Quantitative detection of fatigue in sport horses using inertial sensors and machine learning

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Identification of fatigue helps prevent injuries and optimise the training of horses. Previous studies tried to identify the important fatigue-related parameters for monitoring performance changes due to training. Besides several identified physiological parameters, some biomechanical parameters have been shown as fatigue-related. However, the number of studied parameters was limited. In this study, using machine learning, we investigated the possibility of detecting fatigue induced by standardised exercise tests (SETs) by identifying important biomechanical indicators extracted from inertial measurement units (IMU). Sixty Warmblood sport horses were measured using seven IMUs attached to the sacrum, withers, poll, and limbs during in-hand walk and trot before and after SET. The intensities of SETs differed (average peak plasma lactate concentration of 3.49±1.90 mmol/l). Fifty-two biomechanical parameters were calculated from IMU signals: stride, stance, and swing durations, speed, 3D linear displacements, and angular ranges of motions (ROM) of sacrum, withers, head, and limbs. Then, we selected the parameters with the highest weights as fatigue indicators using neighbourhood component analysis. Using support vector machine and considering the fatigue indicators as input features, we trained a model to detect non-fatigued (before SET) and fatigued (after SET) strides. Stance duration for walk, swing duration for trot, and limbs protraction and longitudinal ROMs for both gaits were identified as important fatigue indicators. The fatigue detector resulted in higher accuracy for walking strides (95%) than trotting (83%). In conclusion, important biomechanical fatigue indicators were identified, and an accurate fatigue detector was developed using IMU and machine learning.

Comparison of a computer vision application to optical motion capture for lameness quantification

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Computer vision provides an exciting new means for the study of equine gait using accessible hardware. This study aimed to explore the lameness assessment capacity of a mobile phone computer vision (CV) application by comparing vertical motion measurements of the head and pelvis to an optical motion capture (OMC) system. Twenty horses were recorded using an iPhone12 (60 Hz) and 13 OMC cameras (200 Hz) trotting two times back and forth in a 30 m trot-up. The videos were processed using three artificial neural networks, which detected the horse action (direction and gait) and performed markerless tracking. Bandpass (CV) and highpass (OMC) filtered vertical displacement curves from the head and mid pelvis were synchronised from both systems using cross-correlation, rendering 546 strides (mean 27.3 per horse). From the vertical displacement signals extreme value differences (ExtrDiff) between the two minima and the two maxima respectively per stride (including the two classic lameness metrics MinDiff and MaxDiff) related to range of motion were compared between the systems. The mean trial error for $ExtrDiff_{head}$ from CV data was 2.7 mm (range 4.5-0.7 mm) and for $ExtrDiff_{pelvis}$ 2.2 mm (range 4.1-0.7 mm). Within-trial standard deviations ranged from 9-25 mm for OMC and 9-30 mm for the CV system. The ease of use and the level of the measurement error indicate that the CV application is a promising tool for studies of clinically relevant levels of asymmetry in horses. It allows frequent observations of large populations of horses through owner-operated monitoring of gait symmetry.