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Owner-Reported Clinical Signs and Management-Related Factors in Horses Radiographed for Intestinal Sand Accumulation

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ABSTRACT

Clinical problems related to intestinal sand accumulation in horses are common in certain geographic areas, but the clinical signs appear nonspecific and the course of the accumulation remains somewhat obscure. This study examined the association between the presence and size of intestinal sand accumulations and owner-reported clinical signs, management, and feeding practices, as well as behavioral patterns in horses with radiographic diagnosis of sand accumulation. Owners of the horses filled in an online questionnaire. A total of 447 responses met the inclusion criteria. The size of the sand accumulation detected in the radiographs was not significantly associated with the age, body condition score, sex, or use of the horses. Horses reported to have expressed colic had significantly larger sand accumulations than those without this sign, and a similar association was detected in horses with poor performance. The highest odds ratio for sand accumulation was for the combination of colic and poor performance, followed by colic combined with diarrhea/loose feces or hyperesthesia to touch of the abdominal wall. Larger sand accumulations were detected in greedy horses that eat all their roughage, whereas dominant position in group hierarchy was associated with less sand. The possibility of abdominal sand accumulation should be considered as one of the differentials in horses with multiple owner-reported clinical signs such as colic, poor performance, diarrhea, and hyperesthesia to touch of the abdomen.

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1. Introduction

In certain geographic areas, sand accumulation of the gastrointestinal (GI) tract is a relatively frequent phenomenon in horses and can be a reason for various clinical signs such as colic, diarrhea,

Animal welfare/Ethical statement: Data were collected as a questionnaire to horse owners. Owners have voluntarily and anonymously given the information of their horses' problems and managerial factors for research purposes. Current national legislation does not demand the ethical statement in this kind of study, but in case the editor feels the study should have it, we can send the study to the Ethical Committee of University of Helsinki; Viikki Campus.

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poor performance, and weight loss [1–9]. The condition has been known for more than 100 years [8], but the course of the accumulation remains to be elucidated. Unintentional sand intake may occur when horses eat their grain directly from the ground, retrieve grain dropped onto a sandy surface [10], eat hay mixed with sand, or graze on an insufficient pasture [11]. The reasons for intentional sand intake or geophagia in horses are unclear, although such explanations as mineral or salt deficiency [12,13] or not getting enough roughage [14] have been proposed.

Sand in the GI tract causes mucosal irritation, potentially leading to mechanical obstruction or motility disorder [8,13,15]. However, the aforementioned nonspecific clinical signs alone are not unambiguously indicative of the diagnosis of sand accumulation, and examinations such as abdominal auscultation, rectal examination, and fecal sedimentation test are also poorly associated with the presence of sand [2,16,17]. Ultrasonography has been demonstrated to be reliable in revealing large and ventrally located accumulations [18], but radiographic examination is currently the most reliable and commonly used diagnostic method for sand

Table 1

Response options of the questionnaire and frequency of the responses filled out by owners.

Question	Response options	N	%
Breed	Finnhorse *(#)	213	47
	Warmblood	85	19
	Pony	59	13
	Icelandic horse	38	9
	Standardbred	19	4
	Other cold-blooded breed	19	4
	Other than these	10	2
Sex	Arabian or Thoroughbred	4	1
	Gelding	212	47
	Mare	210	47
Body condition score ^a	Stallion	25	6
	3 - 8/9, median 5	447	100
	Age of the horse	447	100
Use of the horse	3 mo - 30 y, mean 9.5 ± 5.2 y	447	100
	Pleasure riding	295	66
	Competition	78	18
	Riding school	14	3
	Breeding	10	2
	Foals and yearlings	32	7
	Resting	9	2
	Other	9	2
Season when radiographed	Autumn	209	47
	Winter	135	30
	Spring	65	15
	Summer	38	8
Presence and size of sand accumulation	No sand	89	20
	Mild	79	18
	Moderate	130	29
	Large	149	33
Reason for abdominal radiography ^b	Recommendation of veterinarian	195	44
	Owner's suspicion of sand	262	59
	Owner has seen horse eating sand	69	16
Clinical signs observed by owners	Diarrhea ^c	241	53
	Colic *(#)	164	37
	Hyperesthesia poor performance *(#)	166	37
	Miscellaneous gastrointestinal signs	174	39
	Not known/no signs reported	80	18
Housing of horse	Other: 13 different signs, total 66 times	29	6
	Stable	368	82
	Walk in walk out	75	17
	Other/not described	4	1
Access to paddock or field	Lives in walk-in/walk-out stable, i.e., free access	63	14
	Every day	383	86
	5 d per week	0	0
	2–4 d per week	1	0
	Once per week or less frequently	0	0
Grouping of horse in the paddock	No	151	34
	Yes, with one horse	172	38
	Yes, with many horses	124	28
Position of horse in group hierarchy	Dominant *(§)	120	27
	Neutral	122	27
	Subordinate	78	17
	Horse is not grouped	127	29
	Salt lick	Yes	280
Feeding management in the paddock	Yes, but does not use it	89	20
	No, but salt is added to food	68	15
	No salt lick or added salt	8	2
	Not known	2	0
	Feeding directly from ground	190	43
Eating behavior	Feeding from trough	158	35
	Use of feeding net	56	12
	Feeding from mats	16	4
	No feeding outdoors	27	6
	Does not eat all of the roughage	22	5
Stereotypic behavior	Does not eat roughage mixed with soil	156	35
	Always eats all of the roughage *(#)	265	60
	Not known/not reported	4	1
Stereotypic behavior	Oral	66	15
	Weaving	5	1

Table 1 (continued)

Question	Response options	N	%
	Other	10	2
	Not present	359	81
	Not known/not reported	7	1

The traits that were significantly ($P < .05$) associated with the size of the sand accumulation are indicated with an asterisk * and further defined by # (significantly larger) and § (significantly smaller sand accumulation). The total number of responses was 447.

^a Scoring of body condition with Henneke et al. method [21].

^b It was possible to select several options.

^c Diarrhea includes loose feces and feces with water.

accumulation [2–4,7,17,19,20]. The quantity of sand needed to affect the health of the horse is not well defined, although one study noted a considerably larger area of sand in the radiographs of horses with GI signs (median length and height 26.5 × 9.0 cm) than in asymptomatic horses (8.3 × 0.9 cm) [19]. Size of sand grain may affect the radiographic opacity, with coarse sand being more opaque than fine sand [17,18]. In our article, sand therefore refers to any geosediment type of mineral opacity in the radiograph.

The aim of this survey was to assess the association between owner-reported clinical signs in horses and the presence and size of intestinal sand accumulations detected in abdominal radiographs based on owner recollection. The relation of selected management practices and behavior of horses to intestinal sand accumulation was also evaluated.

2. Materials and Methods

2.1. Survey Design and Distribution

Horse owners in Finland were approached using a web-based questionnaire. The link to the survey was distributed in horse shows, via social media online, and in the web pages of a nationwide equine magazine. Owners were asked to answer the questionnaire if their horse's abdomen had been radiographed to detect intestinal sand accumulation. Radiographs had been taken at equine clinics around Finland, and the accumulation size reported by the owner in the survey was expected to be based on the veterinarian's assessment. As Finland is one of the countries with a high prevalence of sand accumulations in horses, veterinarians at equine clinics are familiar with performing radiography of the cranioventral abdomen [2,4]. There were no limitations on horses' age, breed, or use. The survey was made accessible for respondents for 15 months, between September 2015 and November 2016. Responses were given anonymously.

The web-based survey consisted of 55 questions. Part of the data was used only for a pregraduate thesis and was not relevant in this study. Here, we include 17 questions with a multiple choice format (Table 1). In addition to preset choices, some questions had an additional category "Other", where respondents could provide another answer or additional information in an open answer section. Some questions had also the option "Not known", which was processed as missing data in the statistical analysis.

Respondents were asked to recall their horse's clinical signs and management before or at the time of the radiographic confirmation of the sand accumulation and to choose the most suitable alternative from the response options provided. Year and season of the radiography were asked; seasons were defined as spring (March–May), summer (June–August), autumn (September–November), and winter (December–February).

The questions covered signalment, size of the sand accumulation (if present), reason for abdominal radiography, clinical signs

Table 2
Owner-reported clinical signs categorized by the size of sand accumulation.

Clinical sign (no. of horses)	No sand (89)	Mild (79)	Moderate (130)	Large (149)	Total (447)
Diarrhea	41	39	75	86	241
Colic ^a	26	23	39	76	164
Hyperesthesia	33	30	41	62	166
Miscellaneous gastrointestinal signs	7	13	29	31	80
Poor performance ^a	23	25	55	71	174
No signs reported	8	8	5	8	29

One horse may have multiple signs.

^a Clinical signs with statistical significance ($P < .05$).

observed by owners, housing and feeding management, and the horse's behavior (Table 1). The respondents were asked to recall the size of their horse's sand accumulation reported by the treating veterinarian, and grade it into one of the following categories: no sand, small accumulation, moderate accumulation, and large accumulation. A modified version of the grading by Korolainen and Ruohoniemi [18] was given as a guideline: no sand, small: less than 5×15 cm, moderate: 5×15 – 10×20 cm, large: more than 10×20 cm. An option of "Sand was present, but the quantity is not known" was also included.

Exclusion criteria were as follows: 1) abdominal radiography had been taken in 2009 or earlier and 2) the size of the sand accumulation was not reported by the respondent.

2.2. Statistical Analysis

Descriptive statistics were calculated (SPSS analytical program for Windows, version 24; SPSS GmbH, Munich, Germany). Categorical data are presented as percentages. Age of the horses is presented as mean \pm standard deviation of the mean, minimum, and maximum. Data of the body score of the horses are presented as median (minimum–maximum). Differences in the amount of sand between the bands of the categorical variables were tested with the Mann–Whitney U test or the Kruskal–Wallis test. Associations of the ordinal scale variables with the size of the sand accumulation were tested using Spearman's rank correlation with Bonferroni correction.

The effect of the four preselected clinical signs, namely diarrhea (including loose feces or water with feces), colic (including both single episodes and recurrent colic), decreased performance level, and hyperesthesia to touch of the abdomen, on the grade of the sand accumulation was assessed with cumulative logit-models (SAS System for Windows, version 9.3; SAS Institute Inc, Cary, NC). In addition to assessing the effects of the individual signs, the effects of the two-way combinations of the signs were analyzed. The cumulative logit-models included the sign or combination of signs as the sole fixed effect. The effects were quantified with odds

Table 3
Associations of owner-reported symptoms and their combinations with increasing size of sand accumulation.

Clinical sign	OR	Lower 95% CI	Upper 95% CI	P
Diarrhea	1.39	0.99	1.94	.058
Colic	2.03	1.42	2.91	<.001
Poor performance	1.89	1.33	2.68	<.001
Hyperesthesia	1.13	0.80	1.60	.49
Diarrhea and colic	2.64	1.69	4.13	<.001
Diarrhea and poor performance	2.12	1.42	3.44	<.001
Poor performance and colic	4.54	2.54	8.13	<.001
Colic and hyperesthesia	2.69	1.55	4.66	<.001
Diarrhea and hyperesthesia	1.29	0.86	1.92	.22

ratios (ORs) and their 95% confidence intervals. In all tests, P -values $< .05$ were considered statistically significant.

3. Results

The questionnaire was filled out 486 times (presumably corresponding to 486 horses, as we cannot assure that each filled out questionnaire related to a different horse); 447 questionnaires were accepted and 39 excluded for the reasons outlined earlier.

The detailed results are presented in Table 1. Size of the sand accumulation was not significantly associated with age, body condition score, sex, or use of the horse. Finnhorse was the most common breed and had significantly larger sand accumulations than the other breeds ($P < .001$). No significant differences could be detected between the other breeds in the size of the sand accumulation. Almost half of the horses had been radiographed for sand accumulation during the autumn months (September to November), but there was no significant association between season and size of sand accumulation.

3.1. Reason for Abdominal Radiography and Clinical Signs of the Horses

In 70 cases (16%), the respondent had chosen more than one reason for abdominal radiography. Owner's suspicion was more common than veterinarian's recommendation in the responses, but no significant differences could be detected in the size of sand accumulations between the reasons. No sand was detected in 14 (20%) of the 69 horses seen to eat sand, whereas 16 (23%) of them had small, 21 (30%) moderate, and 18 (26%) large sand accumulations.

The associations between the clinical signs observed by horse owners and the size of sand accumulations are presented in Table 2. More than half of the horses (294/447, 66%) expressed more than one sign. Horses reported to have expressed colic had significantly larger sand accumulations than those without this sign, and a similar association was detected in horses with poor performance. The highest OR for sand accumulation was for the combination of colic and poor performance, followed by colic combined with diarrhea or hyperesthesia to touch of the abdominal wall (Table 3).

In addition to the most common signs listed in Table 2, the following ones were mentioned more than two times in the open section: irritated or angry behavior (11), difficult urinating or stretching stance (8), bloated abdomen (8), poor hair coat (7), sensitivity to saddle girth (7), weight loss (6), kicking with hind limbs (4), bucking (4), swelling (3), teeth grinding (3), increased intestinal sounds (3), and skittish behavior (3). Moreover, in 13 cases reluctance to move was mentioned; these 13 answers were included in the poor performance category of Table 2. Finally, four owners reported gastric ulcers in the open section; two of these horses had no sand and two mild sand accumulation.

Table 4
Roughage eating behavior of the horses categorized by size of sand accumulation.

Question	No sand	Mild	Moderate	Large	Total
Does not eat all of the roughage	9	3	5	5	22
Does not eat roughage that is mixed with soil	36	37	45	38	156
Always eats all of the roughage	44	38	80	103	265
Total	89	78	130	146	443

Data missing for four horses.

3.2. Management of the Horses

The details of management including housing and feeding of the horses are presented in Table 1. No significant differences could be detected in the size of the sand accumulation between housing or feeding practices. Access to salt or salt lick was not associated with sand accumulation.

3.3. Behavior of the Horses

The size of sand accumulations correlated positively with how much roughage the horse consumed (Table 4, Spearman $\rho = 0.18$, $P < .001$). Furthermore, the position in the hierarchy correlated negatively with the size of sand accumulations (Table 5, Spearman $\rho = -0.17$, $P = .02$). No difference was detected in the size of sand accumulation between horses with and without reported stereotypical behaviors.

4. Discussion

During the past two decades there has been increased awareness of problems caused by intestinal sand accumulations in our country, which was evident also in the high number of respondents in this study. In addition, the small number of unanswered questions shows that the respondents had answered the questionnaire in earnest. The contribution of owners is important in research on the topic of course of sand accumulations, as the condition has been related to factors under the control of owners such as housing, feeding, and management of the horse [8,13,22].

4.1. Clinical Signs

The owners most frequently reported diarrhea in their horses, in contrast to the study of Kaikkonen et al. in which colic was reported as the most common complaint for radiographic examination of the abdomen [6]. In our study, diarrhea was a more common sign than colic also in the group of horses with large sand accumulations. However, diarrhea alone was not significantly associated with the size of sand accumulation. The ORs for individual signs revealed that only poor performance and colic were associated with large sand accumulations by themselves. However, most of the horses expressed multiple clinical signs, and, for example, the combination of diarrhea and hyperesthesia of the abdomen significantly

Table 5
Position in group hierarchy of horses with intestinal sand accumulation, categorized by size of sand accumulation.

Question	No sand	Mild	Moderate	Large	Total
Dominant	40	19	31	30	120
Neutral	16	18	42	46	122
Subordinate	12	14	24	28	78
Not grouped in paddock	21	28	33	45	127
Total	89	79	130	149	447

increased the likelihood of having a large sand accumulation. In general, the signs described by the owners in this study were largely similar to those reported by Kaikkonen et al. [6]. In their study, all horses had a moderate to large amount ($>75 \text{ cm}^2$) of sand in the large colon, which might have increased the likelihood of expressing colic over solely changes in feces [6]. In our study, colic may have been under-represented, if a high number of horses had responded to initial treatment in field conditions and had not been admitted to an equine clinic for radiography. Our study design did not allow evaluating the temporal sequence of the signs that have previously been suggested to occur [8,9]. Already a century ago, McIntyre described the first signs of sand accumulation as being a decline in general condition and attacks of diarrhea that worsened after exercise, before actually having colic due to a larger accumulation, which is in line with the present findings [8]. Conversely, when studying poor performance, sand accumulation has not been shown to be causative [23–25], but some cases in these reports went undiagnosed [23,24]. In our study, weight loss was an uncommon finding, whereas other nonspecific signs, such as poor hair coat and mild abdominal pain or hyperesthesia, were more common. Interestingly, some owners did not report any symptoms even in horses with large sand accumulations. Therefore, based on our results, it is impossible to determine the amount of sand that would produce specific symptoms.

4.2. Season

Problems associated with large colon sand accumulation seemed to intensify during autumn and early winter because most of the horses were then examined both in our study and in a previous retrospective study [6]. Pasture season in Finland is limited to a few months during summer, but nearly all horses go out daily to paddocks during the rest of the year, and thus readily have access to sand. Seasonal variation in horse management in Finland may therefore predispose horses to sand accumulations compared with other countries. However, no difference was detected in the size of the accumulations compared with horses examined in other seasons. The time lag between gaining a sand accumulation and showing clinical signs is unknown, and may depend on a horse's pain tolerance [26]. The beginning of winter and freezing of the ground varies from year to year in Finland, and sometimes horses' access to sand only ends in January. Along with variation in spontaneous clearance of sand accumulation [27,28], this could explain why sand accumulations can also be detected during winter months, although the problem is supposed to diminish when the horses are expected to have no access to sand. Autumn and winter time might also have other predisposing factors for colic such as dry hay instead of grass, colder water, and more hours inside.

4.3. Behavior and Management

Our results suggest that some behavioral characteristics can be linked to intestinal sand accumulation. Greedy horses that eat all their roughage had larger sand accumulations. Less than half of all horses had their feed straight off the ground, but, in any case, way

of feeding was not directly linked to sand accumulation. We did, however, demonstrate that dominant behavior was associated with smaller sand accumulation. This might be due to dominant horses getting the best or the uppermost hay. For example, an Icelandic study [29] demonstrated that dominant horses eat more hay, whereas subordinates eat more winter grass, and thus, lose weight during winter. Already at the beginning of the 20th century, McIntyre recommended observing horses' feeding and behavioral habits and tying dominant horses when horses were fed together to prevent sand accumulations [8].

The native breed Finnhorse is a very common breed in Finland, and in our study it was both over-represented and exhibited larger sand accumulations than other breeds. The Finnhorse as a cold-blooded breed is often considered stoic and may show pain less readily than more extrovert breeds [26], and is therefore often diagnosed with larger accumulations of sand than other breeds [30]. The Finnhorse is considered a very greedy and precise eater, and thus might be predisposed to accidental soil eating.

No major management issues were associated with intestinal sand accumulation, although some owners may have followed earlier recommendations of geophagia prevention, for example, not feeding from the ground [10,13]. McIntyre suggested that some horses exhibit geophagia to get salt from the ground, which might be prevented by addition of salt [8], but we found no relationship between salt lick and sand accumulation.

4.4. Mechanism of Sand Accumulation

It remains unclear why some horses had no sand accumulation despite being observed to eat sand. The mechanisms of accumulation are obscure, but when accumulation occurs, the weight of the sand might hinder the physiological movements of the colon. Korolainen et al. demonstrated with ultrasonography that colon motility improved when the accumulation was removed [18]. One theory to explain the original accumulation might be an initial decline of intestinal motility. It has, for example, been shown that horses with large colon impaction had less pacemakers in pelvic flexure than healthy horses [31]. Horses with sand colic often present with colon impaction [12,32–34]; both of these conditions can be related to insufficient intestinal motility. Furthermore, the response to treatment varies between individuals and is not always associated with the size of the sand accumulation [27]. Therefore, individual variation in gut motility and associated physiology may affect the accumulation of sand and the rate of its removal.

4.5. Limitations of the Study

This retrospective questionnaire study selected cases that had already been radiographed, indicating that the owner was concerned about the horse's welfare, and moreover, there was always some indication to suspect sand accumulation. Although the size of the accumulation had been assessed by the treating veterinarian at the site of radiography, some owners may have reported it incorrectly, especially the ones who were filling the questionnaire several years after the accumulation. However, we enquired about the grade along with the exact size, and assume that the vast majority of the owners were able to recall the grade satisfactorily. As the horses had been examined by a veterinarian, some of the more common diagnoses (such as impaction colic) had probably been ruled out before the radiographic examination. Still we cannot exclude some other undetected reason for the clinical signs. These limitations make the study population biased. Nevertheless, the results show that sand accumulation is a differential diagnosis when a horse exhibits clinical signs or their combinations as discussed. It is possible that the questionnaire did not reveal clinical

signs that were not on the given list, although many owners added written details. Were the study to be repeated, the signs mentioned most often in the open answer section should be inserted in the given list of clinical signs.

5. Conclusions

Our study suggests that the possibility of abdominal sand accumulation should be kept in mind as one of the differentials in horses with multiple owner-recognized clinical signs such as colic, poor performance, diarrhea, and hyperesthesia to touch of the abdominal wall. On the other hand, some horses may have large abdominal sand accumulations even if the owners note no evident signs. We could not demonstrate any protective housing factors, but horses' feeding habits and position in the hierarchy were associated with the presence and size of sand accumulations.

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