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BIOMECHANICS AND ITS APPLICATIONS IN VETERINARY PRACTICE

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Introduction

Biomechanics is mechanics applied to biological system. It is governed by laws of statics and dynamics. it combines mechanics with essential elements from biology, physiology, anatomy, mathematics, physics and computer science. Biomechanics is a combination of biostatics and biodynamics. Biostatics is concerned with the principles of construction which ensure that individual parts or body as a whole are in equilibrium when the animal is moving or standing. Biodynamics applies to the movement of body especially during locomotion. The anatomical feature of the animal body can be best compared with the mechanical structure like a bridge or a machine.

Principles

The structural principles of the body are best understood with regard to its overall construction of trunk and limbs. The trunk is compared to a bow and string or an arched bridge, while the fore and hind limbs act as supporting columns or cantilevers. Biodynamic movements can be in the individual parts of the body or the body as a whole.

Centre of Gravity and Stay Apparatus

The position of body's centre of gravity is of great static importance in this regard. The centre of gravity in most animals is found in the median plane at the intersection of a transverse plane lying immediately behind the xiphoid process and a horizontal plane drawn below the lower and middle third of the trunk. The position of the centre of gravity is not constant and has great significance as it determines the proper distribution of load in draught animals and proper saddling, seating of a rider on the horse.(Nickel et al.,1986)

The conditions for maintaining equilibrium are conducive to animals in standing position compared to man. This is because points of the four toes outline the relatively large rectangular surface supporting the centre of gravity. The body weight is not evenly distributed through the four limbs. Since the centre of gravity lies nearer the fore limbs they carry more weight than the hind limbs, even when the animal is standing square. About 55% of the body weight is carried by the forelimbs.

Stay Apparatus

Horses can rest for long periods of time in standing position. This has the advantage of giving them a more distant horizon to spot the approach of predators and also allows a faster getaway should the predators surprise them. This is due to the stay apparatus, a system of muscles and ligaments that "lock" the main joints into positions without expending much energy. So the muscles do not get fatigued. The arrangement is much the same in the fore and hind limbs. Normally both the forelimbs are "locked" but one hindlimb is relaxed or 'rested'.

The stay apparatus in the forelimb consist of

1. Suspensory ligament
2. Deep digital flexor tendon with deep digital flex muscle running from elbow to the back of the pedal bone.
3. Carpal check ligament which joins the deep digital flexor tendon to the cannon bone.
4. The superficial digital flexor tendon and muscle from elbow to short pastern joint.
5. Radial check ligaments.

The stay apparatus of the lower hindlimb is similar to the forelimb but the superficial flexor tendon does not have an equivalent to the radial check ligament higher up, therefore the patella or stifle plays a vital role. The bone has 'hook' which can lock over the inner trochlear ridge of the femur in order to fix

the whole hind limb rigid. If one point of the leg is locked it contracts the tensor fascia muscle which attaches to the patella, so slightly lifting and freeing the bone during movement.(Ommer and Harshan,1995)

Biomechanics describes motions of the body during typical activities, predict which muscles are responsible for controlling movement, quantify the forces acting on the body during movement, understand the limitations of different experimental and analytical techniques used to quantify movement, interpret motion data accurately and evaluate studies of movements. Biomechanics focuses on 3 important themes for analysis: safety, effectiveness and efficiency. Safety means free of injury. Effectiveness is closely related to the level of performance. The main interest here is to maximize the output and effectiveness is the main target for training; efficiency is related to the amount of effort required to do certain mechanical tasks.(Reul et al.,1980)

APPLICATIONS OF BIOMECHANICS

Alternate Medicine

Over the last 10 years, natural healing methods for animals have become a hot topic. Not long ago, alternate treatments, such as chiropractic care and acupuncture were considered by veterinarians and horse owners as nothing more than a mere quackery. As humans begin to embrace the leading powers of alternate methods of treatment for themselves, equine patients too are receiving the benefits.

Chiropractic Medicine

Chiropractic medicine involves the use of specific, controlled forces or thrust applied to a joint or bone to cause a change in the reflexes of the joint, nerve or muscle. The spinal column is made up of individual vertebrae, which surround and protect the spinal cord and sensitive nerve fibers. As nerve bundles exit the spine, they branch off and travel to the horse's joint, skin and muscles. As the horse moves, the spinal column flexes and bends. Chiropractic medicine focus on the musculoskeletal, neurological and vascular conditions of the spine, nerves and muscles near the spinal cord. as they become thickened overtime, which can produce painful and crippling spasms. Performance-horses are asked to turn, twist, stop, leap and jump, all of which increase the amount of muscle tension and can cause damage to the back and spine. As a result the normal range of motion of a horse is compromised and it cannot perform to the highest ability.(Hodgson and Rose,1994)

Bone and Fracture Repair

An explosion of new information and techniques available to the veterinary orthopedic surgeon with regard to fracture fixations has occurred. Because of the numerous options available for successful fracture management, it has become increasingly necessary for an orthopedic surgeon to have a basic understanding of the biomechanics pertaining to bone and implant systems (Robert, 1999). Mechanics describes the dynamic sources acting on a structure which got to change the structure's form and directions of motion. Biomechanics is the applications of mechanical engineering principles to biological systems in the hope of gaining insight into

1. The material and structural characteristic of a living material such as bone.
2. Input of intrinsic as well as extrinsic physiological and non physiological forces on biological systems, and
3. Influences of modern technology on biological system.

Testing the applicability, the use of newer biocompatible materials may offer biological advantage in repair and reconstruction processes, for example, combining the principles of biomechanics and instrumentation, intra-medullary, inter-locking nail fixing systems were developed in veterinary practice.(Mc Duffee et al., 2000 and Wheeler et al.,2004)

Mechanics of Walking and Running

The gait of mammals is described by means

of a few parameters. Dimensionless parameters show marked similarities in walking and running behaviours, between mammals of very different sizes. Only certain gaits allow a quadruped to remain stable throughout the stride. Records have been struck of the forces exerted by the feet of man and other mammals in different gaits. Different pattern of forces are exerted in walking and running but simple equations capable of describing both form the basis of mathematical modes. Force plates, force shapes, pressure sensitive mats, strain gauges and accelerometers are used to measure the pressure exerted by the foot of animals.

A model of running shows how tendon elasticity can save metabolic energy and also explains the observation that oxygen (hence, energy) used per unit distance traveled tends tc be independent of speed.

Measurement and Analysis System

Parameters of measurement

Basic stride and gait descriptions consist of linear and temporal variables. Temporal variable (eg. stride duration) are calculated mainly from frame numbers in high speed cinematography or video recordings. Some temporal variables also can be derived from force plate and measuring shoe recordings. Linear gait variables (eg. stride length) can be measured from well defined reference points in film and video registrations.(Sarah and Zeo,1996)

Joint Kinematics

Joint kinematics ie, angular displacement, is mainly investigated by applying reference points to the skin of horse at standard positions in relation to the points under study. The position of reference points under locomotion is determined from high speed cinematography video or other opto-electronic system. At slow gaits electro-goniometry has been used for some joints.

Confirmation

Subjective and objective judging of confirmation

Confirmation is the body shape, form or outline of an animal. While selecting horse and pet animals for breeding, racing, show purpose etc., confirmational details have long been used as markers of such qualities of performance and soundness. Traditional confirmation has been judged subjectively against an ideal or standard of perfection. In studies where several strides were evaluated in the same horse, good agreement was achieved for some overall type traits, but large discrepancies were rendered for most conformational details.(Hodgson and Rose,1994)

Biomechanics and body balance

Biodynamic research involved in injury impact is of great social significance and is a challenging mechanics problem. Perception of the external world, reaction and motions of living organism require the action of highly specialized mechano-receptive system. In the auditory system, the vestibular apparatus and the pacinian corpuscles (mechanic receptors) have been selected as representative examples.

Summary

The principles of biomechanics are applied in video and optical motion analysis in biomedical research. In veterinary research and therapeutics, biomechanics play a major role in gait analysis, clinical chiropractice, certification of animals, acupuncture therapy, diagnosis and therapeutic measures in fracture repair and other musculoskeletal disorders. Thoroughbred evaluation in commercial horse racing performance is inevitable without biomechanics applications as also in detection and monitoring of bone disorders in Thoroughbred horses. Biomechanics is an area of science that has many applications in improving sporting and safety; and reducing the risk of injuries in animals.

References

1. D.R.Hodgson and R.J.Rose., 1994. Biomechanics, Gait and Confirmation. Chapter 3. In text book. The Athletic Horse, Ist edn, W.B.Saunders Company. pp:27-44.

2. McDuffee .L.A., S.M.Stover, J.M.Bach, and K.T.Jaylor, 2000. An invitro biomechanical investigation of an equine interlocking nail. Veterinary Surgery. 29(1) : 38-47.
3. Nickel R. Schummer, A.and E.Seiferle, 1986. "Statics and dynamics of locomotor system". In text book. The Anatomy of Domestic Animals, Vol-1. Vth edn., Verlag paul parey. Berlin. pp: 444-446
4. Ommer, P.A. and K.R.Harshan, 1995. Chapter 9. Applied Anatomy of Domestic Animals, Ist edn, Kerala Agricultural University. pp.92-97.
5. Reul H., Ghista D.N. and G.Rau 1980. Perspectives in Biomechanics. Vol-1 A&B. Ist edn., Harwood academic publishers, London.
6. Robert M. Radasch., 1999. Biomechanics of bone and fracture. Veterinary clinics of North America, Small Animal Practices. Vol-29, pp. 1045-1079.
7. Sarah Pilliner and Zeo Davies, 1996. Equine Science, Health and performance. Ist edn.. Black well publishers. Pp.237-247
8. Wheeler,J.L., W.P. Stubbs, D.D.Lewis, A.R.Cross, and S.R.Guerin, 2004. Intramedullary Interlocking nail fixation in dogs and cats, Biomechanics and instrumentation. Compendium-on-continuing education-for-the practicing Veterinarians. Veterinary Surgery, 26(7):519-529.

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