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Kinematics of human spine during hippotherapy

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1. Introduction

Hippotherapy is a method used for relaxation and balancing of trunk muscles, especially paravertebral postural muscles. It is a form of physical and occupational therapy in which a therapist uses the characteristic movements of a horse to provide carefully graded sensory input. This method is usually used for children with cerebral palsy (Benda et al. 2003; Casady and Nichols-Larsen 2004) and spinal cord injury treatment (Lechner et al. 2003). The aim of this study was to find out suitable methods that could be used for the description of biomechanical reactions of passive horse rider.

2. Methods

In order to solve this task, telemetric surface EMG and 3D motion analysis were used. Markers for movement identification were installed on the body of experimental rider at anatomically significant points (proc. spinosus of vertebrae C2, C7, Th5, Th10, L1, L5, acromion, spina scapulae, etc.). Measured specimen had installed surface EMG electrodes on dorsal, ventral and lateral muscle stabilisers of trunk (paravertebral muscles, m. rectus abdominis, m. obliquus abdominis internus et externus). Self-adhesive diagnostic surface electrodes Biotabs Ag (MIE Ltd, Leeds, UK) were used. Electrodes were connected to EMG preamplifiers. EMG signal led into an EMG transmitter. Six channels were used for EMG signals and seventh channel was used for synchronisation with cameras. A receiver used was telemetric EMG MTR8 (MIE Ltd). Raw electromyograms were bandpass filtered (20–500 Hz), rectified and smoothed using a RMS. Similarly, raw maximum voluntary isometric contraction EMG_{max} data were processed and used to normalise the EMG data associated with the trunk movements (De Luca 1997).

Outdoor 3D motion of rider's trunk was experimentally analysed by four video recorders and then processed with APAS software (Ariel Dynamics, Inc., San Diego, CA, USA). Simultaneously with an experimental measurement of movement parameters were recorded EMG's. The experimental area was calibrated for 3D analysis and later movement simulations. Coordinates of markers were obtained from video records. These data led to computations of other geometric and kinematic parameters of horse-rider movement.

Video analysis provides the visual information on horse walking phases and quantification of the rider's trunk motion. Both of these are being passed to create a correlation between rider trunk motion and EMG signal from trunk stabilising.

3. Results and discussion

This experiment shows rider's movement as reaction to horse-back motion. Axial motion can be characterised as waving originating in low back and spreading upwards. The time period of one whole wave is 0.8 s and frequency is 1.25 Hz.

The lumbar part of the spine is moving slightly to the right side at the beginning of the step phase of horse walk. Moreover, on the upper part of the spine the rider is slightly bending to the right side. During this phase, the horse is in the foothold of both pectoral limbs and left hindlimb, is stepping onto the right hindlimb and the trunk is moving to the right side. These movements are distinct in the reaction of rider's trunk on the movement of horse trunk.] Increased activity was providing this phase only on left-side lateral stabilising muscles. It corresponds to their active correction of right-side shift.

During the next phase, the upper part of the spine is still moving to the right side and the lumbar part to the left side. Generally, rider's lateral flexion occurs on the right side. The horse has moved to diagonal foothold of left pectoral and right hindlimb, and the horse trunk is being shifted to the left side. Rider's lumbar spine follows the movement of horse's trunk. On the contrary, the upper shift part of the spine can be explained as a compensating movement to the shift of lumbar spine.

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In the following time period, the lumbar spine reaches maximum of left-side shift and the upper part of the spine reaches maximum of right-side shift simultaneously. The horse stays on diagonal foothold of the left pectoral and the right hindlimb lifts the left hindlimb. The foothold of the main two same-side limbs changes to the diagonal. This movement has markedly increased the activity of left-side lateral stability muscles and the abdomen muscles.

During the following phase, the upper part of the spine is moving just slightly to the left and the lower part markedly to the right. At the beginning of this shift, the horse stays on the same foothold as during the previous phase and the trunk is moving to the right. At the moment when the right-side shift of the lower part reaches maximum and the horse is already standing on both pectoral limbs and the right hindlimb, the trunk is moved to the right side. This maximal shift of the lower part of the spine to the right side corresponds to the increased activity of the left-side lateral stability muscles.

There are markedly different courses between trajectories of all vertebras in the upper part of the spine and trajectories of vertebras in the lower part. Figure 1 shows that this fact corresponds to the investigated different courses of lateral shift of both upper and lower parts of a spine. Vertebra L5, L1 and Th10 circumscribe during whole horse walk twice ellipse with identical left-right shift – analogy of sinusoid curve. Vertebras C7, C2 and Occiput circumscribe a loop, which describes increase, right-side shift with decrease and return to the original position.

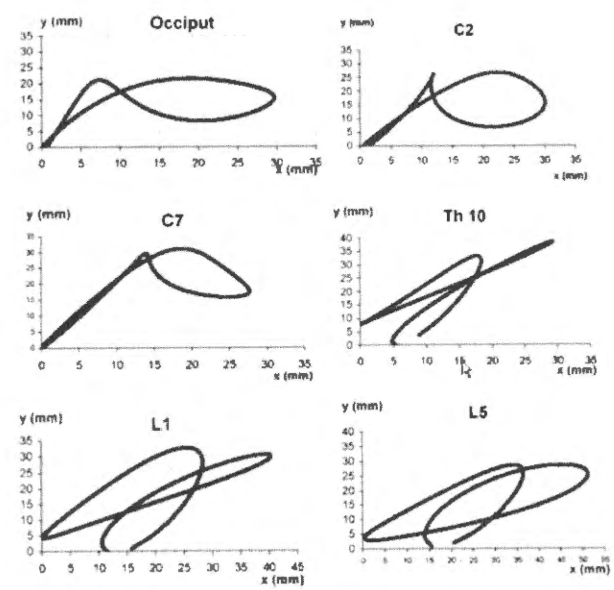

Figure 1. Trajectories of significant points in left–right (x-axis) and vertical (y-axis) directions.

Vertebras L5, L1 and Th10 are in the middle phase of the horse walk moving to the left side and the vertebras C7, C2 and Occiput moving slightly to the right side. The difference between maximal and minimal distance of C2 and L5 is 7 cm when comparing the left and the right shift. Vertebra Th5 is moving with minimum latero-lateral shift even if with the same character as vertebras C2 and C7. We assume that the middle part of spinal column is threshold in latero-lateral motion between the upper and the lower part of spine.

In this study, surface telemetric EMG is much complicated to interpret, because of its extent of registered electrical frequency and air-through transmission. There is an apparent correlation between backward leaning and rising activity of abdominal muscles as well as lateral leaning and rising activity of contra-lateral trunk stabilising muscles in this experiment.

4. Conclusion

The existence of correlation between the time-dependent muscular activity and the trunk movement of rider in relation to the step phase of horse walk was detected. Trunk movement was represented with anatomical significant points. It is especially concerned with dorso-anterior movement and partly lateral movement. We can characterise this correlation as a reaction of stabilising muscles on opposite lateral escape of rider's trunk which has been generated by movement pulses of the horse trunk.

From this study, it was found that horse's pelvis has the same 3D movement of the human's pelvis at the walk. The vertical movement provides the same attributes for all investigated points while the lateral shift is variable for each point. The side shift of lumbar spine correlates with horse trunk movement. Its course is sinusoid shaped and this curve is completed once during the horse walk cycle. The upper spine is moving with different frequency and range of motion then lower spine. The middle part of the spine creates kind of mid-point of contrary side shifts of the upper and lower spine.

Whole spine movement correlates in vertical plane with the movement of horse trunk while lateral movement can be characterised as waving. This waving originates from horse-back motion during horse walk and is transmitted upwards to the upper parts of the spine.

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References

Benda W, McGibbon NH, Grant L. 2003. Improvements in muscle symmetry in children with cerebral palsy after equine-assisted therapy (Hippotherapy). J Altern Complem Med. 9:817–825.

Casady RL, Nichols-Larsen DS. 2004. The effect of hippotherapy on ten children with cerebral palsy. Pediatr Phys Ther. 16:165–172.

De Luca CJ. 1997. The use of surface electromyography in biomechanics. J Appl Biomech. 13:135–163.

Lechner HE, Feldhaus S, Gudmundsen L, Hegemann D, Zäch GA, Knecht H. 2003. The short term effect of hippotherapy on spasticity in patients with spinal cord injury. Spinal Cord. 41:502–505.