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DISCRIMINATION OF HORSE SWIMMING STRATEGIES USING SPATIOTEMPORAL PARAMETERS FROM IMU

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Introduction

Aquatic training is believed to be an effective method for maintaining the cardiorespiratory system while minimizing the impact on the musculoskeletal systems of horses. Despite the clinical advantages offered by swimming pool training, there has been limited attention to the biomechanics of horse swimming [1], particularly in understanding limb coordination. Based on data from a previous study conducted in 2023 [2], we have identified three main distinct swimming strategies: (1) 4 beats per stride, (2) 2 beats per stride with diagonal symmetry, and (3) 2 beats per stride with lateral symmetry. However, the post-processing of this setup is time-consuming and not easily applicable for clinical purposes. The objective of this study is to propose a method for discriminating between horses' swimming strategies using only Inertial Measurement Units (IMU).

Methods

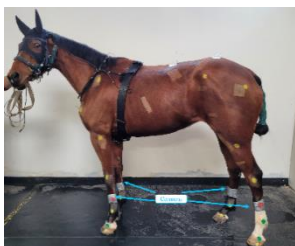


Figure 1: Horse equipped with 4 IMUs: one on each metacarpal region.

Nine horses underwent a twelve-week mixed training program, including three weekly swimming sessions in a U-shape swimming pool during the final eight weeks. Each week, IMUs were attached to the metacarpal region of the swimming horses (Figure 1). Using Matlab Signal Labeler, signals from all four limbs during swimming sessions were segmented, and the swimming cycle time was extracted from hind limb vertical acceleration.

Three primary indicators – speed, stride frequency, and stride length – were calculated, normalized based on horse height and studied both independently and in relation to each other.

Strategies were defined by quantitatively analysing limb coordination in swimming videos. Spatiotemporal data (including duty factors, advance placement of the limbs in relation to each other and overlap) and symmetry, were used to identify distinct swimming strategies.

Results

Figure 2 displays the normalized stride frequency of U-turn $i+1$ (pass $i+1$ in the swimming pool) compared to that of U-turn i for each horse (represented by different colours), during weeks 5 to 12 (indicated by distinct symbols). The different strategies can be identified with respect to their normalized stride frequency: below 0.270 = strategy 1, between 0.270 and 0.300 = strategy 2, and above 0.300 = strategy 3 (boxes on Figure 2).

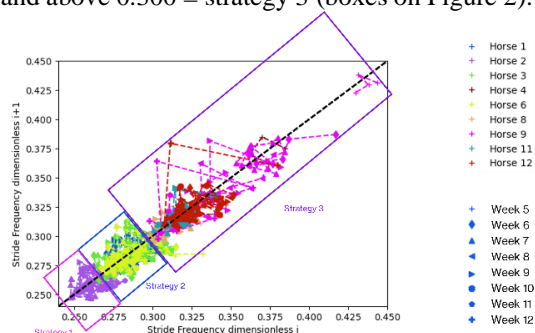


Figure 2: Normalized stride frequency for U-turn $i+1$ with stride frequency for U-turn i for each horse and each week.

Discussion

We showed that the swimming strategy of the horses can be discriminated by the normalized stride frequency, with distinct patterns emerging for each horse. The variations in stride frequency provide valuable insights into the individualized swimming techniques employed by the horses during the observed sessions.

Despite the limited dataset, the discernible patterns in Figure 2 suggest that normalized stride frequency holds promise as a key indicator for discriminating swimming strategies in horses. Extrapolating from the observed trends, it becomes evident that even with a modest dataset, meaningful insights into individualized swimming techniques can be gained.

References

1. Santosuosso et al, Front. Vet. Sci, 8:752375., 2021.
2. Giraudet et al, Sensors, 23(21):8832, 2023.

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