WHAT MAKES A FAST RACEHORSE?
THE BIOMECHANICS OF CONFORMATION & GAIT
&
RELATIONSHIP TO SPEED©

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At top speed, Secretariat's stride length was about 22 feet, while the monument to Man O' War in Kentucky Horse Park states that his stride length was 28 feet. In the pedigree of around 80 per cent of modern thoroughbred horses, stands Eclipse – unbeaten in his entire racing career. A recent press release from the Biotechnology and Biological Sciences Research Council (BBSRC) has revealed that what made Eclipse fast was his 'averageness' !

The question of what makes a fast racehorse still puzzles owners, trainers and racing fans some 200 years later, but researchers at The Royal Veterinary College may have found some answers. Integrating portraits of Eclipse and contemporary accounts of his gallop, the researchers reconstructed one of his legs and have discovered that his legendary speed may have been due to the 'averageness' of his conformation. Dr Wilson, leader of the research team, said that the analyses 'show that Eclipse's body shape and everything about him seems to have been right in the middle of the normal range, suggesting that all the factors for speed were perfectly matched.'

Dr Alan Wilson likens a horse's leg to a pogo stick - in that it uses energy stored in the muscles and tendons to propel the animal forwards and upwards. Fast horses can bring their legs forward more quickly in preparation for the next stride. These results suggest that speed is as much a factor of stride 'turnover' as stride length. They also show that 'stiffer legs' restrict how quickly the horse can transmit force to the ground and bounce back up again and that greater stiffness also increases the chances of injury.

Other studies in Maryland reached similar conclusions. Looking at bone length and skeletal proportions, naval engineer Larry Wellman shed light on how nature has selected for leverage and speed efficiency in hooved runners. He looked at skeletal length and found that certain bone ratios allowed faster speeds. For the hind limb, the most speed-efficient formula was a hock-to-hoof length of 1.7 times the length from the stifle to the hip. In the front end, the length from the point of the elbow to the knee and from the knee, in the study of conformation and motion, the mechanics of the forehand have been likened to a pendulum. Like clockwork, the front end of the horse starts from a "fixed" point at the centre of the wither span. By drawing an imaginary line to the point of the shoulder, the slope of the shoulder can be assessed. During exercise, the knee is lifted as the shoulder rotates back and down - so a more upright shoulder angle allows greater knee lift – an advantage for jumpers. A longer slope was desired by draft horse breeders who wanted an easier fit for the harness collars. However, horses with longer sloping shoulders often land toe-first and then slam their heels down.

The length and resting angle of a line draw from the point of the shoulder to the elbow determines the 'scope' and 'way of going'. Scope is defined as the ability to move the elbow away from the chest wall and is a desirable feature for many equestrian disciplines - allowing the camp-drafter to crouch, the jumper to clear an obstacle, the dressage horse to perform lateral work and the racehorse to lengthen stride.

The angle of the humerus determines if a horse can raise his knees or is a "grass clipper". Open angles (90 degrees or better compared to the angle of the scapula) allow show-jumpers and eventers to lift their 'knees to their ears' and the best jumpers usually have a moderately upright shoulder, a long steep (open) humerus and moderately long cannon bones with high knees - the more horizontal the humerus the less natural ability a horse will have for the high action or tight folding required of jumpers. A long humerus is defined as over 50% of the length of the scapula or shoulder. For better speed leverage in the racing thoroughbred a shorter humerus (shoulder to elbow) and longer elbow to knee span were advantageous.

The length of the forearm or radius – from the elbow to the knee - gives the forward pendulum action necessary for ground-covering strides. Length in the forearm is more advantageous than long cannons when breeding for height and is more beneficial for soundness. For maximum speed efficiency, Wellman found that the length from the knee to the ground should comprise at least 38% of the ground to wither height.

In overall conformation, Wellman found that when total hind limb length is 25% more than back length (defined as wither-to-croup), bounding recoil was superior – a long back just providing excess baggage - and withers higher than the croup was a feature in outstanding racing success over classics distances.

Most young horses have the ability to reach well underneath them with their hind legs. Dr. Hilary Clayton's new book called 'The Dynamic Horse' describes the concept of "diagonal advanced placement" as '..the time elapsed between successive footfalls of a diagonal (LH-RF or RH-LF) pair of limbs..'. She assigns diagonal dissociation a positive value if the hind footfall precedes the front footfall, '..dissociation is zero if the footfalls occur synchronously, and the value is negative if the front footfall precedes the hind footfall…'.

Whilst most young horses have a positive value for diagonal advanced placement, as the yearling thoroughbred enters training it may lack the strength to lift the body and front legs out of the way quickly enough – leading to 'over-reaching' and potential for injury. Most will then adjust their movement to place the hindlimbs just outside the range of motion of the front limbs. Speeding the break-over of the front feet (including steep as opposed to low hoof angles and shorter rather than longer toes) combined with adequate development of the hind-end muscles is required to prevent abnormal ways of moving and to prevent young horse from travelling wide behind in an effort to avoid injury. Developing the hind-end muscles which carry and thrust the body forwards before asking for speed is achieved in non-racing horses by incorporating hills, cavaletti, jumps, frequent changes of gait and the "school figures." All racehorses benefit from the effects of positive dissociation and one way to teach this is through sudden brief accelerations. 3 workouts of accelerations, one a week, has been found to be effective.

To develop aerobic muscle power takes months and recent research has shown why it can’t be achieved in a few weeks – and it involves genes. A large number of genes were activated after exercise. They act to increase the production of specific proteins – ‘stress response’ genes are activated quickly and control the production of ‘heat shock’ and other proteins; ‘metabolic priority’ genes make proteins that are required as a consequence of a particular metabolic stress, such as when blood glucose or muscle glycogen levels become low. Interestingly, their activity peaks during the initial few hours of recovery from exercise and returns to control levels within 24 hours. The third category ‘metabolic/mitochondrial enzyme’ genes, encode proteins whose function is to convert food to energy. These genes are activated much more slowly, which is why it takes months of aerobic training to improve aerobic fitness. In addition, an increase in certain skeletal muscle proteins (called GLUT4) induces mice to voluntarily run four times farther each day than normal mice – suggesting that the brain senses the potential of skeletal muscle to remove glucose from the blood, the function of GLUT4.

Nutrition, training and farriery are central to gait efficiency. Ensuring that muscle fibre size and number reach their genetically programmed maximum – providing the correct ratio of essential amino acids during the window of opportunity (from 2 to 12 months of age) is fundamental for hind quarter drive power and back strength. The maximum speed attainable translates to efficiency of stride and is pretty much genetic. Some characteristics of conformation clearly provide a biomechanical advantage for a more efficient stride and the diet must provide the raw materials for muscle protein building. Computer calculations and high speed film will become valuable management tools for assisting breeders and trainers in selecting and achieving genetic potential – and for avoiding management decisions that result in the subtle gait changes that decrease biomechanical efficiency and speed and increase risk of injury.