taking place in November 2018. This conference will offer an opportunity to meet in person to discuss the progression of data analysis, research outputs and future collaborative studies.

2. How have you personally benefitted from the award?

[e.g. new knowledge or skills, new contacts and collaborations]

This study would not have been possible without access to the veterinarians, researchers and facilities at Utrecht University. Therefore, this award has allowed me to conduct an original study in a field that I am passionate about developing. I have personally benefitted from this award and the subsequent research in a number of ways. The most significant benefit was the opportunity to work with, and learn from established, reputable researchers and veterinarians at Utrecht University. I was also introduced to a number of highly regarded equine biomechanists and veterinarians, whose work I am familiar with and look up to. This has allowed me to develop international research networks and new research skills.

Utrecht University's Equine Clinic has access to the expertise, horses, technology, software, and facilities, which were required to conduct this research. I benefitted from learning new data acquisition and analysis skills using Utrecht's motion capture and IMU systems. Furthermore, UCLan's sEMG system had to be integrated with Utrecht's motion capture system for synchronous collection of sEMG and kinematic data. Some troubleshooting issues arose from this synchronisation, but all were resolved and acted as an excellent learning opportunity for me.

It is hoped that this pilot study will lead to the development of a new research area, which employs sEMG to understand the mechanisms of neuromuscular adaptations to lameness. This could lead to larger collaborative studies with Utrecht University, which will have long-term benefits for my career progression as an equine biomechanics researcher.

3. Benefit of the award to the animal science community, academic and industrial:

Surface electromyography (sEMG) offers a non-invasive, quantitative method for measuring muscle activation, using electrodes placed on superficial muscles. sEMG has been successfully used in humans and dogs to investigate adaptive muscle activity during induced musculoskeletal disorders. However, only one known study has investigated the relationship between lameness and neuromuscular function in horses using sEMG (1), reporting increased muscular activity in the non-lame limb at walk and greater muscle relaxation between contractions at trot. However, these findings were not considered alongside kinematic data and the functional significance of adaptive muscle activity remains unknown. Furthermore, (1) only examined chronic cases, where the degree and location of lameness were not standardised, complicating between and within-group comparisons. This pilot study therefore represents the first known study to employ lameness induction techniques to compare movement and muscle activity within the same subject, using 3D kinematic and sEMG technologies.

It is envisaged that the information obtained from this work will further our understanding of locomotor adaptations during lameness and may aid in the further development of objective lameness-detection methods. This offers vast benefits to the animal science and equine industries, as veterinary lameness evaluation is inherently subjective and low reliability and repeatability have been reported for mild lameness (2). As such, commercial products for objective lameness-detection have been developed and validated using kinematic data from non-lame and lame conditions (3, 4). These products are increasingly employed by veterinarians and the same opportunities may be available for sEMG, as a complementary tool for existing products. Findings from this study may therefore offer a starting point for determining whether sEMG can be clinically applied for the detection and treatment of equine lameness. This information may also be used to inform the development of lameness-detection methods for other species, such as cows and dogs where lameness also represents a prevalent welfare issue. Ultimately, research contributing to more efficient diagnosis and treatment of lameness may serve to reduce pain and incapacity in lame horses and in other species.

References:

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