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

THE UNIVERSITY OF NORTHAMPTON

Moulton College NORTHAMPTONSHIRE Profit through Skill

Jessica York

jessica.york@moulton.ac.uk

Dr Wanda McCormick
Moulton College
Dr Anna Walker
Royal Veterinary College

Introduction

First described in the literature for horses by Auer in 1989[1], 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[2] suggesting that aqua-treadmill practices are more anecdotal. It is well documented that the biomechanics of equine treadmill locomotion differs to over ground locomotion[3-6] but evidence to document the changes on an aqua-treadmill is increasingly being investigated.

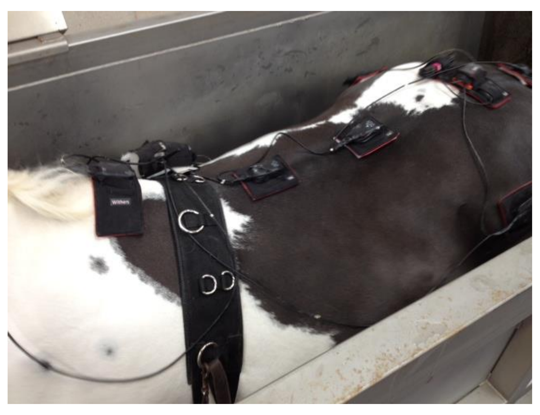
Recent studies have started to document kinematics of aqua-treadmill locomotion[7-9]. Joints of the lower limb have been found to have an increased range of motion (ROM) when walking in water and percentage duration of stance and swing phases have been found to decrease and increase respectively[7] and stride length has been found to increase with an increase in water depth up to ulna level with a subsequent decrease in stride frequency[8]. 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[9].

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.

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 sacrale 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 sacrale and the withers at increasing water depths up to mid knee.**
- **Identifying effects of water depth on vertical pelvic displacement and vertical forelimb displacement.**



Collecting data on an equine aqua-treadmill using both Qualisys© (a) and Xsens© (b)

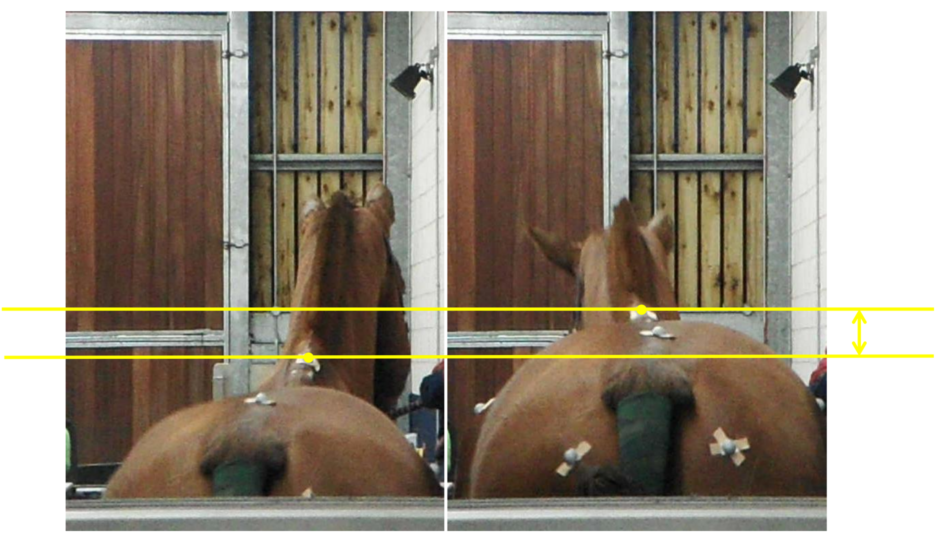
Methods

Seventeen horses were habituated to aqua-treadmill exercise[10]. 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 sacrale 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).

An image to illustrate the vertical displacement of the tuber sacrale or 'croup', the highest point of the equine pelvis and axial skeleton in the hind limb. Image is taken from two frames in the same video clip.

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 (withers p>0.05; tuber sacrale p>0.05) (Fig 3).



An image to illustrate the vertical displacement of the withers, the highest point of the axial skeleton in the forelimb. Image is taken from two frames in the same video clip.

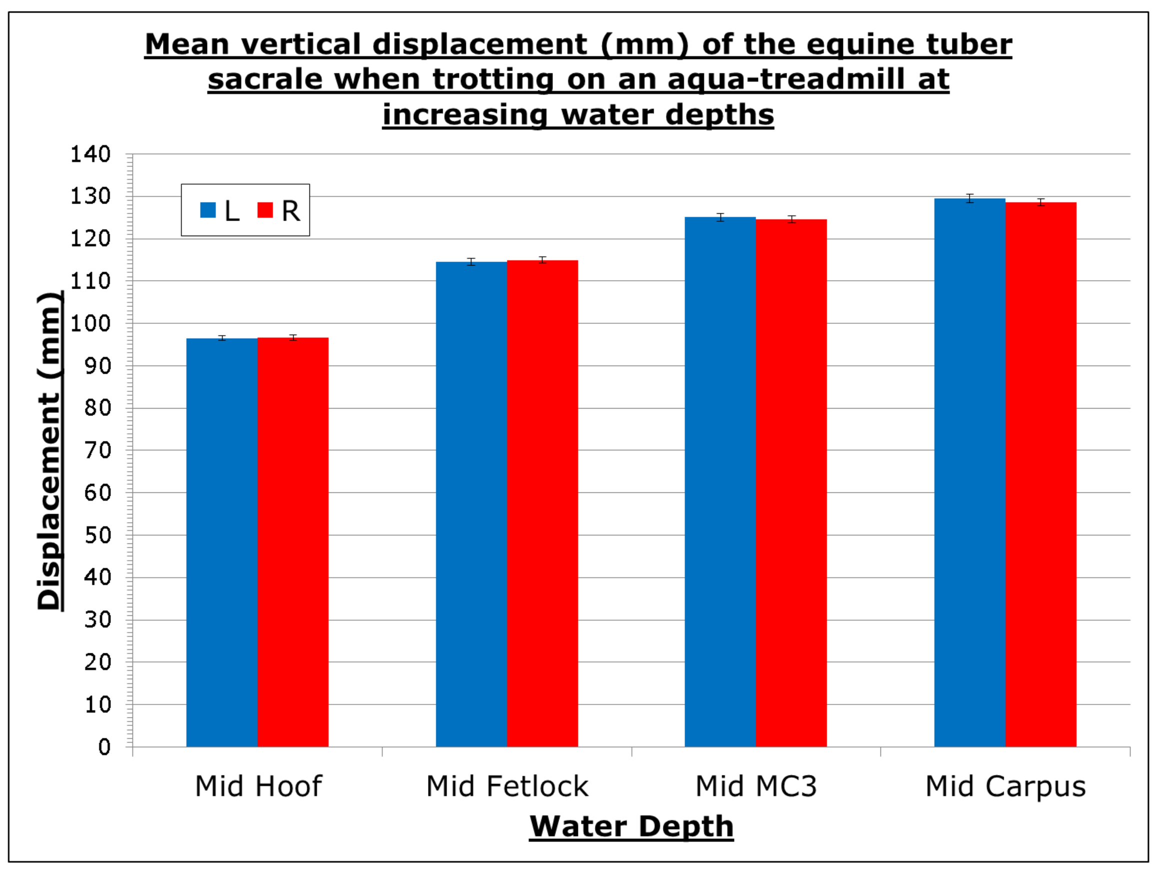


Figure 1: Vertical displacement of the tuber sacrale increases significantly from the baseline level of water at mid hoof (P3) to mid fetlock, mid MC3, and mid carpus (F=28.78, p<0.01). There is no evidence that there is an interaction between diagonal limb pair and the depth of the water (F=0.00, p=1).

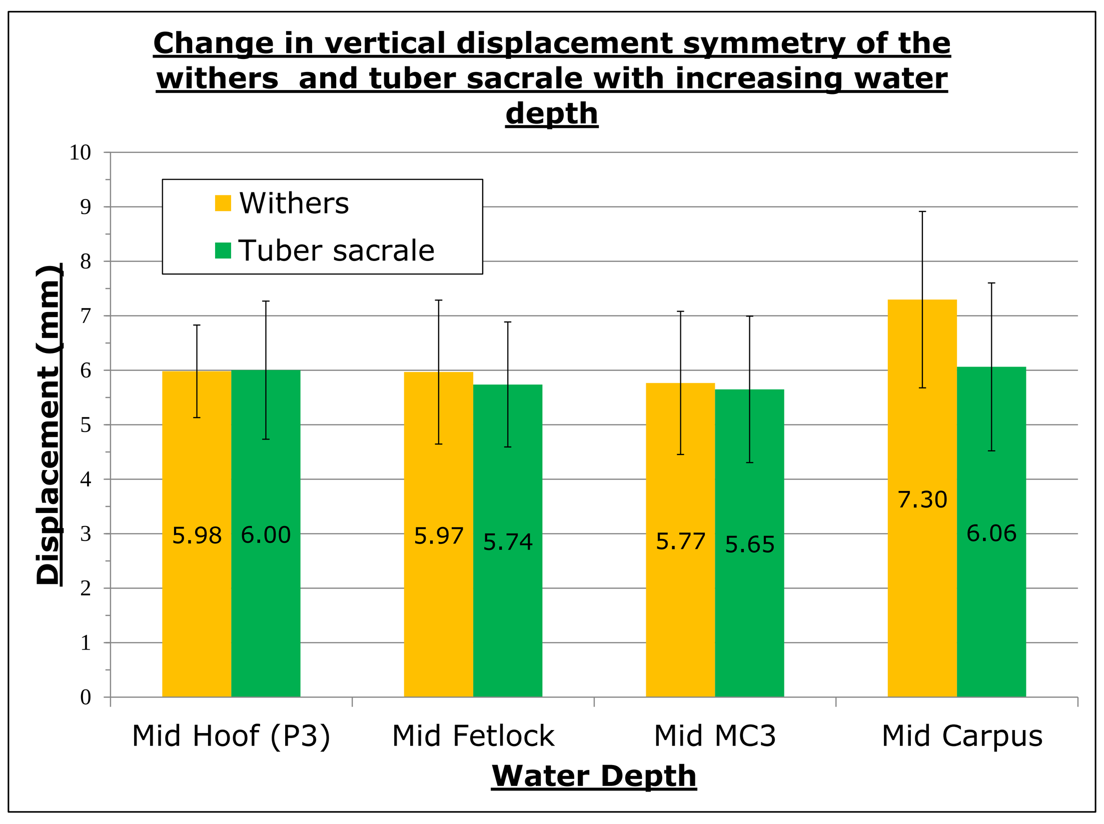


Figure 3: Displacement symmetry within a stride appears to increase from mid hoof (P3) to mid fetlock and to mid MC3. Symmetry appears to decrease between mid MC3 and Mid Carpus however, Kruskal Wallis revealed no significant effect of depth on symmetry for the withers (H=0.97, p=0.808) or the tuber sacrale (H=0.26, p=0.967).

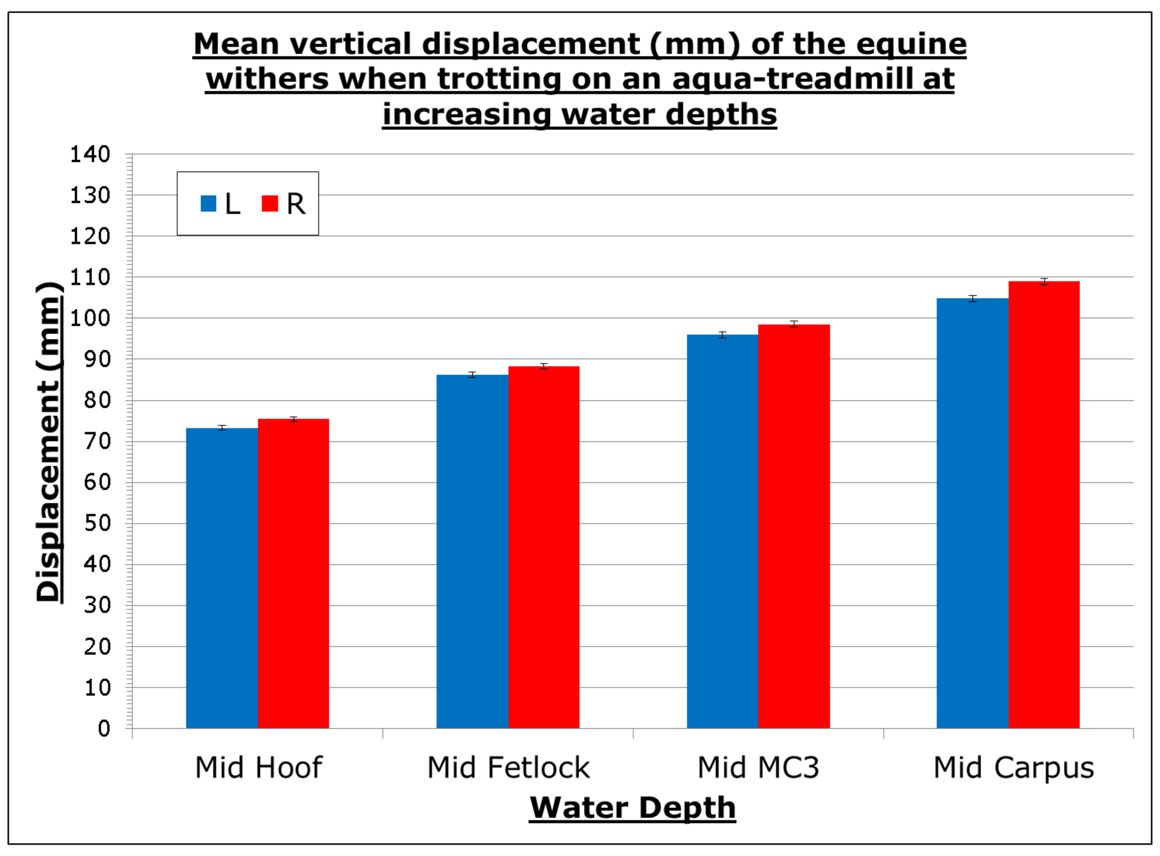


Figure 2: Vertical displacement of the withers increases significantly from the baseline level of water at mid hoof (P3) to mid fetlock, mid MC3, and mid carpus (F=29.55, p<0.01). There is no evidence that there is an interaction between diagonal limb pair and the depth of the water (F=0.01, p=0.999).

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 themself higher out of the water. This may agree with a previous study where pelvic flexion was found to increase at increasing water depths, although horses studied were walking not trotting and a deeper water depth was used[9]. Horses became most symmetrical in the stride 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

Vertical displacement of both the pelvis (tuber sacrale) and withers increased significantly with increasing water depth with an associated trend in displacement symmetry albeit not statistically significant in the current study.

Further Work

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.

Acknowledgements

Many thanks to the Royal Veterinary College for the loan of the equipment and to the Thomas Harrison Trust at Moulton College for funding the project.

References

1. Auer, J. A., (1989) *Physical therapy and rehabilitation.* In: Jones, W. E., Equine Sports Medicine. Malvern PA: Lea and Febiger, p249-251.
2. Tokuriki, M., Ohtsuki, R., Kai, M., Hiraga, A., Oki, H., Miyahara, Y., and Aoki, O., (1999) EMG activity of the muscles of the neck and forelimbs during the different forms of locomotion. *Equine Veterinary Journal Supplement* 30: 231-234.
3. Buchner, H. H. F., Savelberg, H. H. C. M., Schamhardt, H. C., Merkens, H. W., and Barneveld, A., (1994a) Kinematics of Treadmill Versus Overground Locomotion in Horses. *The Veterinary Quarterly 16 Suppl*. 2: 84-90.
4. Buchner, H. H. F., Savelberg, H. H. C. M., Schamhardt, H. C., Merkens, H. W., and Barneveld, A., (1994b) Habituation of horses to treadmill locomotion. *Equine Veterinary Journal Supplement 17*: 13-15.
5. Leach, D. H., and Drevemo, S., (1991) Velocity-Dependent Changes in a Stride Frequency and Length of Trotters on a Treadmill. *Equine Exercise Physiology*. 3: 136-140.
6. Fredricson, S., Drevemo, S., Dalin, G., Hjertén, G., Björne, K., Rynde, R., and Franzen, G., (1983) Treadmill for Equine Locomotion Analysis. *Equine Veterinary Journal* 15(2): 111-115.
7. Mendez-Angulo, J. L., Firshman, A. M., Groschen, D. M., Kieffer, P. J., Trumble, T. N., (2013) Effect of water depth on amount of flexion and extension of joints of the distal aspects of the limbs in healthy horses walking on an underwater treadmill. *American Journal of Veterinary Research* 74(4): 557-566.
8. Scott, R., Nankervis, K., Stringer, C., Westcott, K., and Marlin, D., (2010) The effect of water height on stride frequency, stride length and heart rate during water treadmill exercise. *Equine Veterinary Journal* 42 Supplement 38: 662-664.
9. Mooij, M. J. W., Jans, W., den Heijer, de Pater, M., and Back, W., (2013) Biomechanical responses of the back of riding horses to water treadmill exercise. *The Veterinary Journal* 198: 120-123.
10. Nankervis, K. J., and Williams, R. J., (2006) Heart rate responses during acclimation of horses to water treadmill exercise. *Equine Veterinary Journal Supplement* 36: 110-112.