

In Vivo Segmental Kinematics of the Thoracolumbar Spinal Region in Horses and Effects of Chiropractic Manipulations

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In vivo segmental kinematics of the thoracolumbar spinal region vary in amplitude, direction and patterns of motion during different gaits. Direct measures of chiropractic adjustments demonstrate substantial induced segmental spinal motion in horses, usually beyond the normal range of segmental motion that occurs during locomotion. Future studies need to evaluate the long-term effects of chiropractic techniques in veterinary medicine. Authors' address: Dept. of Biomedical Sciences, NYS College of Veterinary Medicine, Cornell University, Ithaca, NY 14853-6401. © 1999 AAEP.

1. Introduction

Understanding the three-dimensional motion characteristics of the spine is important for clinical evaluation and investigating the pathophysiology of altered motion associated with back pain and spinal disorders. In horses, the thoracolumbar spinal region is often overlooked during lameness evaluation due to subtle or poorly localized injuries. Disorders of the equine thoracolumbar spinal region have been characterized as causing reduced performance, without objective measures of dysfunction.¹ Therefore, controversy exists about the function and perceived lack of motion of the equine thoracolumbar spinal region.

Currently, there are no reported measures of direct *in vivo* segmental spinal kinematics in horses. However, a few recent studies have investigated regional spinal kinematics in either standing² or trotting horses.³ Prior studies in humans⁴ and canines⁵ have evaluated *in vivo* segmental spinal kine-

tics with transducers attached to implanted Steinmann pins in the dorsal spinous process.

There is a need for objective evaluation of segmental spinal kinematics to further our understanding of the complex interactions present in the equine spine. The purpose of this study is to describe *in vivo* segmental kinematics of the thoracolumbar spinal region in locomoting horses. Additionally, chiropractic manipulations were applied to instrumented vertebrae to quantify induced segmental spinal motion.

2. Materials and Methods

Segmental spinal kinematics were recorded for three horses that were clinically sound and did not have a known history of a back problem. A spinal transducer consisting of two fixtures and an array of liquid metal strain gauges (LMSGs) was directly attached to Steinmann pins implanted in the dorsal spinous processes of two adjacent vertebrae in three

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different spinal regions (T14 to T16, L1 to L3, and L5 to S2). The vertebral location and placement of the Steinmann pins were confirmed radiographically. The horses were treated with antibiotics and analgesics as indicated.

Active and temperature-compensating LMSGs were incorporated into individual balanced Wheatstone bridge circuits. Six active LMSGs were attached to the fixtures to optimally detect three-dimensional segmental spinal motion. Calibration procedures utilized *ex vivo* spinal segments as anatomically proportionate calibrating devices. Calibration of the spinal transducer required application of three known, independent displacements (5° of flexion, 5° of right lateral bending, and 5° of right axial rotation). Matrix algebra was used to calculate rotational displacements from the acquired LMSG voltages. Back calculations were performed on the calibration data files to confirm matrix conversion accuracy. The voltage outputs of the six active LMSGs were multiplexed at 1800 Hz (i.e., sampling rate of 300 Hz per channel) for 3- to 6-s intervals. Peak amplitudes of dorsoventral flexion, lateral bending and axial rotation were recorded for each stride during a walk, trot and canter on a treadmill. Peak amplitudes were averaged for 6 to 13 strides during each gait. In two horses, similar recordings were made during chiropractic manipulations (i.e., manually applied, high-velocity, low-amplitude forces) that were applied to the instrumented vertebrae (e.g., directed lateromedial toward the spinous processes or dorsoventral toward the articular processes) while the horses were standing quietly.

3. Results

The apparent resolution of the spinal transducer (i.e., the smallest angular rotation distinguishable from electrical noise) was 0.07° of dorsoventral flexion, 0.46° of lateral bending, and 0.56° of axial rotation. The largest motion of the three instrumented spinal segments was at the lumbosacral junction (Table 1). In general, the greatest amount of segmental spinal motion occurred during the canter and the least during the trot. At the canter, L5 to S1 segmental motion was 5.2° ± 0.6° of dorsoventral flexion, 4.6° ± 0.5° of lateral bending, and 5.0° ± 0.9° of axial rotation. Bimodal spinal motion was noted for each stride of the walk and trot. Chiropractic manipulations applied to the instrumented vertebrae induced substantial segmental spinal motion (Table 2). At the L6–S1 spinal segments, chiropractic manipulations induced 3.0° ± 1.2° of dorsoventral flexion, 2.7° ± 0.4° of lateral bending, and 2.7° ± 0.5° of axial rotation.

4. Discussion

Locomotion and spinal motion were not visibly affected by the weight or resistance of the spinal transducers when viewed pre- and postspinal instrumentation. The spinal transducer attachment to the dorsal spinous processes was minimally invasive

Table 1. Peak Amplitudes of Spinal Motion at Three Spinal Segments During Normal Locomotion. (percentage of maximal spinal motion at each segment).

Segments	Dorsoventral Flexion	Lateral Bending	Axial Rotation
Walk			
T14–T16	77	94	100
L1–L3	50	100	62
L5–S1	42	72	68
Trot			
T14–T16	70	81	62
L1–L3	30	100	50
L5–S1	46	80	88
Canter			
T14–T16	100	100	81
L1–L3	100	88	100
L5–S1	100	100	100

and allowed direct measurement of segmental spinal motion. Based on clinical observations pre- and post-pin placement and other reports,^{4,5} it appears that spinous process pins are well-tolerated and do not induce clinical lameness.

The largest amount of segmental motion was recorded at the lumbosacral junction, as anticipated. However, the presence of considerable lateral bending and axial rotation at the lumbosacral junction was not expected, based on known articular features. Segmental spinal motion characteristics induced during chiropractic manipulations in horses are similar to those reported in humans.⁶ Direct measures of chiropractic manipulations demonstrate substantial induced segmental spinal motion in horses, usually beyond the normal range of segmental motion that occurs during locomotion. The induced spinal motion supports current theories on the effects of chiropractic manipulations on joint physiology. Future studies need to evaluate the long term mechanical and neurophysiologic effects of chiropractic techniques in veterinary medicine. Knowledge of normal segmental spinal motion and response to manual therapies will further our understanding of the pathophysiology, clinical diagnosis, and treatment of back problems in horses.

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Table 2. Peak Amplitudes of Spinal Motion at Three Spinal Segments During Chiropractic Manipulations. (percentage of average spinal motion at each segment during a walk).

Site of Contact	Segments Measured	Dorsoventral Flexion	Lateral Bending	Axial Rotation
T16	T14–T16	140	227	69
L3	L1–L3	220	138	180
L6	L5–S1	136	82	79
S5	L5–S1	123	70	59

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