Kinematics of the Thoracolumbar Spine of the Horse during Dorsoventral Movements: A Preliminary Report

J.-M. DENOIX
Laboratory of researchs INRA in the competitive horse, Ecole Nationale Veterinaire de Lyon, Marcy l'Etoile—B.P. 31, 69752 Charbonnieres Cedex, France.

Introduction

Few biomechanical studies of the dorsoventral movements in the equine thoracolumbar (TL) spine have been performed. Jeffcott and Dalin (1980) concluded that there was very little flexibility in the equine back. Townsend, *et al.* (1983) detected no significant difference in the amounts of dorsoventral movements measured in the intervertebral joints from T2 to L6.

The purpose of the present study was to assess regional TL mobility particularly in relation to the position of the neck and head. The second objective was to establish the position of the instantaneous centers of rotation (ICR) in each TL intervertebral joint during the different dorsoventral movements of the spine. Special attention was given to the types of movement that take place in the intervertebral joints as well as the associated displacements undergone by related structures such as the spinous processes, articular facets, intervertebral foramina and intervertebral discs.

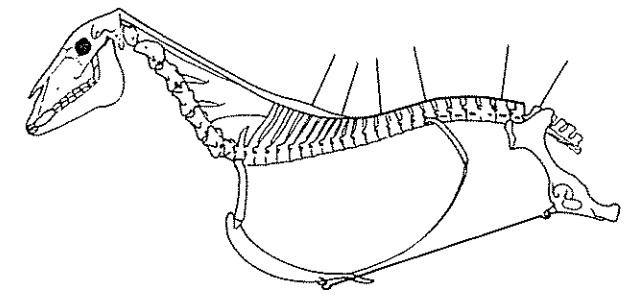
Methods

Measurements were made on five freshly dissected carcasses. Flexion and extension of the TL spine was carried out in two ways (Fig. 1): a) when the cervical spine was held up in extension, the nuchal ligament being slackened and b) when it was lowered in flexion, the nuchal ligament being stretched. The mobility of the different regions of the TL spine was evaluated and the ICR of each intervertebral joint determined from radiographs using both geometric and computerized methods after Gonon *et al.* (1984).

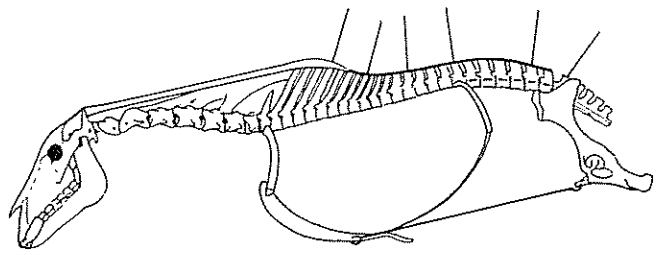
Results

The data obtained on regional mobility revealed several essential points:

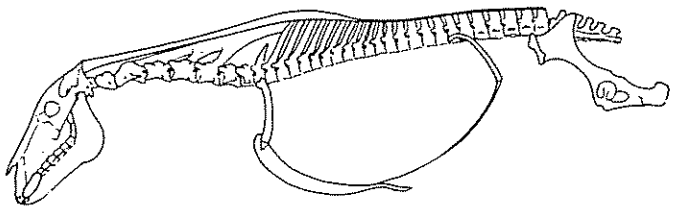
1. In agreement with previous works, the most flexible area of the spine was the lumbosacral joint (Fig. 2). In addition, the present study showed a range of dorsoventral displacements around the TL junction when the flexion forces were applied on the rib cage between the sternum and the pubis.
2. Lowering of the neck, i.e. increasing the tension of the nuchal ligament, provoked flexion in the thoracic spine (Fig. 3).



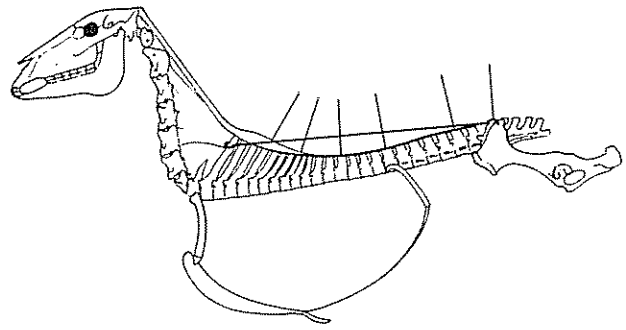
Thoracolumbar flexion



Cervical and thoracolumbar flexion



Cervical flexion



Cervical and thoracolumbar extension

FIGURE 1. Diagrammatic representation of methods used to produce flexion and extension in the thoracolumbar spine.

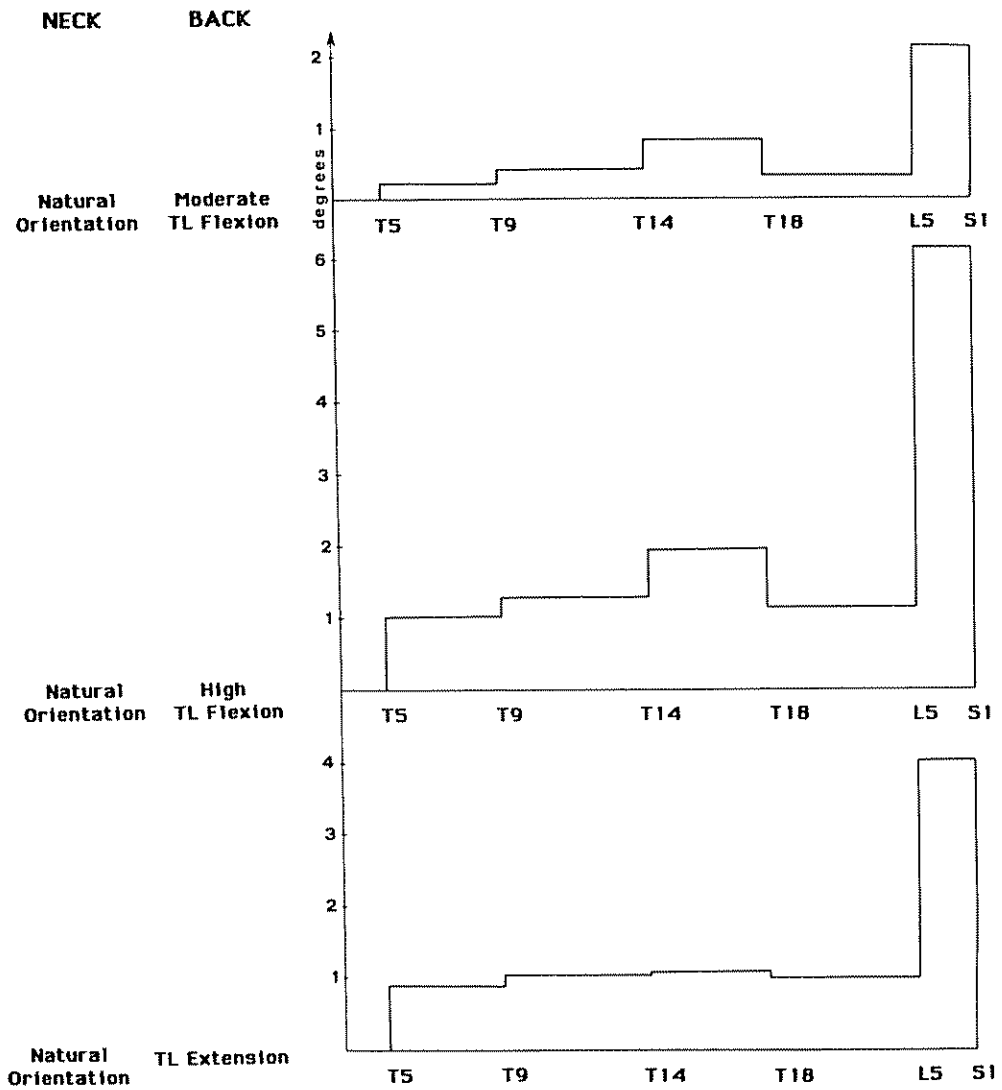


FIGURE 2. Average amount of dorsoventral movement (degrees) in the intervertebral joints of different regions of the thoracolumbar spine. The cervical spine (neck) was held in its natural position while the back was flexed or extended.

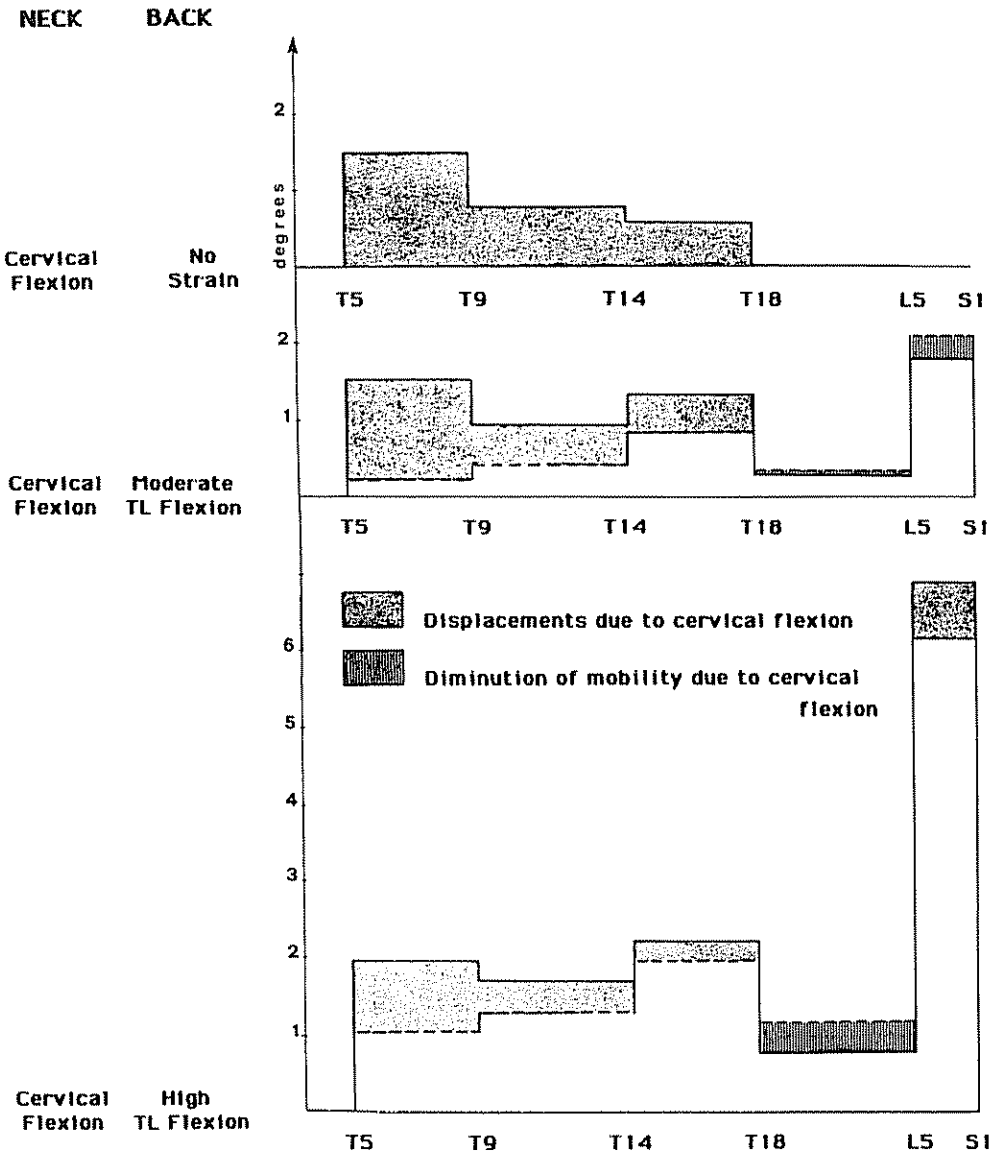


FIGURE 3 Average amount of dorsoventral movement (degrees) in the intervertebral joints of different regions of the thoracolumbar spine. The cervical spine was held flexed while the back was flexed to varying degrees

3. In the latter case, when tension was applied between the pubis and the sternum, flexion of the lumbar spine seemed to decrease and be compensated by a greater lumbosacral participation in flexion.

4 The ICR of each intervertebral joint were situated within or near the adjacent following vertebral body (Fig. 4 and 5). Thus, during flexion, each vertebral body lowered with regard to the following one. The inverse displacement appeared during extension (Fig. 6).

The biomechanical events occurring in the associated structures of an intervertebral joint especially in the articular facets and within the intervertebral disc can be evaluated by these techniques.

Conclusions

This anatomophysiological method used to test vertebral mobility provides some new data about the kinematics of the whole equine vertebral column. These results may

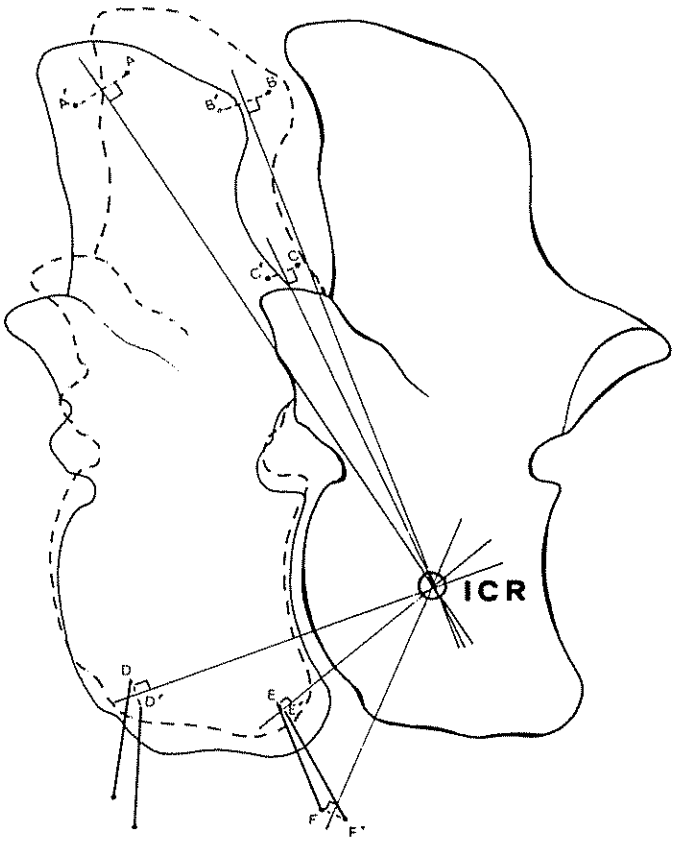


FIGURE 4. Geometric method used to determine the instantaneous center of rotation of the intervertebral joints for each dorsoventral movement of the vertebral column.

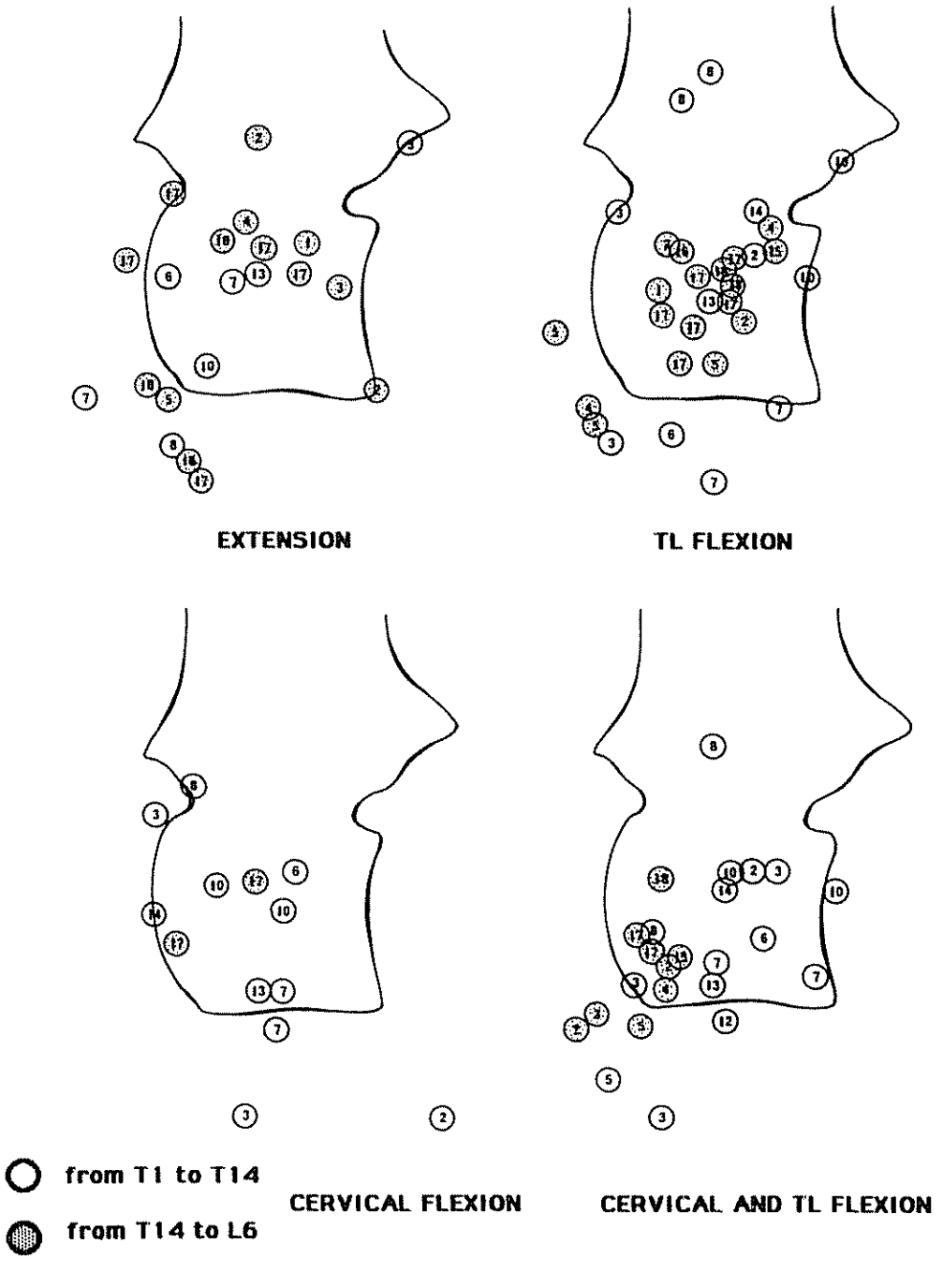


FIGURE 5. Positions of the instantaneous center of rotation of the thoracolumbar (TL) intervertebral joints.

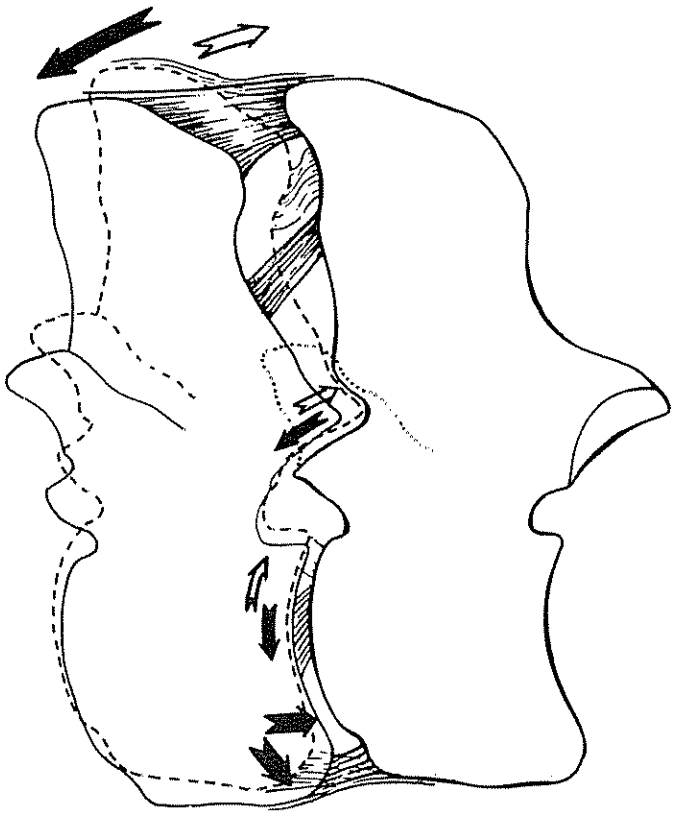


FIGURE 6. The displacements which can occur within an intervertebral joint during dorsoventral movements.

have important applications in horse training and can be related to several diseases of the horse's back.

References

Badoux, D. M. (1975). General biostatics and biomechanics. *In: Sisson and Grossman's The Anatomy of the Domestic Animals*. 5th Ed. Getty R., (ed.), W. B. Saunders & Co., Toronto, pp. 48–83.

Dalin, G. and Jeffcott, L. B. (1986). Sacroiliac joint of the horse 1. Gross morphology. *Anat. Histol. Embryol.* **15**, 80–94.

Denoix, J.-M. (1985). Mécanique du cheval au travail, Videocassette VHS, *Ecole Nationale Vétérinaire*, Lyon.

Denoix, J.-M. (1986). Biomécanique de la colonne vertébrale. Acquisitions récentes. C.R. 12e *Journée d'Etudes Paris*, CEREOPA, 88–106.

Gloobe, H. (1984). Lateral foramina in the equine thoracolumbar vertebral column: An anatomical study, *Equine Vet. J.* **16**, 469–470.

Gonon, G. P., Dimnet, J., Carret, J. P., de Mauroy, J. C., Fischer, L. P. and de Mourgues, G. (1984). Utilité de l'analyse cinématique de radiographies dynamiques dans le diagnostic de certaines affections de la colonne lombaire. *Ann. Kinesitherap.* **11**, 229–247.

Jeffcott, L. B. (1975). The diagnosis of diseases of the horse's back. *Equine Vet. J.* **7**, 69–78.

Jeffcott, L. B. and Dalin, G. (1980). Natural rigidity of the horse's backbone. *Equine Vet. J.* **12**, 101–108.

Jeffcott, L. B. (1980). Disorders of the thoracolumbar spine of the horse. A survey of 443 cases. *Equine Vet. J.* **12**, 197–210.

Rooney, J. R. (1982). The horse's back: Biomechanics of lameness. *Equine Pract.* **4**, 17–27.

Strecher, R. M. (1962). Lateral facets and lateral joints in the lumbar spine of the Horse. A descriptive and statistical study. *Am. J. Vet. Res.* **23**, 939–947.

Townsend, H. G. G., Leach, D. M. and Fretz, P. B. (1983). Kinematics of the Equine thoracolumbar spine. *Equine Vet. J.* **15**, 117–122.

Townsend, H. G. G. and Leach, D. H. (1984). Relationship between intervertebral joint morphology and mobility in the equine thoracolumbar spine. *Equine Vet. J.* **16**, 461–465.

Townsend, H. G. G., Leach, D. H., Doige, C. E. and Kirkaldy-Willis, W. H. (1986). Relationship between spinal biomechanics and pathological changes in the equine thoracolumbar spine. *Equine Vet. J.* **18**, 107–112.

Vanneuville, G., Gaurel, G., Escande, G., Chazal, J., Verge, J. and Guillot, M. (1980). Biomécanique du disque intervertébral. *In: Eléments de biomécanique du Rachis*, 63e Congrés de l'Association des Anatomistes, pp. 136–149.

White, A. A. (1971). Kinematics of the normal spine as related to scoliosis. *J. Biomech.* **4**, 405–411.

White, A. A. and Panjabi, M. M. (1978). The basic kinematics of the human spine. A review of past and current knowledge. *Spine* **3**, 12–20.