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Chapter 7

Effect of chiropractic manipulations on the kinematics of back and limb in horses with clinically diagnosed back problems

Under revision

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Summary

Reasons for performing the study: Chiropractic treatment is one of the most commonly used therapies for the treatment of back pain in horses. Although there is anecdotal evidence of clinical effectiveness, little scientific work has been done on the subject.

Objectives: To quantify the effect of chiropractic manipulations on back and limb kinematics in horse locomotion.

Methods: Kinematics of 10 Warmblood horses was measured over-ground at walk and trot at their own, preferred speed before, and 1 hour and 3 weeks after chiropractic treatment that consisted of manipulations of the back, neck and pelvic area. Speed was the same during all measurements for each horse.

Results: Chiropractic manipulations resulted in increased flexion-extension range of motion (ROM) ($p<0.05$) at trot in the vertebral angular segments: T10-T13-T17 (0.3°) and T13-T17-L1 (0.8°) 1 hour after treatment, but decreased ROM after three weeks. The angular motion patterns (AMPs) of the same segments showed increased flexion at both gaits 1 hour after treatment (both angles 0.2° at walk and 0.3° at trot, $p<0.05$) and 3 weeks after treatment (1.0° and 2.4° at walk and 1.9° and 2.9° at trot, $p<0.05$). The lumbar (L3 and L5) area showed increased flexion after 1 hour (both angles 0.3° at walk and 0.4° at trot, $p<0.05$) but increased extension after 3 weeks (1.4° and 1.2°, at trot only, $p<0.05$). There were no detectable changes in lateral bending AMPs. The inclination of the pelvis was reduced at trot 1 hour (1.6°) and 3 weeks (3°) after treatment ($p<0.05$). The mean axial rotation of the pelvis was more symmetrical 3 weeks after the treatment at both gaits (1.4±6.0° before treatment and 0.1±4.7° after 3 weeks at walk; and 1.6±3.1° before treatment and -0.3±3.4° after 3 weeks at trot, $p<0.05$). At trot, the protraction of the forelimbs was decreased by 4.8° and 4.4° (right and left respectively) 1 hour after the treatment, and 4.7° (right) after 3 weeks. One hour after treatment the protraction of the hindlimbs was decreased by 5.9° and 6.0° (right and left, respectively) and the retraction by 5.3° and 5.5° (right and left, respectively); after 3 weeks, changes were only found on the left side (protraction reduced by 3.6° and retraction by 3.1° at trot). There were no changes in limb angles at walk and almost no changes at trot ($p>0.05$).

Conclusions: The main overall effect of the chiropractic manipulations was a less extended thoracic back, a reduced inclination of the pelvis, improvement of the symmetry of the pelvic motion pattern and a more physiologic reduced maximal protraction and maximal retraction.

Potential relevance:
Chiropractic manipulations elicit slight but significant changes in thoracolumbar and pelvic kinematics. These changes are likely to be beneficial, but clinical trials with increased number of horses and longer follow-up are needed to determine clinical effectiveness unequivocally.

Keywords: Back kinematics, limb kinematics, horses, chiropractic treatment, back pain, back problems.

Introduction

Back problems or alleged back problems are not a new phenomenon in horses (Lupton 1876), but they certainly are reported more frequently nowadays (Ross and Dyson 2003). Whether this apparent increase in incidence is due to the changes in the use of horses over the past decades, or in fact is biased because of a better awareness within the equine community of the existence of back problems is unclear, but it is a fact that the present-day equine orthopaedic practitioner is often confronted by these challenging cases. Equine back patients are difficult patients in both a diagnostic and therapeutic sense because of the relative inaccessibility of the huge structures that make up the equine back and the lack of objective criteria that can be used to define back movement and monitor the effect of interventions. These conditions, and the lack of responsiveness of many back patients to traditional medication-based treatments alone, have fomented the application of many alternative remedies and integrative treatments in equine back patients.

Among the more frequently used complementary therapies are various techniques that rely on direct or indirect manual manipulation of segments of the equine spine. Chiropractic manipulations, which is defined as a high-velocity, low-amplitude (HVLA) manual thrust (Haussler 1999), is one of the most commonly used techniques. Chiropractic treatment aims at the resolution of musculoskeletal disorders that are induced by biomechanical factors. The benefits that are claimed for the chiropractic treatment of equine back disorders include improvement of the vertebral symmetry by restoring normal joint motion in one or more planes (reversing hypermobility or hypomobility), restoring normal pain sensation (by inhibition or facilitation), and improving altered (muscle, connective, vascular) tissue function (Haussler, 1999). The effectiveness of chiropractic manipulations has been widely documented in human medicine (Eisenberg *et al.* 2007; Gaumer

2006; Hurwitz *et al.* 2006; Leaver *et al.* 2007). Although there is abundant anecdotal clinical evidence on the effectiveness of chiropractic techniques in horses, the scientific research in this area has been limited to studies using relatively few horses (Haussler *et al.* 1999) , or only a single case in which another form of manipulative technique was used (Faber *et al.* 2003).

The close relationship between back and limb function has been investigated in some field studies. Landman *et al.* (2004) found lameness and concomitant back pain in 26% of the horses from a population of 805 patients that were presented with orthopaedic problems, and Dyson (2005) observed concurrent forelimb and hindlimb lameness in 46% of horses with thoracolumbar or sacroiliacal pain. Recent experimental studies into this field showed the intricate link between back and limb kinematics. Artificial induction of reversible back pain by the injection of lactic acid did not lead to changes in temporal or linear stride characteristics in either trotters (Jeffcott *et al.* 1982) or Warmbloods (Gómez Álvarez *et al.* 2007c), but it caused statistically significant changes in both back kinematics (Wennerstrand, unpublished results) and in angular limb kinematics (Gómez Álvarez *et al.* 2007c). In a reverse sense, induction of even a very subtle lameness in either forelimbs or hindlimbs had a statistically significant effect on thoracolumbar kinematics (Gómez Álvarez, 2007a, b), giving support to the clinical impression that chronic subclinical lameness may be implicated in the pathogenesis of back dysfunction. Because of the intricate relationship between back and limb function, attempts to quantify the effect of any proposed treatment for back disorders should ideally try to asses the effects on both thoracolumbar and limb kinematics.

The present study aims at the quantitative assessment of the effect of chiropractic manipulations on back and limb kinematics. The hypothesis to be tested was that chiropractic manipulations will affect both thoracolumbar and limb kinematics in the sense that they improve vertebral movement and enhances symmetry of pelvic motion in horses with back problems, thus altering the motion pattern towards a more normal [and symmetrical] pattern. For this purpose, we determined the kinematics of the vertebral column and the limbs in back pain patients at walk and trot before and after chiropractic manipulations.

Materials and Methods

Horses

The patient population consisted of 10 Warmblood horses (12.8±6.3 years of age, height at the withers 1.69±0.05 cm, and body mass of 640±53.3 kg). These horses were selected from horses presented for various reasons to a three-person veterinary practice located in Northern Germany, specialised in, and performing only, equine chiropractic manipulations (n=6), and from horses used by the Dutch Veterinary Student Riding Association (n=4). Both groups were treated and measured in their respective location. All horses underwent clinical and chiropractic examinations by a qualified veterinarian with formal training in equine chiropractic techniques. Horses were selected on the presence of signs of back pain and/or dysfunction, and the absence of lameness. The animals included in the study were those considered to have greater than normal sensitivity over the thoracolumbar region upon examination (Table 7.1). Such horses can be described as typically “sore-backed” horses seen by veterinary chiropractors on a regular basis. Patients with signs of lameness or considered as having a very poor prognosis, regardless of the therapy chosen, were excluded. The Committee on the Ethics of Animal Experiments of Utrecht University had approved the experimental protocol.

Chiropractic manipulations

The chiropractic techniques employed in this study are based originally on those widely used in human chiropractics, which have been adapted to the equine anatomy over the past twenty years. Following a chiropractic examination assessing joint motion of the entire body, the treatment consists of high velocity, low amplitude (HVLA) thrusts, directed at very specific directions, in accordance with the anatomy of the joint(s) being treated. These manipulations, or “adjustments”, are intended to restore the normal range of motion of the joints. The techniques are those used by the majority of veterinarians in both Europe and North America who have received formal training and are practicing veterinary chiropractic manipulation techniques. These are the techniques promoted and recognised by both the International Veterinary Chiropractic Association (IVCA) and the American Veterinary Chiropractic Association (AVCA). All treatments were performed by one of two qualified veterinarians. After the treatment, horses were hand-walked for around 10 minutes.

Table 7.1. Description of the vertebral and pelvic chiropractic findings in 10 patients with back pain/dysfunction included in this study. FE: flexion-extension; LB: lateral bending; C: cervical; T: thoracic; L: lumbar; SI: sacroiliac; I: ilium, TM: temporo-mandibular; *r*: right; *l*: left; *s*: superior; *p*: posterior. Pain/sensitivity scale (1-5): 5 is higher score of pain. Motion scale (1-5): 5 is bigger motion.

Patient	Pain/sensitivity (1-5) and location	Motion (1-5) and location	Location of spinal segmental dysfunction	Location of other relevant dysfunctions/ subluxations
1	1 in the whole back bilateral	FE 1 and LB 2 from T18-L4	C1 *rs*, C2 *p*, C4 *rp*, C4-5 *l*, T9-16 *d*, L1-4 *d.*	Both SI joints
2	2.5 in T10-L4 bilateral	3 from T10-L4.	C1 *rs*, C2 *p*, C4 *r*, T5-8 *l*, T12-14 *ld*, L3-6 *d*.	Asymmetric motion of the pelvis. Right SI joint. TM joint.
3	3.5 T13-T17 bilateral	3.5 T13-L4	C4 *r*, T7 *l*, L1 *d*, L2 *d*.	Bilateral pain in the costo-vertebral joints. SI right side.
4	2 in the whole back bilateral	2 in the whole back	C1 *ls*, C5 *l*, T16-18 *ld*, L3-4 *rd,* L5 *d*.	Right SI joint. TM joint.
5	2 in the whole back bilateral	2 in the whole back	C6 *l*, T10 *d*, L5-6 *lr*.	Right SI joint
6	1 in the whole back bilateral	4 in the whole back	C1 *rp*, C3 *l*, T18 *d*, L2 *ld,* L3-4 *rd*.	Back extremely bent to the left. Left SI joint. TM joint.
7	3 from T7-12 bilateral	5 in the thoracic back	C1 *lp,* C3 *l,* T6-11 *l,* T16 *l,* L2-5 *d*.	Caudal extreme of sacral bone more to the left.
8	2.5 T10-L5 bilateral	4 in the neck from C1 to C5 bilateral	C1 *rp,* C2 *p,* C3 *l,* C5 *r*, T1-9 *l*, T15-17 *rd,* T17-L5 *d*.	Kyphosis L1-5. Epaxial muscle atrophy T10-L4 bilateral.
9	1 in the whole back bilateral	5 in the whole back	C1 *rp ls*, C4 *l*, T8 *l*, T13-14 *d*, T16-17 *ld*, L2-3 *ld*, L5 *rd*.	Short stride length right hindlimb. Right SI joint.
10	4 from T16-17 bilateral	3 in the whole back	C1 *rp*, T8 *l*, T16-17 *rd*, L3 *d*.	Right SI joint. Caudal extreme of sacral bone more to the left.

Data collection

Kinematic measurements were performed with the horses walking and trotting over-ground. The surface consisted of either tarmac or gravel, depending upon the location. Measurements were done before the treatment, immediately after and 3 weeks after the treatment for short-term and long-term assessments. Markers placement was documented by photography and written description for each horse in order to accurately asses the same locations between measurements. The effects of the chiropractic interventions were assesed by kinematic measurements and by subjective reports of the owners/trainers, based on the athletic performance of the horses and on other observations. For the kinematic data collection the infrared-based ProReflex® automated gait analysis system[1] was used at 240 Hz. Spherical infrared light reflective markers with a diameter of 19 mm were glued to the skin over the spinous processes of thoracic vertebrae 6, 10, 13 and 17 (T6, T10, T13, T17), the lumbar vertebrae 1, 3 and 5 (L1, L3, L5), the 3rd sacral vertebra (S3) and left and right sacral tuberosities. Markers were also placed on the lateral side of the left limbs on the centres of rotation of the shoulder, elbow, carpal, hip, stifle, hock and fetlock joints; and on the left coxal tuberosity. Markers were also placed on the medial side of the right hooves and on the left wing of the atlas (Fig. 7.1). Six infrared cameras situated at one side of the track recorded the marker locations while the horses were standing square and at walk and trot. Recordings were made at the individual horse's preferred speed. Speed was calculated from the distance covered and the time required recorded with a laser chronometer. Recordings were repeated until obtaining the same speed for a given individual horse.

Subjective evaluation

Questionnaires were given to the owners/riders to obtain information about their observations of the horses before and after the treatment. The questions were divided over 5 sections: general, back, head and neck, limbs and attitude. Pain and motion were described using a semi-quantitative scale of 1 to 5, with 5 being the most painful or the biggest motion.

Data analysis

Qualisys Track Manager Software[1] was used to capture and process the data and Matlab®[2] for further analyses. A standard right-handed orthogonal Cartesian coordinate system was used to describe the motions. Vertebral motion was described as flexion-extension (in the sagittal plane), lateral bending (in the horizontal plane), and axial rotation of the pelvis (in the transversal plane). All the vertebral movements were calculated using Backkin® [1] and presented as angular motion patterns (AMP) during the stride cycle. The range of motion (ROM) was calculated for each AMP and was defined as the difference between maximal and minimal values of the AMP. Data captured in the square standing horse were used to determine the zero (reference) value in the AMPs in each horse. The vertebral angles were defined as the angle between three adjacent marked vertebrae (e.g., the angle at T10 is the angle between the line from T6 to T10 and the line from T10 to T13). The beginning of each stride cycle was taken to be the initial ground contact of the left hindlimb. The angles calculated in the left limbs were for the shoulder, elbow, carpal, hip, stifle, hock and fetlock joints. Pelvic inclination was calculated with the markers on the left hip and left coxal tuberosity. Pelvic axial rotation was calculated with the markers on the left and right sacral tuberosity and S3. For the graphical representation of pelvic axial rotation, the linear trend in each curve was determined and represented by straight line as the relative position in the stride cycle of the intersection of this line with the zero axis is an indication of symmetry of movement. The neck angle was calculated as the angle between the markers on T6 and atlas and the horizontal plane. Stride length was calculated from the marker on the left hind hoof. Protraction-retraction angles were calculated for the limbs using the markers on the hooves and T6 for the forelimbs, and the hooves and S3 for the hindlimbs.

Statistical analysis

The distribution of values for kinematic variables was tested for normality. If normally distributed, analysis was carried out using ANOVA for repeated measures and a Bonferroni correction. If data were not normally distributed a Wilcoxon signed rank test was used. The level of significance was set at $p<0.05$.

Results

Chiropractic manipulations

The chiropractic manipulations were all carried out to the satisfaction of the treating veterinarian in all horses, with no signs of distress or any other adverse side-effects noted in any of the treated animals.

Subjective evaluation

The veterinarian evaluated the treatment results as effective for each horse, based on his assessment of spinal mobility at the conclusion of the treatment. According to the opinion of the owners/riders of the treated horses expressed on questionnaire, the horses varied in their reactions to the treatment, *i.e.* after the treatment five horses had no back or neck pain anymore, or sensitivity had decreased considerably. Five horses had a better motion of the back or neck; five were reported to have a longer and easier stride length; three horses were described as “feeling happier and more relaxed”. Three horses showed temporary (from day 2 to day 10 after the treatment) muscle pain in the back and two horses showed slight lameness, but these two horses were at the same time described as having less back pain and better back motion. Most of the effects were still reported after 3 weeks. None of the horses were reported to show any sign of stress in the period between measurements.

Speeds

There were no statistical differences between the speeds selected for the horses. The averaged speed for all horses was 1.5±0.1 meters per second (m/s) at walk and 3.4±0.3 m/s at trot.

Stride parameters

There were no significant changes in stride duration or stride length at any gait (Tables 7.2 and 7.3).

Protraction-retraction angles

There were no changes in protraction and retraction angles at walk. At trot, maximal protraction and maximal retraction were reduced in the hindlimbs 1 hour after the treatment. Only in the left hindlimb this was still the case after 3 weeks. Also at trot, maximal protraction was reduced in the forelimbs 1 hour after the treatment, which was only in the right forelimb still present after 3 weeks (Tables 7.2 and 7.3).

Neck angle

There were no changes in the neck angle at any gait (Tables 7.2 and 7.3).

Limb kinematics

There were no changes in angular limb kinematics at walk and the changes were minimal at trot. The hip was 2.9 degrees more flexed during the swing phase 3 weeks after the treatment. The minimal vertical distance between the elbow and the hoof decreased 2.8 cm during the swing phase at trot indicating greater limb flexion.

Table 7.2. Range of motion (ROM) and angular motion pattern (AMP) values (mean ± SD, degrees) of vertebral and pelvic angles; mean ± SD of neck angle (degrees), stride length (meters) and stride duration (seconds); and protraction-retraction angles ROM, maximal protraction and maximal retraction (degrees) in horses with back pain before and after treatment with chiropractic manipulations at walk.

Motion			Before treatment	1 hour after treatment	3 weeks after treatment
Flexion-extension	T10	AMP ROM	0.6±1.6 6.0±1.5	0.7±2.1 6.3±1.9	1.5±2.3 6.0±1.2
	T13	AMP ROM	-3.2±1.3* 7.8±1.8	-3.0±0.9* 7.7±1.6	-2.2±3.6* 7.8±1.0
	T17	AMP ROM	-3.1±1.2* 8.0±1.6	-2.9±1.1* 7.8±1.4	-0.5±2.2* 7.9±1.0
	L1	AMP ROM	-2.9±1.2 7.8±1.4	-2.5±1.3 7.8±1.1	-2.6±1.6 7.8±1.2
	L3	AMP ROM	-3.0±1.2* 7.7±1.4	-2.7±1.3* 7.4±1.2	-3.5±2.1 7.3±1.3
	L5	AMP ROM	-1.3±1.2* 6.4±1.1	-1.0±0.8* 6.4±1.5	-1.9±2.6 6.2±0.9
Lateral bending	T10	AMP ROM	3.9±4.8 9.3±3.3	2.7±4.8 10.0±2.9	2.5±3.5 8.8±1.9
	T13	AMP ROM	1.7±5.5 5.3±0.9*	1.2±4.6 5.1±1.1	1.2±2.0 4.2±1.2*
	T17	AMP ROM	1.4±5.3 4.3±0.7*	-0.9±6.2 4.0±1.3	-0.8±3.3 3.3±0.6*
	L1	AMP ROM	-0.9±5.5 5.6±1.2	-0.7±5.9 5.2±1.3	-0.6±5.1 5.8±0.7
	L3	AMP ROM	-1.7±6.5 6.0±1.8	-1.4±5.3 6.0±1.8	-1.3±5.2 6.7±1.7
	L5	AMP ROM	-0.9±7.4 7.2±2.1	-1.8±6.2 6.1±1.8	-1.5±6.3 6.9±1.7
Pelvic inclination	Coxal tuberosity-hip	AMP ROM	31.6±2.5 8.5±3.5	29.1±1.9 6.7±5.4	30.8±1.9 6.9±5.4
Pelvic axial rotation	Sacral tuberosities	AMP ROM	1.4±6.0* 18.2±4.2	0.6±3.5 18.0±2.4	0.1±4.7* 17.0±3.1
Neck angle		AMP	84.6±2.0	83.1±1.0	83.5±1.5

Stride length		1.8±0.2	1.8±0.2	1.9±0.1
Stride duration		1.2±0.1	1.2±0.1	1.2±0.1
Protraction-retraction angles	Right hindlimb max protraction max retraction ROM	 14.0 -22.1 36.0±12.3	 9.0 -15.8 19.4±9.9	 10.0 -16.7 26.7±10.0
	Left hindlimb max protraction max retraction ROM	 14.0 -21.3 35.3±11.4	 10.9 -14.5 25.4±10.3	 9.7 -17.2 26.9±9.4
	Right forelimb max protraction max retraction ROM	 12.5 -22.4 34.9±10.1	 7.6 -18.5 26.1±13.3	 7.6 -19.0 26.5±12.4
	Left forelimb max protraction max retraction ROM	 12.0 -22.7 34.7±11.8	 10.1 -16.0 26.1±12.7	 8.9 -17.5 26.4±11.0

* Statistically significant differences between before and after first and/or second treatment.

Table 7.3. Range of motion (ROM) and angular motion pattern (AMP) values (mean ± SD, degrees) of vertebral and pelvic angles; mean ± SD of neck angle (degrees), stride length (meters) and stride duration (seconds); and protraction-retraction angles ROM, maximal protraction and maximal retraction (degrees) in horses with back pain before and after treatment with chiropractic manipulations at trot.

Motion			Before treatment	1 hour after treatment	3 weeks after treatment
Flexion-extension	T10	AMP	1.8±1.9	1.6±1.8	3.0±2.2
		ROM	4.2±1.4	3.9±1.2	3.6±0.9
	T13	AMP	-2.0±1.4*	-1.7±1.6	-0.1±4.0*
		ROM	2.8±0.5*	3.1±0.2*	2.5±0.7*
	T17	AMP	-2.0±0.8*	-1.7±0.2*	0.9±1.8*
		ROM	2.4±0.4*	3.1±0.3*	2.2±0.8*
	L1	AMP	-1.8±1.3	-1.7±1.1	-2.5±1.5
		ROM	3.0±0.5	3.6±1.5	3.1±0.7
	L3	AMP	-2.4±1.8*	-2.0±1.*	-3.8±1.5*
		ROM	4.0±1.5	3.9±1.6	4.2±0.6
	L5	AMP	-2.3±1.3*	-1.9±0.8*	-3.5±2.0*
		ROM	3.8±1.0	3.1±1.3	3.2±0.3
Lateral bending	T10	AMP	2.7±2.3	1.9±2.2	1.9±2.1
		ROM	5.8±2.0	6.3±2.0	6.5±2.9
	T13	AMP	1.9±5.2	1.6±3.7	1.7±2.9
		ROM	4.7±1.7	4.5±2.2	4.7±1.1
	T17	AMP	-1.9±4.2	0.3±1.6	0.4±1.7
		ROM	5.3±2.3	4.2±0.9	4.4±0.8
	L1	AMP	-0.9±3.2	-0.4±2.6	-0.7±3.9
		ROM	5.1±0.8	4.8±1.5	4.6±1.9
	L3	AMP	-0.9±4.5	-0.7±3.0	-0.7±2.9
		ROM	5.3±2.3*	5.8±2.3*	4.7±1.7
	L5	AMP	-2.1±6.0	-1.3±5.2	-1.5±6.0
		ROM	5.1±3.3	5.1±2.6	3.8±2.0
Pelvic inclination	Coxal tuberosity-hip	AMP	31.8±2.1*	30.2±1.2*	28.8±1.5*
		ROM	7.4±4.9	4.4±4.8	5.2±4.7
Pelvic axial rotation	Sacral tuberosities	AMP	1.6±3.1*	1.8±3.2	-0.3±3.4*
		ROM	22.6±3.5	18.5±2.3	17.8±4.0
Neck angle		AMP	80.8±1.4	83.6±0.9	81.1±0.9
Stride length			2.5±0.2	2.4±0.2	2.5±0.1

Stride duration		0.7±0.1	0.7±0.0	0.7±0.0
Protraction-retraction angles	Right hindlimb max protraction max retraction ROM	 10.5* -18.7* 29.2±9.6	 4.6* -13.4* 18.0±6.6	 7.8 -15.3 23.0±8.0
	Left hindlimb max protraction max retraction ROM	 10.9* -18.9* 29.8±8.7	 4.9* -13.4* 18.4±7.3	 7.3* -15.8* 23.2±7.4
	Right forelimb max protraction max retraction ROM	 8.3* -21.4 29.7±9.9	 3.5* -16.7 20.2±9.2	 3.6* -20.0 23.6±8.6
	Left forelimb max protraction max retraction ROM	 8.8* -20.9 29.7±6.6	 4.4* -15.8 20.2±8.8	 6.3 -9.6 23.4±7.9

* Statistically significant differences between before and after first and/or second treatment.

Vertebral Range of motion

There were no changes in flexion-extension (FE) ROM at walk. At trot the FE ROM was increased at T13 (0.3 degrees) and T17 (0.8 degrees) 1 hour after treatment and it was decreased after three weeks compared with before treatment (0.3 and 0.2 degrees, respectively). The other vertebral angles showed no significant changes in range of motion (Tables 7.2 and 7.3).

Lateral bending ROM was decreased in the angles at T3 and T17 after 3 weeks (1.1 and 1.0 degrees, respectively) at walk. At trot, lateral bending ROM was increased at L3 (0.5 degrees) at trot 1 hour after treatment, but there was no difference after 3 weeks compared to the situation before treatment (Tables 7.2 and 7.3).

No changes were seen in the range of motion axial rotation of the pelvis (Tables 7.2 and 7.3).

Vertebral angular motion patterns (AMPs)

All changes that were observed were present during the entire stride cycle and not only during certain phases of it.

The mean flexion-extension motion of some vertebral angles showed increased flexion at both gaits (Tables 7.2 and 7.3). At walk the segments at T13 and T17 were more flexed (by 0.2 degrees) during the first post-treatment measurement and by 1 and 2.4 degrees respectively during the last measurement. At trot, there was increased flexion at T17 (by 0.3 degrees) 1 hour after treatment; the flexion of the segments at T13 and T17 was, like at walk, increased 3 weeks after treatment by 1.9 and 2.9 degrees, respectively (Fig. 7.2). Also at trot, the segments at L3 and L5 were more flexed both by 0.4 degrees, during the first measurement after treatment, and more extended by 1.4 and 1.2 degrees respectively, during the second measurement after treatment. No changes were observed in the angle at L1 (Tables 7.2 and 7.3).

The mean lateral bending AMPs did not show significant changes at any gait; however the variability, showed in the SD, between horses was large (Tables 7.2 and 7.3).

The pelvic inclination was not affected at walk. At trot, the inclination of the pelvis was decreased 1.6 and 3 degrees 1 hour and 3 weeks after treatment, respectively (Tables 7.2 and 7.3).

There were no significant changes in the mean axial rotation of the pelvis 1 hour after treatment (Fig. 7.3). The AR AMP of the pelvis changed from 1.4 degrees before treatment to 0.1 degrees after 3 weeks at walk and from 1.6 degrees before treatment to -0.3 degrees after 3 weeks at trot, 0 being the mean of a perfectly symmetrical motion (Tables 7.2 and 7.3).

Discussion

All the patients included in this study had some degree of back pain and/or vertebral dysfunction as evidenced by the chiropractic examination. These cases were selected as cases representative of horses with back problems eligible for chiropractic treatment. In other words, the patient group can thus be seen as a good representation of the patient population for which it is claimed that chiropractic treatment can have beneficial effects. The treatment given was considered the most appropriate according to normal chiropractic practice. The treatment was exclusively applied by qualified veterinarians with formal training in equine chiropractic techniques. The chiropractic treatment aimed to restore normal joint motion, and at the improvement of altered neurological and tissue function.

In addition to clinically detectable back, neck or pelvic region pain, the horses in this study before the treatments showed reduced vertebral and pelvic motion compared with the motion of healthy horses described elsewhere (Johnston *et al.* 2004). These findings were similar to another study with horses with naturally occurring back pain, namely diminished flexion-extension range of motion of the thoracolumbar back and diminished axial rotation of the pelvis (Wennerstrand *et al.* 2004). It is known that induced back pain provokes stiffness in the thoracolumbar spine (Jeffcott *et al.* 1982) and this stiffness could become manifest as reduced ROM.

The present study was carried out using over-ground locomotion and not treadmill locomotion, which has been the method of choice in most studies concerning the equine back. It is acknowledged that the use of a treadmill would have reduced the variability in locomotion patterns and would have facilitated the capture of a greater number of strides, thus allowing for more accurate averaging procedures. However, it was the intention to carry out the present project under as much “real-life” clinical conditions as possible, including the selection of a patient population that was representative of the caseload at an equine veterinary chiropractic practice. This approach precluded the use of a treadmill because a reliable and repeatable locomotion pattern on a treadmill in horses not used to the device can only be obtained after various training sessions (Buchner *et al.* 1994) and any such intensive training programme was not feasible in this population of client-owned horses. There is an advantage in the use of over-ground locomotion as well, because horses could now be measured at their own preferred speed whereas on the treadmill they would have had to proceed at a predetermined speed because of the need for standardisation. In this study, the preferred speed of each horse was matched on each measurement because it is known that even minor changes in speed at the same gait may lead to subtle changes in back motion (Robert *et al.* 2001).

The effects of the chiropractic manipulations in this study were minor, but consistent. Range of motion tended to increase directly after treatment, but was decreased 3 weeks later compared with before the treatment; what may possibly have played a role here is the recurrence of back dysfunction. If the underlying cause of the problem was still present and left untreated, chiropractic treatment may just have had a temporary palliative effect. It is also possible that some of the horses would require several treatments at intervals to achieve a longer-term effect, while in this study horses received a single chiropractic treatment. The changes in angular motion patterns pointed at a more flexed back in the mid-thoracic area. This more flexed position had become more exaggerated after 3 weeks, both at walk and at trot. This increased flexion of the thoracic back contrasts with the more extended back observed in horses with induced back pain (Wennerstrand, unpublished results). The overall increased range of motion that was achieved is in agreement with other studies of manipulations in horses (Faber, *et al.* 2003; Haussler *et al.*1999) where it was concluded that manipulations improve segmental spinal motion.

Improvement of symmetry is one of the most important goals of chiropractic care. In this study, the treatment changed pelvic motion making it more symmetrical. This effect lasted at least 3 weeks. It goes without saying that a symmetrical pelvic rotation is one of the hallmarks of good gait and restoration of symmetry of pelvic motion will therefore be beneficial, but it should be realised that small asymmetries in pelvic motion may represent compensation for subtle lameness. If corrected for, the original lameness may become manifest and this may have happened in two of the horses in this study.

The treatment did not have clear effects on the angular motion patterns of the joints of the limbs. However, the protraction of the forelimbs and the retraction of the hindlimbs were reduced. These changes in protraction-retraction will increase back flexion according to the bow-and-string concept of the mammalian back as proposed by Slijper (1946). The changes in pro-retraction angles are interesting because, although it is known that severely and moderately lame horses modify their protraction-retraction patterns in order to unload the painful limb (Buchner *et al.* 1996b), changes in these angles are not distinctive of the locomotion pattern of horses with induced back pain (Jeffcott *et al.* 1982).

The subjective evaluations of the riders or owners were in most of the cases in agreement with the changes observed in the kinematic analyses. They observed decreased pain and improvement of motion (more symmetrical or increased back motion) when riding or exercising unridden still after 3 weeks. At the same time, some horses were noted “happier and moving easier”. These are, of course, highly subjective evaluations. It is generally assumed that there is a large placebo factor in the appreciation of the effects of treatments for back disorders by owners or riders and the reliability of the questionnaire outcome may be doubted. In fact, the longer stride length that was subjectively noted could not be substantiated by the kinematic analysis.

It can be concluded that the chiropractic manipulations had a subtle but statistically significant effect on several variables describing vertebral, pelvic and limb motion. These changes consisted of increased vertebral sagittal motion, increased pelvic rotational symmetry and an overall more flexed thoracic back with changes in protraction and retraction of the limbs. Given the increasing evidence of measurable effects on thoracolumbar and pelvic motion following chiropractic principles, the conclusion seems justified that veterinary equine chiropractic merits consideration as a valid therapy, alone or in conjunction with other methods, in the treatment of equine back problems. Investigations using larger cohorts of patients and having a longer follow-up than in this study are needed to assess the real clinical value of this therapeutic approach and to determine its place within the therapeutic options that are available to the equine practitioner to treat horses suffering from back pain.

Manufacturers’ addresses

[1] Qualisys Medical AB, Gothenburg, Sweden.
[2] Matlab® The MathWorks, Inc. Natick, MA.

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