

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-old problem of shivers is making a resurgence. Clinical signs include periodic and involuntary spasms of the muscles in the pelvic region, pelvic limbs, and tail that are exacerbated by backing or picking up of the hindlimbs. Suggested causes include genetic, traumatic, infectious, and neurologic diseases. The condition is frequently progressive and debilitating. Authors' addresses: Department of Clinical Studies, Ontario Veterinary College, University of Guelph, Guelph, Ontario N1G 2W1, Canada (Baird); Department of Clinical Sciences, College of Veterinary Medicine, Oregon State University, Corvallis, OR 97331 (Firshman); and Department of Veterinary Population Medicine, College of Veterinary Medicine, University of Minnesota, St. Paul, MN 55108 (Valberg); e-mail: 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 horses¹⁻⁹ that has been recognized for centuries.^{1,2,10} The condition has been stated to be reasonably common,^{8,9,11} uncommon,¹² rare,^{6,13-15} and very rare.⁴ In a comparative neuropathology textbook published in 1962, it was stated that "in the heyday of equine practice," shivering was "as common as dirt."¹¹

The syndrome principally affects the draft-horse breeds.^{2,6-8,12,13,15-25} Shivers has also been reported in Warmbloods,^{15,26} Warmblood cross-breeds,^{21,26} and occasionally, lighter breeds of horses including light harness horses, hunters, hunter-jumpers, hacks, Quarter Horses, and Thoroughbreds.^{2,3,7,11,13,14,17,20,21,27-29} In ponies, shivers is considered uncommon^{11,16} to rare.^{3,15,27} The condition has an insidious onset;¹⁵ it can occur at any age,^{3,5,6,8,27,30} and reports document horses as young

as 1-2 yr of age with shivers.^{8,17,30,31} Leeney³¹ stated that "shivering usually comes on in colthood." In a recent study in Belgian draft horses, no significant difference was observed in the age and sex distribution of horses with shivers from horses without shivers.⁸

2. Clinical Signs

The clinical spectrum of shivers in horses is very variable in the degree or manifestation of signs.^{3,4,6,32} The diagnosis of a characteristic case of shivers seldom presents a problem.^{12,13} However, the signs of shivers may be intermittent, occasional, or latent and very difficult to confirm.^{2,3} Shivers may be extremely difficult to detect in the early stages,^{2,5,13,22,27,33,34} and careful observation may be required before the diagnosis can be made.^{2,13}

The disease primarily affects one or both hindlimbs and the tail.^{2,3,5,7,8,11,13,21,27,33} Shivers is characterized by periodic, involuntary spasms of the

NOTES



Fig. 1. A Belgian mare exhibiting signs of shivers while backing up. Note the elevated tailhead, hyperflexion of the hindlimb, exaggerated flexion of the croup, and forward extension of one forelimb. Muscle mass in the hindlimbs is generally decreased.

muscles in the pelvic region, pelvic limbs, and tail.^{1,2,6,10,11,15,27} Mildly affected horses show a tenseness or trembling of the hindlimbs and sudden jerky extensor movements of the tail that cause it to elevate.^{2,6,13,15} The degree of tail elevation varies considerably in different cases.² In more severely affected animals, the hindlimb is suddenly raised, semi-flexed, and abducted with the hoof held in the air poised in a spastic state for several seconds⁷ to 1 or more min (Fig. 1) when backing.^{4,5,15,29} The limb trembles or shivers in suspension, and the tail is usually elevated and trembling simultaneously.^{1,3-7,11,14-16,19,21,27-29,33,35} The superficial muscles of the thigh and quarter quiver while the tail is elevated and tremulous. After a few moments, the spasms of the limb and tail gradually subside; the limb is then slowly extended, and the foot is brought slowly to the ground.^{3,5,13,27,35} The signs may reappear, however, when the horse is again forced to move backwards.¹³

The most characteristic signs of shivers occur when an attempt is made to move the horse backwards.^{1,2,5,6,11,13,16,19,31,36} Occasionally, a horse will exhibit signs if made to move over suddenly in the stall or box.^{2,3,13,16,19,27} Shivering may also be seen when lifting or attempting to lift a hindlimb^{1,2,3,5,16,19} or when the horse is being shod, especially when the foot is hammered during shoeing.^{2,3,16,21,27} In the early stages, the owner may notice that the horse snatches up the hindlimbs when they are being picked up for cleaning or shoeing. The condition may progress until the horse becomes impossible to shoe.^{7,21} Even in well-developed shivering cases, signs may not be shown when the horse is standing still. When the horse is

moved forward, there may be no signs, or the signs may be restricted to the first 2–3 steps.^{2,5} In advanced cases, the affected animal may be unable to move backward more than a few paces, and sometimes, this cannot be performed at all.^{1,3,5,6,13,17,21} Many shivering horses may attract attention by frequently raising and abducting the shivering hindlimb while standing in harness.³ A slippery surface exaggerates the signs of shivers, particularly when the horse is in harness.² In severe cases, one or both hindlimbs may be held out behind the animal in rigid spastic extension. The animal may stand on its toes with the heels raised off the ground. In the most severe cases, the animal may fall over.¹⁵ Severely affected animals may be hesitant to lie down when confined indoors. As a result, they may lose body condition^{1,13,16} and consequently, appear older.¹

Stress or excitement, such as when the horse is led out of the box into the open or into a straw bed or wooden floor, may often initiate episodes of shivering.^{2,15,16} When turned out onto pasture, the “shiverer” horse may lay down, and there may be an improvement in the disease.¹⁶ Signs of shivers may also become apparent when affected horses are offered a pail of water on the ground. They become excited, and on extending the neck, muscular spasms occur in the hind quarters. Additionally, the forelimbs remain implanted on the ground, the body sways backwards, the back is arched, and the tail is jerked upwards. This behavior, although typical of the disease, is not constant.²

Occasionally, there is involvement of the muscles of the forelimb, neck, or even trunk and face.^{5,11,13,14,27,35} Forelimb signs are considered to be rare.^{6,15,16} On attempting to lift a front foot, the limb is thrust forward in full extension with the foot barely touching the ground or the limb with the carpus flexed is elevated and abducted; the extensor muscles above the elbow then quiver until the spasm ends or the foot returns to the ground.^{2,3,5,6,13,16,19,27,33} Shivers may occasionally affect the muscles of the ears, eyelids, neck, lips, and cheeks.^{2,3,19,22,27,33} When the muscles of the head or neck are involved, they contract spasmodically.^{13,19} With involvement of the face, there is rapid blinking of the eyelids, quivering of the ears, and twitching with spasmodic retraction of the commissures of the lips.^{3,5,11,15,19,22}

With progression of the disease, a gradual and progressive atrophy of the muscles of the thigh occurs,^{3,24,25,27,35} and this may progress to generalized muscle atrophy.^{7,24} Hind quarter weakness was present in 11 of 19 (58%) horses with shivers.⁸ The limbs may become more or less stiff or rigid.^{3,24} Affected animals sleep standing, and their front fetlocks and knees are bruised and disfigured by frequent half-falls.^{3,27} Affected horses frequently adopt an abnormal stance with a base-wide stance in the hindlimbs.^{7,24} Excessive sweating has been noted in some cases.⁷

3. Clinical Pathology

There is no significant difference in baseline serum creatine kinase (CK) and aspartate aminotransferase (AST) activities in horses with shivers compared with horses without shivers.⁸ The mean serum CK in 19 Belgian draft horses with shivers was 289 ± 203 U/l (reference range = 108–430 U/l), and the mean AST was 412 ± 321 U/l (reference range = 259–595 U/l). In the same study, there was also no significant difference in serum selenium and serum vitamin E concentrations in horses with shivers compared with horses without shivers.⁸

4. Differential Diagnosis

Stringhalt is the condition most often confused with shivers.^{1,2,14,19,22,29,33,34} Stringhalt occurs in all breeds of horses¹⁸ and may occur at any age.¹¹ Stringhalt is characterized by a spasmodic and excessively rapid flexion of one or both hindlimbs that occurs when the horse is made to move. It is best seen in the slower paces and particularly, in turning or backing.² In stringhalt, the hocks are suddenly markedly flexed with a violent jerk toward the abdomen and are then brought forcibly and noisily back to the ground in one quick motion as the leg is advanced.^{4,11,14,19,37,38} The hindlimb motion may be mild, like a slightly excessive flexion, or violent, like movements during which the fetlock or toe will contact the abdomen, thorax, and occasionally, elbow with attempted steps leading to a peculiar “bunny hopping” and plunging type of gait.³⁸ The severity of the gait abnormality in stringhalt is variable and may be accompanied by hindlimb muscle atrophy and laryngeal paralysis.³⁷ The diagnosis of stringhalt in the early stages is extremely difficult.² In both conditions, the horse may show signs only intermittently.^{2,14} However, in shivers, the limb is flexed, abducted, and held in a spastic state for a few moments instead of being immediately returned to the ground as in stringhalt.

Upward fixation of the patella may occur in horses as an apparently acquired disorder. Upward fixation of the patella occurs when the medial patellar ligament become momentarily (mild) or permanently (severe) caught above the medial trochlear ridge of the femur.³⁴ When the patella releases, the limb flexes forward rapidly, resembling stringhalt. The acquired condition may mimic stringhalt, because the hyperextended limb may release rapidly to hyperflex.¹⁸

Fibrotic myopathy results from scar tissue formation to the semitendinosus and semimembranosus muscles that occurs after injury.³⁹ The gait is usually characterized by an abnormal slapping-type gait in one pelvic limb of a light-breed horse. Adult Quarter Horses are the most frequently affected breed.¹⁸

“Stiff-horse syndrome” (SHS) has recently been reported in horses in Belgium with intermittent stiffness and spasms in the axial muscles of the lower back and in the muscles of the pelvic

limbs.^{40,41} The contractures were typically precipitated by voluntary movements, fright, or sounds. There was no weakness or muscle atrophy but rather a muscle hypertrophy. After the first steps, the movements became more relaxed, and after the horse was walking or trotting, no spasms were evident. Because this disease was considered to have many similarities to an entity in human medicine designated “stiff-person syndrome” (SPS), the condition has been called SHS.⁴⁰ SPS is thought to be the result of an immune-mediated deficiency of gamma-aminobutyric acid (GABA), a major inhibitory neurotransmitter in the central nervous system (CNS). The majority of SPS patients have high titres of autoantibodies directed against both isoforms of glutamate decarboxylase, GAD65 and GAD67, which are the enzymes that catalyze the conversion of glutamate to GABA.⁴² Only 2 of 8 SHS horses had elevated GAD antibodies compared with values measured in normal horses.⁴¹ In 7 of 8 SHS horses, electromyographic (EMG) findings showed persistent motor-unit activity in the axial and gluteal musculature that persisted for minutes before tapering off gradually. These EMG findings were considered to be strongly suggestive of SPS.⁴¹

Equine motor neuron disease (EMND) is clinically characterized by progressive weight loss despite a good appetite, symmetrical muscle wasting, muscle fasciculations, excessive sweating, tucked-up abdomen, abnormal gait, excessive recumbency, and an abnormally low head carriage.^{43,44} There are some similarities between the clinical signs of shivering and EMND.²³ Bizarre stringhalt-like movement of a front or rear leg has been observed in some chronically affected EMND horses.⁴⁴ Subacute to chronic EMND cases frequently have an abnormal elevation of their tail, which is caused by denervation atrophy and contracture of the sacrocaudalis dorsalis medialis muscle.⁴⁴

There are rare reports of spinal-cord disease as a result of equine protozoal myeloencephalitis (EPM) that causes a stringhalt-like gait.¹⁸ This disease may be ruled out on absence of *Sarcocystis neurona* antibodies in the serum and/or in the cerebrospinal fluid (CSF).

5. Pathology

No documented lesions have been found in horses with shivers.^{2,6,9,15} No histopathological lesions were detected on detailed examination of the brain, the cervical, thoracic, and lumbar portions of the spinal cord, the dorsal and ventral spinal roots obtained from the cervical and lumbosacral intumescences, the associated spinal ganglia, or the peripheral nerves of two Belgian geldings with shivers syndrome.⁷

6. Etiology

The etiology of shivers and the pathophysiologic alterations associated with the clinical signs have not been determined.^{2,3,5–8,10,12,13,16,19,22,27,28,33,45} Neur-

ological, myopathic, genetic, infectious, and traumatic causes have been postulated. There are also reports stating that horses may show signs of shivering after a long rail or road journey.^{2,16}

Neurological Cause

The hyperkinesia that characterizes shivering in horses has been considered to be suggestive of basal nuclei lesions.⁴⁶ It has also been suggested that shivers probably involves motor and reflex hypertonia of flexor and/or extensor muscle of the pelvic limbs, back, and tail.^{9,32} Lesions in the sensory or motor pathways anywhere from the brain stem to the affected muscles and associated joint and tendon sensory receptors potentially could initiate the abnormal muscle tone and movements observed in shivers.^{9,32} Others have suggested that the muscle atrophy and weakness seen in severe advanced shivers in draft horses are typical of a progressive neuromuscular disease.^{7,22} It has been stated that "it will likely take a very thorough, detailed and expensive pathological investigations of freshly harvested central and peripheral nervous system tissues on many cases to unravel the mystery of shivers."³² It is possible that neurotransmitter defects may be responsible.⁹

Myopathic Cause

In one study¹⁷ involving a yearling Clydesdale gelding with a clinical diagnosis of shivers, muscle biopsies showed decreased carbohydrate content in type II muscle fibers. It was thought that horses with shivers may have less stored glycogen, and thus, they deplete their stores more rapidly. This may lead to localized muscle cramping, manifesting itself when the horse was forced to move backwards.¹⁷ It has also been suggested that the underlying cause of shivers may be a metabolic myopathy resulting in muscle weakness and cramping.⁷ However, it was stated that if shivers was the result of an underlying myopathy, it would seem that there is little correlation between the severity of clinical signs and the severity of histologic findings.⁷

Sullins¹² found it difficult to positively attribute the signs of shivers to glycogen-storage abnormalities, because so many asymptomatic draft horses have these abnormalities. In a recent study⁸ involving 103 Belgian draft horses, 31 had polysaccharide storage myopathy (PSSM) but did not have shivers, 13 had shivers but did not have PSSM, 6 had both PSSM and shivers, and 53 did not have PSSM or shivers. No significant association was found between a diagnosis of PSSM and a diagnosis of shivers. The mean muscle-glycogen concentration for horses with PSSM but not shivers (207 ± 56 mmol/kg) was significantly higher than the mean concentration for horses with shivers but not PSSM (122 ± 40 mmol/kg). The conclusion was that PSSM and shivers were common but unrelated disorders in Belgian draft horses.⁸

Genetic Cause

Many have suggested that shivers is inherited or has a hereditary pre-disposition,^{1,2,3,10,13,19,20,31,36} and although this has not been proven,^{13,15} a familial tendency is suspected.¹⁵ In some countries, it is recommended that stallions with this disease not be used for breeding purposes.¹³ In the United Kingdom, shivering has been classified as an hereditary disease under the Horse Breeding Act of 1918.¹⁶

Infectious Disease

Some have suggested that the occurrence of shivers may be preceded more or less remotely by an attack of influenza, strangles, or other systemic infections.^{2,3,5,12-14,16,22,27,45} This led to the suggestion that shivers is connected with neuropathic lesions produced by infection or toxins derived from an antecedent disease.³

Trauma

Cases of shivers have also been attributed to accidental injuries like those incurred from a severe fall.^{2,4,16} However, the connection, if any, has not been determined.^{3,16} In the 1930s, it was stated that "a horse which is a shiverer will always show some evidence of osteoarthritis, often clinically, but certainly on post-mortem examination."³⁰ The investigator contended that shivering was caused by osteoarthritis affecting the vertebral column and that the varying site of muscular spasm depends on the nerve roots implicated.^{30,47} The greater frequency of signs in the hindlimbs was attributed to the peculiar anatomical relationship of the intervertebral foramina associated with the last three lumbar nerves that form the lumbosacral plexus.³⁰

7. Treatment

There is currently no effective treatment for shivers.^{3,5,6,10,12-16,19,22,27,33,45} Occasionally, the signs may improve or regress after long periods of rest,^{3,6,11,13,15,22,25,27,33} but the condition returns when work is resumed.²² It has been suggested that dietary treatment of affected draft horses with a high-fat, low-carbohydrate feed may be beneficial if instituted early in the course of the disease.⁷ However, the clinical signs of shivers in horses did not resolve when affected Warmblood or Warmblood-cross horses were fed grass hay and a high-fat supplement instead of dietary grain. These dietary recommendations were combined with a gradually increasing daily exercise program and maximal turnout.²⁶

8. Course of the Disease

In many horses, the clinical signs of shivers may remain static.²⁵ However, in almost all cases, the condition is a slowly progressive and debilitating disease.^{1,2,3,6,7,10,12-15,19,20,22,27,33,36} Horses that are slight "shiverers" may work satisfactorily for many years, but eventually, the spasms increase both in frequency and severity.^{2,3,7,25,27} Hunting horses

that are occasional shiverers may hunt and jump for several years without problems, but eventually, they lose power behind; although able to gallop and willing to jump, they are unable to clear the obstacle with the hindlimbs or rise sufficiently to jump a moderate fence.^{3,13,16,27} It has been stated that shivering involving the forelimbs seldom interferes with an animal's capacity to work.³ The signs gradually increase in severity and intensity until the horse is eventually rendered useless.²⁷

9. Prognosis

The prognosis for affected individuals is generally unfavorable^{5,12,13} to poor,^{22,32} because the disease is usually progressive.^{2,12,22} In a horse with shivers, the tendency is for the spasms to increase both in frequency and severity.^{15,16} The long-term prognosis for athletic function is grave.¹⁵ Eventually, shivers symptoms may result in death or euthanasia because of profound weakness, muscle wasting, and apparent discomfort and incapacitation associated with episodic muscle cramping.^{15,19,24}

References

- Williams W. Immobilite, shivering, sprained back, etc. In: Williams W, ed. *The principles and practice of veterinary surgery*, 6th ed. New York: William R. Jenkins, 1886;247–249.
- McCall JR. "Stringhalt" and "shivering," in *Proceedings*. 28th General Meeting of the National Veterinary Association 1910;23–56.
- O'Connor JJ. Shivering. In: O'Connor JJ, ed. *Dollar's veterinary surgery: general, operative, and regional*, 4th ed. London: Baillière, Tindall and Cox, 1950;941–943.
- Neal FC, Ramsey FK. Shivering. In: Bone JF, Catcott EJ, Gabel AA, et al. eds. *Equine medicine & surgery*, 1st ed. Santa Barbara, CA: American Veterinary Publications, Inc., 1963;326.
- Frank ER. *Veterinary surgery*, 7th ed. Minneapolis: Burgess Publishing Co., 1964;333–334.
- de Lahunta A. Upper motor neuron system. In: de Lahunta A, ed. *Veterinary neuroanatomy and clinical neurology*, 2nd ed. Philadelphia: W.B. Saunders, 1983;130–155.
- Valentine BA, de Lahunta A, Divers TJ, et al. Clinical and pathologic findings in two draft horses with progressive muscle atrophy, neuromuscular weakness, and abnormal gait characteristic of shivers syndrome. *J Am Vet Med Assoc* 1999;215:1661–1665.
- Firshman AM, Baird JD, Valberg SJ. Prevalences and clinical signs of polysaccharide storage myopathy and shivers in Belgian draft horses. *J Am Vet Med Assoc* 2005;227:1958–1964.
- Mayhew J. Does the stiff horse syndrome exist?, in *Proceedings*. 23rd American College of Veterinarians of Internal Medicine Forum 2005;151–153.
- Fintl C. Idiopathic and rare neurologic diseases. In: Robinson NE, ed. *Current therapy in equine medicine 5*. Philadelphia: W.B. Saunders, 2003;760–763.
- Innes JRM, Saunders LZ. V. Stringhalt and shivering of horses. In: Innes JRM, Saunders LZ, eds. *Comparative neuropathology*. New York: Academic Press, 1962;804–805.
- Sullins KE. Shivering. In: Stashak TS, ed. *Adams' lameness in horses*, 5th ed. Philadelphia: Lippincott Williams & Wilkins, 2002;985–986.
- Neal FC, Ramsey FK. Shivering. In: Catcott EJ, Smithcoors JF, eds. *Equine medicine and surgery*, 2nd ed. Wheaton, IL: American Veterinary Publications, Inc., 1972;486–487.
- Deen T. Shivering, a rare equine lameness. *Equine Pract* 1984;6:19–21.
- Green SL, Davies M, Doucet M, et al. The nervous system and behaviour. In: Higgins AJ, Wright IM, eds. *The equine manual*. London: W.B. Saunders, 1995;967–1005.
- Tutt JFD. Diseases of the nervous system. In: Hayes MH, ed. *Veterinary notes for horse owners: a manual of horse medicine and surgery*, 15th ed. London: Stanley Paul, 1964;137–155.
- Andrews FM, Spurgeon TL, Reed SM. Histochemical changes in skeletal muscles of four male horses with neuromuscular disease. *Am J Vet Res* 1986;47:2078–2083.
- Mayhew IG. Opisthotonus, tetanus, myoclonus, tetany, tremor, and other localized muscle spasms and movement disorders. In: Mayhew IG, ed. *Large animal neurology A handbook for veterinary clinicians*. Philadelphia: Lea & Febiger, 1989;197–225.
- Neumann AJ. Well, Doc, what do you do now? *Draft Horse J* 1990;27:34–35.
- MacKay RJ, Mayhew IG. Diseases of the nervous system. In: Colahan PT, Mayhew IG, Merritt AM, et al. eds. *Equine medicine and surgery*, 4th ed. Goleta, CA: American Veterinary Publications, Inc., 1991;723–845.
- Dyson SJ. Bizarre hindlimb gait abnormalities: primary musculoskeletal or neurological dysfunction?, in *Proceedings*. 15th Bain-Fallon Memorial Lectures presented by Australian Equine Veterinary Association 1993;9–14.
- Adair HS, Andrews FM. Diseases of the peripheral nerves. In: Kobluk CN, Ames TR, Geor RJ, eds. *The horse diseases & clinical management*. Philadelphia: W.B. Saunders, 1995;473–485.
- Rooney JR, Robertson JL. Nervous system. In: Rooney JR, Robertson JL, eds. *Equine pathology*. Ames, IA: Iowa State University Press, 1996;308–343.
- Valentine BA. Polysaccharide storage myopathy in draft and draft-related horses and ponies. *Equine Pract* 1999;21:16–19.
- Malikides N, Hodgson DR, Rose RJ. Neurology. In: Rose RJ, Hodgson DR, eds. *Manual of equine practice*, 2nd ed. Philadelphia: W.B. Saunders, 2000;503–575.
- Hunt LM, Valberg SJ, Steffenhagen K, et al. A retrospective study of myopathies and associated gait abnormalities in 65 warmblood horses. *J Vet Int Med* 2005;19:428–429.
- Hickman J. Shivering. In: Hickman J, ed. *Veterinary orthopaedics*. Philadelphia: J.B. Lippincott Company, 1964;427–428.
- Rooney JR. *Clinical neurology of the horse*. Kennett Square, PA: KNA Press Inc., 1971.
- Davies PC. Shivering in a Thoroughbred mare. *Can Vet J* 2000;41:128–129.
- Mitchell WM. Some further observations on pathological changes found in horses affected with "shivering," and their significance. *Vet Rec* 1930;10:535–537.
- Leeney H. *Home doctoring of animals*, 5th ed. London: Macdonald & Martin, 1921.
- Mayhew IG. In: *Proceedings*. 18th Bain-Fallon Memorial Lectures presented by Australian Equine Veterinary Association 1996;75–79.
- Adair HS. Common lameness problems of the draft horse. In: Robinson NE, ed. *Current therapy in equine medicine 3*. Philadelphia: W.B. Saunders, 1992;85–91.
- Sullins KE. Upward fixation of the patella. In: Stashak TS, ed. *Adams' lameness in horses*, 5th ed. Philadelphia: Lippincott Williams & Wilkins, 2002;1022–1025.
- Palmer AC. *Introduction to animal neurology*, 2nd ed. Oxford, UK: Blackwell Scientific Publications, 1976.
- Hahn CN, Mayhew IG, MacKay RJ. Diseases of the peripheral (spinal) nerves. In: Colahan PT, Merritt AM, Moore JN, et al., eds. *Equine medicine and surgery*, 5th ed. St. Louis: Mosby, 1999;975–980.
- Huntington PJ, Jeffcott LB, Friend SCE, et al. Australian stringhalt—epidemiological, clinical and neurological investigations. *Equine Vet J* 1989;21:266–273.
- Mayhew J. Neuropathies in horse, in *Proceedings*. 23rd American College of Veterinarians of Internal Medicine Forum 2005;154–156.

39. Reed SM, Andrews FM. Disorders of the neurologic system. In: Reed SM, Bayly WM, Sellon DC, eds. *Equine internal medicine*, 2nd ed. St. Louis: W.B. Saunders, 2004;533–541.
40. Nollet H, Vanderstraeten G, Sustronck B, et al. Suspected case of stiff-horse syndrome. *Vet Rec* 2000;146:282–284.
41. Nollet H, Van Ham L, Vanderstraeten G, et al. “Stiff horse syndrome”? *J Vet Int Med* 2005;19:288.
42. Raju R, Foote J, Banga JP, et al. Analysis of GAD65 auto-antibodies in stiff-person syndrome patients. *J Immunol* 2005;175:7755–7762.
43. Divers TJ, Mohammed HO, Cummings JF, et al. Equine motor neuron disease: findings in 28 horses and proposal of a pathophysiological mechanism for the disease. *Equine Vet J* 1994;26:409–415.
44. Divers TJ, Cummings JF, Mohammed HO, et al. Equine motor neuron disease in the eastern United States—clinical and laboratory findings, in *Proceedings*. 1st International Workshop on Grass Sickness, EMND and Related Disorders 1997;9–11.
45. Grubbs ST. Shivers (shivering). In: Brown CM, Bertone J, eds. *The 5-minute veterinary consult: equine*. Baltimore: Lippincott Williams & Wilkins, 2002;978–979.
46. King AS. *Physiological and clinical anatomy of the domestic mammals. Volume 1: central nervous system*. Oxford, UK: Oxford University Press, 1987.
47. Mitchell WM. Some aspects of osteo-arthritis of the vertebral column. *Vet Rec* 1930;10:89–93.