Vertical Displacement of the Equine Withers and Pelvis when Trotting on an Aqua-Treadmill

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Aims
This study aimed to investigate the effect of water depth on both forelimb and hindlimb movement of the horse during aqua-treadmill exercise by:

- Quantifying the vertical displacement of both the tuber sacræ and the withers of the horse in trot at a baseline level of water in the aqua-treadmill (mid-hoof).
- Measuring vertical displacement of the tuber sacræ and the withers at increasing water depths up to mid knee.
- Identifying effects of water depth on vertical pelvic displacement and vertical forelimb displacement.

Methods

Seventeen horses were habituated to aqua-treadmill exercise. Horses were trotted on an aqua-treadmill at four different water depths that were specifically anatomically matched to each individual horse (third phalanx (P3) mid hoof, mid fetlock, mid third metacarpal (MC3), and mid carpus). Data were recorded using either an optical motion capture system (Qualisys®) N = 8 or an inertial sensor system (Xsens®). N = 9. Markers for the motion capture system were located on the tuber sacrale, tuber coxae, withers and lumbar spine while sensors were located on the tuber sacrale, tuber coxae, withers and poll. Data were cut into strides and displacement amplitudes calculated using custom written scripts (Matlab®) before undergoing statistical testing. Statistics: Two way ANOVA was carried out on displacement values of the tuber sacræ to identify the effect of increasing water depth (Fig 1). Two way ANOVA was carried out on displacement values of the withers to identify the effect of increasing water depth (Fig 2). Kruskal Wallis was used to establish the effect of depth on displacement symmetry (Fig 3).

Results
Increasing water depth significantly effects vertical pelvic displacement (Fig 1) and vertical withers displacement (Fig 2). There is no significant effect of depth on displacement symmetry (wither p=0.05; tuber sacrale p=0.05) (Fig 3).

Discussion
Vertical displacement of the pelvis and withers (Figs 1 and 2) increased with increasing water depth suggesting that the horse worked harder to lift itself higher out of the water. This may agree with a previous study where pelvic fixation was found to increase at increasing water depths, although horses studied were walking not trotting and a deeper water depth was used. Horses became most symmetrical in aqua-treadmill when the water was at Mid MC3 (Fig 3) and least symmetrical at Mid Carpus. Although this displacement symmetry was not shown to be significant, likely due to the varied and low number of horses, the trend in the data is an important consideration when rehabilitating horses. Currently, no other studies have investigated the symmetry of the trot on an aqua-treadmill.

Conclusion
Understanding how a horse moves on an aqua-treadmill is vital for tailoring specific therapy treatments in order to most successfully rehabilitate the horse from injury. Investigation to quantify the effects of increasing water depth on asymmetric horses should be carried out to further inform and support its application as a tool for rehabilitation.

Further Work

Acknowledgements
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References

First described in the literature for horses by Auer in 1988, exercise on an aqua-treadmill has increased in popularity as a mode of rehabilitation and therapy. Following this article there appears to be no further reference to an equine aqua-treadmill for over ten years. The reasons for this are not clear but we are more anecdotally of the biomechanics of equine treadmill locomotion differs to that of ground locomotion 1-4 but evidence to document the changes on an aqua-treadmill is increasingly being investigated.

Recent studies have started to document kinematics of aqua-treadmill locomotion 5-8. Joints on a lower limb have been found to have an increased range of motion (ROM) when walking in water and percentage duration of stance and swing phases have been found to decrease and increase respectively 9-11 and stride length has been found to increase with an increase in water depth up to a level with a significant decrease in stride frequency 12. Significant increases in flexion and rotation of the back have been noted at increasing water depths while bending of the back was reduced at elbow and shoulder depth 13. Control of locomotion aided with knowledge of the properties of water (buoyancy, viscosity, hydrostatic pressure, surface tension, specific gravity and temperature effects) should equate to constructive, specific and controlled therapeutic rehabilitation.

Mean vertical displacement (mm) of the equine tuber sacræ while trotting on an aqua-treadmill at increasing water depths

Mean vertical displacement (mm) of the equine withers while trotting on an aqua-treadmill at increasing water depths

Mean vertical displacement (mm) of the equine tuber sacræ (Fig 1.1) and withers (Fig 2.1) increased with increasing water depth suggesting that the horse worked harder to lift itself higher out of the water. This may agree with a previous study where pelvic fixation was found to increase at increasing water depths, although horses studied were walking not trotting and a deeper water depth was used. Horses became most symmetrical in aqua-treadmill when the water was at Mid MC3 (Fig 3) and least symmetrical at Mid Carpus. Although this displacement symmetry was not shown to be significant, likely due to the varied and low number of horses, the trend in the data is an important consideration when rehabilitating horses. Currently, no other studies have investigated the symmetry of the trot on an aqua-treadmill.

Mean vertical displacement (mm) of the equine withers while trotting on an aqua-treadmill at increasing water depths

Vertical Displacement of the pelvis and withers (Figs 1.2 and 2.2) increased with increasing water depth suggesting that the horse worked harder to lift itself higher out of the water. This may agree with a previous study where pelvic fixation was found to increase at increasing water depths, although horses studied were walking not trotting and a deeper water depth was used. Horses became most symmetrical in aqua-treadmill when the water was at Mid MC3 (Fig 3) and least symmetrical at Mid Carpus. Although this displacement symmetry was not shown to be significant, likely due to the varied and low number of horses, the trend in the data is an important consideration when rehabilitating horses. Currently, no other studies have investigated the symmetry of the trot on an aqua-treadmill.