The Gravelproof Hoof

- not just a dream

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MAGNESIUM

Why do horses need supplemental magnesium?

Magnesium is needed directly for over 350 biochemical processes within the body, and is additionally involved in thousands of others. Magnesium is vital for energy production, metabolism of other minerals, regulation of blood sugars, maintaining normal muscle and nerve function, and maintaining strength of bones and teeth.

The majority of readily available horse feeds and forages are grown commercially with the help of fertilizers that contain little or no magnesium. Over time, soils become depleted of magnesium and some other minerals, which are then not available for uptake by the growing plants. The result is an over-abundance of minerals such as phosphorous and potassium and a deficit of magnesium. Some legume forages such as lucerne and clover are naturally high in calcium but will be low in magnesium if grown in magnesium deficient soils. High levels of calcium, phosphorous or potassium inhibit absorption of the small amount of magnesium that may be present in the forage. Many areas of Australia have naturally acidic soils with low magnesium levels; horses grazing such pastures will be likely to need supplemental magnesium.

The ideal environment in which equines thrive includes vast areas of low-sugar native pastures on which to roam freely in the daily search for feed and water. The reality is that domestic horses are frequently kept in small paddocks or fields that were previously used for dairying and/or cattle production. These pastures were often 'improved' by the addition of imported grass species that can accumulate a very high sugar content, suitable for achieving high milk yields and rapid growth in cattle. It has been well documented that the equine digestive system is not adapted to processing large amounts of sugar or non-structural carbohydrates (NSC). Horses grazing high NSC pastures become susceptible to blood sugar disorders such as insulin resistance, which can result in footsoreness or laminitis and poor hoof quality. High levels of blood glucose, from a diet high in sugar/NSC, increases the body's need for magnesium but at the same time will cause magnesium to be excreted through the kidneys and urine, thus magnifying any existing dietary magnesium deficiency.

Medical Nutritionist Dr N Campbell-McBride states that 56 molecules of magnesium are needed to metabolise each molecule of sugar that humans consume (*Gut & Psychology Syndrome*, N. Campbell-McBride, MD, MMedSci (neurology), MMedSci (nutrition), Medinform, 2010). If the same ratio applies to equines, it is not hard to see why horses consuming high-sugar grasses or feeds require large volumes of magnesium to metabolise that sugar.

What are the signs of magnesium deficiency?

As magnesium is needed for such a wide range of body processes, deficiency signs can present in an equally wide range of ways. Ten horses living in the same paddock may show signs of magnesium deficiency in ten different ways, influenced by individual genetic traits that govern how much magnesium can be absorbed and how much is excreted.

Some common signs of magnesium deficiency may include:

* Nervous, anxious temperament
* Sudden shying at familiar objects
* Violent pulling-back when tied
* Dislike of grooming
* Aggression towards owners or herd-mates
* Separation anxiety, herd-bound
* Restless under saddle, unable to focus on rider
* Bucking
* Poor hoof quality, footsore without shoes or boots on hard or rough ground
* Short stride with inappropriate toe-first hoof landing
* Laminitis
* Grass belly
* Insulin resistant with heavy crest
* Stiff, braced posture with deep 'V' behind withers
* Front feet placed far back under body when resting
* Tight, sloping croup
* Stifle catch
* Tying-up
* Excessive sweating in hot weather, shivering in warm, wet weather
* Dry, flaky skin
* Sweet-Itch
* Watery eyes

Consequently many horses owners have been forced to remove their horses from all pasture, or at least have grazing limited to one or two hours per day.

Some have established a 'track' system where a narrow track around the perimeter of a paddock is fenced off, and most of the grass either killed or grazed down to virtually nothing. This has been an expensive and time-consuming solution as pasture must be replaced by hay.

It has now been found that some horses are able to remain permanently on pasture with no restrictions to grazing, even those highly prone to laminitis. This has been achieved by feeding magnesium to those horses in sufficient amounts to counteract the effects of a high sugar intake.

As well as a high consumption of sugar, stress of any kind will cause large amounts of magnesium to be excreted. This would include, for example, travel, changed living or herd environment, inappropriate training techniques, extremes of heat and cold, injury, pain, even the physical exertion of exercise.

Very few domestic horses would consume enough magnesium from pasture or feeds to meet their daily needs, and have sufficient magnesium stored in body reserves to counter the amount lost each day.

The link between magnesium deficiency and insulin resistance

There appears to be a clear connection between lack of cellular magnesium and metabolic problems such as insulin resistance (IR). The Magnesium Factor (details below) is a book co-authored by Associate Professor Mildred Seelig that contains a wealth of information about the role of magnesium in human health. For those who like to see the detail, there are 75 pages of references. Dr Seelig was both a practicing physician and researcher who devoted some 40 years to investigating magnesium; she was a President and Executive Director of the prestigious American College of Nutrition and founding editor of its Journal.

The chapter on 'Metabolic Syndrome X, Diabetes and Magnesium' includes reports on the research done by Prof Lawrence Resnick and colleagues at Cornell who concluded that a low magnesium ion inside cells causes metabolic syndrome.

Quote from p.41:

"As a cell's magnesium ion level falls, the calcium ion level rises. The result is a low magnesium/high calcium cell ratio. This affects the functioning of various kinds of cells in ways that bring on syndrome X "

A chart then follows that lists the consequences of low magnesium/high calcium for cells in the pancreas, fat tissue, muscle, blood-vessels, blood platelets, heart muscle, adrenal glands, nerves, liver and kidneys.

Magnesium deficiency has been reported to result in insulin resistance by other researchers. Some studies have been done to investigate the role of insulin resistance in magnesium transport, concluding that insulin resistance and magnesium depletion 'may result in a vicious cycle of worsening insulin resistance and decrease in intracellular Mg(2+) which may limit the role of magnesium in vital cellular processes'. (*Magnesium transport induced ex vivo by a pharmacological dose of insulin is impaired in non-insulin-dependent diabetes mellitus.* Magnes Res. 1995 Dec;8(4):359-66. Hua H, Gonzales J, Rude RK. Department of Medicine, University of Southern California School of Medicine, Los Angeles.)

Numerous horses displaying external signs of insulin resistance such as a cresty neck and localised fat pads around the withers and tail-head have been observed to lose those external signs of IR within weeks of commencing magnesium supplementation. Visible improvements to hoof structure and function generally commence within a couple of months.

Research is needed to determine if hoof lamella cells could be added to an equivalent equine list of the consequences of low cellular magnesium, on the basis that low magnesium/high calcium may disrupt magnesium-dependent ATP production, resulting in a weakened lamella connection. This may be different from what is conventionally thought of as 'laminitis'.

What about fructan?

Much publicity has been given to the risk for laminitis in horses grazing high-fructan pasture or hay. Fructan is the form in which energy is stored in C3 plants growing in cool-season climates. In warm-season regions, C4 plants store energy as starch, not fructan. However, owners of horses grazing non-fructan pastures in warmer regions will verify that their horses are just as susceptible to laminitis and hoof problems as horses grazing fuctan-rich pastures in cooler regions. A sore foot is a sore foot, regardless of the diet of the horse who owns it.

Some fascinating research has been done recently by Prof Richard Johnson which indicates that both fructan and starch can be metabolised to fructose by gut bacteria, suggesting that it is fructose that is ultimately the cause of weight-gain and obesity in both horses and humans (see details below for Prof Johnson's book The Fat Switch). The rapid breakdown of fructose by the enzyme fructokinase in the liver, small intestine, caecum and large intestine etc causes 'cell shock', a brief period in which the cells become depleted of ATP energy. This leads to the production of oxidants, and systemic inflammation via bacterial products entering the blood, and could be implicated in the cascade of biological events that lead to founder.

It would be interesting to know if supplemental magnesium is able to assist in reducing or preventing the depletion of ATP energy consequent to the action of fructokinase on fructose produced from ingested fructan and starch. Some work has already found that dietary magnesium may prevent fructose-induced insulin insensitivity as indicated in this study: *Dietary magnesium prevents fructose-induced insulin insensitivity in rats.* *TW Balon, A Jasman, S Scott, WP Meehan, RK Rude and JL Nadler Department of Diabetes, Endocrinology, and Metabolism, City of Hope National Medical Center, Duarte, CA 91010.*

If proved to be correct, this could perhaps explain why horses grazing C4 fructan-free grasses that accumulate starch appear to be just as vulnerable to laminitis and hoof problems as horses grazing C3 fructan accumulating grasses; they both have the potential to be metabolised to fructose by gut bacteria.

The metabolic pathway through which magnesium could be involved is in the essential production of ATP energy within all cells, including hoof lamella. Magnesium is needed directly for over 350 biochemical processes within the body, energy production being foremost. Many sources designate ATP as MgATP because ATP must be bound to a magnesium ion in order to be biologically active. Neurosurgeon Russell Blaylock has described the importance of maintaining cellular energy in protecting neurons from exposure to toxic substances, and the role of magnesium in limiting cell damage from the influx of excess calcium (details below for Dr Blaylock's book on Excitotoxins).

How can magnesium be given to horses?

Many different forms of magnesium are available for horses, ranging from very expensive chelated organic magnesium products to cheap inorganic raw materials.

Magnesium chloride is a very good source of magnesium as it is already in ionic form and therefore easily absorbed by the body. Other forms of magnesium, such as magnesium oxide, magnesium hydroxide and others, must first be broken down in the stomach by hydrochloric acid. A study was done to compare absorption rates of various types of magnesium supplements, all of which were taken with a meal; it was found that magnesium chloride had a high bioavailability rate, similar to the chelated supplements magnesium lactate and magnesium aspartate. (*Bioavailability of US Commercial Magnesium Preparations, Firoz & Graber, 2001)*

What is Magnesium Chloride Hexahydrate (MgCl2.6H20) ?

The white crystalline flakes of magnesium chloride hexahydrate are produced from evaporated, naturally-occurring saltwater from which sodium has been removed. Raw material sources include the pure waters of high-altitude salt lakes or deep underground salt deposits, both of which are remnants of prehistoric inland seas.

The magnesium chloride hexahydrate flakes referred to in this article contain 156mg of elemental magnesiumper one gram of flakes, and were obtained

from Elektra Life Pty Ltd. Whichever brand is used, it is important to ensure the product is certified as Food Grade and free from heavy metal contamination, especially lead and mercury.

How can magnesium chloride be used?

All forms of dry magnesium chloride are bitter tasting and likely to be unpalatable for most horses. The unpleasant taste can be masked by dissolving the flakes in water before mixing into a feed. The flakes dissolve quickly in hot water but will dissolve slowly in cold water. A convenient way to prepare the magnesium chloride solution is fill a large bottle with a measured amount of water, add an appropriate number of tablespoons of flakes, shake well and leave to dissolve. The solution does not need to be prepared fresh each day so a bottle may last several days, depending on the number of horses being fed and the desired strength of the solution.

How much can be fed?

There is no rigid rule that determines how much supplemental magnesium is needed by any individual horse. Just as every person has a need for magnesium that is likely to be different to other people, every horse is also likely to have individual needs. Gut tolerance appears to act as a guide to the upper limit for each individual horse's specific needs. Obviously, if all signs of magnesium deficiency have disappeared before the limit of gut tolerance is reached, there is no need to continue increasing the amount of magnesium fed each day. The aim is to always feed the least amount necessary to eliminate the signs of deficiency.

Failure to provide sufficient magnesium for the horse's daily needs will result initially in a small daily gap between need and intake, which may not be noticed. The daily gap may progressively expand to a whole-body deficit, which may result in negative consequences for the horse's longterm health and soundness.

Experience with numerous horses indicates that the strength of the magnesium chloride solution can be slowly increased over a couple of months until no more than a slight softening of the manure is observed (assuming visible signs of magnesium deficiency have not been eliminated prior to that point). When that point is reached, the amount of magnesium chloride being fed is reduced to the previous level. This lower level can be maintained until a known increased need arises, for example, impending travel, competition or increase in sugar intake.

Any major changes in weather will have an impact on sugar levels in pasture grasses. Periods of overcast, cloudy, weather can result in lower levels of sugar in some pasture grasses which reduces need for magnesium; a softening of manure consistency may be noticed during this time, indicating magnesium supplementation can be temporarily reduced. Conversely, lack of sunlight can increase pasture potassium levels which may inhibit magnesium absorption, thereby increasing need for magnesium. Horses should be monitored individually.

Sugar levels may increase rapidly with the return of warm, sunny conditions so it is beneficial to increase magnesium before deficiency signs are obvious. For laminitis-prone horses, delays of even a day or two may result in damage to the lamina that can take weeks or months to repair. Similarly, during drought conditions when there is almost no grass available for grazing, sugars may be very high in what little grass is left; when rain does return the rapid growth of new shoots will very quickly increase the volume of sugar being ingested. Under these conditions, it is advisable to increase magnesium on the day it starts raining, not wait for the new shoots to appear a couple of days later. Helpful information on pasture sugar content can be found in the 2010 RIRDC publication Equine Laminitis, Managing Pasture to Reduce Risk.

It is important for the sugar and starch content of any hard feeds to be kept as low as possible at all times. Magnesium cannot be expected to compensate for the high levels of sugar and starch found in grains, cereals, molasses and other sweetfeeds. Similarly, any hay being fed should ideally be low-sugar grass hay, although this can frequently be difficult to obtain.

Suggested Use:

Step 1
Dissolve 15g (1 tbsp) flakes in 150ml water and add 10ml of the resulting solution to each feed, preferably twice daily. Increase by another 10ml every 2 or 3 days until 50ml is being added to each feed. Starting with this very weak solution allows the horse's body time to adjust to a new source of magnesium. Increasing quantity or strength too quickly may cause scouring.

Step 2
Slowly increase the strength of the solution by increasing the quantity of flakes being dissolved, again increasing the amount given to the horse by 10ml every 2 or 3 days.

Step 3
Continue slowly increasing the strength of the solution over a period of some six weeks or so until signs of deficiency have disappeared, or until a slight softening of the manure is noticed. If this happens, reduce the amount of magnesium chloride fed each day to the previous level, then maintain at this level provided manure consistency is normal.

It is advisable to monitor the horse closely for any signs of returning magnesium deficiency so that the dosage rate can be increased if necessary. When body stores of magnesium have been replenished, it should be possible to reduce the amount fed. As the body can only absorb so much at a time, this may take many months and will depend on the quantity of high-sugar feeds ingested, how much magnesium is excreted and the needs of each individual horse.

Body stores of magnesium cannot be assessed by blood test as only around 1% of body magnesium is found in the blood. Cessation of deficiency signs has been found to be the only reliable way to determine that any individual horse is receiving an adequate daily supply of magnesium from all sources.

How long does it take to work?

The first changes to a quieter, calmer temperament are often seen within a week, with progressive improvements continuing over a couple of months. For laminitis or footsore horses, improvements in hoof form and function can take several months to

be consistent as the new stronger lamellar connection grows down from the coronet, although improvements in foot comfort can often be seen within a month. Overweight horses have been seen to lose weight within a month. Relaxation of a stiff, braced posture usually occurs after a couple of weeks.

Feeding magnesium twice per day has been found to produce better results than feeding just once per day as the horse is able to absorb a higher overall daily amount. For severe problems, an introductory period of feeding small amounts of magnesium throughout the day may be beneficial, providing there is no intestinal disruption.

Is anything else needed?

The majority of horses who are supplemented with magnesium chloride do not need additional sources of vitamins or commercially prepared minerals, although this is dependent on individual horses and living conditions. For more information see the subpages for Feeds, Chromium, Salt, Boron, Iodine and Toxin Binder.

What about calcium?

Despite the need for calcium being heavily promoted, many horses only start to develop strong feet when dietary calcium is limited. For more information see the subpage for Calcium.

Is magnesium safe?

Many reference sources for both humans and animals indicate that magnesium is not toxic; it is found in abundant quantities throughout the body. The major sign of excess dietary magnesium is diarrhoea, or scouring, so the horse should be monitored closely at all times for any indication of loosening manure. Magnesium should be reduced before the horse reaches the point of scouring.

Too much magnesium of any form is not desirable but even small amounts of some forms of magnesium, for example magnesium sulphate (Epsom salts) can cause scouring as it acts as an irritant to the intestinal lining. Scouring can also be caused by increasing the strength of the magnesium chloride solution too quickly; as with any new feed, the horse's body needs time to adjust. If this happens, reduce the amount fed, or even skip entirely for a few of days, then start again at a much lower level, working up more gradually.

Important: Supplemental minerals, including magnesium, should not be fed to any horse with existing renal problems. Consult a veterinarian for advice before feeding any minerals to any horse with suspected kidney function issues.

Recommended reading:

Books

The Magnesium Factor
Mildred S Seelig, MD, MPH, MACN
Andrea Rosanoff, PhD
Avery, 2003

The Magnesium Miracle
Carolyn Dean, MD, ND
Ballantine Books, 2003

Transdermal Magnesium Therapy
Mark Sircus, Ac, OMD
Phaelos Books, 2007

The Fat Switch
Richard J Johnson, MD
Mercola Books, 2012

The Calcium Lie
Robert Thompson, MD
Kathleen Barnes
InTruthPress, 2008

Excitotoxins, The Taste That Kills
Russell L Blaylock, MD
Health Press, 1997

Articles

Magnesium Chloride for Health and Rejuvenation
B. Bourke, W. Last
Nexus, 2008

Rapid Recovery from Major Depression using Magnesium Treatment
G. Eby, K. Eby, 2006
http://intl.elsevierhealth.com/journals/mehy

Magnesium and Potassium in LAF
P. Chambers, 2003
http://www.mgwater.com/laf.shtml

Magnesium Oxide Bioavailability Update
G. Miller, PhD, Premier Chemicals
www.premierchemicals.com/corner/articles/update.htm