BCET
Beaufort Cottage Educational Trust

Evaluation of a novel device for functional respiratory assessment in horses

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Introduction: Background

Respiratory assessment in poor performing racehorses

- Failure to perform is frequently attributed to respiratory dysfunction and sub-clinical disease in performance horses [1]. The nature and functional significance of a dysfunction are often not evident at rest and so evaluation during exercise should be performed.

- Comprehensive lung function exercise testing requires access to highly specialised equipment and a treadmill [2].

- Overground endoscopy provides a visual assessment of the upper airways [3] during exercise in the field but gives little information about lower airway conditions.

- Heart rate monitors are widely available, low-cost and easy to use. Subsequently heart rate is a commonly used diagnostic parameter in exercise performance assessment [4, 5]. The potential value of respiratory rate as a diagnostic parameter has not been extensively characterised. If it were found to be of clinical interest, a low-cost, non-invasive device for measurement of respiratory rate could be utilised for respiratory assessment.

Introduction: Aims

Hypothesis: A low-cost and portable device to measure accurately breathing rate and gait parameters can be constructed.

Aims:

- To design and build a mounting system with sufficient mechanical stability and security for safe operation.
- To obtain data to establish proof of concept for the device.
- To evaluate the reliability and accuracy of the data produced.

Methods: Designing a mounting system

Maximising quality of data

- Experiments with the prototype system in various designs and positions were performed at rest to establish which position and design produced an adequate breathing rate signal.
- All systems that produced satisfactory data at rest were used for experiments at walk and trot in hand, on two horses. Once a prototype was thought to be viable it was trialed on a third horse, on the lunge in walk, trot and canter. The system that produced data on the lunge was taken forward for use in ridden experiments.

Mechanical stability assessment

- Visual inspection of prototype during use.
- Quality of data produced.
- Use of mechanical horse and slow-motion video capture to view movement in early versions of prototype.

Reliability and accuracy of prototype

- At rest accuracy was determined by comparing the breathing rate produced by the device to that determined by visual assessment.
- Breathing rate in walk is within reference values.
- Accelerometer data showed that head movement is lowest in trot, so any device movement should be minimal and thus trot data should be accurate.
- In canter the evidence of 1:1 respiratory-stride coupling was used to assume device accuracy.

Methods: Data Collection

Ridden testing:

Experiments used an incremental exercise protocol designed to assess respiratory rate at walk, trot, canter and recovery. A second protocol was designed to assess how the trot to canter, and canter to trot transitions affected the data quality.

A 16.3 hh 8 yo TB x Selle Francais mare was used for ridden testing. Free of clinical signs of disease and lameness. The same tack and rider were used for all experiments. Experiments were performed over a variety of terrains.

Test protocol 1: Incremental testing

1. Fit device to horse and calibrate
2. Mount rider, turn device on to allow GPS signal connection
3. 5 minute walking, with device not recording
4. Begin recording
5. 1 minute walk
6. 5 minute trot
7. 5 minute canter
8. Halt
9. 5 minute recovery (due to data processing restrictions)

Test protocol 2: Incremental testing

Steps 1 – 4 as for Protocol 1

5. 1 minute walk
6. 1 minute trot
7. 1 minute canter
8. Repeat trot-canter transitions as necessary
9. Halt
10. 5 minute recovery (due to data processing restrictions)

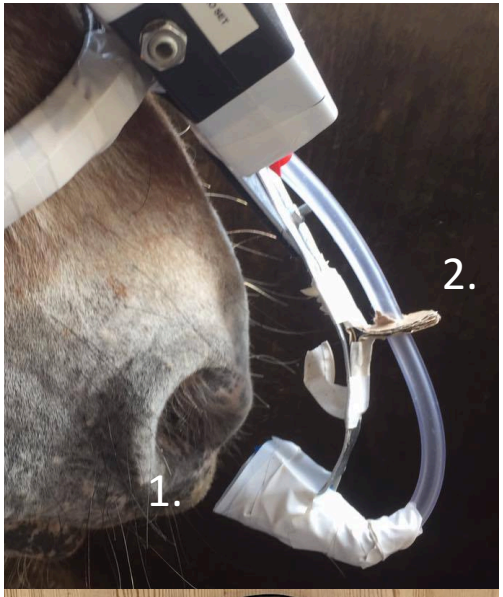
Results

Designing a mounting system

- The project successfully found a suitable mounting system for the device utilising an adapted cavesson bridle that can be worn with the horse's normal bit and saddle.
- A cushioned metal bar on the dorsal aspect of the face is attached to the padded browband and noseband. The device is attached to the bar.
- A second curved metal bar is connected via a sliding pivot. This supports the expirate collection tube and allows it to be positioned at the optimum location and distance in front of the naris.
- Distinct signals for respiratory rate were produced at rest and at exercise, with minimal artefacts and interference.
- The prototype design can now be refined for the manufacture of a system suitable for use in research.

Results – Prototype design features

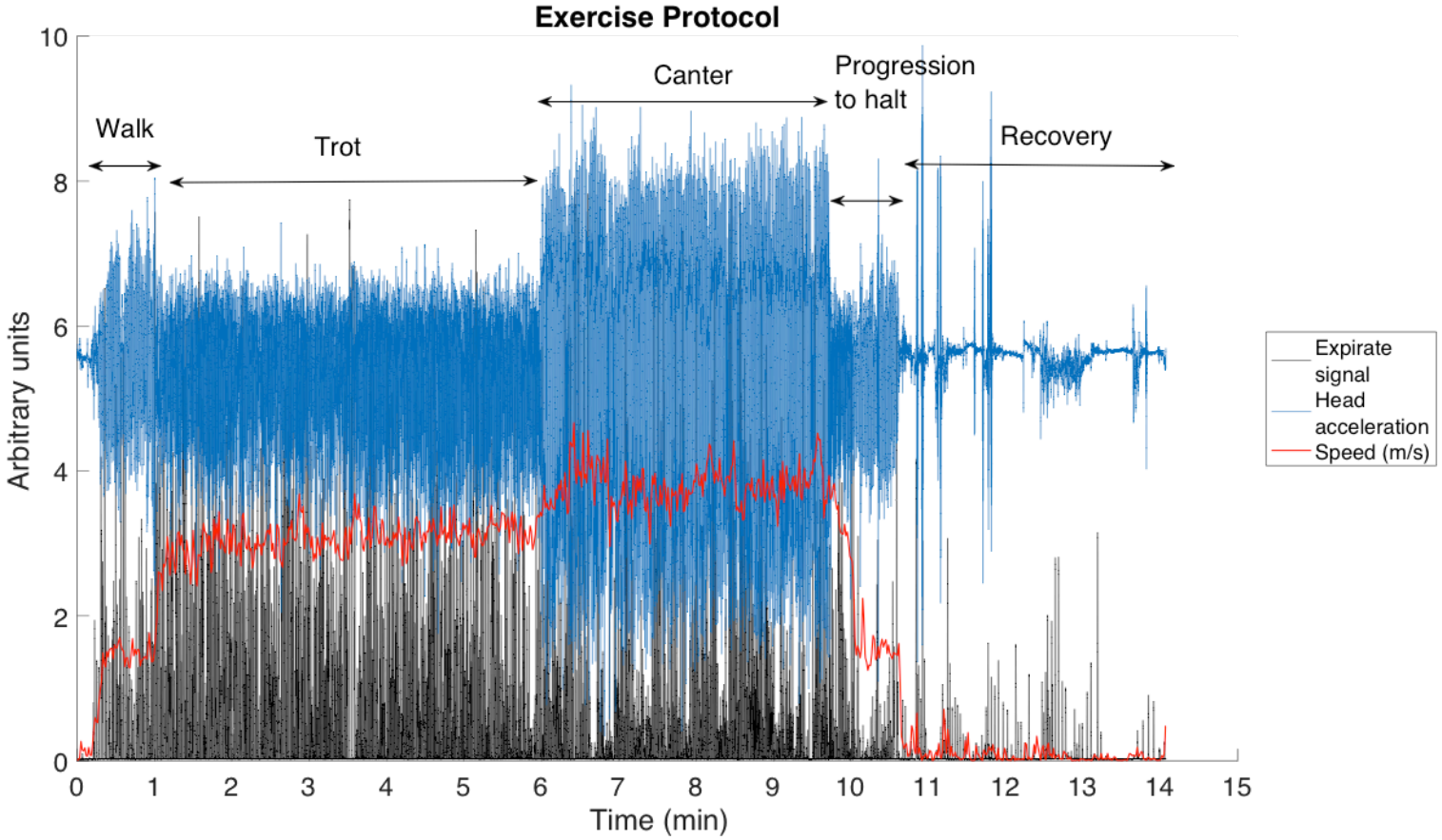
Feature	Function	Justification
Non-invasive	Allows the horse to be ridden in its normal bit.	*Conventional mask systems require use of a Hackamore bit.*
Positioned on dorsal aspect of face	Gives mechanical stability and allows GPS signal to be received.	*GPS signal was impaired when positioned on lateral and ventral aspects of face. Data artefacts occurred more frequently in these positions.*
Collection funnel (1)	Amplification of expirate flow to sensor.	*Initial tube diameter is too small to collect enough collect adequate air to produce a signal at rest and walk. Compromise between funnel size and distance from naris.*
Tubing support (2)	Dampens movement of the expirate tubing.	*Previous iterations of the prototype had data artefacts or did not pick up a signal due to tube movement.*
Sliding pivot (3)	Allows vertical and horizontal adjustability to enable the same device to fit a variety of horses.	*Having a mounting system that can fit a variety of horse head size would alleviate the need to have multiple sizes of the mounting system available. Also means the most appropriate funnel position can be used for individual animal.*
Noseband reinforcement (4)	Stiffens noseband to prevent horizontal movement.	*Noseband was found to be a cause of movement in early models.*
Two-point bar attachment (5)	Stabilises device on the horse's face.	*Initial inadequate anchorage at the browband resulted in device movement, causing signal problems.*



Results

Exercise protocol data output

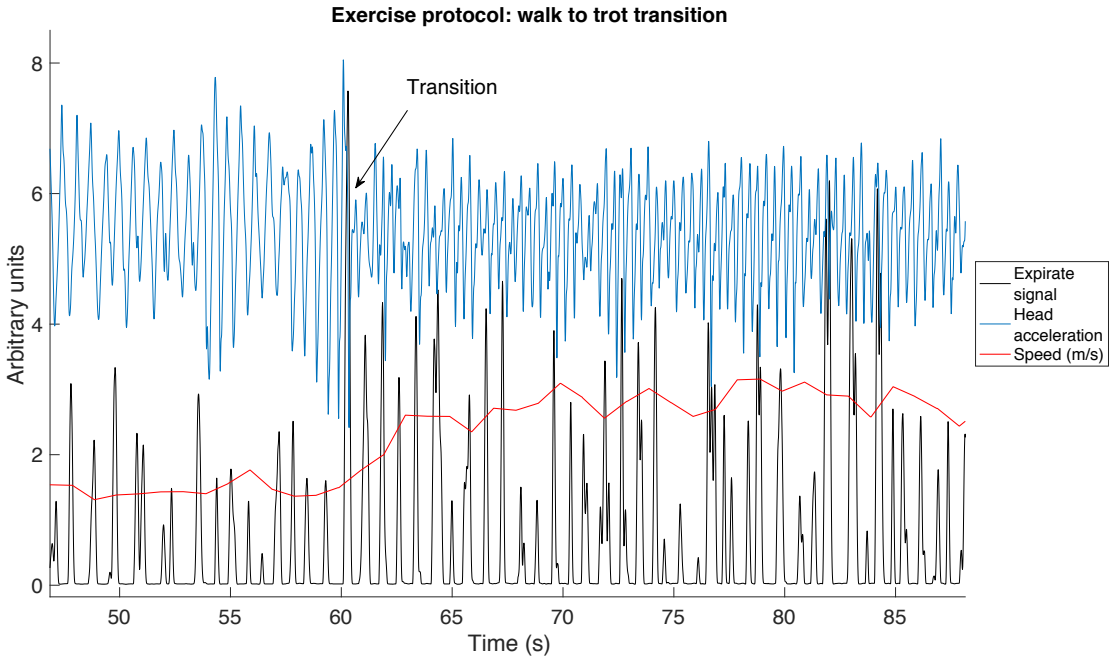
- Data is recorded for duration of exercise and recovery – approximately 15 minutes for specified protocol.
- Speed of horse is recorded by GPS. Gait transitions can be identified.
- Head acceleration gives stride frequency – assume one cycle of head movement corresponds to one stride. Also allows gait identification.



Results

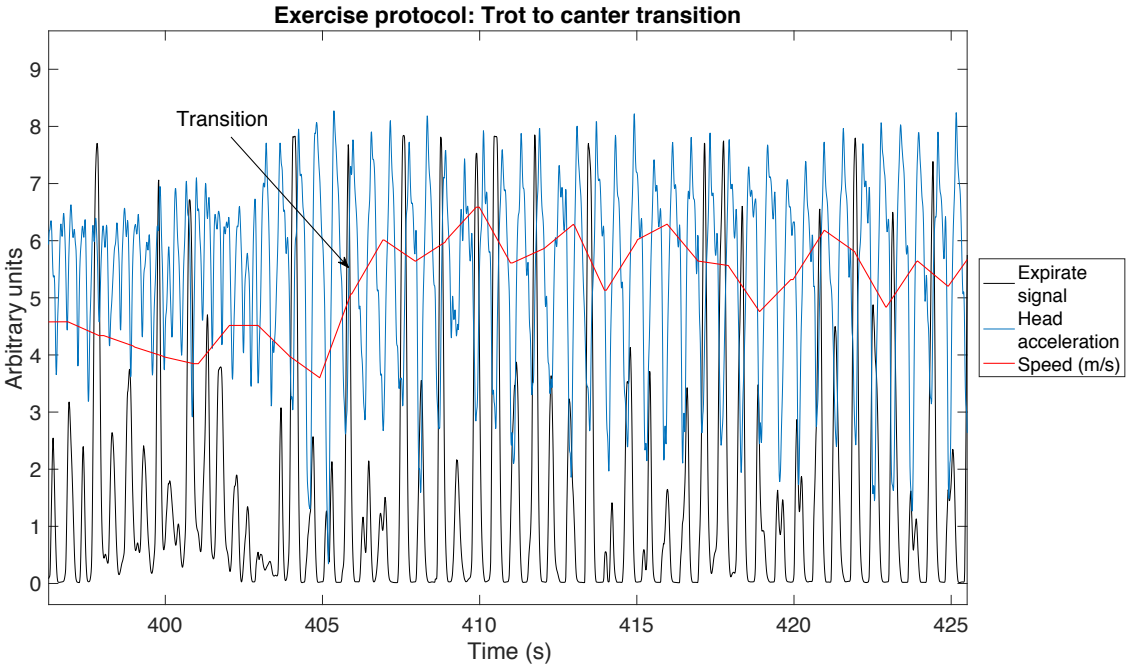
Walk to trot transition

- Head acceleration is lowest in trot.
- Transition is easily identifiable through increase in speed and change in head acceleration magnitude and frequency.



Trot to canter transition

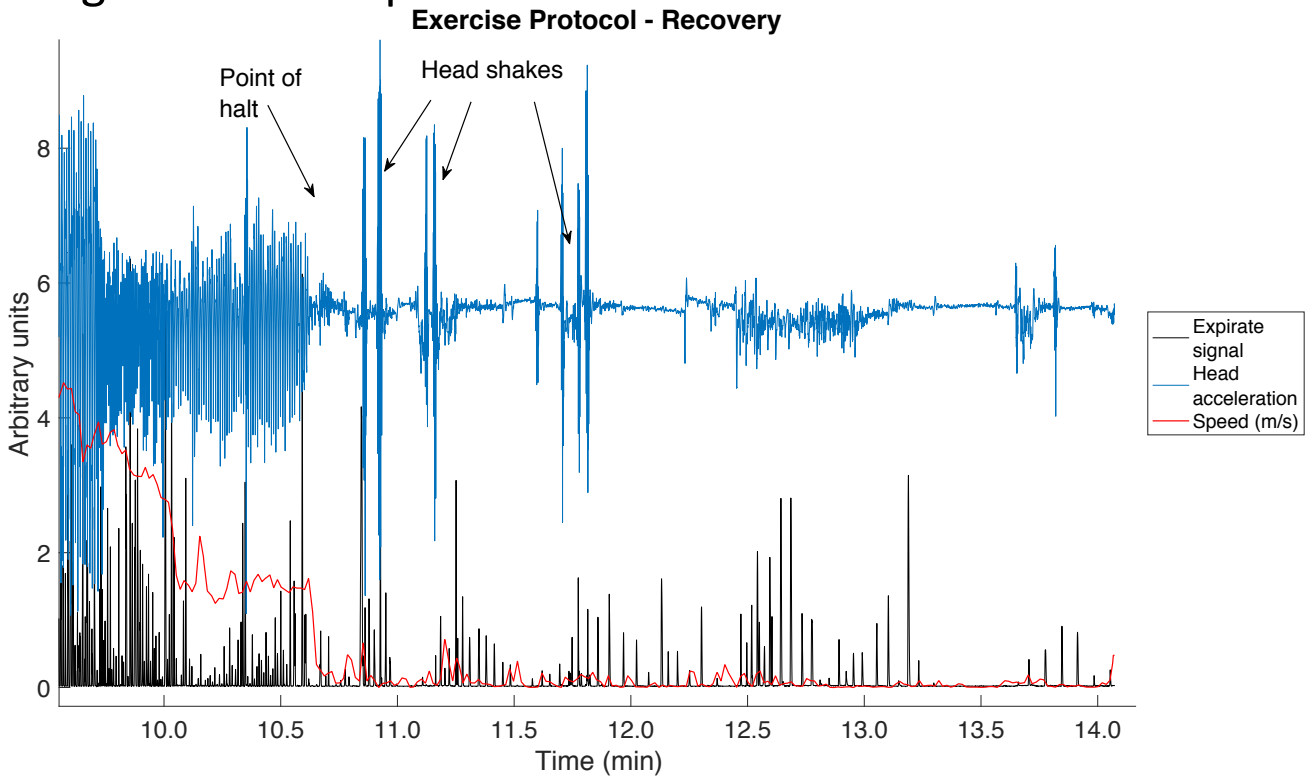
- Transition shows immediate respiratory-locomotor coupling.
- Coupling persists throughout the canter, and stride frequency is regular.
- Reduction in expirate signal at point of transition may be due to prototype instability.



Results

Recovery

- Easily able to identify recovery breaths and hence recovery breathing rate. Size of peak does not necessarily correspond to volume of expirate.
- Breathing rate pattern is irregular during recovery. The same pattern was observed for all protocol recoveries in the horse tested.
- Accelerometer data indicated head shaking during recovery as there was no corresponding increase in speed.



Conclusions

The project has shown that the concept of the device presents a viable method of measuring respiratory rate during exercise in horses.

1. A safe and secure mounting design has been found that is non-invasive, low-cost and allows the horse to be ridden in normal tack.

2. Breathing rate, gait and speed data were obtained successfully for walk, trot, canter and during standing after exercise.

3. Future models of the device could be used as research tools to establish whether breathing rate during exercise is a useful diagnostic parameter for respiratory assessment in the poorly performing equine athlete.

4. Several design improvements were identified including miniaturisation and the incorporation of additional sensors for heart rate and respiratory sound. The device has potential both as a research tool and ultimately as a low-cost clinical diagnostic aid.

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