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Saddle Sore: Skeletal Occupational Markers of Habitual Horseback Riding

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Saddle Sore: Skeletal Occupational Markers of Habitual Horseback Riding

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Abstract

Horses became a prominent part of everyday life for many tribes and communities many centuries ago. The horse has been used for transportation, war, and pleasure. These people who habitually used horses for all of these different functions show evidence of this within their skeletal remains in antiquity. The human skeleton can deform and change based on the amount of stress and activity put onto the bones. Seeing the affects of horseback riding on the human skeleton can help researchers, archaeologists and anthropologists find out more about the communities that they are looking at. The skeletons from antiquity and modern-day horseback riders can be affected in similar and differing ways, the body can start to form different growths or pits based on the level of stress. The human skeleton is amazing, but can give great insight into the lives of people everywhere.

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Introduction

For centuries horses have been used as domesticated animals to supplement people's needs on their farms, transportation, pleasure and war. They are still a definite part of modern humans' way of life. The use of these animals can be seen through the examination of bone and muscle attachments. Bone can deform based on the level and extent of repetitive activity. These so-called occupational markers can be examined in order to determine which activity has been performed repeatedly over an individual's lifespan. This paper will examine the following: 1) How has bone deformation happened within habitual horseback riders and what evidence should we look for in the archaeological record to indicate this activity? And 2) Does this archaeological pattern differ from the injuries in modern equestrians and could it change based on occupation discipline? This paper will examine trauma, in the sense of repeated work and impact, on the body and spinal column in relation to habitual horseback riding and modern horseback riding.

Origins of Horseback riding

Horses have been a part of domestication for centuries. There are estimations that date domestic horses back to 3000 BC. (Anđelinović *et al*.) All throughout history we have seen the great and powerful horse beside man during all of their battles. Whether for war, transportation, work, or pleasure the grace and strength of the horse has been depended upon as far back as man can recall. Yet, where and when did the horse as companion get it's start? Where do we first see evidence for the domestication of this useful steed?

Some of the research concerning the origin of horse domestication places the start of horses in central Asia around 1000 B.C. As further research has been conducted, new evidence has been found that can place horse domestication between 4300 – 3500 B.C. Archaeologists have used changes in horse dentition to show that domestication first appeared around this time during the Ukrainian Copper Age. Anthony *et al.* (1991) examined attrition on the teeth of modern domestic horses in order to compare their wear patterns to that of the horse remains found in the Ukraine. This research looked into when people started to use bits to control their horses while riding. So, bit wear marks the beginning of horse riding.

Researchers continue to look for evidence for early horse domestication today. Archaeologists and Anthropologists work hard to put the pieces of the past back together and to understand what the meaning was behind everything found.

Mechanics of Horseback Riding

Horseback riding can affect many parts of the human body. Without understanding the mechanics of the sport, you cannot really understand how it impacts the spine. The ability to ride a horse takes a specific amount of balance that can make or break your ride in general. Whether it is for fun or for work, balance is a key part. Also, riding the 'wrong' way can affect your body in the long run, but any amount of repeated trauma whether your form is correct or not, will have some effect on the body.

The horse and rider have to be in-sync and balanced in order to have a successful ride together. The rider's balance itself can throw the horse off and cause an accident to happen. If horses do not feel 100% balanced or secure, they can react negatively, trying to throw their mount off or they may even trip and injure themselves. The rider can help the horse become more supple and balanced throughout their rides, helping them engage their muscles and move forward with a nice bend and forward movement. "The range of back motion of the horse is affected first by the presence of a rider and, second, by the riding technique. When weight is added to the horse's back, regardless of whether it is dead weight or the rider's weight, it causes extension of the thoracolumbar spine (hollowing of the horse's back) both when the horse is standing and during locomotion." (Clayton and Hobbs, 2017: 126-127)

A rider learns how to move with the horse in order to best stay out of the way of the horse. One of the reasons that the skeletal patterns will show consistent changes (to be discussed below) has to do with the way the rider engages on horseback. A rider's pelvis has to become supple and learn to rock with the motion of the horse. It has to move laterally and be able to rotate, if the rider is not matched in movement with their mount, they can obstruct the horse and have a very uncomfortable ride. Aside from the pelvis, the rider must also control their hands and upper body. The hands need to be quiet and/or move only slightly with the horse's head to give them the ability to take control. Controlling the upper body helps with the balance for the horse and rider, if a rider's shoulders get "in front" of the horse the horse may be getting signals to stop completely or to go faster.

Lastly, the legs are an important aspect of the rider's form in the saddle because they help anchor, drive, and balance both the horse and rider. The ankles, thigh muscles, and calf muscles are used to anchor oneself on their horse. The ankle is extended downward at the heel of the foot and the thigh/calf muscles are constricted to help grip without pinching the horse.[1] The leg muscles are the driving force of the ride; horses are 1100 pound animals, so it takes a significant amount of muscle power in order to convince the horse to listen to your leg. Overtime the amount of power it takes can be reduced. Lastly, without strong legs it becomes increasingly

[1] Pinching of the knees can also restrict the horse and/or injuring their muscles

harder to find one’s balance on horseback. While it is not impossible (paraplegic people do ride) the legs do give a great amount of help to keep the rider up in the saddle.

Horseback riding takes a significant amount of muscle and strength. Understanding what the rider uses when riding can help the reader to understand why certain bones are impacted through habitual horseback riding.

Occupational Markers

Throughout antiquity we find evidence of skeletal changes at the muscle attachment sites. These show obvious compensation for the repetitive stresses being placed upon the bones, based upon the lives these people lived. These markings are known as occupational stress markers. Occupational markers can give anthropologists a better idea as to the activity level of the individual being studied. When a muscle is repeatedly used and stressed during the same activity it responds by increasing in size, which causes the muscle attachment site on the bone to grow is size. An overgrowth of the muscle attachment site called a hypertrophy or enthesophyte. An enthesophyte appears as a way to compensate for the tension on the surface of the bone from muscles that are overworked.

Certain occupational markers are consistent for different types of stressors. These markers for habitual horseback riders are seen in the spine, hips, legs and pelvic area. While the whole body is engaged in horseback riding, riders in antiquity spent a lot of time in the saddle, meaning the exaggeration will be on areas engaged the most. This is where these elements come in. The lower body acts as an anchor and ‘seat belt’ for the rest of the body. Without the strength and the core balance, horseback riding becomes nearly impossible. The lower half of the body supports the upper half causing the occupational markers to be bigger on the bottom, since they are working twice as hard.

Osteoarthritis

Osteoarthritis is one of the most common forms of arthritis, which is an inflammation between the bone joints in the body. Osteoarthritis is the wearing down of the protective joint cartilage of the bone. The ends of bone in a joint are protected by hyaline cartilage, this helps cushion the bone and allows the bones to slip past each other as the joint works. The hyaline cartilage coats the end of the articulating bones, protecting them and slowing down the process of breaking down. In osteoarthritis, this protective end eventually wears away and become thin or may even disappear completely due to the amount of pressure on the joint. The most typical joints affected are the knees, hips, and spine. This type of arthritis may also be seen on the base of the skull, due to the rubbing between the cranial base against parts of the cervical spine. (Anđelinović *et al.*, 2015)

Osteoarthritis is seen in horseback riders due to the pressure put onto all of the joints. The knees are at a slightly bent angle making the joint have to absorb and release impact forces through the whole ride, eventually this will cause the protective cartilage to wear away - so much that the cartilage will start to break down. Another key area to look at would be the spine, since the back is always compressing due to the general nature of the ride. In this case, the movement puts stress on the cartilaginous intervertebral discs, another common location for arthritic changes in the body. Osteoarthritis occurs in most people as they age and is caused by normal life activity. However, raising the intensity of activity (degree of and temporal extent) will raise the risk of breaking down your body's protective surfaces causing the horseback riders joints to degrade faster and at a younger age.

Schmorl's Nodes

Schmorl's Nodes (Fig. 1) are caused by a protrusion of a spinal disk's soft tissue that pushes into the bony tissue of another vertebrae. (Shiel n.d.) These nodules go hand in hand with the degeneration of the spinal column. Schmorl's nodes are common traumas in modern populations and are frequently found in people who engage in high impact sports (Wentz and Gummond, 2009). This being said, it is no surprise why these protrusions would be consistent with early horseback riding as well.

Horseback riding puts stress on every part of your body, but is concentrated on the spine and hip bones. The spine and hips take the brunt of impact when riding, especially during running and jumping. This stress creates larger muscle attachments to the spinal column and legs in order to compensate for the muscle usage during this sport. Schmorl's nodes also develop due to trauma to the spine caused by continual small impact forces squeezing the intervertebral discs. The spine eventually compresses from these repetitive movements, causing the disks rupture and press into the bones, leaving their impressions in the neighboring vertebra.

Figure 1, Evidence of Schmorl's Nodes on Lumbar Vertebrae, (Piontek *et al.* 2017)

Poirier's Facets

Poirier's facets (Fig. 2) are concentrated in the leg on the head and neck of the femur. These facets are considered to be "an extension of the articular surface of the head onto the neck." (Villotte and Knusel, 2009: 96) Basically a growth on the surface of the head and neck of the femur where it comes in to contact with the acetabulum. [2] This is said to be related to the "habitual flexion and abduction of the thigh" (Villotte and Knusel, 2009: 96), or, the position the rider takes when on the back of a horse. In this position, which requires the rider to pull their legs

[2] Acetabulum is the socket where the femur fits in, making the hip bones

up, with flexion at the knee and hip causes the thigh to be flexed slightly, but also pushed down to compensate for having to ride with an extended heel and flexed ankle.

Figure 2, Evidence of Poirer's Facet on Femoral Neck, (Radi *et al.* 2013)

Allen's Fossa

The Allen's fossa is related to the Poirier's facets, they usually show up in places that also contain these facets. Allen's fossa can be explained as "a depressed and roughened area, in which the bone is eroded to a greater or lesser extent." (Fig. 3) (Villotte and Knusel, 2009: 96) These areas can be seen as bone pits, and can be found on the front side of the femoral neck.

The Allen's fossa is seen hand in hand with the Poirier's facers due to forming in conjunction and by the same situations/activities. (Fig. 4) In some of the research I read, bioarcheologists found that Allen's fossa is a reaction to the hyper-extension of the thigh. They also suggest that "the fossa of Allen can be due to capsular pull and 'then occur as a result of extension (as in walking or standing) or of flexion (as in squatting) of the hip joint.'" (Villotte and Knusel, 2009: 96) In habitual horseback riding the hip is flexed for extended periods of time and depending on the style of riding, the legs can experience a state of extension and then flexion. I would assume that this back and forth between extension and flexion can have a significant impact on the way Allen's fossas form.

Figure 3, Evidence of Allen's Fossa on Femoral Neck, (Ghosh *et al.* 2014)

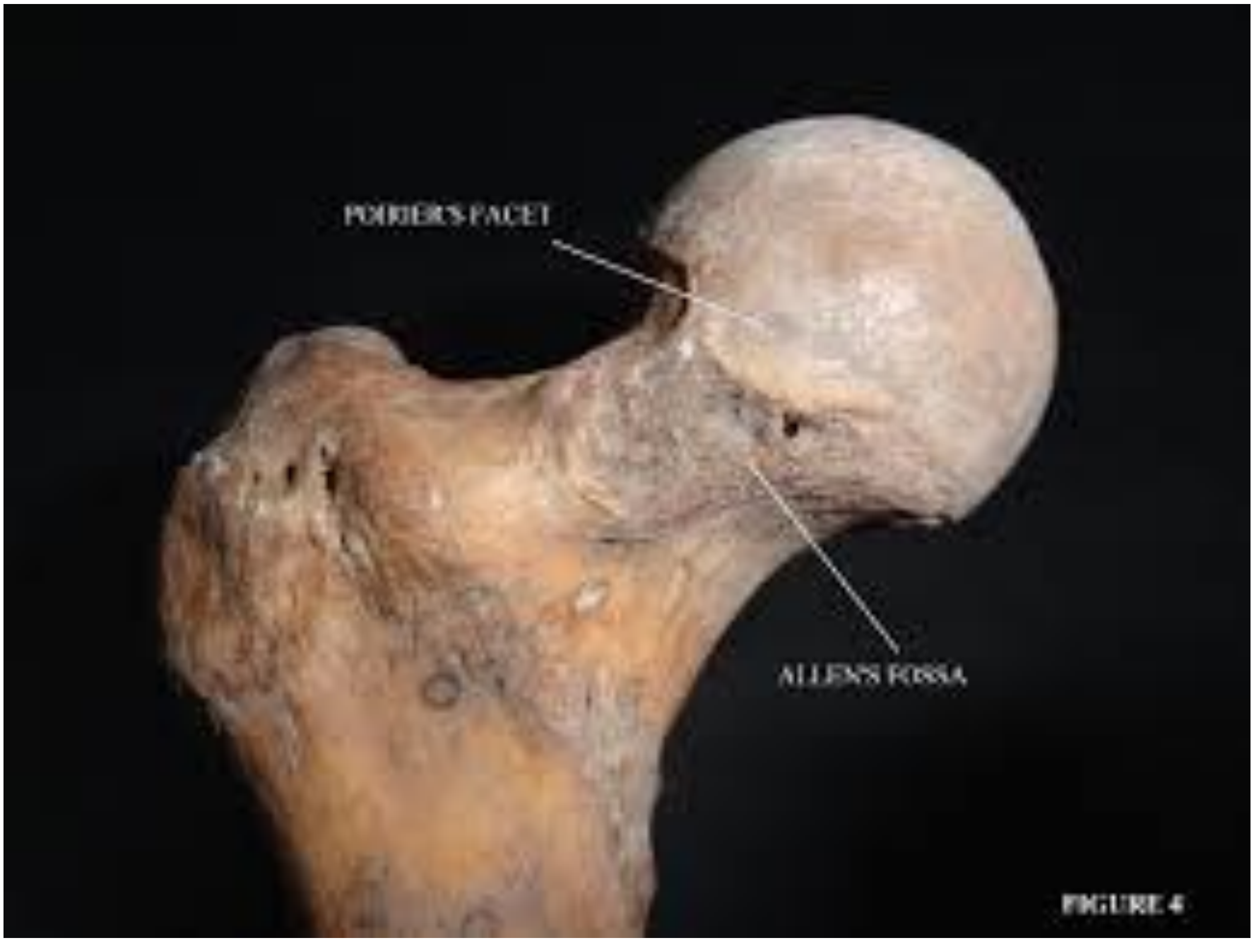

Figure 4, Allen's Fossa and Porier's Facet on Femur, (Ghosh *et al.* 2014)

Traumatic Periostitis

Periostitis is an inflammation of tissue, or the periosteum, that surrounds the bone. It looks like a deposit of rough woven bone on the surface of the affected bone (Fig. 5) This can be caused through repeated stress on the limbs (bones) or from an infection. It is the inflammatory response of bone to injury. When the periosteum is attacked by infection or repeatedly damaged, bone reacts by laying down new layers of bone to heal that damage. There are two types of periostitis, acute and chronic. Acute periostitis can be caused by infections, autoimmune diseases, chronic ulcers, or even unhealed cuts that can become worse over time. Chronic periostitis is caused by the repeated stress and trauma on the bones. Repeated stress such as running, lifting weights, *etc*. - actions that athletes typically perform. The stress can cause the inflammation to occur and then the periostitis to form. (Roland, 2018)

Traumatic periostitis just refers to chronic periostitis. In habitual horseback riders this appears prominently on the lower limbs. The lower limbs already take the brunt of the force (gravity) from our body, but adding horseback riding to the picture puts even more force/weight on these limbs. The legs are used for balance and to anchor/hold oneself onto the horse throughout the entire ride. This causes a lot of strain on the leg muscles. Thus, causing the repeated stress to trigger inflammation and the formation of periostitis.

Periostitis is benign and can be tolerated, yet it can also become extremely painful. The best way to help stop periostitis would be to rest and let the bone recover and fully heal, but when horses were used habitually for transportation or war, there was not much time for this. I believe that is why chronic/traumatic periostitis is evident in antiquity in relation to horseback riding. The riders never took a break from the action that caused this issue.

Figure 5, Evidence of Periostitis on Lower Limb, (HxBenefit Editorial Team, 2012)

Heterotopic Bones

The human body is a mystery that doctors, anthropologists, and other scientists are trying to better understand every day. When dealing with a fracture, the bone does not always heal as expected or look the way it did before the injury. Heterotopic bones are an abnormal growth of bone that are found inside soft tissue and muscles. (Fig. 6) This can happen due to soft tissue trauma (tears) or through intense muscle activity that continually injures the skeletal muscles. (Anđelinović *et al.*, 2015)

Because of the continual stress on their muscles, horseback riders can develop heterotopic bones, called ‘rider’s bones.’ (Anđelinović *et al.* 2015) Typically, ‘rider’s bones’ are found in the thighs and backs of horseback riders. I believe this is because the intensity of the muscles used in these two sections of the body. Yet, these growths can happen anywhere.

Figure 6, Heterotopic Bone on the Knee Joint, (Woon, 2019)

Pronounced Muscle Attachments

Horseback riders engage every single muscle within the body while riding and training, so it is no wonder that the skeleton will show pronounced muscle attachment sites. These pronounced attachments can be found primarily in the sacro-lumbal part of the spine, gluteal muscles, and the upper legs.

The bone will show the enlarged muscle attachments. For horseback riders, the position used for riding puts a strain on the muscles of the lower half of the human body. Bioarcheologists have observed these pronounced areas of insertion on the skeletons of riders in antiquity. The areas present as roughened ridged areas on the bone. While this can be seen on all skeleton's muscle attachment, they will be bigger and more pronounced on those engaging in more muscle use. The thigh and Gluteus muscle attachments will show a more pronounced area on habitual horseback riders due to those muscles having to work harder than normal during this activity. (Anđelinović *et al.*, 2015)

Common Traumas and Injuries

As with any sport or hobby there can be consequences from a bad fall or wrong step and horseback riders are no exception to this rule. There are a few injuries that are commonly found in antiquity that are consistent and associated with habitual horseback riding. These include crushing injuries, fractures to the upper and lower extremities, fractures to the foot and clavicle fractures. (Anđelinović *et al.*, 2015) These fractures are known to be common amongst riders due to what is seen in modern day horseback riders and due to knowing the history of sites examined.

Skeletons in antiquity can show traumas and injuries due to falls or injuries from the ground by horses. Ancient riders may also show evidence of cuts marks and related trauma due to using their horses to ride in battle and war.

Crushing Fractures

A crushing fracture happens when the bone is under a lot of pressure causing the bone to collapse under the pressure become compressed and flattened. This can happen when the bone is stuck between too hard objects making it impossible for the bone to go anywhere. For habitual horseback riders this is common when a horse takes a spill and lands on you. This could also happen if a horse puts their whole-body weight on one of your extremities, by stepping on the individual.

Fracture to Upper and Lower Extremities

The limbs are very susceptible to injury during any physical activity that it is no surprising that they are one of the major parts of the body to see fractures with horseback riders. Common injuries include crushing fractures as discussed above, but also include other types of fractures, like transverse, oblique, spiral, greenstick and compression fractures. (Nordqvist, 2017)

Horseback riders can be thrown many times throughout their career without suffering a fracture, but landing in the wrong way can cause some pretty nasty fractures. A direct fall onto an extended leg or arm can result in a fracture, due to the force in which the body is stopped by the ground, causing the weakest part of the bone to give in. Also, a direct fall onto one of these limbs, can cause a fracture, the bones just cannot withstand such a powerful force between two sturdy/heavy objects.

Foot Fracture

The foot is a valuable part of the body, it helps an individual walk and balance. For horseback riders it helps anchor them into the saddle while riding. With a lowered heal and slight outward turn of the toe, correct positioning of this part of the body can make or break a successful rider. So, the foot is often the site of different kinds of fractures in horseback riders.

A fracture to the foot is one of the most common injuries in horseback riders, this can happen due to the sheer force and weight of the horse. (Anđelinović *et al.*, 2015) If a horse steps on an individual's foot, the weight of the horse may crush or fracture the person's foot. Some people get lucky and do not experience this, but others may give right on impact. Unfortunately, it is difficult to know exactly what caused an injury in Antiquity. A foot could simply get caught in a stirrup during an accident and become fractured. The foot is a vulnerable part of the body during those long hours spent in the saddle or on the ground working with these animals.

Clavicle Fracture

The clavicle has many functions, it connects the shoulder to the trunk of the body and helps provide support for the shoulder. Like every bone it has job to protect underlying and intertwining structures that run between the upper extremities and the trunk of the body. The clavicle is not a huge bone, and since it supports and works with the upper limb, it has a greater chance of suffering a fracture. "The most common mechanism of injury [to the clavicle] is a fall onto the shoulder, or onto an outstretched hand." (Jones, 2018)

Aside from the most two common ways to break the clavicle it is also possible to take a fall directly onto it potentially causing a fracture. Any number of these fracture traumas could happen with horseback riders. It is so common to see within habitual horseback riders because of the nature of falling off of one of these animals. A natural instinct as a human is to save yourself when taking a spill. When coming off a horse an individual might be inclined to extend their hand or roll off of their shoulder to try and limit to stop the impact, thus causing a fractured clavicle.

Case Studies

There have been numerous case studies done that have examined consistent changes to the human skeleton in horseback riders. I have compiled and will discuss some of the most enlightening of these case studies in this paper. These case studies all discuss evidence of habitual horseback riding through the presence of specific trauma to the body and the presence of horses at the sites. Some of these archaeologists and anthropologists whose work I examined also have knowledge of the communities they are looking at and whether not they are known for participating in habitual horseback riding.

Ukraine – 325 BC

Horses were used for many functions throughout the centuries, whether it was for meat or transportation. Some of the earliest civilizations treated horses are prized possessions, due to their versatile value to their communities. In one of the earliest examples of cultures with domestic horses a series of burials dating to 325 BC (from the Royal Scythian burial mounds) included both humans and horses. This culture was known for their “semi-nomadic lifestyle spent on horseback and in wagons, their burials reflect the importance of their horses.” (Wentz and Grummond, 2009: 107) The horses were found with ornamental bridles and iron bits, showing off how valued they were.

There were two human burials unearthed. Burial 1, discovered in 2004, and burial 2, discovered the following year in 2005. The first burial contained 50% of a young man's skeleton. This skeleton belonged to a young man that probably used a bow and arrow throughout his life, indicated by occupational markers (enthesophytes) in the shoulder and upper arm of the arm used to draw the bow string. Burial 2 contained an adult male seeming to be around 40 to 50 years old at the time of his death, with 8 intact vertebras found. These vertebrae showed clear degenerative changes, showing the aging and stress that the man's spine took.

The most interesting part about both of these skeletons, was the presence of Schmorl's nodes on both of the spinous processes of some of their vertebrae. The Burial 1 skeleton had a Schmorl's node present on one of his lumbar vertebra and Burial 2's Schmorl's nodes were found on both one lumbar and one thoracic vertebra. These people were labeled as "small, plagued with arthritis, with swelling of the vertebrae and hip problems associated with life on horseback." (Wentz and Grummond, 2009:112) The occupational stress markers found just among these two skeletons alone, help to prove that Schmorl's nodes were a common aspect of life on horseback.

In addition to the Schmorl's nodes found on Burial 2's skeleton, severe trauma was also found on the right upper extremities and the right clavicle. (Wentz and Grummond, 2009) These types of trauma patterns are common with horseback riders, especially when they have taken a rather hard fall. Finding evidence of these fractures is also a good indicator that at least some of the people in this community, spent a lot of time on horseback and likely hit the ground from the level of horseback.

Schmorl's nodes can be linked to degeneration happening within the spinal column of individual that put a lot of strain on their vertebrae. The older man showed evidence of multiple

Schmorl's nodes, which makes sense if he was constantly training and riding. His spine would have been under constant pressure, on top of his everyday activities within the community. It is interesting that the young man showed evidence of this degeneration at such an early age. These people must have worked extensively long hours with their horses to already have ruptured discs and to have formed these protrusions so early on in life. This evidence helps show the amount of impact that habitual horseback riding can have on one's spinal column.

Croatia – 14th and 15th Centuries

In present day Croatia archaeologists found a site named Kamen Most-Kaldrma that dates back to the 14th and 15th centuries, putting it in the medieval period. At this site the archaeologists found 25 graves that housed a total of 35 skeletons, a few of these graves contained a double burial and some contained triple burials. Out of these 35 skeletons, eight were sampled for further analysis in order to examine them for any potential occupational markers that might indicate what activities these individuals were involved in.

During the medieval period the horse became increasingly important, their history changed as their work as farm animals took the place of oxen. (Anđelinović *et al.*, 2015) Horses became more than just transportation or steeds for hunting and warfare, they also became the muscle that drove the ploughs for agricultural activities.

After each of the 35 skeletons were examined and analyzed, eight of them were chosen to be further examined due to specific skeletal markers. They were examined overall to find any markers that could be a direct result of habitual activity. These eight were found to have typical characteristics of bone that come with habitual horseback riding. They were all found to be male and seven out of the eight were found to have well preserved vertebrae.

On each of the eight skeletons there were specific occupational markers found that go hand in hand with habitual horseback riding. In all of the preserved vertebrae found there was evidence of Schmorl's nodes. "Signs of advanced osteoarthritis were found on all articular surfaces in all persons, and only in the person from grave 14 were the signs less pronounced." (Tables 1 and 2)(Anđelinović *et al.*, 2015: 712) These tables show the evidence of all the various traumas and stress markers found on the bones. Seven out of eight of the skeletons were found to have pronounced gluteal muscles and the eighth skeleton was just not preserved. Five out of eight of the skeletons were also found to have Poirier's facets. These traumas were amongst others that were also detailed in the charts provided.

Table 1, Evidence of Skeletal Stress Markers and Trauma at Kamen Most-Kaldrma

Grave Number	Grave 3	Grave 4	Grave 4	Grave 11	Grave 14	Grave 15	Grave 18	Grave 19
		Person 1	Person 2			Person 2	Person 1	
Wide Incisura Ischiadica	Yes	Yes	Yes	Yes	Yes	Yes	No	Yes
Presence of longitudinal cuts between sacrum and ilium	Yes	Yes	Yes	Yes	No	Yes	Yes	No
Pronounced gluteal muscles' attachments	Not preserved	Fragmented	Yes	Fragmented	Yes	Yes	Yes	Yes
Acetabular notch	Yes	Yes	Yes (right acetabulum)	Yes	Yes	Yes	Yes	Yes

(Anđelinović *et al.*, 2015: 713)

Table 2, Evidence of Hypertrophy and Enthesophytes at Kamen Most-Kaldrma

Grave Number	Grave 3	Grave 4	Grave 4	Grave 11	Grave 14	Grave 15	Grave 18	Grave 19
		Person 1	Person 2			Person 2	Person 1	
Poirier's facets	Yes (left femur)	No	Yes (right femur)	Yes	Yes	No	Yes	No
Intertrochanteric enthesophytes	Yes	Yes	Yes	Yes	No	Yes	Yes	Yes
Pronounced linea aspera	Yes	Yes	Yes	Yes	No	Yes	Yes	Yes
Great trochanter (robust and curved)	Yes	Yes	Yes	Yes	No	Yes	Yes	No
Bone spicules (adductor and gluteal)	No	Yes	No	No	No	Yes	No	No
Pronounced fossa poplitea	Bone not preserved	No	No	Bone not preserved	Yes (right femur)	No	No	No

(Anđelinović *et al.*, 2015: 714)

The eight burials analyzed at Kamen Most-Kaldrma show strong evidence for habitual horseback riding. The authors compared these burials with those of known habitual horseback riders and found the same kinds of pathological conditions in both populations. This evidence helps researchers to further understand how much horseback riding can affect the human skeleton. This case study illustrates that the horse riders were not a dominant part of society, instead an aspect of the traditional culture they were trying to preserve.

Northeastern Nebraska – AD 1200 – 1400 and AD 1750 – 1840

In Northeastern Nebraska, Karin L. Sanders and Karl J. Reinhard examined the vertebral pathologies of prehistoric and historic Native American groups. They wanted to examine both pre-historic and historic group in order to analyze the skeletal changes that come with changes in activity. They looked at two different classes of degenerative diseases: osteoarthritis and osteophytosis.[3]

Sanders and Reinhard (1992) examined the vertebrae, recovered from five sites in Northeastern Nebraska, for any signs of pathology. St. Helena Phase cemeteries[4], dating back to AD 1200 to AD 1400, are the designated prehistoric sites examined. The sites included: three St. Helena phase cemeteries (AD 1200-1400), where eighteen burials were analyzed; and two historic period cemeteries, the Omaha and Ponca cemeteries (AD 1750-1840), where twenty-one skeletons were analyzed.

The vertebrae from the prehistoric contexts showed a much greater overall occurrence of osteoarthritis (94.5%) compared to the approximate of 71% of historic spines with arthritic changes. 16.7% of the prehistoric spines showed Schmorl's nodes in comparison to the 42.8% of

[3] Osteophytosis refers to degeneration on the discs of the vertebrae
[4] 25DK9 and 25DK13

historic spines also showing these protrusions. Lastly, Spondylosis, which does not make an appearance on the prehistoric spines, is present on 19% of the historic spines. All of these markers may form due to occupational stress. (Sandness and Reinhard 1992)

The researchers in this study were able to conclude that the increase in horseback riding (or even breaking/training horses) was responsible for the various forms of degeneration and trauma in the spine. Hyperextension and hyperflexion of the spine happens often throughout the process of riding and training, so these occupational markers are consistent with the activities of these people. The authors argued that the higher occurrences of Schmorl's nodes, and Spondylylosis in the historic contexts indicated that contact ere populations would have been under greater social and economic stresses from European and American contact, "horseback riding would have figured prominently in both the increased hunting and intensified warfare of the early nineteenth century." (Sandness and Reinhard, 1992: 307)

Trauma and Markers on the Horse

Just like the humans that ride them, horses can also suffer trauma and changes to parts of their bodies. In modern days, starting a horse too young or doing too much high impact riding without rest days or therapies to help repair their muscles, can cause extensive damage. This is consistently seen within antiquity as well.

Depending on the saddle and the way it fits the horse, it can cause extensive damage to the horse's spine as well as the back and shoulder muscles. Starting horses too young can also cause extensive damage to the knees and legs. Just like in humans, young horses have growth plates and intense work, early on, can cause damage to the growth plates resulting in improper growth of the affected bones.

In antiquity certain pathologies can indicate that the horse was worked and used frequently. Bone deformation, such as spondylosis deformans, are noted in many horses found in archaeological contexts. There is also evidence of bit wear patterns on the teeth of horses, indicating both riding and domestication. Lastly, changes to the spine especially influenced by certain saddles used has been recorded within the archaeological record. (Bulatovic *et al.* 2014)

When humans began to domesticate horses, they completely changed the routines of these animals. Levine et al. (2000) suggests that the cervical vertebrae were greatly affected with the domestication of horses because of the way they are housed and fed. This could be due to the fact that wild horses mainly keep their heads down, grazing the grass below them. Yet when horses are kept in barns their food is often at head level or higher, so they have to hold their heads up to eat. This makes the horse change their normal routines that they genetically were used to.

Case Studies – Horse Markers

There have been a few studies that suggest that pathologies caused by the stress of horseback riding can also be seen on horses. These pathologies are indicators that horses were used for both riding and draft work. Marks include more than just those left by a saddle or bit because when horse domestication first started, the communities were most likely riding these horses bareback and without any sort of equipment.

Ranutovac-Meaniste – Southern Serbia – Early Bronze Age/Early Iron Age

A complete horse skeleton was analyzed from the Early Iron Age at the site Ranutovac-Meaniste in southern Serbia. The horse skeleton was discovered near two pits, filled with a mix of fragmented artifacts. The horse was located in the northern, circular shaped pit, surrounded by pieces of daub. The horse had been laid on its left side with extended legs and its head tucked down. (Bulatovic *et al.* 2014)

Bulatovic *et al.* (2014) used tooth attrition in the lower incisors to estimate the age of the horse at the time of its death. The mare was determined to be approximately 4 to 5 years of age and a mare based on her pelvic characteristics. No evidence of slaughter was found and it was determined that she had to have been buried shortly after death.

Current dental changes associated with equines that are consistently ridden include creating a pit or notch in the cheek-teeth that keeps the bit in place, avoiding collision with the teeth. This gives the rider more control and the horse a more comfortable ride. Archaeological horse remains also show evidence of this type of bit wear, so its presence in the back teeth can help determine whether the horses were used for riding or not. The horse recovered from the Serbian site was noted to have "enamel exposure in the form of a narrow band on the anterior surface of both lower and second premolars." (Bulatovic *et al.*, 2014: 78) This may be caused from the way the bit hit the premolars and wore the cementin away.

This horse was also noted to have multiple pathologies on its vertebral column. Specifically, lesions on the thoracic and lumbar vertebras (which tends to be the most commonly affected vertebrae in riders as well.) The changes were more marked on the right side of the vertebral bodies, with both osteophytes and ankylosis of the joints. Along with the changes to the spinal column, the authors also noted changes in the head of the eleventh right rib. "Bone proliferation with exostoses on the lateral surface below the rib head was observed on the eleventh right rib. This change corresponds to well-developed spondylotic changes in the associated spine." (Bulatovic *et al.*, 2014: 78) The muscle attachments on the tibias were observed to be quite robust, but definitely more prominent on the right side of the horse.

Bulatovic *et al.* (2014) went on to argue that the evidence found on the spine could have been caused from the horse being ridden before she was finished growing. Some of the pathologies found in the leg would most likely have caused dysfunction and lameness in the leg, but the extent of damage means that the mare was still continually ridden. The prominence of the right leg muscle attachments is probably due to uneven weight balance on top of the horse, making her have to compensate more on one side to stay balanced.

All of these pathologies observed, can be linked back to frequent stress caused by riding and/or working. Just like the human skeleton, a horse's skeleton will react to occupational stress. Routine stress and trauma can cause extensive damage to many different parts of the horse's body.

Modern Day Horseback Riding Injuries

Throughout this paper, I have discussed the effects of habitual horseback riding on the bodies of historic and prehistoric horse-riding peoples, but in modern times, people do not use horses to the same extent as they did centuries ago. With cars, public transportation, and motorized ploughs there is no use for horses as major forms of transportation or work. Yet, there are still people who dedicate their lives to riding and caring for these animals. Some people use horses strictly for pleasure and competition, but there are still farms and ranches out there that use horses everyday to complete various tasks.

Just like habitual horseback riders in ancient times, modern horse riders are at risk of experiencing horse-related injuries. In one study, 108 riders were interviewed about injuries they experience. "Out of the 108 members, 48% had experienced back-pain…" (Morgan, 2015: 9)

Back pain and injury is frequently experienced by riders due to the impact the vertebral discs and bodies take during the process of riding. The spine goes through extensive changes based on the amount of stress that is put on it.

Horseback riders not only sustain injuries from the stress of normal riding, but also through falls off of horses, being bitten, kicked, pulled, *etc*. These common injuries observed in modern riders often occur during farrier work, grooming, saddling, or during any handling of a horse and can result in different injury patterns such as soft tissue injuries or fractures.

The injury rate in modern horseback riders tends to be higher in females than in males. This is likely due to the fact that the concentration of females involved in the sport is higher than the males. Modern riders typically use the sport of horseback riding more for recreational enjoyment than for work or battle, unlike what was seen in antiquity.

Paix (1999) looked at 4220 competitors in a series of 35 events in modern horsemanship. 37 of these competitors were injured.

> *In keeping with other studies, head and neck injuries predominated (despite the universal use of approved helmets), being present in 19/37 cases. Other common injuries were lower limb fractures (3/37), rib fractures (3/37), and soft tissue injuries of the thoraco-lumbar spine (5/37)*
>
> (Paix, 1999: 46)

These injuries are consistent with injuries found in antiquity as well. The most common injuries in the sport of horseback riding are seen in the neck and skull, due to the height and the force of either falling from a horse or just from the strength of the horse itself. This particular study focus on cross-country events, so these riders were likely riding at great speed and jumping odd/tall obstacles.

Discussion

After examining the data and evidence I find that there are consistencies in the skeletal pathologies in antiquity that are linked to habitual horseback riding. The presence of these stress markers can help determine and conclude whether a group of people partook in the practice of horseback riding. The bones of the human body are in a delicate balance between protecting us and supporting our daily activities, and many people do not think about the affects their activities have on their skeletons. Repeated stress and repetitive action can impact the body greatly, making drastic changes to our bones.

Riders may not have always know about what was happening to their bones. Some changes, like periostitis are painful, but the development of large muscle attachments is not, so they would not affect your everyday life. Habitual horseback riders in the past probably did not think anything of a sore back or sore legs because they depended on them for so many tasks. In antiquity people did not just hop on the back of a horse because they had down time or wanted to ride for pleasure. These people relied on the use of the horses in order to get between places or even to carry them through battle.

Horses are still used frequently today whether for pleasure or for work (which is still very common on farms across America). Studies of modern riders reveal that all riders suffer from lumbar disc degeneration, no matter what discipline of riding they follow. Also, since modern riders often ride for different reasons than people in the past, the degree of degeneration may be somewhat different because the intensity and length of time is not exactly the same. Either way, the injuries present among habitual horseback riders in the past and those of modern times do show some consistencies. The biggest difference is that we can observe soft-tissue injuries in modern populations, but cannot see much evidence for this in antiquity due to the lack of preservation (unless we see examples of heterotopic bone or remains are mummified).

The horses ridden are also subject to trauma and bone changes because they are the ones packing people around and have pressure put directly on to their skeletons as well. These horses may actually show trauma similar in pattern to those of the riders, namely in the spine and the extremities. The fact of the matter is that any kind of stressors put on animals or humans can result in changes in the skeleton. All of the data, shows that the skeleton is a sturdy, but highly reactive part of the body. Bones have the ability to tell a biological anthropologist the story of that person's life due to the patterns of the types and locations of occupational markers on the body. This is helpful in giving insight on past populations.

Conclusion

Based on this study, I think it is obvious that bone deformation of the vertebral column, the femur, and the pelvis/hips is quite prominent in habitual horseback riders. These boney changes are caused by the heavy use of the muscles in these areas, thus forming occupational markers. These skeletal changes are compensation by the body to support the weight and pressure changes that happen to the joints and muscles while in the saddle. I found that occupational markers in modern day horseback riders do not differ very much across disciplines, as the position and actions of body affect the skeleton in similar ways across the board. I also conclude that similar traumas can also be seen on the horse's skeleton, especially if the saddle does not fit properly or if the horse was started at a very young age so as to affect skeletal development. Based on the study I did; I can also determine that modern day horseback riders do experience similar injuries and bone deformations as those found in archaeological cultures.

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