DESCRIPTION AND ANALYSIS OF SWIMMING STRATEGIES IN HORSES IN A POOL

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ABSTRACT

This thesis is part of the CAPT-ESE project, launched in 2020, which brings together a multidisciplinary team. Research on equine swimming is conducted at the Kinésia center at CIRALE, the equine hub of EnvA in Normandy. This study is based on 124 underwater videos taken of 11 horses. Veterinary analysis identified three swimming strategies: (S1) two-beat with lateral overlap, (S2) two-beat with diagonal overlap, and (S3) four-beat. Moreover, kinematic analysis using an algorithm allowed these movements to be classified into four categories. These categories were then matched with the identified swimming strategies, with a 97.6% correlation. The results show that lateral and diagonal ratios are discriminating parameters. The study also revealed both inter- and intra-individual variability in swimming strategies. These results contribute to a better understanding of locomotor patterns in horses during aquatic training and may assist in adapting rehabilitation processes.

INTRODUCTION

Equine aquatic training, used in rehabilitation, reduces strain on the limbs while maintaining physical activity. Despite its popularity, the biomechanics of equine swimming remains under-studied. Recent research reveals that horses modify their locomotion in water, involving changes in joint amplitude and muscle activity.

This study aims to analyze limb coordination during swimming by adapting terrestrial locomotion analysis methods to the aquatic environment. The "propulsion" and "return" phases in swimming are simplified compared to the weight-bearing and support phases on land, with the addition of a sliding phase unique to the aquatic environment. The objectives are to determine limb coordination patterns and identify quantitative parameters to describe and differentiate them. This study offers an original methodological framework to analyze, for the first time, equine swimming gaits to optimize training and rehabilitation protocols.

MATERIAL AND METHODS

The study focuses on analyzing swimming strategies in horses during twelve laps of a swimming session in a U-shaped pool. A total of eleven saddle horses, non-lame but possibly presenting cervical or dorsal lesions compatible with pool exercise, were included. A twelve-week training plan was established, incorporating both terrestrial and aquatic exercises. Video recordings were made with six synchronized, submerged GoPro cameras, allowing for limb movement analysis during swimming.

Qualitative Analysis

Two veterinarians visually identified the start and end of the "propulsion" and "return" phases during the swim cycle. The duration of these phases was calculated and then normalized as a percentage of the swim cycle duration per pass. Coordination graphs were created, describing the temporal windows of the two phases as a percentage of a full swim cycle. Swimming strategies were defined by analyzing the overlap times between the propulsion phases of the limbs (lateral and diagonal coordination).

Quantitative Analysis

A quantitative analysis was performed to define parameters such as the duty factor (propulsion duration/cycle duration ratio), overlap, sliding, and delay between limbs. Lateral (α) and diagonal (β) ratios were calculated to assess limb synchronization. A classification process using a k-means clustering algorithm distinguished four swimming categories based on the calculated parameters. Although three strategies were identified by veterinarians, a fourth category was introduced to account for variations in the four-beat strategy. The correlation between the veterinary strategies and the categories derived from classification was evaluated using a confusion matrix.

RESULTS

Veterinarians visually identified three main swimming strategies in horses, two two-beat strategies, and one four-beat strategy. These strategies were then refined by the algorithm into four distinct subcategories, splitting the four-beat strategy into two subcategories. The α and β thresholds distinguish lateralized and diagonal swimming strategies, as well as variations within the four-beat strategies.

The observed swimming strategies in horses can be classified into three main categories, each with distinct characteristics:

- Strategy 1 (Category A): A two-beat swimming style characterized by lateral overlap. In this approach, limbs on the same side of the body move predominantly in synchrony.

- Strategy 2 (Category B): Another two-beat swimming style, but with diagonal overlap. Here, diagonally opposite limbs (e.g., right forelimb and left hindlimb) move predominantly together.

- Strategy 3 (Categories C and D): A four-beat swimming style where each limb moves independently. This can be subdivided into two subcategories:

  - Category C: Characterized by moderate overlap between limb movements.

  - Category D: Characterized by minimal overlap between limb movements.

DISCUSSION

The study used machine learning algorithms to analyze limb coordination in horses during swimming. Veterinarians identified three distinct swimming strategies. The comparative analysis between the strategies identified by the veterinarians and those derived from the algorithm showed a 97.6% correlation, though some classification errors were noted between certain strategies.

The study demonstrated variations in horses' swimming abilities, influenced by intrinsic and extrinsic factors. The inter-individual variability may be explained by different natural abilities or differentiated strategy manifestations, potentially influenced by intrinsic factors (e.g., lesions). Further studies planned in this project will help better understand these links.

Intra-individual variability could be explained by the turn position (U-shaped pool), fatigue, or training. A right/left asymmetry seems to emerge, suggesting that the swimming direction influences the locomotor pattern in horses using multiple strategies.

CONCLUSION

This research identified three distinct swimming strategies in horses, which can be used either exclusively or conjointly. This discovery is particularly significant as it reveals a unique movement sequence specific to the aquatic environment, with no equivalent in terrestrial locomotion.

This study significantly contributes to our understanding of equine biomechanics in aquatic environments. However, further studies are essential to precisely define the indications and contraindications of pool exercise.

In conclusion, these novel results open the door to a wide range of future research in this field, promising significant advancements in the use of equine swimming for therapeutic and sporting purposes.

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