The advance of clinical biomechanics

Research about equine locomotion has developed from merely descriptive studies to an integral part of equine medicine and competitive events. During the last 25 years, developments in modern audiovisual and computer technology have enabled major progress to be achieved in the analysis of both athletic locomotion and patterns of pathological deviations. Many aspects of the research catalogue, elaborated by Leach and Crawford (1983), have been successfully completed. Measurement techniques have been newly developed or adapted from human gait laboratories. Conformation and gait patterns of various breeds or sport disciplines have been described in detail and parameters indicative of high performances have been elaborated (Back et al. 1994; Clayton 1994; Holmström et al. 1994; Barrey et al. 1995). Inertial properties have been determined as a basis for kinetic calculation of forces exerted by head and neck, limbs and trunk (Sprigings and Leach 1987; Buchner et al. 1997). Finally, general characteristics of the locomotor pattern of lame horses and their lameness compensation patterns have been described using both kinematic and kinetic methods. The results of this research period have recently been published in a compendium of current knowledge about equine locomotion (Back and Clayton 2000).

Clinical biomechanics, i.e. the use of biomechanic research techniques on various aspects of equine diseases including the study of pathogenesis, objective diagnosis of lameness or evaluation of therapeutic regimens, was always a major branch in equine locomotion research. The kinematic patterns of various orthopaedic ailments have been described (Ratzlaff et al. 1982; Clayton 1986; Girtler 1988), the principles of load redistribution evaluated and lameness indicators identified (Merkens and Schamhardt 1988; Buchner et al. 1996; Peham et al. 1996; Pourcelot et al. 1997). Since an accurate and specific lameness diagnosis is the basis of successful therapy, but often represents a difficult and laborious part of equine orthopaedics, the most ambitious aim of clinical biomechanics in horses might be specific computer diagnosis. The analysis of multiple kinematic or kinetic characteristics should offer specific signs which allow for an early and objective diagnosis to identify a lameness and specify the location and nature of the problem, thereby offering increased opportunity to introduce therapy before the condition deteriorates further and/or avoid compounding it through continued exercise.

At the moment, we are still far from reaching this advanced goal of an automatic computer lameness diagnosis. Several factors contribute to the difficulty of this project. Some general influences on the locomotion pattern of each individual have to be considered before further interpretation of a specific pattern is possible. The speed of the horses influences most stride parameters as well as joint angle patterns, and this factor has to be excluded using treadmills or appropriate correction methods. Skin movement disturbs the assessment of real joint movement and has to be corrected or considered by interpreting only relative joint angle changes. Artefacts or influences of voluntary movements of body segments have to be identified, excluded or avoided by suitable data analysis methods. Head movement has proven to be a very sensitive lameness indicator, but is also very prone to errors due to voluntary movements. Within this issue (p 446), Keegan et al. (2001) present one refined analysis method to exclude such influences and to secure the accuracy of lameness quantification. Such advanced techniques are the basis for a reliable assessment of small gait deviations only after the exclusion of such disturbances, which are filtered subconsciously by the experienced veterinarian during a classical lameness examination.

One factor remains, however, which severely limits the diagnosis of either slight ‘subclinical’ lameness or a specific condition; the high level of individuality in the locomotion pattern of horses. Several studies have shown a very low intra-individual variability for a single horse even between different recording days, allowing the individual joint angle pattern to be described very accurately or even slight left to right asymmetries detected. However, there is a high interindividual variability, revealing a wide range of locomotion patterns even in a group of horses of same breed and use. Each sound horse shows asymmetries provided that it is recorded accurately enough. Such asymmetries can originate from an intra-individual variation during a short recording session; they may represent a laterality (Dreverno et al. 1987; Deuel and Lawrence 1987), a functional asymmetry (Meij and Meij 1980) or a real pathological deviation. There is a grey zone where particular slight asymmetries could be either a characteristic individual locomotion pattern or a sign of small discomfort in a limb, therefore a slight lameness. An accurate kinematic analysis can never make this decision, but makes the problem of distinguishing between sound and lame individuals even more obvious. Therefore, the diagnosis of insidious, ‘subclinical’ lameness that is below the detection level of a experienced veterinarian might be impossible, based only on a single measurement.

Similarly, the differentiation between a particular lameness pattern and the individual locomotion pattern is...
an unsolved problem. Already sound horses show distinct
characteristic motion patterns as specific as fingerprints
(van Weeren et al. 1993). Additionally, lame horses, even
suffering from very similar diseases or syndromes, such as
navicular disease or carpal lameness, show a variety of
different orthopaedic and radiological findings. In 2
studies analysing 7 horses with carpal lameness, 7
different diagnoses were reported (Ratzlaff et al. 1982;
Clayton 1986). Navicular disease may be more uniform,
but the problem may be centred more in the tendon, the
bursa or the coffin joint. Furthermore, in the thorough
study by Girtler (1988), 6 out of 7 horses with navicular
disease had additional problems, such as arthrosis,
tendinitis, sesamoiditis or bone spavin. As this unlimited
number of specific lamenesses interferes with individual
pattern, it is very difficult to extract specific patterns of
orthopaedic diseases. Only a very high number of horses
might enable such a differentiation, but experiences in
human gait studies indicate that the size of a patient group
of similar diagnosis has to be beyond 100 individuals
before their specific pattern could be identified.
Therefore, we have to learn that clinical biomechanics
cannot replace the diagnostic function of the veterinarian
in integrating all aspects of the lameness examination.

However, beside the search for the specific diagnostic
goal, clinical biomechanics offer multiple aids both for
the clinical setting and orthopaedic research.

• The objective documentation of individual locomotion
pattern and lameness degree allows the accurate
assessment of diagnostic anaesthetics or therapeutic
success. Further refinement of both hardware and
software will increase the use and make it cheaper and
more reliable.

• The efficacy of specific therapeutic regimens such as
drugs, shoeing, or surgery can be evaluated, not only
in terms of a change in the locomotion pattern, but
also calculating the effects on internal structures,
tendons or joints, using inverse dynamic analysis. The
integration of both kinematic and kinetic input into the
calculation of internal forces, moments or power
transfers offer new insights into load transfer and the
efficacy of the new therapeutic method.

• An intricate new field of research is the analysis and
modelling of the locomotion of complex structures,
such as the hoof or back. Although highly inaccessible
also for kinematic methods, newly developed
sophisticated measurement devices offer detailed
knowledge on the 3D movement of the spine.
Modelling of spine movement, including the
influences of rider loading, may enable new insights
into back movement and pathology. Similarly, modern
computer capacity and modelling software will
increasingly be used for the prediction of loading
effects on bones or the equine hoof. Finite element
analysis (FEA) considering the highly sophisticated
architecture of the hoof already enables almost
realistic prediction of deformation and may become a
powerful tool for assessment of all hoof therapies and
shoeings (Hinterhofer et al. 2000).

Both aspects, refinement of automatic lameness
assessment (Keegan et al. 2001) as well as the
introduction of new sophisticated computer models, form
part of an ongoing developmental process in clinical
biomechanics and have great potential to expand
scientifically based clinical applications.

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