Anatomy and Biomechanics

In Nature, everything has a design reason, even if we can't quite work it out. In simple terms, bones and joints create levers with muscles providing the active control. Tendons, fascia and ligaments provide passive elastic control. It is the combination of these levers with passive and active control that produces animal locomotion in all its forms. In order to understand the resultant biomechanics we do not need new laws of physics: Newton's three laws are quiet sufficient and explain everything that needs explaining.

Levers and Muscles

There are three classes of levers which describe the location of the pivot (fulcrum) with respect to the force and load. As animals locomote, their various bones and joints create these three lever classes, but the classes are not fixed. For example, in protraction (forward motion) of the limb, the limb represents the load but on weight-bearing and retraction (rearward motion) the foot-to-ground contact becomes the pivot and the body becomes the load. This is why the protractor muscles are long and slender whilst the retractor muscles are large and powerful: the protractors need to pull the limb forwards quickly ready for the next stride, whilst the retractors provide the power and stability needed to thrust the animal forwards over the limb.

Passive Control

When looking at locomotion, one tends to be drawn to the muscle activity, whereas in truth you should be thinking about energy storage and efficiency. Locomotion, particularly in horses, should be thought of as rubber ball bouncing along the ground. Energy input is only needed to maintain speed against wind resistance and some heat losses – the elastic walls of the ball translate the kinetic energy of landing into elastic energy in the ball walls and back to kinetic energy as the ball recoils again. It is the return of elastic energy back to kinetic energy that means the energy of one stride can be saved and used in the next stride. About 17% of the landing energy is returned to the animal as the limb leaves the ground. So where is the energy stored in animals? Quite simply in the tendons (and ligaments to some degree).

The tendons need to be stiff enough to allow muscle contraction to be effective at the distant insertion point of the tendon, yet elastic enough to store energy. This is why there are positional and elastic tendons: positional tendons are typically the limb and digit extensors (e.g. common digital extensor in the forelimb) whereas elastic tendons

are found in the digital flexors (e.g. deep digital flexor). As such, the stiffer positional tendons are used to guide the limb accurately to its landing point, whereas the elastic tendons absorb and store the landing energy, to return it to the animal as the limb unloads at the end of weight-bearing. In horses the degree of efficiency is such that the digital flexor muscles only contract by about 3 mm: the forelimb behaves like a giant pogo stick!

Active Control

Now looking at muscles, we can see that they act with the passive elements during locomotion. Animals need active control of limb movement to actually move the limbs and generate thrust, but also during changes of direction to cope with the shifting centre of gravity. Muscles are controlled by nerves from the spinal cord, but there are various sensors within muscles and tendons which feedback information into the spinal cord. In this manner reflex arcs are created.

These reflexes can be local or central and constitute the rather ethereal central pattern generators. The key to controlled movement is the interplay of reflex arcs coupled with other sensory inputs such as joint position, balance and vision. Even head and neck position assist in the control of movement. This whole concept is called proprioception and is a core part of any veterinary physiotherapist's knowledge.

These elements are all covered on our MSc Veterinary Physiotherapy course at Nottingham, which will enable you to become a qualified veterinary physiotherapist. To find out more, please visit: **www.nottingham.ac.uk/pgstudy/vetphysio**

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