Water and speed affect upper body kinematics and limb timing in horses walking on a water treadmill

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This study aimed to describe upper body movement and limb timing in horses walking on a dry treadmill (DT) and water treadmill (WT) at incremental belt speeds. Upper body vertical range of motion (ROMz) and limb timing variables of twelve owner sound Warmblood horses were collected on a DT and WT. Water was set at the height of 30 cm and horses were measured at five different speeds (0.9-1.2 m/s) using ten IMU sensors (EquiMoves®, 200 Hz) attached to the head, withers, 15th thoracic vertebra, tuber sacrale, both tuber coxae and mid-lateral aspect of the cannon bones. Linear mixed models were used, with horses as random effect and the interaction of speed with treadmill condition (DT/WT) as fixed effects. Significance was set at $P<0.05$ and only results with $P<0.01$ are presented. The presence of water increased the ROMz of head (+16.4%), withers (+72.9%), T15 (+53.4%) and pelvis (+65.2%). Incremental speeds increased ROMz of the head on the WT and pelvis on the DT and WT. The presence of water increased stride duration (+16.0%), stance duration (front limbs: +4.7%, hind limbs: +5.6%) and swing duration (front limbs: +44.9%, hind limbs: +33.4%). Stride- and stance duration decreased with increasing speed on the DT and WT, swing duration only decreased on the WT. The presence of water increased the ROMz of the head, withers, T15 and pelvis. Incremental belt speeds only affected ROMz of head and pelvis. Limb timing changed with the different conditions. These effects should be considered for training purposes of the individual horse.

The effects of water and speed on limb kinematics in horses walking on a water treadmill

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This study aimed to describe limb kinematics of horses walking on a dry treadmill (DT) and water treadmill (WT) at increasing belt speeds. Limb angle variables of twelve owner sound Warmblood horses were collected on a DT and WT (water height: 30 cm) at five different speeds (0.9-1.2 m/s), using four IMU sensors (EquiMoves®, 200 Hz) attached to the mid-lateral aspect of all metacarpal/metatarsal bones. Maximal front limb (FL) and hind limb (HL) protraction, retraction and sagittal range of motion (ROM) angles were calculated, as well as maximal FL and HL abduction, adduction and coronal ROM angles. Linear mixed-effects models were used to test the effects of water and speed. Significance was set at $P<0.05$. The presence of water significantly increased maximal HL protraction (+14.5° / 49.5%), FL (+7.5° / 23.6%) and HL (+3.4° / 15.0%) retraction, FL (+7.4° / 11.7%) and HL (+17.9° / 34.4%) sagittal ROM, FL (+1.69° / 42.7%) and HL (+1.65° / 46.7%) abduction, FL (+1.39° / 37.1%) and HL (+1.59% / 44.8%) adduction and FL (+3.08° / 39.9%) and HL (+3.24° / 45.8%) coronal ROM. On the DT and WT, increasing belt speed resulted in increased values for maximal FL protraction, FL and HL retraction, and FL sagittal ROM. In the coronal plane, only maximal HL coronal ROM was reduced significantly at increasing belt speed on the WT. The presence of water affects multiple sagittal and coronal limb angle variables during WT exercise, and increasing belt speed shows more pronounced effects on sagittal rather than coronal limb angles.