

A close-up, grayscale photograph of a horse's head, focusing on its eye and the surrounding facial structure. The horse's coat is light-colored, and its eye is dark and expressive. The background is a solid dark color, creating a high-contrast effect. Overlaid on the lower half of the image is white text.

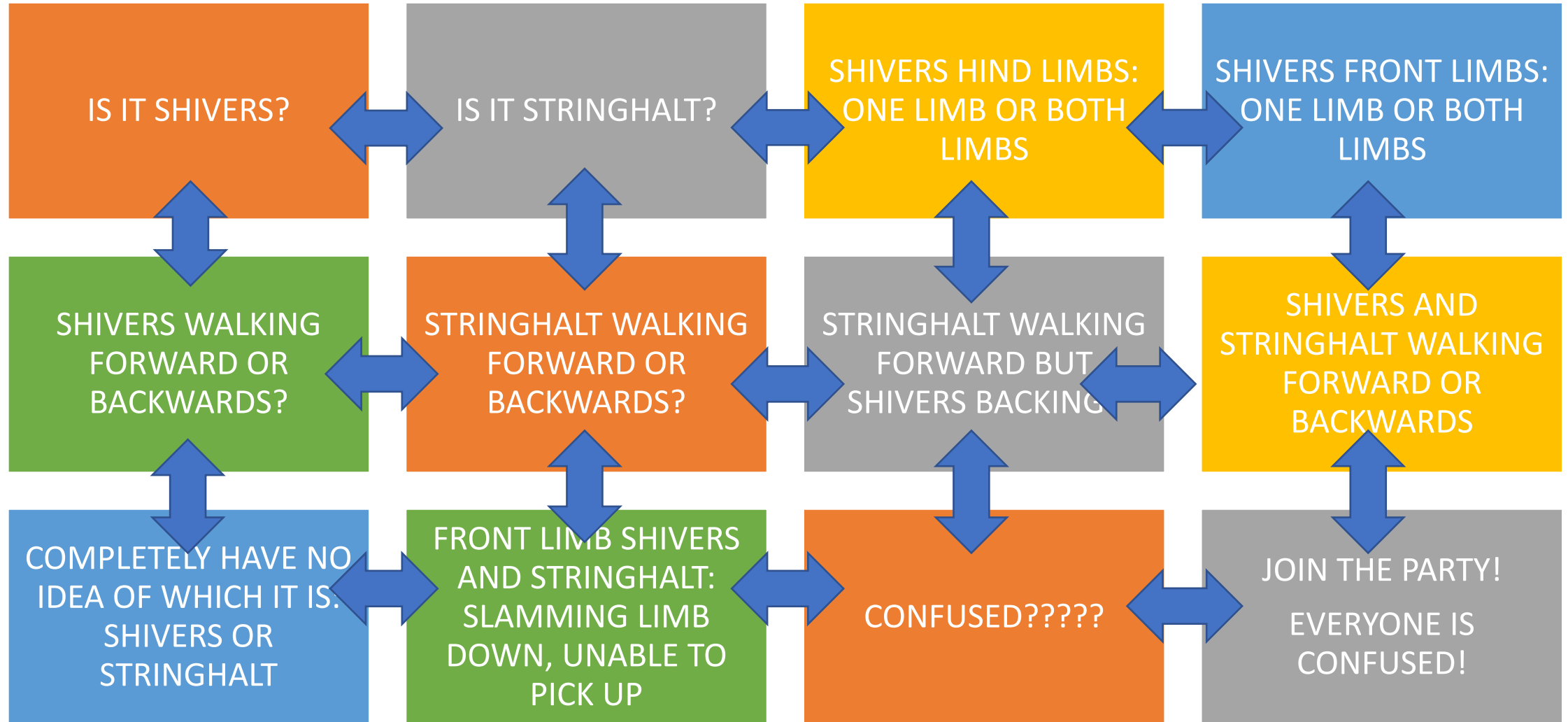
# SHIVERS-STRINGHALT SYNDROME

## PART 1: HISTORY

Audrey DeClue, DVM

DeClue Equine, LLC

# WHY IS IT SHIVERS-STRINGHALT SYNDROME?



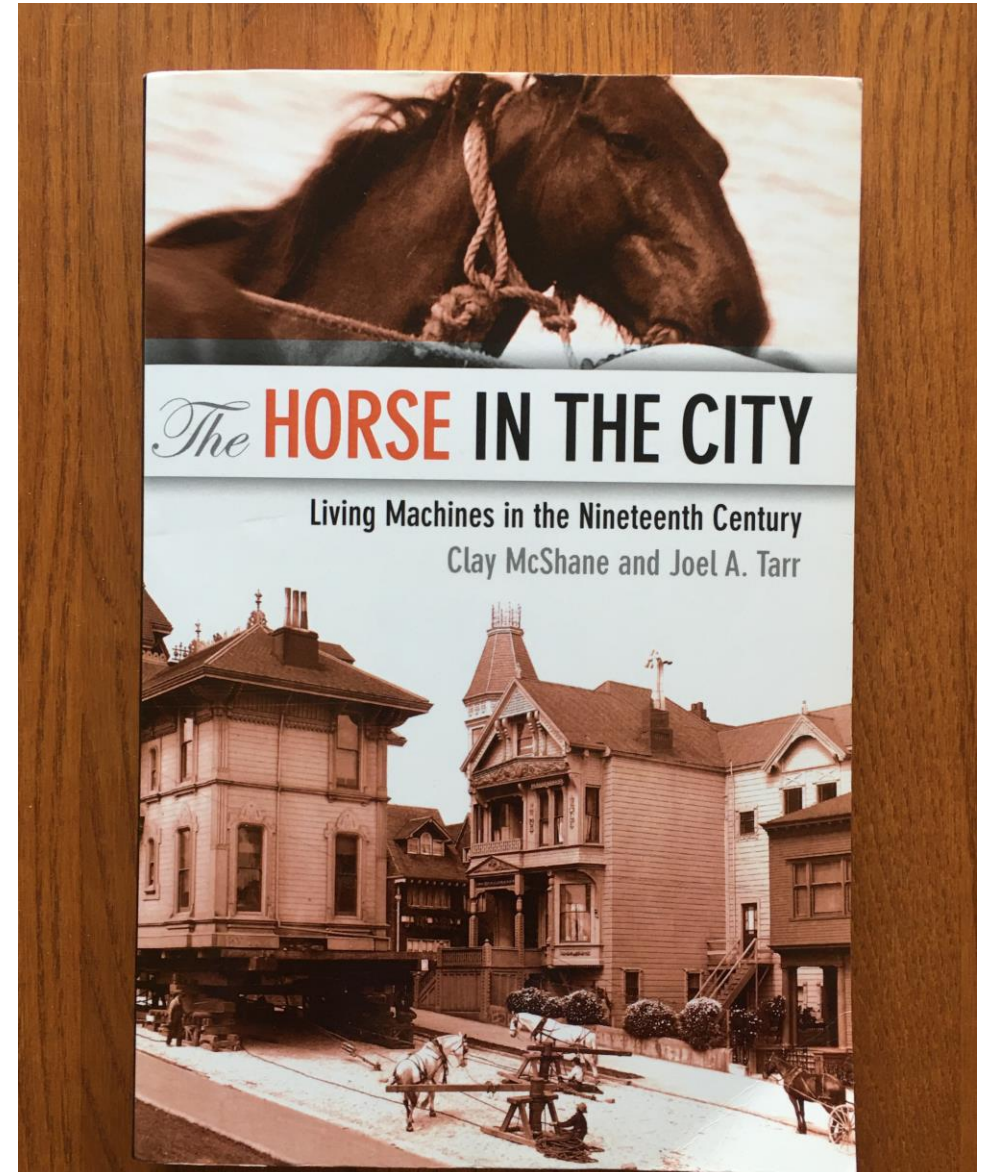
# SHIVERS

- TODAY'S DEFINITION: PROGRESSIVE, LOCOMOTION-INDUCED MOVEMENT DISORDER
- AFFECTS HORSES WORLD-WIDE
- PRESENT IN HORSES FOR HUNDREDS IF NOT THOUSANDS OF YEARS
- NO KNOWN EFFECTIVE TREATMENT
  - HUMANE EUTHANASIA



## SHIVERS: PRE-INDUSTRIAL REVOLUTION

- HORSES WERE
- “THE LIVING MACHINE”
  - TRANSPORTATION
  - FARMING-WORK
  - HAULING AND CARRYING







# SHIVERS: HISTORY

- SHIVERS CONSIDERED:
  - “COMMON AS DIRT”
- PREVALENCE HIGH:
  - SHIVERS
  - STRINGHALT
  - SHIVERS AND STRINGHALT



# HAY FOR THE HORSES

## Scows at the Hay Wharf

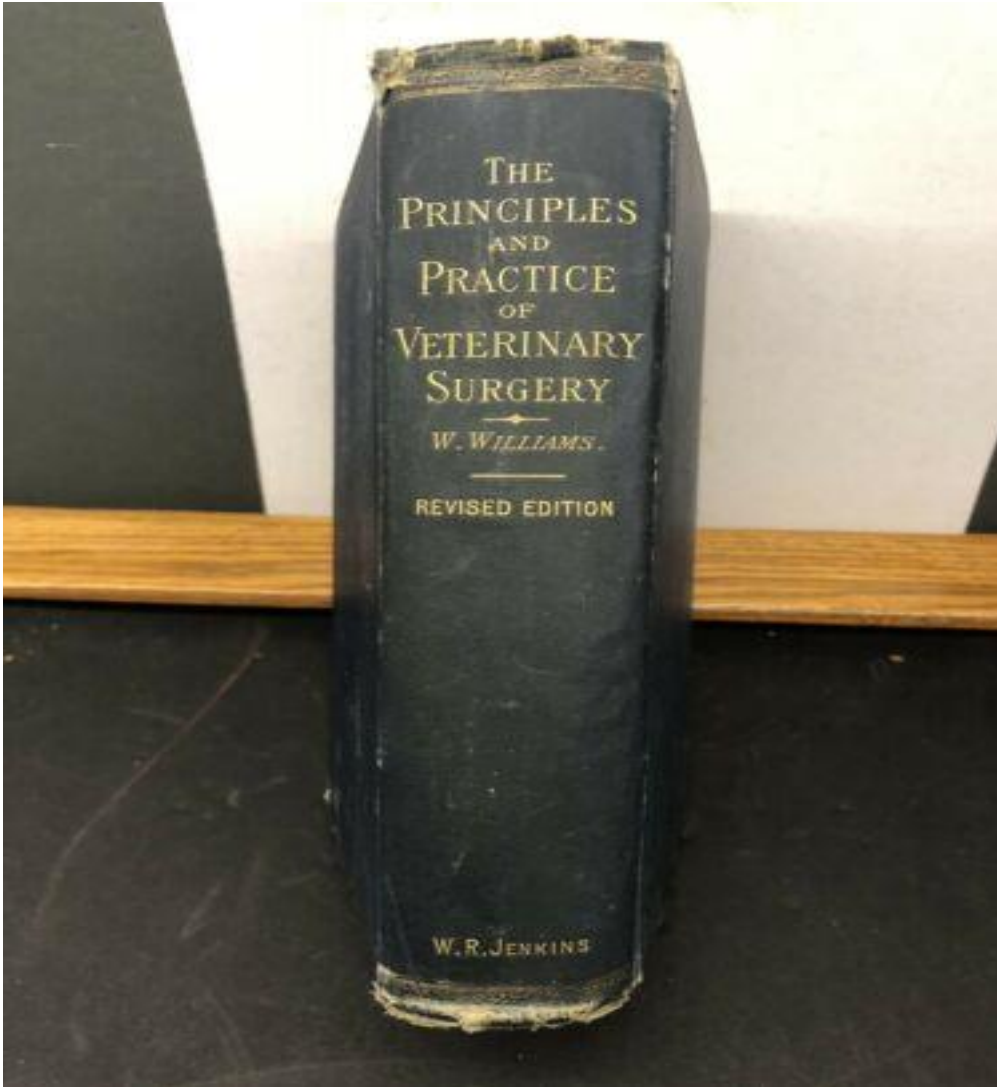
Nineteenth century San Francisco ran on horse power, and hay was the fuel of the day. With their high deck loads, the scows resembled floating haystacks. Some 400 scow schooners — square-ended sailing barges — brought hay into the wharf on Channel Street (near the ballpark). The hay wharf was at the southern end of the waterfront, so that the fires that regularly broke out could be contained.



Vehicles ranging from passenger rail cars to heavy dray wagons were



# SHIVERS: HISTORY



- William Williams
- The Principles and Practice of Veterinary Surgery. 4<sup>th</sup> Edition. 1882
- J.R. McCall
- "Stringhalt" and "Shivering".  
Proceedings 28<sup>th</sup> Meeting of National Veterinary Association, London 1910



# William Williams 1882

## Chorea = Shivers = Stringhalt

- Page 245:
- *Definition.* — An irregular convulsive clonic action of the voluntary muscles, confined generally in the horse to the posterior extremities, constituting "stringhalt," and in the dog as a sequel to distemper, to the anterior ones, neck, and face, by which they are withdrawn from the control of volition.
- Professor Dick was of opinion that it was due to the presence of tumours in the lateral ventricles of the brain, and supported his views by a post mortem proof. But tumours in the ventricles may be present without chorea; and chorea is very often present without such tumours. Other writers have traced its origin to a hypertrophied condition of the nerves given off from the lumbar plexus, to the pressure of some exostoses on a nerve, and to paralysis of the muscles antagonistic to those affected with the spasm.



# William Williams 1882

## Chorea = Shivers = Stringhalt

- Stringhalt may be defined to be an involuntary convulsive motion of the muscles, generally those of one or both hind legs, but occasionally it is seen in the fore legs also.
- The limb or limbs affected are convulsively elevated from the ground, and brought down again with more than natural force. It is not always to be noticed at every step the horse takes. He may go several paces, as many as twenty, without exhibiting any signs of stringhalt; then, all at once, the limb or limbs will be suddenly elevated from the ground with a peculiarly sharp sudden jerk. It is necessary sometimes to turn the animal round from right to left, and from left to right, in order to make him show any signs of stringhalt, the symptoms of the disease being exhibited as he turns one way only. It is generally developed slowly, but I have seen very aggravated cases come on in one night, and as age advances it always becomes worse. It should be viewed as an unsoundness, and as a cause of depreciation of the animal's value. In two horses which had suffered from very violent stringhalt, the *post mortem* examination revealed exostoses on the shaft of the ilium, involving the great sciatic nerves.
- In grey horses, stringhalt is occasionally due to a deposition of melanotic material in the sheath of the great crural nerves.. This view is supported by the fact that injuries to the feet, or any part of the limbs affected with stringhalt, are very prone to be succeeded by increase of the spasm, by much nervous excitement, and by tetanus.

# William Williams 1882

## Chorea = Shivers = Stringhalt

- Some horses affected with stringhalt, when injured in the feet, become almost unmanageable from the extent of the spasm; they are soon exhausted by the expenditure of nervous and muscular force, and the mortality from such injuries is much greater than in horses free from stringhalt.
- There is no treatment in chronic stringhalt I have divided the tibial nerves when it has been associated with bone-spavin. In this case it was confined to one leg only, and to a fearful extent, the foot being caught up with extreme rapidity, and brought down with great violence, insomuch that the shoe was repeatedly broken by the violence of the concussion. There was a bone- spavin on the hock, with considerable heat and tenderness. After trying various remedies upon the hock without good result, I divided the tibial nerves; but the animal derived no benefit from the operation. In aggravated cases the limbs are adducted, the foot thrown outwards, as well as elevated, during the act of progression.

# William Williams 1882

## Immobilite, Shivering, Sprained Back, Etc

- "*Shivering* " is another peculiar nervo-muscular affection of the posterior extremities, resembling stringhalt, and manifested more particularly during the acts of " backing " or " turning round."
- In a case of this kind the animal, when made to back, will perform that act with some difficulty; the muscles of the gluteal and femoral regions are thrown into a state of " clonic spasm," contracting and relaxing in a very irregular manner; hence the term " shivering," from the resemblance of the muscular action to trembling or shivering. In many cases the tail is spasmodically elevated and depressed in the manner of a pump-handle, and the limbs elevated from the ground by a peculiar rigid or stiff movement; the foot often suspended for a moment, as if the animal were unable to direct the action of the muscles.
- When moved forwards, the necessary actions will be performed tolerably well, but the backward movement is done with more or less difficulty, and sometimes it cannot be performed at all.



# William Williams 1882

## Immobilite, Shivering, Sprained Back, Etc

- Shivering, *immobilite*, strained back, and their various modifications, must be considered as causes of unsoundness, since their tendency is to increase in severity as the animal becomes older. They often interfere with his condition, and generally give him an aged appearance before he has reached his prime; and they prevent him lying down, particularly if he is confined in a stall. Some horses, while so affected, lie down well enough; the majority, however, scarcely ever do so, but fall down in their sleep occasionally, and being unable to rise again without assistance, often injure themselves by struggling. Animals of this kind should always be slung at night.
- *Hereditary tendency.* — I think there can be no doubt as to hereditary predisposition being one of the causes of the foregoing diseases; indeed, I have had sufficient proof, in my own experience, to convince me that such is the case.

# The Veterinary Record.

FOUNDED BY WILLIAM HUNTING, F.R.C.V.S., 1888.

No. 5.

FEBRUARY 1, 1930.

VOL. 10.

## Some Aspects of Osteo-Arthritis of the Vertebral Column.\*

By W. M. MITCHELL, M.C., M.B., Ch.B., B.Sc. (Edin.),  
M.R.C.V.S., Professor of Surgery and Obstetrics, Royal  
(Dick) Veterinary College, Edinburgh.

Over a year ago I came across a horse, slaughtered for food purposes at the Scottish Zoological Park, whose vertebral column, as far as the thoracic bodies were concerned, was completely ankylosed and showed varying knob-like excrescences projecting into the thoracic cavity.

A portion of the thoracic part of the vertebral column was obtained and boiled and is placed before you as the starting point of my growing interest in clinical aspects of osteo-arthritis, or perhaps it would be better to say osteitis and arthritis, as it affects the vertebral column (specimen exhibited). I have no intention of going into detail of the pathology of osteo-arthritis in this short paper, though it will be necessary for me to try and correlate clinical signs and pathological findings.

From September last I have taken every opportunity of examining horse carcases, more particularly the thoracic and lumbar regions, and the specimens laid out illustrate the diversity of pathological changes occurring in the vertebral column.

The total number of horses destroyed at the Zoo from September to April inclusive was 116, and I have, from 23 of these horses, obtained some portion or other of the vertebral column showing osteo-arthritic changes.

These horses were all aged and therefore the proportion of affected specimens is no doubt unusually high, but nevertheless shows that the condition under discussion is

medially, and laterally, it struck me that the nerves emerging from these foramina were peculiarly liable to suffer from the effects of osteo-arthritic change if these neighbouring joints should ever be affected.

From this deduction I began to wonder if the conditions shivering and stringhalt might be explained in this way.

It so happened that about this time a shiverer came to my notice which I managed to get the Zoo to buy for slaughter and I thus got an opportunity of testing the hypothesis I had formulated. (See Case 1 below.)

I am still waiting for an opportunity to examine a stringhalt case *post-mortem*, though I will give you the history of a case which is suggestive of a causal lesion in the lumbar region.

The conditions known as jinked or sprained back, grunting and broken wind I am also going to discuss briefly, but I fear you will think I am skating on very thin ice in some of my arguments.

### SHIVERING.

#### CASE 1.

*History.*—A heavy draught gelding, about 16 years old and in somewhat poor condition, came under treatment on account of a large superficial burn on the rear thigh, but as the area would have taken a long time to heal and the horse was a marked shiverer in the off hind leg, destruction was advised.

*Post-mortem examination.*—The carcase when hung up revealed little wrong with the thoracic vertebrae. On removal of the sub-lumbar muscles a large rounded spherical excrescence about 2 in. in diameter was found on the left side, i.e. on the opposite side to that in which clonic spasms of the thigh muscles had been noticed, whereas at first glance

## SHIVERS: HISTORY 1930

- William M. Mitchell
- The Veterinary Record. "Some Aspects of Osteo-Arthritis of the Vertebral Column".
- February 1, 1930

# WILLIAM M. MITCHELL

## FEBRUARY 1, 1930

- From September last I have taken every opportunity of examining horse carcasses, more particularly the thoracic and lumbar regions, and the specimens laid out illustrate the diversity of pathological changes occurring in the vertebral column.
- The total number of horses destroyed at the Zoo from September to April inclusive was 116, and I have, from 33 of these horses, obtained some portion or other of the vertebral column showing osteo-arthritic changes.
- From the frequency with which specimens were obtained in this region in September, I was led to believe that the Lumbar Vertebrae, with their more complicated articulations associated with the transverse processes of the 4th, 5th and 6th., would in all probability show similar changes.
- Remembering that the Lumbo-Sacral plexus of nerves was formed by the ventral roots of the 4th, 5th and 6th Lumbar and 1st and 2nd Sacral nerves, and that the ventral intervertebral foramina, by which the first three of these roots emerge, were in close proximity to joints medially. and laterally, it struck me that the nerves emerging from these foramina were peculiarly liable to suffer from the effects of osteo-arthritic change if these neighbouring joints should ever be affected.
- From this deduction I began to wonder if the conditions shivering and stringhalt might be explained in this way. It so happened that about this time a shiverer came to my notice which I managed to get the Zoo to buy for slaughter and I thus got an opportunity of testing the hypothesis I had formulated. (See Case 1 below.)



# Case 1

- *History.* -A heavy draught gelding, about 16 years old and in somewhat poor condition, came under treatment on account of a large superficial burn on the near thigh, but as the area would have taken a long time to heal and the horse was a marked shiverer in the off hind leg, destruction was advised.
- *Post-mortem examination.* –The carcass when hung up revealed little wrong with the thoracic vertebrae. On removal of the sub-lumbar muscles a large rounded spherical exostosis about 2 in. in diameter was found on the left side, *i.e.* on the opposite side to that in which clonic spasms of the thigh muscles had been noticed, whereas at first glance the other half of the vertebrae appeared normal. More careful dissection, however, showed that the ventral intervertebral foramen between the 4th and 5th Lumbar Vertebrae on the right side was markedly diminished compared with the other side which had the large exostosis and that the ventral root of the 4th Lumbar nerve was definitely compressed by the osteo-arthritic change.

# Case 2

- The horse was 23 years old and he said that for the last ten years the horse had been "nerved" in the off hind leg and about a year ago signs of similar trouble commenced in the near hind leg. The animal became so bad lately that at times he would catch up the leg and almost fall over.
- For some time there had been considerable difficulty in backing.

# Case 2

- *Post-mortem examination.*
- (a) Osteo-arthritis of the costo-vertebral articulations was easily seen on inspection of the thoracic part of the spine owing to the marked lipping of the joint margins. These articulations, I find, are a very good guide in determining the likelihood of osteo-arthritic change elsewhere in the body.
- (b) A very distinctive feature on viewing the carcase was the pale salmon-coloured appearance of the 6th intercostal space on the left side; all other spaces were of a normal reddish brown colour.....it was filled by osteo-arthritic over-growth from the two adjacent costo-vertebral articulations completely bridging the space and so involving the intercostal nerve supplying the intercostal muscles. (Specimen exhibited.)
- This appears to me to be an excellent example of how osteo-arthritis may produce remote effects on muscles even to the point of complete paralysis.
- (c) Lumbar Vertebrae. (Specimen 'exhibited'.)-This horse possessed no inter-transverse articulations between the 4th and 5th vertebrae.
- The most obvious bony change was a rounded bony boss uniting the transverse processes of the 4th and 5th on the left side.
- The inter-transverse articulations between the 5th and 6th on both sides showed lipping with encroachment upon the ventral intervertebral foramina.
- The bodies of the vertebrae on either side of the articulations between the 3rd and 4th and the 4th and 5th bulged externally so that the depression on either side of the body of the 4th vertebrae was deeper than normal.
- Examination of the floor of the vertebral canal showed corresponding slight encroachment on the canal, from osteo-arthritic change of the adjacent ends of the bodies of the 4th and 5th. The vein lying at the side of the dorsal longitudinal ligament on the right side above the 5th vertebra was only about 1/5th the normal diameter.
- The general impression gained from consideration of the lumbar region as a whole was that the 5th vertebra had been the chief sufferer in the chronic changes, appearing as if it had had a slight twist on a longitudinal axis running through the centre of the body.
- The variety of changes in the vertebral column makes it difficult to point to any particular site as the cause of the signs shown during life.



# William M. Mitchell

## Discussion:

- I think you must all agree, from the figures given and specimens exhibited, that osteo-arthritis affecting the vertebral column is not only fairly common, in old horses at any rate, but also that the lesions are very variable. A pure pathological study of the specimens would have been very interesting, but my object has been to try and connect up clinical signs of some conditions the etiology of which is unknown, with gross pathological findings.
- This investigation is obviously very incomplete without considerably more evidence, especially from young animals, and I must confess that my main object in putting forward my views is to gain your help to obtain such animals for further study.
- *Stringhalt and Shivering.*
- The cause of the conditions "Stringhalt" and "Shivering" was last investigated in this country, as far as I can gather, by McCall (1) who had the spinal cord and brain examined for degenerations in a case of each, but nothing abnormal was found.
- My contention is that shivering and stringhalt are merely signs of osteo-arthritis affecting the vertebral column and that the varying site of muscular spasm depends upon the nerve roots implicated. The greater frequency of signs of these two conditions occurring in the hind limbs depends upon the peculiar anatomical relationship of the intervertebral foramina associated with the last 3 Lumbar nerves which help to form the Lumbo-Sacral plexus.
- In the early stages of the osteo-arthritic change no clinical signs are noticeable, then later some irritation of nerve roots develops and the signs of shivering, and to a less extent stringhalt, gradually increase in frequency.
- In the worst cases the blood supply to the spinal cord may be interfered with, producing a congestion of the cord, and this would account for the terminal paraplegia sometimes met with in shiverers.
- So far no microscopical examination of nerve roots or spinal cord has been carried out to see if there is any degeneration of nerve fibres associated with the suspected factor of osteo-arthritis.

# The Veterinary Record.

FOUNDED BY WILLIAM HUNTING, F.R.C.V.S., 1888.

No. 25.

JUNE 21, 1930.

VOL. 10.

## Some Further Observations on Pathological Changes Found in Horses Affected with "Shivering," and their Significance.\*

By W. M. Mitchell, M.C., T.D., M.R., B.Sc. (Edin.),  
M.R.C.V.S., Professor of Surgery and Obstetrics, Royal  
(Dick) Veterinary College, Edinburgh.

In a previous paper, I discussed the problem of shivering as met with in three old horses and expressed the opinion that an investigation of the condition in young horses might throw more light on its cause.

In the old horses which I examined, gross changes of an osteo-arthritic nature were the outstanding features, especially in the vertebral column, and I suspected that the signs of shivering might be due to pressure effects on the roots of the nerves going to form the lumbosacral plexus. Since then, I have been able to examine, *post-mortem*, three definite shivers, aged 2, 4½ and 5 years respectively, and again osteo-arthritis has been a prominent feature, though there were no marked exostoses on the vertebrae which one could incriminate as possibly causing pressure on lumbar or sacral nerve roots.

In all I found synovitis of the costo-vertebral articulations with varying-sized erosions of the heads of ribs from the effects of synovial overgrowth in these joints.

The hip, stifle, shoulder, elbow and hock-joints showed some degree of early arthritis, though the joints from the fetlocks downwards showed no appreciable change.

The erosion of joint surfaces occurs more especially in areas which anatomists have considered as normal excavations on joint surfaces, but in some joints, particularly the elbow joints, in addition to synovial congestion and overgrowth of villi, grooving of the articular cartilage was visible. In other joints, epi-articular echondroses, or merely a yellowish degenerate change of articular cartilage, may be observed.

The point I wish to stress is that I have yet to examine a shiverer, young or old, in which there is no osteo-arthritis.

The difference between old and young horses affected

4½-year-old showing complete ossification of all cartilages. (Specimens exhibited.)

I think I can assert that a horse which is a shiverer will always show some evidence of osteo-arthritis, often clinically, but certainly on *post-mortem* examination.

*Periosteal Separation.*—In the case of the 5-year-old, while examining the right hip joint, I found there was a partial disintegration of the accessory ligament and, following its course in the groove on the ventral surface of the pubis, I was surprised to find that the periosteum over the ventral surface of the pubis was completely detached from the bone. There was no evidence of any hæmorrhage between the bone and the periosteum.

When I came to examine the sciatic nerves just behind the hip joints I found marked hæmorrhage and œdema around the nerves which were connected with similar fractures of both sciatic tubers. On boiling out the hip bones (specimens exhibited) a fine deposit of new bone can be seen over both thoracic and ventral surfaces of the pubis and ischia. You will see from the specimen that the fractured portions are only small similar detachments, as if the fractures were due to a pathological condition of the bones associated with excessive muscular action.

*Hæmorrhage.*—In such diverse situations as the loose connective tissue between the external and internal oblique abdominal muscles, and the fat-loaded connective tissues in the neighbourhood of the elbow and stifle joints, groups of petechial hæmorrhages have been noticed.

Diffuse hæmorrhagic areas are common in the retro-peritoneal fat, but these are always in the vicinity of encysted larval *sclerostomes*. A serous semi-coagulated exudate has frequently been seen in the sublumbar muscles near the points of origin of the muscle fibres from the bodies and transverse processes of the lumbar vertebrae. It should be remembered that it is in the sublumbar muscles that the marked hæmorrhagic infiltration is most frequently found in hæmoglobinuria in the horse and that this disease may merely be a very acute form of the disease under consideration.

*Lymph Glands.*—All the lymph glands are enlarged and have a slightly congested, pink appearance.

*Stomach.*—In shiverers and other osteo-arthritics the stomach frequently shows ulceration of the mucous mem-

## SHIVERS: HISTORY 1930

William M. Mitchell

The Veterinary Record. "Some Further Observations on Pathological Changes Found in Horses Affected with "Shivering" and Their Significance".

June 21, 1930

# William M. Mitchell

June 30, 1930

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- The point I wish to stress is that I have yet to examine a shiverer, young or old, in which there is no osteo- arthritis.



# William M. Mitchell

June 30, 1930

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## June 30, 1930

- *Nervous System.* - As I was not satisfied that pressure upon nerve roots could account for clinical signs of shivering, it became obvious that a more careful examination of the nervous system was necessary. So far, I have found no gross change in the brain or spinal cord removed from the three young shiverers, but they have been retained for future investigation. In my previous series of cases I had already noticed a marked congestion, one might almost call it a definite haemorrhage, involving the roots of some of the lumbar nerves. I have not seen any such change in the three young horses, but examination of the sciatic nerve has revealed a varying extent of slightly congested edematous nerve trunk, in marked contrast to the pale portions immediately above and below the affected area. The lesion is a bilateral one. This area of the nerve varied from three to five inches in length and in all cases was situated just behind the level of the hip joint. In the 2 and 4 ½ year old horses, in addition to this diffuse pink appearance, there were small petechial haemorrhages scattered throughout the edematous area. A similar bilateral change has also been seen in the median and radial nerves on the inside of the arm in the 4 ½ year old, which during life showed inability to flex the fore limbs when backed, tending rather to slide the feet back along the ground. The 5-year-old had the gross haemorrhage associated with the apparent fracture of the sciatic tubers which I have already described, extending to, and involving the nerve trunks.

# William M. Mitchell

## June 30, 1930

- *Provisional Conclusions Regarding Shivering.*- Even at this stage of a very incomplete investigation, from the various pathological facts recorded, it appears to me that shivering is merely one of the many local manifestation of a general disease from which horses in general suffer. I leave it to you to picture to yourself the numerous local manifestations likely to be due to a common etiological factor or factors which at present are diagnosed as definite clinical entities.
- *Heredity.*-
- *Concussion.*-
- *Diet.*-



2006

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IN-DEPTH: MUSCLE DISORDER

## Shivers (Shivering) in the Horse: A Review

John D. Baird, BVSc, PhD; Anna M. Firshman, BVSc, PhD, Diplomate ACVIM;  
and Stephanie J. Valberg, DVM, PhD, Diplomate ACVIM

With the increasing popularity of draft and Warmblood horses in North America, the age- of shivers is making a resurgence. Clinical signs include periodic and involuntary spasms of muscles in the pelvic region, pelvic limbs, and tail that are exacerbated by backing or picking up the hindlimbs. Suggested causes include genetic, traumatic, infectious, and neurologic disease. The condition is frequently progressive and debilitating. Authors' addresses: Department of Veterinary Studies, Ontario Veterinary College, University of Guelph, Guelph, Ontario N1G 2W1 (Baird); Department of Clinical Sciences, College of Veterinary Medicine, Oregon State University, Corvallis, OR 97331 (Firshman); and Department of Veterinary Population Medicine, University of Minnesota, St. Paul, MN 55108 (Valberg). [jbaird@ovc.uoguelph.ca](mailto:jbaird@ovc.uoguelph.ca) (Baird). © 2006 AAEP.

### 1. Introduction

Shivers or shivering are the names that have been applied to a chronic nervous or neuromuscular syndrome in horses<sup>1-9</sup> that has been recognized for centuries.<sup>1,2,10</sup> The condition has been stated to be reasonably common,<sup>8,9,11</sup> uncommon,<sup>12</sup> rare,<sup>6,13-15</sup>

as 1-2 yr of age with shivers.<sup>8,17,30,31</sup> In a recent study in Belgian draft horses, a significant difference was observed in the age distribution of horses with shivers from horses without shivers.<sup>8</sup>



2010: Thesis

Dequier Laure-Aline

Lyon, France



***LE SHIVERING OU MALADIE DES TREMBLEMENTS CHEZ  
LE CHEVAL***

***Synthèse bibliographique  
Etude épidémiologique et clinique personnelle***

**THESE**

Présentée à l'UNIVERSITE CLAUDE-BERNARD - LYON I  
(Médecine - Pharmacie)  
et soutenue publiquement le 30 avril 2010  
pour obtenir le grade de Docteur Vétérinaire

par

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2013: Thesis

Alex Draper, DVM

University  
of  
Minnesota

Pelvic Limb Movement Disorders in Horses

A Thesis  
SUBMITTED TO THE FACULTY OF  
UNIVERSITY OF MINNESOTA  
BY

Alexandra Claire Elizabeth Draper

IN PARTIAL FULFILLMENT OF THE REQUIREMENTS  
FOR THE DEGREE OF  
MASTER OF SCIENCE

Stephanie Valberg

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## Posture and movement characteristics of forward and backward walking in horses with shivering and acquired bilateral stringhalt

A. C. E. DRAPER\*, T. N. TRUMBLE, A. M. FIRSHMAN, J. D. BAIRD<sup>†</sup>, S. REED<sup>‡</sup>, I. G. MAYHEW<sup>§</sup>, R. MACKAY<sup>#</sup> and S. J. VALBERG

Department of Veterinary Population Medicine, College of Veterinary Medicine, University of Minnesota, St Paul, USA

<sup>†</sup>Ontario Veterinary College, University of Guelph, Guelph, Ontario, Canada

<sup>‡</sup>Rood and Riddle Equine Hospital, Lexington, Kentucky, USA

<sup>§</sup>Institute of Veterinary, Animal and Biomedical Sciences, Massey University, Palmerston North, New Zealand

<sup>#</sup>College of Veterinary Medicine, University of Florida, Gainesville, USA.

\*Correspondence email: acedrape1@gmail.com; Received: 21.10.13; Accepted: 25.02.14

### Summary

**Reasons for performing study:** To investigate and further characterise posture and movement characteristics during forward and backward walking in horses with shivering and acquired, bilateral stringhalt.

**Objectives:** To characterise the movement of horses with shivering (also known as shivers) in comparison with control horses and horses with acquired bilateral stringhalt.

**Study design:** Qualitative video analysis of gait in horses.

**Methods:** Owners' and authors' videos of horses with shivering or stringhalt and control horses walking forwards and backwards and manually lifting the limbs were examined subjectively to characterise hyperflexion, hyperextension and postural abnormalities of the hindlimbs. The pattern and timing of vertical displacement of a hindlimb over one stride unit was evaluated among control, shivering and stringhalt cases.

**Results:** Gait patterns of shivering cases were characterised as follows: shivering-hyperextension (-HE, n = 13), in which horses subjectively showed hyperextension when backing and lifting the limb; shivering-hyperflexion (-HF, n = 27), in which horses showed hindlimb hyperflexion and abduction during backward walking; and shivering-forward hyperflexion (-FHF, n = 4), which resembled shivering-HF but included intermittent hyperflexion and abduction during forward walking. Horses with shivering-HF, shivering-FHF and stringhalt (n = 7) had a prolonged swing phase duration compared with control horses. Horses with shivering-HE during backward walking. With the swing phase of forward walking, horses with stringhalt had a rapid ascent to adduct the hindlimb, compared with a rapid descent of the hindlimb after abducted hyperflexion in horses with shivering-FHF.

**Conclusions:** Shivering affects backward walking, with either HE or HF of hindlimbs, and can gradually progress to involve intermittent abduction during forward walking. Shivering-HF and shivering-FHF can look remarkably similar to acquired bilateral stringhalt during backward walking; however, stringhalt can be distinguished from shivering-HF by hyperflexion during forward walking and from shivering-FHF by an acute onset of a consistent, rapidly ascending, hyperflexed, adducted hindlimb gait at a walk.

**Keywords:** horse; movement disorder; neurology; dyskinesia; myopathy

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## Analytical Clinical Studies

# Epidemiology of shivering (shivers) in horses

A. C. E. DRAPER\*, J. B. BENDER, A. M. FIRSHMAN, J. D. BAIRD<sup>†</sup>, S. REED<sup>‡</sup>, I. G. MAYHEW<sup>§</sup> and S. J.

Department of Veterinary Population Medicine, College of Veterinary Medicine, University of Minnesota, St Paul, USA

<sup>†</sup>Ontario Veterinary College, University of Guelph, Ontario, Canada

<sup>‡</sup>Rood and Riddle Equine Hospital, Lexington, Kentucky, USA

<sup>§</sup>Institute of Veterinary, Animal and Biomedical Sciences, Massey University, Palmerston North, New Zealand.

\*Correspondence email: drape064@umn.edu; Received: 17.10.13; Accepted: 27.04.14

## Summary

**Reasons for performing study:** Investigating the epidemiology of shivering in horses.

**Objectives:** The purpose of this study was to characterise the signalment, clinical signs and management factors associated with shivers), a relatively rare, poorly defined movement disorder in horses.

**Study design:** Web-based case series survey and case-control study.

**Methods:** A Web-based survey was used to obtain information from owners, worldwide, who suspected that their horse had shivers. Owners were asked to answer standardised questions and to provide a video of the horse. Authors reviewed the surveys and videos, and identified horses with shivering if they displayed normal forward walking, with difficulty during manual lifting of the hoof and backward walking, or hyperextension of the pelvic limbs. Cases confirmed by video were designated 'confirmed shivering', while those with compatible video confirmation were designated 'suspected shivering'. Owners of confirmed shivering horses were asked to provide information on signs of shivering (control group).

**Results:** Three hundred and five surveys and 70 videos were received; 27 horses were confirmed shivering (50 controls), 67 were the rest had a variety of other movement disorders. Suspected shivering horses resembled confirmed shivering cases, except the group contained fewer draught breeds and fewer horses with exercise intolerance. Confirmed shivering signs often began at <5 years of age in 74% of cases. Owner-reported additional clinical signs in confirmed cases included muscle twitching (85%), muscle atrophy (44%) and exercise intolerance (33%). Shivering horses were significantly taller (confirmed shivering, mean ~173 cm; control horses mean ~158 cm; male:female ratio (confirmed shivering, 3.2:1 vs. control, 1.7:1). No potential triggering factors or effective treatments were reported.

**Conclusions:** Shivering is a chronic, often gradually progressive movement disorder that usually begins before 7 years of age and is more common in tall male horses.



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## The Equine Movement Disorder “Shivers” Is Associated With Selective Cerebellar Purkinje Cell Axonal Degeneration

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S. J. Valberg<sup>1</sup>, S. S. Lewis<sup>1</sup>, J. L. Shivers<sup>2</sup>, N. E. Barnes<sup>1</sup>, J. Konczak<sup>3</sup>,  
A. C. E. Draper<sup>1</sup>, and A. G. Armien<sup>1,2</sup>

### Abstract

“Shivers” is a progressive equine movement disorder of unknown etiology. Clinically, horses with shivers show difficulty walking backward, assume hyperflexed limb postures, and have hind limb tremors during backward movement that resembles shivering. At least initially, forward movements are normal. Given that neither the neurophysiologic nor the pathologic mechanisms of the disease are known, nor has a neuroanatomic locus been identified, we undertook a detailed neuroanatomic and neuropathologic analysis of the complete sensorimotor system in horses with shivers and clinically normal control horses. No abnormalities were identified in the examined hind limb and forelimb skeletal muscles nor the associated peripheral nerves. Eosinophilic segmental axonal spheroids were a common lesion. Calretinin-positive axonal spheroids were present in many regions of the central nervous system, particularly the nucleus cuneatus lateralis; however, their numbers did not differ significantly from those of control horses. When compared to controls, calretinin-negative, calbindin-positive, and glutamic acid decarboxylase-positive spheroids were increased 80-fold in Purkinje cell axons within the deep cerebellar nuclei of horses with shivers. Unusual lamellar or membranous structures resembling marked myelin decompaction were present between myelin sheaths of presumed Purkinje cell axons in the deep cerebellar nuclei of shivers but not control horses. The immunohistochemical and ultrastructural characteristics of the lesions combined with their functional neuroanatomic distribution indicate, for the first time, that shivers is characterized by end-terminal neuroaxonal degeneration in the deep cerebellar nuclei, which results in context-specific hypermetria and myoclonus.

### Keywords

axonal degeneration, cerebellum, horse, myelin decompaction, myoclonus, Purkinje cell, shivering



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## Abnormal locomotor muscle recruitment activity is present in horses with shivering and Purkinje cell distal axonopathy

J. E. AMAN<sup>†\*</sup> , S. J. VALBERG<sup>‡</sup> , N. ELANGOVA<sup>§</sup>, A. NICHOLSON<sup>¶</sup>, S. S. LEWIS<sup>¶</sup> and J. KONCZAK<sup>§</sup>

<sup>†</sup>Department of Neurology, University of Minnesota, Minneapolis, Minnesota, USA

<sup>‡</sup>Department of Large Animal Clinical Sciences, College of Veterinary Medicine, Michigan State University, East Lansing, Michigan, USA

<sup>§</sup>School of Kinesiology, University of Minnesota, Minneapolis, Minnesota, USA

<sup>¶</sup>Department of Veterinary Population Medicine, College of Veterinary Medicine, University of Minnesota, St. Paul, Minnesota, USA.

\*Correspondence email: aman0038@umn.edu; Received: 22.03.17; Accepted: 10.01.18

### Summary

**Background:** Cerebellar Purkinje cell axonal degeneration has been identified in horses with shivering but its relationship with abnormal hindlimb movement has not been elucidated.

**Objectives:** To characterise surface electromyographic (sEMG) hindlimb muscle activity in horses with shivering, correlate with clinical scores and examine horses for Purkinje axonal degeneration.

**Study design:** Descriptive controlled clinical study.

**Methods:** The hindlimb of seven shivering and six control draught horses were clinically scored. Biceps femoris (BF), vastus lateralis (VL), tensor fasciae latae and extensor digitorum longus were recorded via sEMG during forward/backward walking and trotting. Integrated (iEMG) and peak EMG activity were compared between groups and correlated with clinical locomotor exam scores. Sections of the deep cerebellar nuclei (DCN) of six of the shivering horses were examined with calbindin immunohistochemistry.

**Results:** In control horses, backward walking resembled forward walking (right hindlimb peak EMG: backward:  $47.5 \pm 21.9\%$ , forward:  $36.9 \pm 15.1\%$ ) but displayed significantly higher amplitudes during trotting ( $76.1 \pm 3.4\%$ ). However, in shivering horses, backward walking was significantly different from forward (backward:  $88.5 \pm 21.5\%$ , forward:  $49.2 \pm 8.9\%$ ), and resembled activity during trotting ( $81.4 \pm 4.8\%$ ). Specific to backward walking, mean sEMG amplitude fell outside two standard deviations of mean control sEMG for  $\geq 25\%$  of the stride in the BF for all seven and the VL for six of the shivering horses. Locomotor exam scores were correlated with peak EMG ( $r = 0.87$ ) and iEMG ( $r = 0.87$ ). Calbindin-positive spheroids were present in Purkinje axons in DCN of all shivering horses examined.

**Main limitations:** The neuropathological examination focused specifically on the DCN and, therefore, we cannot fully exclude additional lesions that may have influenced abnormal sEMG findings in shivering horses.

**Conclusion:** Shivering is characterised by abnormally elevated muscle recruitment particularly in BF and VL muscles during backward walking associated with selective Purkinje cell distal axonal degeneration.

**Keywords:** horse; shivers; cerebellum; electromyography; gait



2019

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Original Research

Three-Dimensional Kinematic Motion Analysis of Shivers in Horses:  
A Pilot Study



Kathy K. Seino<sup>a</sup>, Tom Secord<sup>b</sup>, Mikala Vig<sup>c</sup>, Sue Kyllonen<sup>a</sup>, Audrey Jo DeClue<sup>a,\*</sup>

<sup>a</sup> DeClue Equine, LLC, Plymouth, MN

<sup>b</sup> Department of Engineering, University of St. Thomas, St. Paul, MN

<sup>c</sup> Midwestern University College of Veterinary Medicine, Glendale, AZ

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ABSTRACT

Our aim was to assess three-dimensional kinematic motion analysis as an objective diagnostic tool for the characterization of the movement disorder of Shivers in horses. Kinematic parameters were measured in three horses with Shivers and were compared with a control group of four normal horses. Multiple parameter differences were found in the horses with Shivers at the walk, during backing, and when asked to pick up their hindlimbs. Most significant changes were a wider hindlimb stance of 0.3 m and increased abduction angle of  $48.7 \pm 7.52^\circ$  and hoof elevation ( $0.77 \pm 0.08$  m left and  $0.9 \pm 0.11$  m right) when the horses were asked to pick up their hindlimbs. Control horses could back easily on a straight line and with symmetrical hoof separation and could maintain their center of weight while picking up their hindlimbs. In contrast, the horses with Shivers had difficulty backing straight, were slower, with a shorter stride and asymmetric hoof separation. They could not maintain their center of balance when picking up their hindlimbs. The findings of this pilot study advance the understanding of the movement disorder of Shivers and could be used as outcome measures to evaluate treatment modalities.

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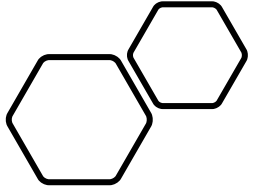
WHAT IS CAUSING SHIVERS



WHAT IS CAUSING STRINGHALT



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