Validation of an Apple Watch for horse movement analysis and stall rehabilitation monitoring

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Outline

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Introduction

- Limb injuries in people are not known to result in death
- For horses, limb injuries are often a death sentence[1,2]
- Major welfare concern in sporting events[2,3,4]
- Large size and heavy reliance on limbs for support make it challenging to manage these horses [2,5,6,7]
- Early detection of complications, such as supporting limb laminitis, during recovery and rehabilitation can significantly influence the treatment outcome[8]
- Most gait events can be subjectively assessed by experienced veterinarians, BUT are limited by temporal resolution of human eye and inter-observer agreement[12]

Introduction

- Changes in movement could indicate onset of complications (e.g. onset of supporting limb laminitis (SLL)) and provide vital information to direct rehabilitation protocols
- A device to track movement during stall confinement could provide veterinarians with up-to-date and continuous monitoring of mobility without constant supervision
- An inertial measurement unit (IMU) can easily be attached to a limb or surcingle for equine gait analysis
- Ideally, such a device should be affordable and easy to use
- An Apple Watch (IMU) is affordable, readily available, and can easily be synchronized with other devices allowing for a quick transfer of data and immediate analysis

Introduction

- A device to track recovery progress or detect early and subtle indicators of lameness would provide an up-to-date objective progress report
- Objective biomechanical tools for assessing and quantitatively tracking injury severity in a horse allow for early detection of complications (e.g., decreased movement) and implementation of preventative measures [3,4,9,10,11]

Objectives

1. To determine if an Apple watch IMU can be used for accurate movement analysis (normal step count) in a stall
2. To determine the ideal location of the Apple watch on the horse

Materials & Methods

- Two healthy Thoroughbreds were used in the study, one female and one castrated male
- Brought in the morning of the trials and returned to their paddock after the trial
- Stall was bedded with shavings
- Allowed access to feed, water and human interaction
- Stalls were mucked out throughout the trial

Materials & Methods

- 10-minute trials for free movement around the stall
- 5-minute trials for the figure-eight and circle portion of the study
- To mimic a rehabilitation environment horses moved about the stall freely, then hand walked in a figure-eight pattern and circles to simulate constant movement within a stall
- IMU data recorded via SensorLog application to allow comparison of peak-threshold (IMU) to visually determined (video) step counts
- IMU was set to 100 Hz sampling rate

Photo credit: Samantha Steinke

Apple watch used as IMU for trials with SensorLog recording application.

Materials & Methods

- All trials were video recorded via Noldus Media Recorder Software 3.0 on a Lenovo Laptop connected to a camera (Axis PTZ IP 1080p camera) mounted to the roof of the stall
- Step count was compared from the IMU (Apple Watch) and a manual count via video recording to determine the best location for accuracy of step count
- One step = lifting of the heel off of the ground and a flexed knee (carpus)
- IMU on a limb (right forelimb and hindlimb cannon bone), only the steps from that limb were counted
- IMU at the withers, both front leg steps were counted

The locations in which the Apple watch was placed for movement analysis trials. A) right forelimb B) withers attached to surcingle C) right hindlimb.

Materials & Methods

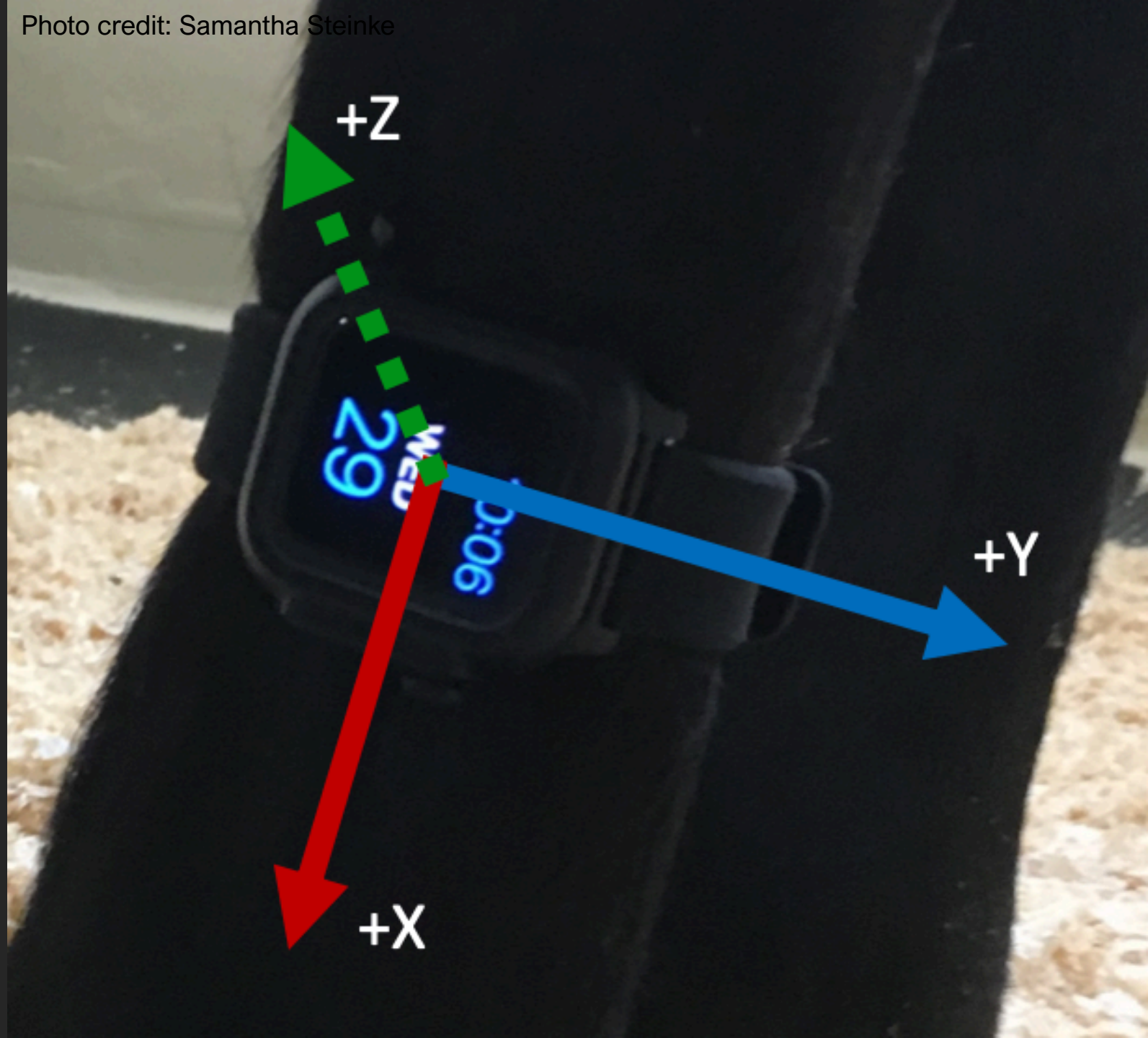
- Because of the location of the stall in the clinic, normal movement cannot be confirmed - horses were more active when the clinic was busy
- Data analysed via MATLAB R2018b to determine the step count recorded by the Apple Watch

Figure 3: Apple Watch axes for movement analysis.

Y axis: forward (anteroposterior),

X axis: downward and

Z axis: to the right side (mediolateral).



Results

- Forelimb average percent difference was 11.90% (Y) and 6.49% (Z)
- Hindlimb average percent difference was 9.06% (Y) and 4.17% (Z)
- Withers average percent difference was 37.05% (Y) and 53.69% (Z)
- Withers were the least accurate
- Forelimb and hindlimb were similar in percent differences between manual step counts and IMU peak-threshold

Results

- Z axis appears to be more accurate for the forelimb and hindlimb (mediolateral for limb orientation)
- Y axis appears to be more accurate for the withers (mediolateral for withers orientation)
- Further testing and analysis is necessary to improve accuracy and determine optimal location of the IMU
- Future trials to include more horses

Discussion/Conclusion

- Early detection of complications and preventative interventions during recovery is desirable
- Forelimb & hindlimb sensor placement appear to be the most accurate for step count during stall confinement
- Hindlimb lowest percent difference in both Y and Z
- Some of the difference could be due to orientation of watch at withers versus on limbs
- Based on results, mediolateral axis appears to be most accurate in all locations

Discussion/Conclusion

- Next steps include further data analysis and testing, more trials with the Apple Watch and refine the code used to analyze the data
- Algorithm used was adapted from human locomotion
- Additional testing will allow for further development of an algorithm specific to horses
- Analysis of all axes

Discussion/Conclusion

- This study aimed to demonstrate the use of an IMU in equine motion analysis and determine its ideal placement for quantifying movement during stall confinement, allowing for early detection of complications and preventative interventions during recovery from injury and rehabilitation
- Based on the results of this study, the use of an IMU for monitoring rehabilitation progress in injured horses looks very promising and could be a valuable tool for veterinarians and rehabilitation specialists

Limitations

- Only two horses
- Slightly modified human step count code used to analyse data
- Camera angle introduced possible error in counting
- Human error
- Instrument (IMU) error

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Acknowledgements:

Funding:

Mitacs Accelerate

Supervisors:

Dr. Julia Montgomery
Dr. John Barden

University of Saskatchewan

University of Regina

The study was approved by the University of Saskatchewan's Animal Research Ethics Board, and adhered to the Canadian Council on Animal care guidelines for humane animal use.