Bellwether Magazine

Volume 1
Number 2 *Winter 1982*

Article 2

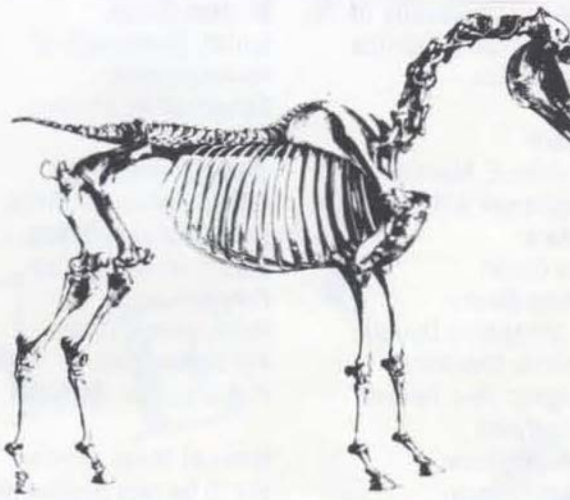
1-1-1982

Just Bone Tired: Equine Bone Stress

Newsmagazine of the School
of Veterinary Medicine

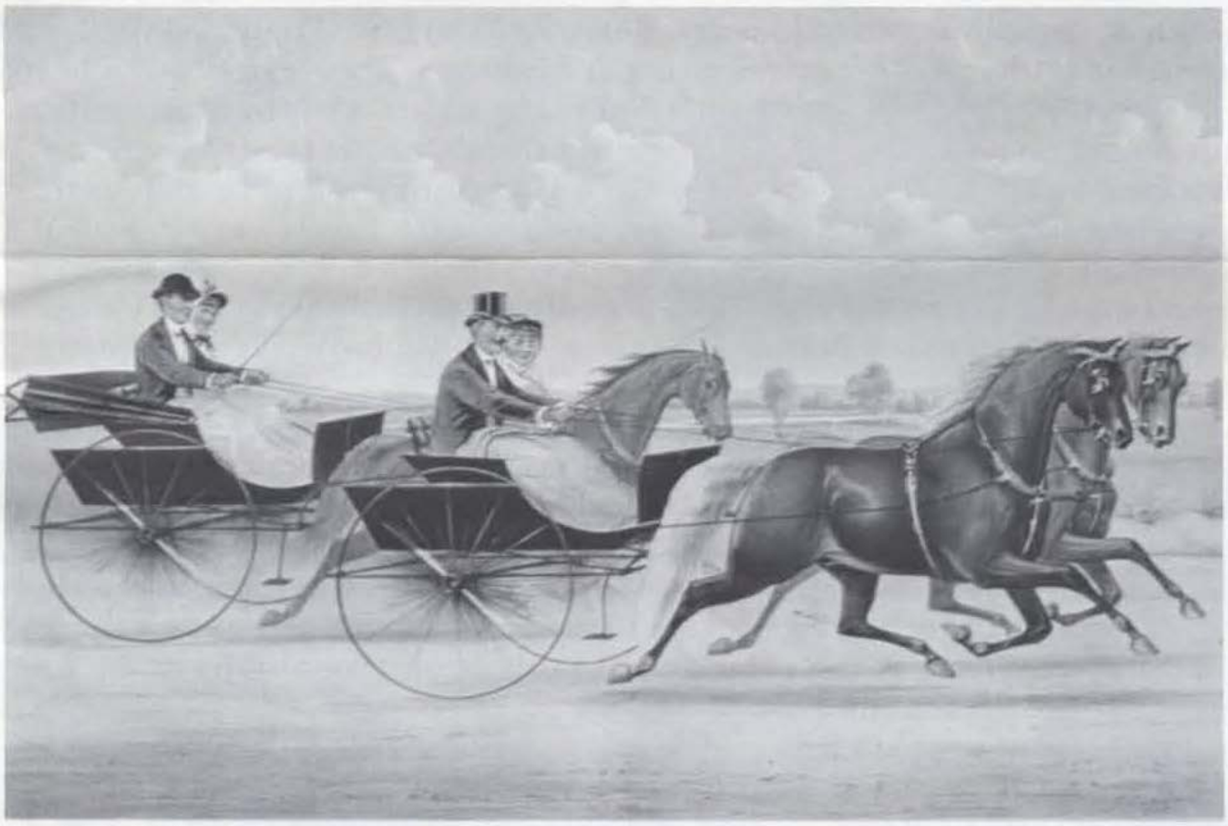
Bellwether 2

University of Pennsylvania Winter 1982



Just Bone Tired

Equine Bone Stress



A Brush with Webster Carts
Currier and Ives, New York, 1884

When we think of fatigue our thoughts usually turn to a decreased functional ability of such tissues as muscle, or the central nervous system as the result of prolonged exertion. Rarely do we relate the term to bone, except perhaps in a subjective sense, when we refer to ourselves as being "just bone tired." In fact, this very hard tissue does become fatigued after prolonged or unusual stress, and may then develop fatigue fractures. For example, in man, there is a condition known as "March fracture" that occurs in military trainees after periods of forced marching, and is the result of bone fatigue. This situation is somewhat akin to the cracks that form in the materials of airplane wings due to constant movement, or in the steel of buildings following earthquakes.

Anyone who has viewed fast-action films of horses at a full gallop must be impressed with the marked distortion that occurs in the lower leg at the time the foot strikes the ground. During this time, leg bones undergo deformation, and this phenomenon is known as a cycle. Thus, in a horse, moving at full gallop, many cycles occur in the leg bones. If certain limits are exceeded in terms of the number of cycles, or the degree of strain, the bone becomes fatigued, and a fracture may occur. Fatigue fractures in horses usually take one of two forms: "buck shins" or saucer fractures.

A study of fatigue fractures of the third metacarpal bone in horses is one aspect of the research being conducted by Dr. David Nunnamaker and associates at New Bolton Center. Aside from the basic information about bone that will be forthcoming from this study, it has great practical importance to those engaged in training and racing horses. It is estimated that seventy percent of thoroughbred horses develop fatigue fractures, usually early in their careers. Horses under two years old are prone to "buck shins," while older animals usually exhibit saucer fractures. These two conditions are estimated to result in the loss of 400,000 racing days annually, at the staggering cost of ten million dollars to the racing industry. And so, one goal of Dr. Nunnamaker's work is to find ways of diminishing the fatigue fracture problem.

(continued on page 4)

Just Bone Tired

(continued from page 1)

This research has three major phases: to quantitate, *in vivo*, the degree (amplitude) of strain that develops on the surface of the third metacarpal bone during different gaits on turf and hard surfaces; to study, *in vitro*, the number of cycles that can be expected to result in fractures when staves of bone are exposed to varying strain levels; and to study the histology of normal and abnormal bone obtained from horses of different age groups who have undergone varying degrees of training and racing.

For the *in vivo* studies on running horses, an instrument known as a *strain gauge* is attached to the front leg of a horse and the strain data recorded by this is transmitted, through telemetry, to an oscilloscope equipped with a computer to analyze and store information. This part of the study addresses one factor responsible for fatigue fractures—the amount of strain placed on the third metacarpal bone.

Since fatigue fractures are related to not only total strain range, but also to the number of cycles, the *in vitro* phase of work will examine the latter factor. Staves of bone (obtained from autopsy material) are placed in a fatigue machine. One end of the bone stave is fixed while the free portion undergoes constant bending (cycles). The amount of bending will be within the strain ranges that were measured in the intact animal. The object is to determine the number of cycles that result in fatigue failure.

Histological work will be done on specimens of the third metacarpal bone obtained from horses destroyed as the result of catastrophic injuries. This will include microscopic examination of normal and abnormal bone (including stress fractures) obtained from several catagories of horses: animals one or two years old that were trained but were never raced; two-year-olds that have been raced; and horses in each ascending age group up to five years of age. This aspect of the research will provide much-needed information about the relationship of age, training, and racing to the structure of bone.

Dr. Nunnamaker believes that this research will allow us to make reasonably accurate predictions concerning the best methods of training for young horses with developing bones. Proper assessment of the number of cycles leading to failure, using racing strain amplitudes, might allow a trainer to condition a horse at strain levels that are acceptable, and then race the animal at higher strain amplitudes but restrict the number of cycles to a safe range while the bone is maturing and remodeling. In this way the animal may pass through the era of risk without valuable time being lost in a prolonged treatment program which may restrict training and racing. Comparisons of standardbreds and thoroughbreds indicate that methods of training play some role in the development of fatigue fractures. Standardbreds, even though they train for much longer distances (and thus have many bone cycles), have a much lower incidence of this type of fracture than thoroughbreds. Presumably, this is related to the lower degree of strain on Standardbreds' bones.

"...this very hard tissue does become fatigued after prolonged or unusual stress..."

Dr. Nunnamaker conducts his research in the C. Mahlon Kline Center for Orthopedic Research and Rehabilitation at New Bolton Center. This facility was conceived by the late Dr. Jacques Jenny, a pioneer in orthopedic research in animals. It was Dr. Jenny who first developed the use of internal fixation for the treatment of fractures in horses. This approach is credited with saving the lives of many horses that would have been destroyed otherwise. In earlier efforts, Dr. Jenny used the available human hardware with a great deal of success. Dr. Nunnamaker points out that his present work is a continuation of Dr. Jenny's, which developed the basic techniques for fixation in the horse. The present research is directed at the development of improved hardware for the horse and of a study of how to use this to the best advantage. To do this, the laboratory is equipped with machinery to manufacture the equipment. To investigate the suitability of various materials in treating fractures in the living animal would be very time-consuming, due to the limited availability of usable clinical material. To obviate this problem, Dr. Nunnamaker uses bone specimens obtained at autopsy. Bones are cut to simulate fractures, fixation materials are applied, and the specimen is then subjected to various numbers of cycles and degrees of stress. The instrument used for this procedure is an *Instron*, and operates under carefully controlled hydraulic pressure. The *Instron* is able to accept whole legs, and can deliver up to 1,000 cycles per second. With this approach, Dr. Nunnamaker is able to test the durability of various materials and to to determine optimum locations for fixation devices.

Another promising area of research is the use of pressure-sensitive shoes for the diagnosis and treatment of lameness in horses. These shoes transmit, via radio, weight-bearing data to a recorder so the investigator can determine the areas of the foot that are bearing greater and lesser amounts of weight. Dr. Nunnamaker is quick to caution that, while this technique offers some fascinating possibilities, there is much to be done in perfecting materials and techniques.

Dr. Nunnamaker's work is an outstanding example of comparative research, an area in which the School of Veterinary Medicine is a recognized world leader. In fact, the accumulation of rooms in which the work is done is known as the Comparative Orthopedic Biomechanical Laboratory. The research is conducted in cooperation with a number of other facilities, including the Department of Orthopedics of the School of Medicine of the University of Pennsylvania, the Veterans Administration, and Harvard University. The present location of the laboratory, within the Kline Center, leaves much to be desired. For example, the computer and testing machinery are located in the same room, without adequate sound-deadening capabilities. Plans have been developed for a separate biomechanics laboratory, attached to the Kline Center, with a suitable functional arrangement of rooms, which will allow this important area of research to be developed to its fullest potential.

Dr. Nunnamaker occupies the prestigious Jacques Jenny Chair of Orthopedic Surgery. In addition to the publication of many papers, he is co-author (with Dr. G. E. Fackelman) of *Manual of Internal Fixation in the Horse*. At present, Dr. Nunnamaker is involved with his colleague, Dr. Charles D. Newton, Associate Professor of Orthopedic Surgery, in preparing the text for a new book on canine orthopedics.

Philly Polars Make Public Debut

This winter, as most Philadelphians fasten coats and turn collars up against the chill, two of the city's newer residents are naturally prepared to enjoy the bitter winds and tiny temperatures of the season.

Adamant opponents of the cold, in fact, might find positive inspiration for winter from a visit to the Philadelphia Zoo, where these two yearling polar bears are happily adapting to the season that most closely resembles their natural habitat.

The creamy white bears, both females, were donated to the Zoo by the Isaly Klondike Company, makers of Klondike Ice Cream Bars. At their public debut on October 25, one bear was named Klondike, in honor of her donor. The other will be named this month by the winner of a naming contest co-sponsored by the Zoo and the Philadelphia Daily News.

Both bears relocated to Philadelphia from New York homes: one arrived from the Bronx Zoo in New York City, the other from the Seneca Park Zoo in Rochester. But, like every polar bear, or *ursus maritimus*, the Philadelphia Zoo bears are descendents of Arctic bears of circumpolar regions.

According to Dr. Dietrich Schaaf, Mammals Curator at the Zoo, the physical characteristics of polar bears allow for their survival in moderate temperatures, but they are best suited for chillier conditions. Thick layers of fat and a dense coat provide polar bears with excellent protection against cold. In addition, fur pads on the bears' feet serve a dual purpose: they act as insulation and provide solid footing in icy environments.

Since their arrival in Philadelphia, the two-year-old bears have grown to weigh about 250 pounds each. Each consumes an unusual mixture of three pounds mackerel, one-half pound suet, two pounds zupreem (a commercial meat preparation), two pounds dogs food, two pounds carrots and apples, and four ounces peanut and vitamin A-D oil. Their meal, except for the mackerel, is mixed together and served up once daily, in the afternoon.

Klondike and her friend are residents of a special section of Bear Country, a support facility which opened in November 1977. All Bear Country inhabitants enjoy indoor shelters, a cubbing and denning area, access ramps to upper enclosures, filter and pumping areas, a food preparation area, and television equipment and controls.

The polar bears' residence also includes a specially contructed, 300,000-gallon capacity fresh-water pool, and is surrounded by rock formations reconstructed of grinite, a concrete mixture sprayed under high pressure onto mesh forms reinforced with steel rods.

Like all polar bears, Schaaf cautioned, the two bears at the Philadelphia Zoo "look cuddly, but they're not." Actually, he warns, "they're predictably dangerous." As a result, the young bears are handled and fed by remote control. The doors to their habitat are opened and closed by outside pulleys, and they are fed indoors. "The indoor feeding," Schaaf explains, "is used as a control mechanism for the bears."

Although the pair at the Zoo may have mean dispositions, their personalities are masked by their beautiful, furry white appearance and playful behavior. Since their October arrival, Klondike and her friend have become one of the more popular attractions at the Zoo. And, as the temperature continues to drop, their natural affinity for the cold will insure that the playful Philly polars will grow increasingly comfortable in their new environment.

Photo courtesy of New York Zoological Society.

Apologia

In the last issue of *Bellwether*, we inadvertently omitted crediting the Philadelphia Zoo for the biographical information and photo for the story: "Massa— The Big Boss."