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# Feeding and supplementation of riding horses with myopathy symptoms

## A survey on feeding strategies in Warmblood horses showing chronic exertional myopathy symptoms

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# Abstract

## Introduction

Chronic exertional myopathies occur in many breeds worldwide and have a tremendous negative impact on performance in affected horses. In Warmbloods, myofibrillar myopathy (PSSM2/MFM) is a newly described disease thought to represent a subset of the Polysaccharide Type 2 Storage Myopathy. Lack of amylase-resistant polysaccharide storage was however recently brought to light for PSSM2/MFM, changing the perception of the disease to protein oxidative and post exercise maladaptive pathophysiologic events. Feeding strategies and their effects on Warmblood horses suspected to suffer from chronic myopathies have not been performed so far.

## Objectives

To conduct a survey on a group of owners whose horse was suspected to suffer from a chronic exertional myopathy with emphasize on dietary changes and their effects on symptoms associated with this condition. The hypothesis was that specific feeding practices are perceived as effective measures to improve myopathy associated symptoms.

## Results

A total of 182 Warmblood horses were included in the studies (107 geldings 58.8%, 74 mares 40.7%, and one stallion 0.5%). The percentage of horses subjectively judged as improved or free of abnormalities according to different category of symptoms was: stiffness and muscle hardening in the back 108/156 (69.2%), exercise intolerance and reluctance to move 87/143 (60.8%), sensitivity to touch in the back muscles 110/120 (91.7%), blocking and refusal to move 84/120 (70%), lameness without orthopedic findings 60/88 (68.2%), muscle atrophy 39/70 (55.7%), and bucking behavior 48/66 (72.7%). When evaluating dietary changes separately, owners perceived symptoms improvements with 13 different feedstuffs including grain-free mixed feed based on other ingredients than rice bran or grass and/or herbs 48/73 horses (65.8%), grain-free mixed feed based on rice bran 23/44 (52.3%), grain-free mixed feed based on grasses and/or herbs 46/104 (44.2%), lysine 95/148 (64.2%),

threonine 89/142 (62.7%), methionine 88/144 (61.1%), other amino acids 69/117 (59%), manganese 77/146 (52.7%), vitamin E 62/131 (47.3%), hemp protein 41/48 (48.8%), rice protein 21/55 (36.8%), soy protein 31/88 (36.4%), Palmitoylethanolamide (PEA) 14/37 (37.8%) and symptoms worsening in 5 feedstuffs including barley 19/25 (76%), lucerne 46/68 (67.6%), maize 18/29 (62.1%), oats 35/72 (48.6), and calcium 15/57 (26.3%).

**Conclusion and clinical relevance**

Owners seem to show a strong interest in supporting their horses through targeted feeding and appear to strongly believe that nutrition significantly influences their horses' symptoms. There is suspicion that many uncertainties exist regarding supportive feed products, and as veterinarians, we may need to better address the needs of these clients.

Independent research projects are needed to investigate the specific effects and dosages of individual feed products in relation to PSSM2/MFM. Currently, there is very limited verified information on this subject, and the sparse studies available seem to be influenced by feed manufacturers.

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## Introduction

Around 80% of muscles diseases in sport horses are so-called exercise-induced myopathies in contrast to other muscle diseases caused by infectious or immunologic causes. [1] The term exertional myopathy refers to symptoms of pain and/or impaired performance attributable to the skeletal muscles apparent during or after exercise. Exertional rhabdomyolysis (ER), a subset of exertional myopathies, is defined as skeletal muscle damages secondary to physical exercise and is accompanied by increased creatine kinase levels (CK) and aspartate transaminase (AST) in the bloodstream. An acute overt ER (also referred to as "tying up") often occur secondary to extrinsic factors like exercise in excess, nutritional imbalances, and viral illness. This disease is characterized by symptoms of acute generalized muscle damages expressed as muscle stiffness, shortened hind limb stride, reluctance to move, sweating, increased respiratory rate, and even myoglobinuria in severe cases. In cases of acute ER, clinicians should rapidly initiate intensive care therapy based on intravenous crystalloid infusions and pain relief.

The main characteristic of chronic myopathies is a dysfunction arising from the muscle itself (i.e. intrinsic muscular disease). This may be caused by a single or multiple genetic mutation, and influenced by environmental stimuli like psychological stress, training strategies, and diet. Common examples of recurrent myopathies include recurrent exertional rhabdomyolysis (RER), malignant hyperthermia, Polysaccharide storage myopathies type 1 and 2. These diseases lead to similar clinical syndromes, but occur in different breeds and are diagnosed in a different way. [2-8] Following literature review will focus on diagnostic challenges, description of clinical symptoms, and therapies of common chronic exertional myopathies. Emphasis will be placed on diagnosis and dietary management of these muscle diseases in Warmblood horses living in Germany.

## Literature review

Recurrent Exertional rhabdomyolysis is a muscular disease affecting thoroughbreds and to a lesser extend standardbreds. Episodes of stiff gait, painful muscle cramping, and sweating are seen when this condition is present. These symptoms are commonly associated with muscle cell damages following mild to moderate exercise in affected horses. This disease is the most common myopathy in racing thoroughbreds with a prevalence of around 5% in the United States and in the United Kingdom. Diagnosis is mainly based on the presence of intermittent elevations of serum CK and AST. Factors influencing the development of clinical signs in horses affected with RER include genetic factors, temperament, sex, and age of the horse as well as diet, and exercise routine. [9-24]

In polysaccharide storage myopathies, the pathological accumulation of intracellular amylase-resistant glycogen is believed to cause symptoms similar to those observed in RER. This abnormal glycogen storage is diagnosed through histopathological evaluation of muscle biopsies in horses exhibiting chronic myopathy symptoms. [25-28] A dominant inheritance pattern has been identified in certain breeds, prompting investigation of candidate genes linked to equine myopathies. A mutation in the *glycogen synthase 1* (*gys1*) gene was confirmed to be associated with inherited myopathies mostly in Quarter Horses (and related breeds) and Draft Horses. This mutation results in a metabolically hyperactive **G**ys1 enzyme, which overproduces glycogen. The excess glycogen accumulates in muscle cells, causing dysfunction and clinical signs. This condition was designated as PSSM1 to distinguish it from another myopathy, PSSM2. Horses displaying similar clinical signs and histopathological muscle abnormalities—but lacking the *gys1* mutation—were initially classified under the PSSM2 terminology. Two new subgroups of PSSM2-affected horses were defined based on presence or absence of muscle breakdown: PSSM2-ER (Polysaccharide Storage Myopathy type 2 Exertional Rhabdomyolysis), and Myofibrillar Myopathy (MFM). [29-32]

Polysaccharide Storage Myopathy type 2 Exertional Rhabdomyolysis is prevalent in Quarter Horse related breeds (but not limited to these breeds). Characteristics of this diseases is the presence of pathologically high creatine kinase (CK) in the bloodstream during episodes of tying up, indicating the occurrence of muscle damages. Specific diet and training recommendations apply in PSSM1-affected horses and consist of a low-starch, high-fat diet

based on the caloric needs, and of daily exercise, respectively. PSSM2-ER responds to the same diet and exercise recommendations as for PSSM1. [4,33]

Myofibrillar myopathy (PSSM2/MFM) is a recently described disease in Warmblood Horses and may be seen as subcategory of PSSM2. This disease was named based on the presence of abnormally aligned myofibrils seen during electronic microscopic examination in affected horses. [34] Myofibrillar myopathy leads to a wide spectrum of symptoms related to muscle pain and reduced fitness. The primary abnormality in these horses is a reluctance to work with reduced hindlimb engagement. In addition to that, horses may have back soreness, mild shifting lameness, difficulties to canter, stiffness, and muscle atrophy. Other orthopedic (e.g. tendons, ligaments, joint diseases) or medical diseases (cardiovascular, lower and upper airways, gastrointestinal diseases) may cause similar symptoms and should be ruled out before specific muscular diagnostic tests are performed. These horses were diagnosed as PSSM2 based on the microscopic appearance of the glycogen in their muscle cells in the past, but refined measurement methods (biochemical assays) recently proved normal polysaccharide values. [29] Beside electronic microscopic examination, immunohistochemistry can be used to stain oxydated desmin, a protein that aggregates in muscle cells of PSSM2/MFM affected horses. Desmin is a protein that align the myofilaments and joints them to the cell membrane, while being a very readily oxidized protein. Myofibrillar myopathy affected horses seem to be unable to effectively neutralize reactive oxygen produced in their mitochondria during exercise. Accumulation of damaged (oxydated) proteins like desmin is therefore the consequence of these pathological events. [35-38] These subtle but typical chronic muscular anomalies accumulate over time in PSSM2/MFM horses and can only be recognized in middle aged and older horses (i.e. older than 10 years of age), rendering diagnosis even more challenging. [34] Another characteristic of the disease in comparison with other chronic myopathies is the absence of muscle necrosis, as shown by a lack of elevated CK values. Also unique to PSSM2/MFM is a suspected maladaptation to training compared to normal horses. These animals therefore seem to have difficulties to strengthen their muscle cells after strenuous exercise, a phenomenon following well known muscle aches in humans but probably in horses as well. Abnormally increased amount of signaling proteins originating from the Z-disc, a protein complex located around myofibrils could therefore be found in PSSM2/MFM-affected horses in comparison to controls, suggesting signaling muscle repair and strengthening pathways dysfunction at molecular level.

All these pathophysiologic PSSM2/MFM characteristics may explain these horses do not respond to the therapy the same way as horses affected with other chronic myopathies. Improvement of previously described symptoms is only seen in 50 % of MFM-affected horses following PSSM-1 diet and exercise recommendations. Myofibrillar myopathy affected horses also do not perform well if trained on a daily basis due to their inefficient capacity to recover and strengthen their muscles after training. Proposed training therefore includes 3 days of training followed by 2 days of turnout. Long warm-up periods are encouraged before training and horses should be turned out as much as possible. Regarding diet, the opposite regiment as for RER is recommended. [36,39]

Veterinarians should be aware of muscular diseases and apply a systematic workup when indicated. This should include thorough static and dynamic clinical examination, assessment of muscle relevant blood values (e.g. CK, AST, serum α-tocopherol), and genetic testing in susceptible breeds (e.g. *gys1*-mutations for PSSM1*, myh1*-mutations for immune-mediated myopathies, *ryr1*-mutations for malignant hyperthermia). If the horse continues to show poor performance attributed to his skeletal muscular system despite changes in diet and exercise management, and if the diagnosis remains unclear after aforementioned blood and genetic tests, then a muscle biopsy should be the next step. [2]

Tremendous research advances have been achieved last years to better understand pathophysiologic mechanisms and develop new therapeutic approaches to chronic equine exertional myopathies. These rapid developments represent challenges for veterinarians since these diseases may not have been taught in veterinary schools until recently. This may lead to a reduced disease awareness among practitioners and to frustrations in horse owners suspecting an undiagnosed or neglected muscular diseases in their horses. Moreover, systematic medical and orthopaedic diagnostic workup is necessary before focusing on a muscle disease, which may seem fastidious for owners and practitioners. Myofibrillar myopathy is likely the most prevalent chronic muscular disease in Warmbloods but may remain a suspected diagnosis even after thorough diagnostic workup if the horse is younger than 10 years of age due to the absence of histopathologic changes in muscle biopsies. Dietary diagnostic/ therapeutic changes may be recommended even by myopathy veterinary experts in younger Warmbloods showing signs of MFM symptoms instead of muscle biopsies based on the current knowledge of this disease. Due to this diagnostic complexity,

low diseases awareness in veterinarians, and potentially financial restraints, owners may try dietary changes based on perceived myopathy symptoms, and/or genetic testing (PSSM1 and PSSM2), even in the absence of scientific evidence for PSSM2-test (i.e. P-variants), and known very low incidence of *gys1*-mutations in Warmbloods.[2,40]

A nutritionally balanced diet based on reduce nonstructural carbohydrates (NSC, less than 12%), concentrates with restricted amount of starch and sugar, supplemental calories supplied with fat, adequate vitamins, and minerals was recommended for all exertional myopathies until recently. [2] Improved understanding of pathophysiologic events at a cellular basis for MFM has led to a complete rethinking of dietary recommendation for this disease. Mainstays of the new concepts are the lack pathologic amylase-resistant storage, pathologic oxidative reactions at a cell basis leading to desmin degradations, and maladaptation to training. [2,36,39] Based on this knowledge, specific concentrates have been developed to improve MFM symptoms. These concentrates contain a large amount of non-structural carbohydrates (20 to 30% of the concentrate) since a glycogen storage is not assumed in this condition. The amount of fat is reduced to less than 8% to reduce the prooxidative stress, and the amount of proteins is increased to 12-14% to support muscle repair. These concentrates also contain N-acetylcystein, an active substance well absorbed and transformed to cysteine in the body, an amino acid essential to synthetize cysteine-based antioxidants like glutathione, peroxiredoxins, and thioredoxins. Other components of the MFM pellets include essential amino acids (e.g. L-leucin) including branched chain amino acids to enhance muscle mass. [39] Since these new dietary concepts represent completely different approaches compared to past recommendations and due to reduced or anecdotical scientific evidence, further independent studies are warranted before definitive dietary recommendations for horses suffering chronic exertional myopathies.

## Objectives

Warmblood breed made 95% of the yearly newly registered horses according to the German riding association (source https://www.pferd-aktuell.de ). As the majority of registered sport horses in Germany, the land where the author lives, are Warmbloods, the following research focused on the feeding and supplementation of Warmbloods with symptoms of myopathy where the disease PSSM2/ MFM was suspected by the owners.

The aim of this study was to conduct a survey on a group of owners taking part to a so called "EMND, PSSM 2, RER" Facebook group to describe which complaints they describe, which diagnostic procedures were undertaken, and which therapeutic and specifically dietary changes were adopted in a group of Warmblood living in Germany. The hypothesis was that specific feeding practices play a crucial role in the management of Warmblood horses perceived by their owners to exhibit symptoms of myopathies, and that certain feeding regiments may contribute to an improvement in myopathy symptoms.

## Material and Methods

A quantitative survey was conducted among members of a Facebook group. This private Facebook group, titled "EMND, PSSM2, RER," comprises approximately 14,500 members and serves as a platform for horse owners to share information and experiences regarding equine myopathies, PSSM2, and RER. The questionnaire was sent as an online document elaborated with an internet-based survey supplier (www.survio.com). Based on current literature, questions were developed to target specific topics regarding diagnosis, perceived clinical abnormalities, and dietary measures in Warmblood horses suspected to suffer from exertional myopathies. The majority of questions were designed in a binary manner for ease of interpretation. The data were collected over a 14-days period. All participants were informed about the purpose of the study, and no personal data were collected. The collected data were analyzed using descriptive statistical analysis.

## Results

The survey was conducted among approximately 14,500 members of the previously described Facebook group, with 293 members fully completing the questionnaire. This represents 2% of this Facebook group. Among the 293 survey participants, 287 (98%) answered "yes" to the question of whether they owned a horse exhibiting myopathy symptoms or had experienced such symptoms in the past, and whether they had achieved improvement through targeted feeding. Six participants out of 293 (2%) answered "no", and were therefore excluded from further analysis.

The remaining 287 participants' horses were categorized as follows: 187 Warmbloods (65.2%), 39 Ponies (13.6%), 24 Half-breds (8.4%), 23 Thoroughbreds (8%), and 14 Coldbloods (4.9%). As the focus of the study is on the feeding of Warmbloods exhibiting myopathy symptoms, all other horse types were excluded from the following analysis. Additionally, 5 Warmbloods that tested positive for PSSM1 were excluded, as the survey focused on the feeding of warmbloods with symptoms related to PSSM2/MFM. The age distribution of the horses was as follows: 71 out of 182 horses were aged between 9 and 13 years (39%), 51 horses were between 4 and 8 years old (28%), 43 horses were between 14 and 18 years old (23.6%), 13 horses were between 19 and 23 years old (7.1%), 3 horses were younger than 4 years (1.6%), and one horse was older than 23 years (0.5%). The horses' gender distribution was as follows: 107 geldings (58.8%), 74 mares (40.7%), and one stallion (0.5%). Regarding weight of the 182 horses, 94 horses weighed between 500 and 600 kg (51.6%), 61 horses weighed between 600 and 700 kg (33.5%), 19 horses weighed between 400 and 500 kg (10.4%), 7 horses weighed between 700 and 800 kg (3.8%), and one horse weighed between 300 and 400 kg (0.5%). The owners assessed the horses' Body Condition Score (BCS) as follows: 94 out of 182 horses were deemed to have a normal weight (51.6%), 39 horses were considered moderately thin (21.4%), 33 horses were considered moderately fat (18.1%), 9 horses were deemed thin (4.9%), and 7 horses were classified as obese (3.8%). Regarding ownership duration, 76 out of 182 horses had been owned by their current owners for 5 to 10 years (41.8%), 44 horses had been owned for more than 10 years (24.2%), 36 horses had been owned for 3 to 5 years (19.8%), and 26 horses had been owned for less than 3 years (14.3%). In terms of pasture access, 70 out of 182 horses had less than 4 hours of daily pasture access (38.5%), 54 horses had 4 to 8 hours of access (29.7%), 35 horses had

more than 12 hours of access (19.2%), and 35 horses had 8 to 12 hours of access (12.9%). Regarding their usage, 101 out of 182 horses were recreationally used (55.5%), 53 horses competed in national competitions up to class L or in Western sports up to class C (29.1%), 13 horses competed in national events from class M or higher or in Western sports from class B (7.1%), 7 horses were retired (3.8%), 6 horses competed internationally or in races (3.3%), one was still growing (0.5%), and one horse was used for breeding purposes (0.5%).

When asked about comorbidities, the owners reported that 124 out of 182 horses (68.1%) suffered from additional diseases, while 58 horses (31.9%) did not have any comorbidities. Out of the 124 horses with comorbidities, 61 had gastrointestinal issues (49.2%), 50 had orthopedic limb diseases (40.3%), 48 had respiratory diseases (38.7%), 38 had spinal orthopedic issues (30.6%), and 10 had metabolic disorders (8%). Participants could indicate multiple comorbidities if applicable. To diagnose the myopathy symptoms, 136 out of 182 horses (74.7%) underwent genetic testing via hair root analysis and 2 had a muscle biopsy (1.1%). The results of the diagnostic tests were as follows: 118 out of 136 horses tested positive for myopathy via hair root genetic tests (86.8%) and one out of 2 horse (50%) had a positive result in a muscle biopsy for PSSM2/MFM. Originally, 187 Warmbloods participated in the survey. Among those, 114 horses were tested for the PSSM1 variant via genetic testing, and 5 horses tested positive (4.4%). These 5 horses were excluded from the analysis as the focus of this study is on Warmbloods exhibiting myopathy symptoms related to PSSM2/MFM.

Before receiving specific feeding, 156 out of 182 horses exhibited stiffness and muscle hardening in the back (85.7%), 143 showed exercise intolerance and reluctance to move (78.6%), 132 showed tenderness in the back muscles (72.5%), 120 displayed blocking/ refusal to move (65.9%), 105 exhibited a pain expression (57.7%), 88 showed lameness without orthopedic findings (48.4%), 72 showed saddle problems (39.6%), 70 showed muscle atrophy (38.5%), 69 showed aggression (37.9%), 66 displayed bucking behavior (36.3%), 58 showed muscle tremors (31.9%), 56 displayed additional symptoms like difficulty gaining muscle, unwillingness to move, fearfulness, and/or muscle indentations (30.8%) and 43 horses showed excessive sweating (23.6%). Through a specific feeding regimen, strong improvements in myopathy symptoms were observed across various groups of horses. Among the 156 out of 182 horses that had previously shown stiffness and hardened muscles in their backs, none experienced a worsening of symptoms, 5 horses (3.2%) showed

no improvement, 43 horses (27.6%) exhibited mild improvement, 88 horses (56.4%) showed strong improvement, and 20 horses (12.8%) were symptom-free. Similarly, 143 out of 182 horses that had previously demonstrated training intolerance and have been reluctance to move, in this group 9 horses (6.3%) showed no improvement, 47 horses (32.9%) showed mild improvement, 71 horses (49.7%) exhibited strong improvement, and 16 horses (11.2%) were symptom-free. For the 132 out of 182 horses that previously exhibited sensitivity to back muscles palpation, there was no worsening of symptoms, 6 horses (4.5%) showed no improvement, 40 horses (30.3%) experienced mild improvement, 58 horses (43.9%) showed strong improvement, and 28 horses (21.2%) were symptom-free. Of the 120 out of 182 horses that had previously demonstrated blocking and refusal to move, no horse experienced worsening. In this group, 11 horses (9.2%) showed no improvement, 25 horses (20.8%) exhibited mild improvement, 64 horses (53.3%) showed strong improvement, and 20 horses (16.7%) were symptom-free. For the 105 out of 182 horses that had shown signs of facial pain, no horse experienced worsening, 8 horses (7.6%) showed no improvement, 31 horses (29.5%) showed mild improvement, 46 horses (43.8%) exhibited strong improvement, and 20 horses (19%) were symptom-free, even though this symptom had existed prior to the specific feeding intervention. Among the 88 out of 182 horses with lameness without orthopedic findings, none showed worsening, 10 horses (11.4%) showed no improvement, 18 horses (20.5%) had mild improvement, 31 horses (35.2%) showed strong improvement, and 29 horses (33%) were symptom-free. Similarly, 72 out of 182 horses that had previously exhibited saddle-related issues showed no worsening. Fourteen horses (19.4%) showed no improvement, 17 horses (23.6%) showed mild improvement, 22 horses (30.6%) showed strong improvement, and 19 horses (26.4%) were symptom-free. For the 70 out of 182 horses that had shown muscle atrophy, no deterioration occurred, 7 horses (10%) showed no improvement, 24 horses (34.3%) showed mild improvement, 22 horses (31.4%) exhibited strong improvement, and 17 horses (24.3%) were symptom-free. Among the 69 out of 182 horses that had displayed aggression, none showed worsening of symptoms. Four horses (5.8%) showed no improvement, 16 horses (23.2%) had mild improvement, 34 horses (49.3%) exhibited strong improvement, and 15 horses (21.7%) were symptom-free. Of the 66 out of 182 horses that had previously shown bucking, none showed deterioration, 9 horses showed no improvement (13.6%), 9 horses showed slight improvement (13.6%), 28 horses showed strong improvement (42.4%), and 20 horses were described as symptom-free (30.3%). Among the 58 out of 182 horses that had previously shown muscle tremors, one horse (1.7%) experienced worsening, 6 horses (10.34%) showed no improvement, 14 horses

(24.1%) exhibited mild improvement, 18 horses (31%) showed strong improvement, and 19 horses (32.8%). Of the 56 out of 182 horses that had additional symptoms, such as difficulty gaining weight, trouble building muscle, bolting, nervousness, or dents in the musculature, no horse showed worsening of symptoms, 7 horses (12.5%) showed no improvement, 10 horses (17.9%) showed mild improvement, 14 horses (25%) showed strong improvement, and 25 horses (44.6%) were symptom-free. Finally, among the 43 out of 182 horses that had previously exhibited excessive sweating, none showed worsening, 9 horses (20.9%) showed no improvement, 12 horses (27.9%) had mild improvement, 11 horses (25.6%) showed strong improvement, and 11 horses (25.6%) were symptom-free.

The impact of individual feed types on myopathy symptoms was assessed by the owners as follows: 163 out of 182 horses (89.6%) were fed grass, and 16 out of 163 horses (9.8%) experienced a deterioration of myopathy symptoms, 55 out of 163 horses (33.7%) showed no improvement, 49 horses (30.1%) experienced mild improvement, and 43 horses (26.4%) had strong improvement due to the feeding of grass. One hundred and fifty-two out of 182 horses (83.5%) were fed dry hay, and one of 152 horses (0.7%) showed a worsening of myopathy symptoms, 83 horses (54.6%) showed no improvement, 23 horses (15.1%) experienced mild improvement, and 45 horses (29.6%) showed strong improvement due to the feeding of dry hay. One hundred and four out of 182 horses (57.1%) were fed grain-free mixed feed based on grasses and/or herbs, and none of these horses showed a worsening of myopathy symptoms, 15 out of 104 horses (14.4%) showed no improvement, 43 horses (41.3%) had mild improvement, and 46 horses (44.2%) had strong improvement due to the feeding of grain-free mixed feed based on grasses and/or herbs. Ninety-two out of 182 horses (50.5%) were fed straw, with 6 out of 92 horses (6.5%) experiencing a worsening of myopathy symptoms, 63 horses (68.5%) showed no improvement, 12 horses (13%) had mild improvement, and 9 horses (9.8%) showed strong improvement due to the feeding of straw. Seventy-three out of 182 horses (40.1%) were fed grain-free mixed feed based on ingredients other than grasses and/or herbs and/or rice bran. Among these, 3 out of 73 horses (4.1%) showed a worsening of myopathy symptoms, 5 horses (6.8%) showed no improvement, 17 horses (23.3%) had mild improvement, and 48 horses (65.8%) showed strong improvement. Seventy-two out of 182 horses (54.9%) were fed oats, and 35 out of 72 horses (48.6%) showed a deterioration of myopathy symptoms. In this group, 13 horses (17.8%) showed no improvement, 13 horses (17.8%) experienced mild improvement, and 11 horses (15.1%) showed strong improvement due to the feeding of oats. Sixty-eight out of 182 horses (37.4%)

were fed lucerne, with 46 out of 68 horses (67.6%) experiencing a worsening of symptoms, 7 horses (10.3%) showed no improvement, 10 horses (14.7%) had mild improvement, and 5 horses (7.4%) experienced strong improvement due to the feeding of lucerne. Fifty-two out of 182 horses (28.6%) were fed green oats, with 6 out of 52 horses (11.5%) showing a deterioration of myopathy symptoms. Fifteen horses (28.8%) showed no improvement, 22 horses (42.3%) experienced mild improvement, and 9 horses (17.3%) had strong improvement due to the feeding of green oats. Forty-fife out of 182 horses (24.7%) were fed silage, and 10 out of 45 horses (22.2%) experienced a worsening of myopathy symptoms, 17 horses (37.8%) showed no improvement, 9 horses (20%) had mild improvement, and 9 horses (20%) showed strong improvement due to the feeding of silage. Forty-four out of 182 horses (24.2%) were fed grain-free mixed feed based on rice bran, with 5 out of 44 horses (11.4%) experiencing a worsening of myopathy symptoms. Six horses (13.6%) showed no improvement, 10 horses (22.7%) had mild improvement, and 23 horses (52.3%) showed strong improvement. Thirty-nine out of 182 horses (21.4%) were fed wet hay, and 2 out of 39 horses (5.1%) showed a worsening of myopathy symptoms, 13 horses (33.3%) showed no improvement, 13 horses (33.3%) had mild improvement, and 11 horses (28.2%) showed strong improvement due to the feeding of wet hay. Thirty-eight out of 182 horses (20.9%) were fed sainfoin whereby 10 out of 38 horses (26.3%) experienced a worsening of myopathy symptoms, 6 horses (15.8%) showed no improvement, 12 horses (31.6%) had mild improvement, and 10 horses (26.3%) experienced strong improvement due to the feeding of sainfoin. Thirty-four out of 182 horses (18.7%) were fed grain-free mixed feed based on sunflower extraction meal, with no horses showing a worsening of myopathy symptoms, 7 out of 34 horses (20.6%) showed no improvement, 14 horses (41.2%) had mild improvement, and 13 horses (38.2%) showed strong improvement. Thirty-one out of 182 horses (17%) were fed steamed hay, and 4 out of 31 horses (12.9%) showed a deterioration of myopathy symptoms, 14 horses (45.2%) showed no improvement, 8 horses (25.8%) had mild improvement, and 5 horses (16.1%) showed strong improvement due to the feeding of steamed hay. Thirty out of 182 horses (16.5%) were fed timothy hay, with 5 out of 30 horses (16.7%) showing a worsening of myopathy symptoms. Seven horses (23.3%) showed no improvement, 7 horses (23.3%) had mild improvement, and 11 horses (36.7%) showed strong improvement. Twenty-nine out of 182 horses (15.9%) were fed maize, with 18 out of 29 horses (62.1%) experiencing a worsening of myopathy symptoms, 5 horses (17.2%) showed no improvement, 3 horses (10.3%) had mild improvement, and 3 horses (10.3%) showed strong improvement. Twenty-five out of 182 horses (13.7%) were fed barley, with

19 out of 25 horses (76%) showing a worsening of myopathy symptoms, 4 horses (16%) showed no improvement, one horse (4%) had mild improvement, and one horse (4%) showed strong improvement. Seventeen out of 182 horses (9.3%) were fed silage, with 11 out of 17 horses (64.7%) showing a worsening of myopathy symptoms, 5 horses (29.4%) showed no improvement, one horse (5.9%) had mild improvement, and no horse showed strong improvement.

The following information was provided regarding supplementary feed for the group of protein sources, amino acids, minerals, vitamins, and oilseeds: A total of 148 out of 182 horses (81.3%) received lysine as a supplementary feed. None of these horses experienced a worsening of myopathy symptoms. In 5 out of 148 horses (3.4%), no improvement was observed, while 48 horses (32.4%) showed mild improvement, and 95 horses (64.2%) showed strong improvement in myopathy symptoms after the administration of lysine. One hundred and forty-six out of 182 horses (80.2%) received manganese as a supplement. In 4 out of 146 horses (2.7%), the myopathy symptoms worsened, in 21 horses (14.4%), no improvement was seen, while 44 horses (30.1%) showed mild improvement, and 77 horses (52.7%) showed strong improvement following manganese supplementation. One hundred and forty-four out of 182 horses (79.1%) received methionine as a supplement. None of these horses experienced a worsening of myopathy symptoms, in 8 out of 144 horses (5.6%), no improvement was observed, while 48 horses (33.3%) showed mild improvement, and 88 horses (61.1%) showed strong improvement following methionine supplementation. One hundred and forty-two out of 182 horses (78%) received threonine as a supplement. There was no worsening of symptoms in any of these horses, in 8 out of 142 horses (5.6%), no improvement occurred, while 45 horses (31.7%) showed mild improvement, and 89 horses (62.7%) exhibited strong improvement following threonine supplementation. One hundred and thirty-six out of 182 horses (74.7%) received mineral supplements other than magnesium, zinc, manganese, selenium, calcium, or copper. In 1 horse (0.7%), symptoms worsened. In 27 out of 136 horses (19.9%), no improvement was noted, while 48 horses (35.3%) showed mild improvement, and 60 horses (44.1%) exhibited strong improvement after supplementation with these minerals. One hundred and thirty-one out of 182 horses (72%) received vitamin E as a supplement. In 5 out of 131 horses (3.8%), the myopathy symptoms worsened. In 16 horses (12.2%), no improvement was observed, while 48 horses (36.6%) showed mild improvement, and 62 horses (47.3%) showed strong improvement after vitamin E supplementation. One hundred and nineteen out of 182 horses (65.4%)

received B-vitamins as a supplement. In 2 out of 119 horses (1.7%), symptoms worsened, while 21 horses (17.6%) showed no improvement. Mild improvement occurred in 54 horses (45.4%), and 42 horses (35.3%) showed strong improvement after B-vitamins supplementation. One hundred and seventeen out of 182 horses (64.3%) received amino acids other than lysine, methionine, threonine, or tryptophan. None of these horses showed a worsening of symptoms. In 9 out of 117 horses (7.7%), no improvement was observed, while 39 horses (33.3%) showed mild improvement, and 69 horses (59%) showed strong improvement following amino acid supplementation. One hundred and twelve out of 182 horses (61.5%) received zinc as a supplement. In 2 out of 112 horses (1.8%), the myopathy symptoms worsened. In 37 horses (33%), no improvement occurred, while 48 horses (42.9%) showed mild improvement, and 25 horses (22.3%) experienced strong improvement following zinc supplementation. One hundred and ten out of 182 horses (60.4%) received flaxseed as a supplement. In 2 out of 110 horses (1.8%), symptoms worsened. In 27 horses (24.5%), no improvement was observed, while 49 horses (44.5%) showed mild improvement, and 32 horses (29.1%) exhibited strong improvement following flaxseed supplementation. One hundred and seven out of 182 horses (58.8%) received tryptophan as a supplement. In one out of 107 horses (0.9%), symptoms worsened. In 16 horses (15%), no improvement was seen, while 30 horses (28%) showed mild improvement, and 60 horses (56.1%) showed strong improvement after tryptophan supplementation. Ninety-eight out of 182 horses (53.8%) received magnesium citrate as a supplement. In 4 out of 98 horses (4.1%), symptoms worsened. In 20 horses (20.4%), no improvement was noted, while 32 horses (32.7%) showed mild improvement, and 42 horses (42.9%) exhibited strong improvement following magnesium citrate supplementation. Ninety-three out of 182 horses (51.1%) received flaxseed oil as a supplement. In 6 out of 93 horses (6.5%), symptoms worsened. In 36 horses (38.7%), no improvement was seen, while 33 horses (35.5%) showed mild improvement, and 18 horses (19.4%) showed strong improvement after flaxseed oil supplementation. Eighty-eight out of 182 horses (48.4%) received soy protein as a supplement. In 19 out of 88 horses (21.6%), symptoms worsened. In 5 horses (5.7%), no improvement occurred, while 32 horses (36.4%) showed mild improvement, and 32 horses (36.4%) showed strong improvement following soy protein supplementation. Eighty-eight out of 182 horses (48.4%) received magnesium chelate as a supplement. In 2 out of 88 horses (2.3%), symptoms worsened. In 16 horses (18.2%), no improvement was observed, while 31 horses (35.2%) showed mild improvement, and 39 horses (44.3%) exhibited strong improvement after magnesium chelate supplementation. Eighty-seven out of 182 horses

(47.8%) received selenium as a supplement. In 4 out of 87 horses (4.6%), symptoms worsened. In 35 horses (40.2%), no improvement was observed, while 28 horses (32.2%) showed mild improvement, and 20 horses (23%) showed strong improvement after selenium supplementation. Eighty-four out of 182 horses (46.2%) received hemp protein as a supplement. In 2 out of 84 horses (2.4%), symptoms worsened. In 13 horses (15.5%), no improvement occurred, while 28 horses (33.3%) showed mild improvement, and 41 horses (48.8%) exhibited strong improvement after hemp protein supplementation. Seventy-seven out of 182 horses (42.3%) received magnesium fumarate as a supplement. In 6 out of 77 horses (7.8%), symptoms worsened. In 13 horses (16.9%), no improvement was noted, while 29 horses (37.7%) showed mild improvement, and 29 horses (37.7%) experienced strong improvement following magnesium fumarate supplementation. Seventy-two out of 182 horses (39.6%) received vitamin C as a supplement. In one out of 72 horse (1.4%), symptoms worsened. In 42 horses (58.3%), no improvement was observed, while 22 horses (30.6%) showed mild improvement, and 7 horses (9.7%) showed strong improvement after vitamin C supplementation. Seventy-one out of 182 horses (39%) received copper as a supplement. In 3 out of 71 horses (4.2%), symptoms worsened. In 41 horses (57.7%), no improvement occurred, while 20 horses (28.2%) showed mild improvement, and 7 horses (9.9%) showed strong improvement following copper supplementation. Sixty-six out of 182 horses (36.3%) received vitamin A as a supplement. In 3 out of 66 horses (4.5%), symptoms worsened. In 40 horses (60.6%), no improvement was noted, while 18 horses (27.3%) showed mild improvement, and 5 horses (7.6%) exhibited strong improvement following vitamin A supplementation. Sixty-five out of 182 horses (35.7%) received magnesium oxide as a supplement. In 2 out of 65 horses (3.1%), symptoms worsened. In 23 horses (35.4%), no improvement was observed, while 19 horses (29.2%) showed mild improvement, and 21 horses (32.3%) exhibited strong improvement following magnesium oxide supplementation. Sixty-one out of 182 horses (33.5%) were fed pea protein as a supplementary feed. Among these, 4 out of 61 horses (6.6%) showed worsening of myopathy symptoms, 13 horses (21.3%) showed no improvement, 22 horses (36.1%) displayed mild improvement, and 22 horses (36.1%) showed strong improvement in their myopathy symptoms following the addition of pea protein. Fifty-five out of 182 horses (31.3%) received rice protein as a supplement. Six out of 55 horses (10.5%) experienced a worsening of myopathy symptoms, 8 horses (14%) showed no improvement, 22 horses (38.6%) showed mild improvement, and 21 horses (36.8%) showed strong improvement with rice protein supplementation. Fifty-seven out of 182 horses (31.3%) were fed with calcium. Among them, 15 out of 57 horses

(26.3%) showed worsening symptoms, 30 horses (52.6%) showed no improvement, 10 horses (17.5%) showed mild improvement, and 2 horses (3.5%) showed strong improvement following calcium supplementation. Fifty-six out of 182 horses (30.8%) were supplemented with rice germ oil. Three out of 56 horses (5.4%) exhibited worsening symptoms, 23 horses (41.1%) showed no improvement, 21 horses (37.5%) showed mild improvement, and 9 horses (16.1%) showed strong improvement due to rice germ oil supplementation. Thirty-eight out of 182 horses (20.9%) received hemp oil. Two out of 38 horses (5.3%) showed worsening of myopathy symptoms, 19 horses (50%) showed no improvement, 13 horses (34.2%) showed mild improvement, and 4 horses (10.5%) showed strong improvement after hemp oil supplementation.

The following information was provided regarding supplementary feed for the group of additional additives: 115 out of 182 horses (63.2%) received salt as a supplement. Of these, 3 out of 115 horses (2.6%) experienced worsening symptoms, 73 horses (63.5%) showed no improvement, 31 horses (27%) showed mild improvement, and 8 horses (7%) showed strong improvement following salt supplementation. One hundred and ten horses (60.4%) were fed carrots. Nineteen out of 110 horses (17.3%) experienced worsening symptoms, 85 horses (77.3%) showed no improvement, 4 horses (3.6%) showed mild improvement, and 2 horses (1.8%) showed strong improvement with carrot supplementation. One hundred and five out of 182 horses (57.7%) were supplemented with apples. Twenty-three out of 105 horses (21.9%) showed worsening symptoms, 79 horses (75.2%) showed no improvement, 2 horses (1.9%) showed mild improvement, and one horse (1%) showed strong improvement with apple supplementation. Eighty-nine out of 182 horses (48.9%) were fed bananas. Eighteen out of 89 (20.2%) horses showed worsening of symptoms, 65 horses (73%) showed no improvement, 4 horses (4.5%) showed mild improvement, and 2 horses (2.2%) exhibited strong improvement due to banana supplementation. Forty-eight out of 182 horses (26.4%) received cannabidiol (CBD) as a supplement. One horse out 48 (2.1%) showed worsening of symptoms, 20 horses (41.7%) showed no improvement, 13 horses (27.1%) showed mild improvement, and 14 horses (29.2%) showed strong improvement following CBD supplementation. Forty out of 182 (22%) received Q10/ Ubiquinol as a supplement. None of these horses showed worsening of symptoms, 17 out of 40 horses (42.5%) showed no improvement, 17 horses (42.5%) showed mild improvement, and 6 horses (15%) showed strong improvement after supplementation with Q10/Ubiquinol. Thirty-seven out of 182 horses (20.3%) were fed with palmitoylethanolamide (PEA). None of these horses showed

worsening of symptoms, 13 out of 37 horses (35.1%) showed no improvement, 9 horses (24.3%) showed mild improvement, and 14 horses (37.8%) showed strong improvement following PEA supplementation. Twenty-nine out of 182 horses (15.9%) received devil's claw. Five out of 29 horses (17.2%) showed worsening of symptoms, 10 horses (34.5%) showed no improvement, 10 horses (34.5%) showed mild improvement, and 4 horses (13.8%) showed strong improvement due to devil's claw supplementation. Twenty-six out of 182 horses (14.3%) were given turmeric as a supplement. Three out of 26 horses (11.5%) showed worsening symptoms, 10 horses (38.5%) showed no improvement, 6 horses (23.1%) showed mild improvement, and 7 horses (26.9%) showed strong improvement following turmeric supplementation. Twenty-three out of 182 horses (12.6%) received frankincense. None of these horses showed worsening of symptoms, 10 out of 23 horses (43.5%) showed no improvement, 8 horses (34.8%) showed mild improvement, and 5 horses (21.7%) showed strong improvement with frankincense supplementation. Eighteen out of 182 (9.9%) were supplemented with alpha-lipoic acid. None of these horses showed worsening of symptoms, 9 out of 18 horses (50%) showed no improvement, 7 horses (38.9%) showed mild improvement, and 2 horses (11.1%) showed strong improvement following alpha-lipoic acid supplementation. When asked whether the feeding was coordinated according to a hay analysis, 50 out of 182 owners (27.5%) answered with "yes," while 132 owners (72.5%) answered with "no."

## Discussion

Based on the symptoms exhibited by this group of horses and the fact that only Warmbloods were included in the analysis, it can be assumed that most of the horses were suspected of having PSSM2/MFM. This study may help gather insights into the feeding habits of these owners and help design future research projects to further evaluate the impact of disease-oriented tailored diet. The study assumes that, with consistent management, training, feeding, and overall care of the horses, only one supplement was added and evaluated at a time. Moreover, effects of dietary adjustments were not evaluated by veterinarians but by owners specifically selected based on their connection to a specific group. Even though this kind of flaws are typical to a survey, this may represent significant selection bias and the single elements gathered in the present study should at best be evaluated in a larger prospective case-control study comparing dietary changes.

Participating owners generally seemed to test different forages, concentrates, and other supplements before finding the feeding regiment they perceived as appropriate to improve myopathy symptoms in their horse. They then describe their feeding regiment as highly effective as a sole therapeutic measure for this condition with significant improvements in all categories of muscular associated symptoms mentioned in this survey (**figure 1**). This emphasizes the role of dietary changes if a horse is suspected to suffer from a chronic exertional myopathy.

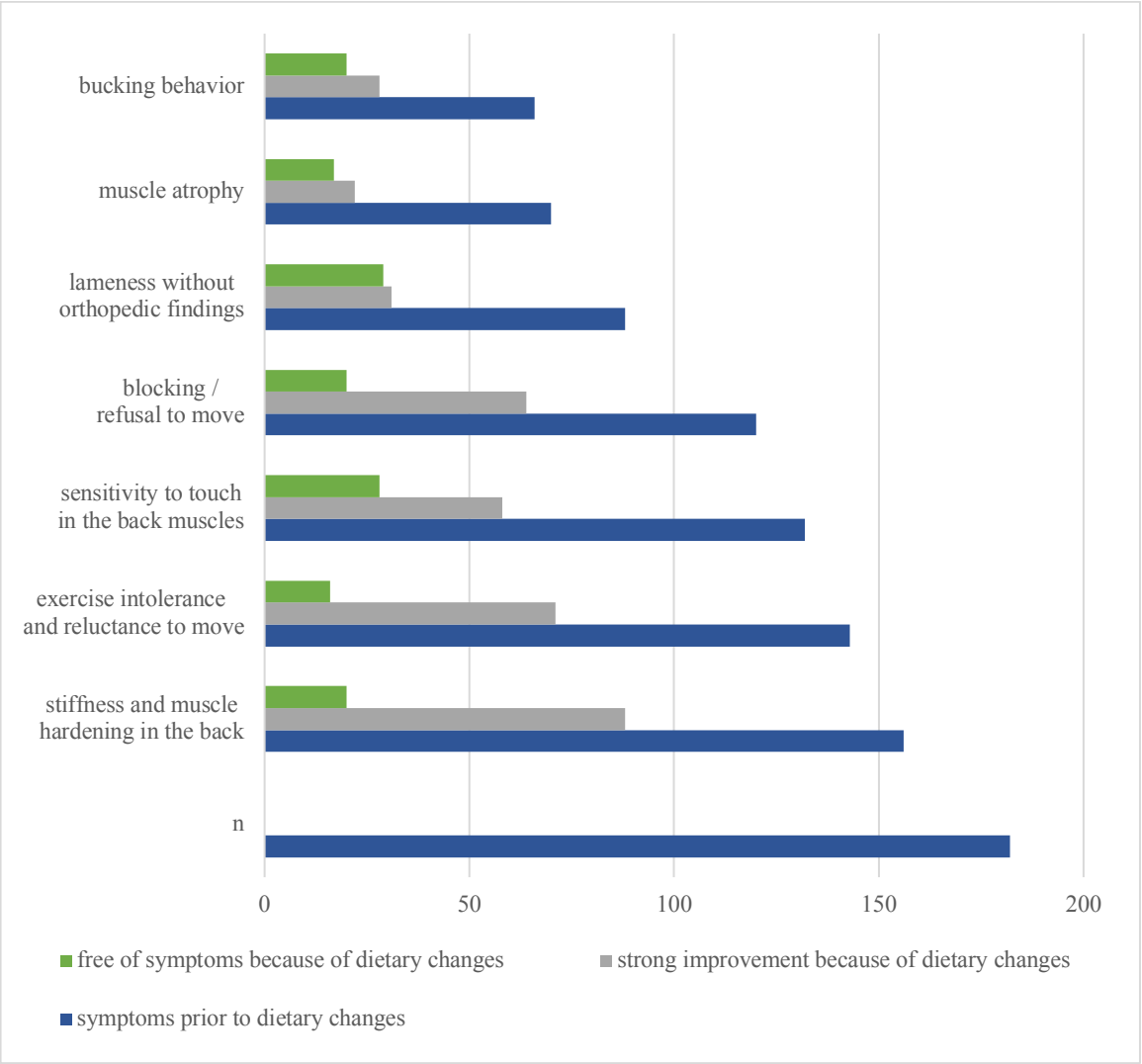


**Figure 1:** Perceived percentage of horses showing improvement after specific diet changes.

Before receiving specific feeding, 156 out of 182 horses (85.7%) exhibited stiffness and muscle hardening in the back, 143 (78.6%) showed exercise intolerance and reluctance to move, 132 (72.5%) showed sensitivity to touch in their back muscles, 120 (65.9%) displayed blocking/ refusal to move, 88 (48.4%) showed lameness without orthopedic findings, 70 (38.5%) showed muscle atrophy and 66 (36.3%) displayed bucking behavior. After dietary adjustments, 88 out of 156 horses (56.4%) which had previously shown stiffness and hardened muscles in their backs, showed strong improvement and 20 horses (12.8%) were free of this symptom. Seventy-one out of 143 horses (49.7%) showed strong improvement of their exercise intolerance and reluctance to move and another 16 horses (11.2%) were free of this symptom after dietary adjustment. Among those horses which showed sensitivity to touch in their back muscles, 58 out of 120 horses (43.9%) showed strong improvement and 28 horses (21.2%) were free of this symptom. Of the horses that had previously demonstrated blocking and refusal to move, 64 out of 120 horses (53.3%) showed strong improvement and

20 horses (16.7%) were free of this symptom. Among those horses with lameness without orthopedic findings, 31 out of 88 horses (35.2%) showed strong improvement and 29 horses (33%) were free of this symptom. Of the horses that had previously suffered from muscle atrophy, 22 out of 70 horses (31.4%) showed strong improvement and 17 horses (24.3%) were free of this symptom. Finally, of the horses that showed previously bucking behavior, 28 out of 66 horses (42.4%) showed strong improvement and 20 horses (30.3%) were described as symptom-free.

A large percentage of horses (124 out of 182, 68.1%) also suffered from non-muscular (gastro-intestinal in 61/124, 49.2%, and orthopedic limb diseases in 50/124, 40.3%) and these conditions may have caused symptoms similar to those seen in exercise-induced myopathies and therefore represent confounding factors. Orthopedic diseases causing chronic pain may lead to reluctance to work and poor hindlimbs engagement, therefore mimicking chronic myopathy symptoms. This may be the case for bilateral hindlimb proximal suspensory desmitis, a disease where horses may show unwillingness to perform due to chronic ligamentous and probably neurogenic pain.[2,41,42] Medical diseases like equine gastric syndrome may as well lead to reluctance to work due to chronic abdominal pain and associated poor general condition. [43,44] These kinds of chronic orthopedic or medical conditions usually require specific treatments and are unlikely to respond solely to dietary changes, supporting chronic exertional myopathies as the predominant cause of symptoms in the present population.

The majority of 136 out of 182 horses (74.7%) underwent a commercial, unvalidated genetic test for PSSM2 with positive results in 118 out of 136 (86.8%) horses. Symptoms of exercise-induced myopathy are non-specific and can occur in a variety of other conditions as well. However, the PSSM2/MFM is a well-documented disease, and it seems that many horse owners who suspect this condition in their horses feel poorly advised by their veterinarians. [2,35,36,39,40] Frustrated owners likely seek help on social medias where they may easily find groups of owners having similar experiences, prompting them to exchange subjective opinions on this topic. Furthermore, if one type the words “horse myopathy test” in a searching internet site like Google, the second result is the page of the genetic commercial company offering the unvalidated PSSM-2 Test. Owners can send in hair samples from their horse directly, without needing further veterinary support or advices. The laboratory does not inform owners that this genetic test is unvalidated. The cost is relatively

low compared to comprehensive diagnostic workup by a veterinarian, and the hair sample collection is quick and non-invasive. In case of a positive result, further investigation pertaining to potential comorbidities may be skipped, as the apparent cause has been subjectively identified, potentially overlooking other underlying conditions. A positive result from the unvalidated genetic test may mislead owners when taking decisions relative to purchasing, breeding, or even euthanizing a horse based on a wrong or inaccurate diagnosis. Veterinarians should therefore be aware of the latest knowledge about PSSM2/MFM and other myopathies to provide the best advices to clients who suspect this condition in their horses. If other causes are excluded by internal and orthopedic examinations, it may make sense to measure blood parameters (CK, AST, α-tocopherol), and if there are no signs of rhabdomyolysis, the working diagnosis in a warmblood could be PSSM2/MFM. For a young warmblood, it could be useful to try an adjusted diet. In the case of a warmblood older than 10 years of age, muscle biopsies may be taken to either confirm the diagnosis or test for other muscle diseases, if an adjusted diet does not lead to expected improvement of myopathy-associated symptoms.

Diagnostic laboratory tests were performed in 149/182 horses. The large majority of 136 out of 149 horses (91.3%) underwent a commercial, unvalidated genetic test for PSSM2 via hair root analysis, where 118 out of 136 (86.8%) horses were tested positive and only 2 horses (1.3%) had a muscle biopsy where one horse out of two was tested positive for PSSM2-MFM (50%). All horses included in this survey have either tested negative for PSSM1 with 109 out of 182 horses (59.9%) or have not been tested for PSSM1 in 73 horses (40.1%).

The assessment of the impact of various feed types on myopathy symptoms revealed notable differences in effectiveness. Grain-free mixed feeds, particularly those based on grasses and/or herbs, or rice bran, were among the most beneficial. Of the horses fed grain-free mixed feed based on other ingredients than rice bran or grass and/or herbs, 48 out of 73 horses (65.8%) showed strong improvement. Similarly, grain-free mixed feed based on rice bran and grain-free mixed feed based on grasses and/or herbs, also demonstrated benefits, with 23 out of 44 horses (52.3%) for based on rice bran and 46 out of 104 horses (44.2%) based on grasses and/or herbs.

Certain feeds were associated with worsening symptoms. Barley performed worst, 19 out of 25 horses (76%) fed, experienced deterioration. Feeding of oats resulted in 35 out of 72

horses (48.6%) showing deterioration. Lucerne had similarly negative effects, as 46 out of 68 (67.6%) of the horses experiencing worsening symptoms. Among horses fed maize, 18 out of 29 horses (62.1%) experienced worsening symptoms. These findings suggest that grain-free mixed feeds, especially those based on grasses, herbs, or rice bran, are the most effective for alleviating myopathy symptoms, while feeds like oats, lucerne, barley, and maize should be approached with caution due to their association with symptom deterioration.

Supplementary feeds showed varied impacts on managing myopathy symptoms in horses. Amino acids such as lysine, methionine, and threonine were particularly effective. Ninety-five out of 148 horses (64.2%) showed strong improvement when supplemented with lysine. Threonine supplementation resulted in 89 out of 142 horses (62.7%) with strong improvement. Similarly, when methionine was provided, 88 out of 144 horses (61.1%) experienced strong improvement. Other amino acids (excluding lysine, methionine, threonine, and tryptophan) also demonstrated strong effectiveness, with 69 out of 117 horses (59%) experienced strong improvement. Mineral supplementation had varying results. Seventy-seven out of 146 horses (52.7%) supplemented with Manganese, showed strong improvement but with supplementation of Calcium, 15 out of 57 horses (26.3%) showed a worsening of the symptoms. Supplemented with Vitamin E, 62 out of 131 horses (47.3%), showed strong improvement. Different protein sources could also contribute to an improvement. Forty-one out of 84 horses (48.8%) supplemented with hemp protein showed strong improvement. When supplementing with rice protein, 21 out of 55 horses (36.8%) showed strong improvement and similarly, 32 out of 88 horses (36.4%) exhibited strong improvement when fed with soy protein. In summary, amino acids such as lysine, methionine, and threonine, along with the mineral manganese, were among the most effective supplements for improving myopathy symptoms in horses. Conversely, calcium had higher rates of worsening symptoms, highlighting the need for careful selection of supplements. The effectiveness of additional additives for myopathy varied widely. Palmitoylethanolamide seems to be the most promising additional supplement caused, as it causes in 14 out of 37 horses (37.8%) strong improvement. Subjective effects of individual feedstuff on myopathy symptoms are summarized in figure 2.

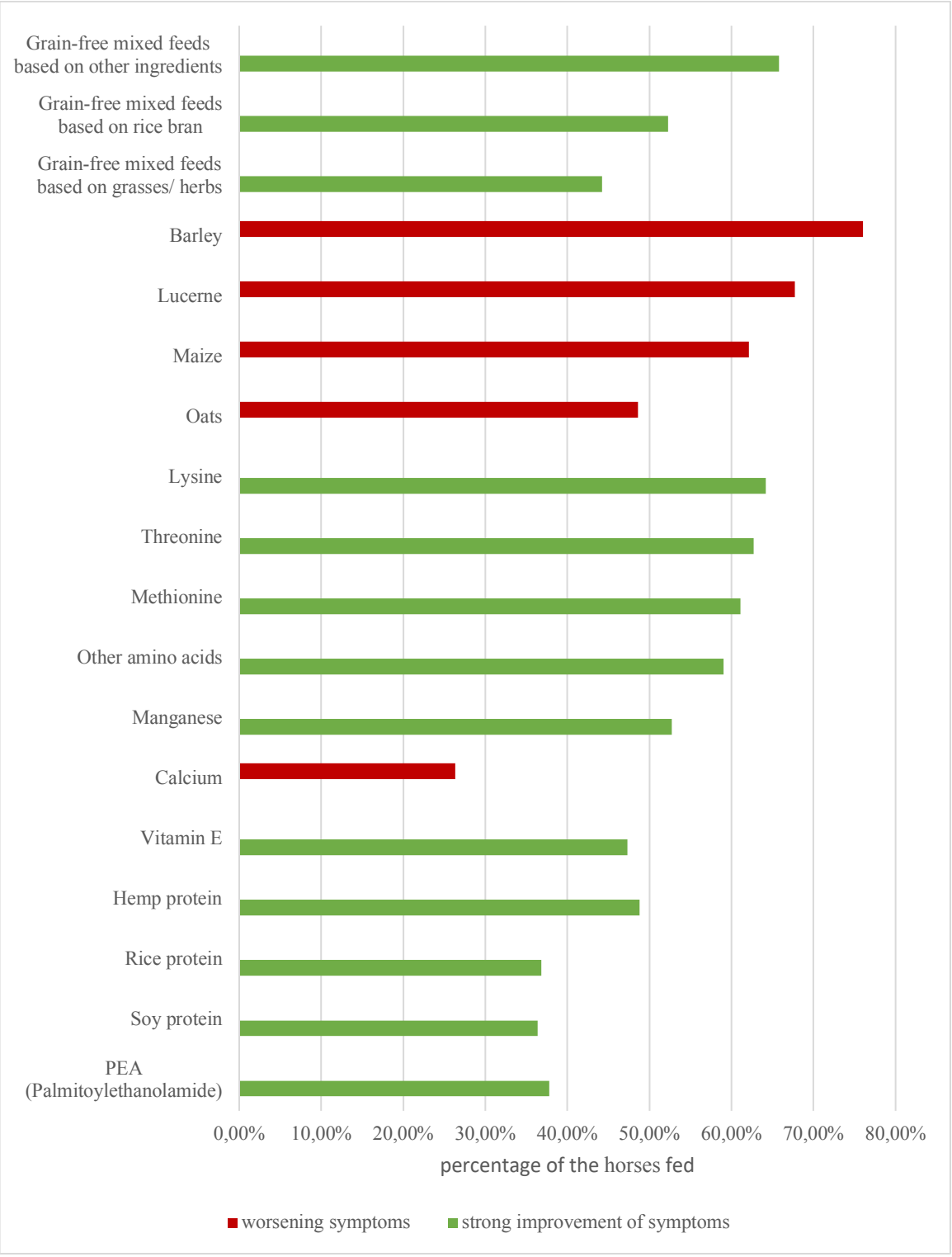


**Figure 2:** subjective percentage horses improved (green) or worsened (red) when fed different feedstuff.

When asked whether the feeding was coordinated according to a hay analysis only 50 out of 182 owners (27.5%) answered with "yes". Even though it can be challenging, and as a customer in a riding center with full boarding, one often has little control over hay quality

and/or hay from varying locations is fed, it would certainly make sense to adjust the supplementation of proteins and minerals based on the results of a hay analysis.

In conclusion, this is the first study investigating feeding strategies in a larger group of horses suspected to suffer from chronic myopathies to the author's knowledge. Statistical analysis is restricted to descriptive calculation and therefore do not enable definitive recommendations for feeding strategies in this particular population. This study however brings interesting insights on the owners' disease perception and strategies they elect for diagnosis and treatment.

## Summary

Chronic exertional myopathies are performance-limiting diseases described in many breeds worldwide. Common examples include recurrent exertional rhabdomyolysis in Thoroughbred horses and Polysaccharide Storage Myopathy Type 1 in Quarter Horses and draught horses. Warmbloods presenting with chronic myopathy symptoms are often diagnosed with myofibrillar myopathy (PSSM2/MFM), a subset of the polysaccharide storage myopathy type 2. Research has focused in the last years on genetic testing, and on proteomics to better characterize pathophysiologic events on a cellular basis. A deeper understanding of different pathways enabled to develop new feeding strategies to treat PSSM2/MFM affected horses. Feeding recommendation for this disease may be biased by the fact that some researcher on that topic have connections to feed-industry partners, rendering independent studies difficult. The aim of this study was therefore to gain insights of owners' perceptions of PSSM2/MFM symptoms in a larger group of Warmblood horses, to describe feeding strategies they elect to manage their horses, and describe the effect they perceive the feeding regiment has on their horses. Horse owners of a Facebook group containing around 14500 members were contacted and asked to fill an online questionnaire using an internet-based survey provider (www.survio.com). A total of 182 owners of Warmblood horses filled the questionnaire and were selected for further analysis.

A total of 182 Warmblood horses were included in the studies (107 geldings 58.8%, 74 mares 40.7%, and one stallion 0.5%). The percentage of horses subjectively judged as improved or free of abnormalities according to different category of symptoms was: stiffness and muscle hardening in the back 108/156 (69.2%), exercise intolerance and reluctance to move 87/143 (60.8%), sensitivity to touch in the back muscles 110/120 (91.7%), blocking and refusal to move 84/120 (70%), lameness without orthopedic findings 60/88 (68.2%), muscle atrophy 39/70 (55.7%), and bucking behavior 48/66 (72.7%). When evaluating dietary changes separately, owners perceived symptoms improvements with 13 different feedstuffs: grain-free mixed feed based on other ingredients than rice bran or grass and/or herbs 48/73 horses (65.8%), grain-free mixed feed based on rice bran 23/44 (52.3%), grain-free mixed feed based on grasses and/or herbs 46/104 (44.2%), lysine 95/148 (64.2%), threonine 89/142 (62.7%), methionine 88/144 (61.1%), other amino acids 69/117 (59%), manganese 77/146 (52.7%), vitamin E 62/131 (47.3%), hemp protein 41/48 (48.8%), rice protein 21/55 (36.8%), soy protein 31/88 (36.4%), PEA 14/37 (37.8%) and symptoms

worsening in 5 feedstuffs: barley 19/25 (76%), lucerne 46/68 (67.6%), maize 18/29, (62.1%), oats 35/72 (48.6), and calcium 15/57 (26.3%).

Owners seem to show a strong interest in supporting their horses through targeted feeding and appear to strongly believe that nutrition significantly influences their horses' symptoms. Independent research projects are needed to investigate the specific effects and dosages of individual feed products in relation to PSSM2/MFM.

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