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Prevalence and risk of orthopedic diagnoses in insured Swedish Warmblood horses

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ABSTRACT

Sweden has a strong tradition of insuring horses for veterinary costs, and orthopedic diagnoses are the most common for insurance claims. The aim of this study was to investigate differences in prevalence and risk of orthopedic diagnoses for Swedish warmblood (SWB) horses classified as jumping (J) or dressage (D) horses. Also, other factors that may influence orthopedic health were investigated, i.e., sex, birth cohort, and participation in young horse tests and competition. The data consisted of 15,619 insured SWB horses born between 2010 and 2020. Horses were classified as J or D horses according to pedigree. The prevalence of orthopedic diagnoses was investigated using logistic regression analysis and presented as Least Squares means. The time from birth to first orthopedic diagnosis was investigated using survival analysis. D horses were at a higher risk of having orthopedic diagnoses compared with J horses (50.9 % vs 43.9 %, $P < 0.0001$). Male horses were at a higher risk than females (49.7 % vs 45.0 %, $P < 0.0001$), and tested horses were at a higher risk than non-tested horses (49.9 % vs 44.9 %, $P < 0.0001$). No significant difference was seen between competed and non-competed horses regarding the risk of having orthopedic diagnoses, but the groups were predisposed to different subgroups of orthopedic diagnoses. Survival analysis showed that later cohorts were more likely to have insurance claims for orthopedic diagnoses at a younger age than earlier cohorts. In conclusion, insurance data can be a useful tool to study which factors influence the orthopedic health status of the SWB horse population.

1. Introduction

Sweden has a strong tradition of insuring animals, more than 70 % of horses and companion animals are insured (Dagens Industri, 2024). The very high proportion of insured animals is unique compared with other European countries (Swedish Competition Authority, 2021). Insurance databases are considered secondary databases when it comes to investigating health and longevity, meaning that data are primarily registered for reasons other than research (Sørensen et al., 1996). The leading insurance company for horses in Sweden is Agria (Agria Insurance, P.O. 70306, SE-107 23 Stockholm, Sweden). Their database contains a considerable amount of information on diagnoses, dates of treatment, and reasons for euthanasia. The database of Agria has previously been used for research when investigating the prevalence of disease and death in the Swedish horse population. Egenvall et al. (2006) investigated the mortality of Swedish horses with complete life insurance by Agria between 1997 and 2000. Similar studies, investigating the morbidity of Swedish horses insured for veterinary care by Agria between 1997 and 2000, have been performed by Egenvall et al. (2005) and Penell et al. (2005). In these studies, variations according to sex, age, breed, location and diagnosis were considered. However, these studies were performed more than 20 years ago, and the SWB horse population has undergone major changes since then.

The SWB horse population has become more specialized towards show jumping and dressage in the last decades (Bonow et al., 2023). More than 80 % of the SWB horses born from 1980 to 1985 were all-round horses, whereas horses born from 2016 to 2020 were mainly jumping (J) horses (58 %) or dressage (D) horses (34 %). Due to differences in usage, conformation, movement and/or temperament between J and D horses, a difference in prevalence and type of injuries between these groups may be expected. Orthopedic diagnoses are by far the most common health problem for riding horses (Egenvall et al., 2013; Murray et al., 2010; Wallin et al., 2000), but whether there is a difference between J and D SWB horses regarding the risk of orthopedic diagnoses has not been investigated before.

Other factors may also influence orthopedic health, e.g., if the horse has been tested at a young horse test or competed. In Sweden, two young horse performance tests are held annually throughout the country,

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where approximately 30 % of the SWB horses are assessed by judges: the Young Horse Test (YHT) and the Riding Horse Test (RHT) (Bonow et al., 2023). These tests are open for participation for all registered SWB horses. However, some pre-selection may occur because owners are probably more likely to have their horse assessed if it has a talent for jumping or dressage and has no severe abnormalities of conformation. There is also most likely a pre-selection based on talent before the horse enters a competition. About 40 % of SWB horses participate in competitions, with a higher proportion of J horses (50 %) than D horses (28 %) (Bonow et al., 2023). Of course, for participation in both young horse tests and competition, the horse also needs to be healthy without any lameness. There are no previous studies of the association between orthopedic diagnoses and the all-or-none traits 'test status' and 'competition status', which are defined as whether or not a horse participated in young horse tests or competitions, respectively.

In this study, we aimed to describe the prevalence, risk, and type of orthopedic disease in the population of SWB horses insured by Agria, and to investigate the effects of sex, discipline category (J or D horses), test status, competition status, and birth cohort. The time from birth to the first orthopedic diagnosis for these groups of horses was analyzed by survival analysis.

2. Materials and methods

2.1. Data

Pedigree information was provided by the Swedish Warmblood Association. Results from young horse tests (YHT and RHT) conducted between 2013 and 2023, as well as competition records for all horses in official competitions from 2014 to October 2023, were also obtained from the Swedish Warmblood Association. SWB horses can compete from four years of age, thus horses born in 2020 and later had no competition records registered at the time of this study. Insurance data was provided by the insurance company Agria and included all insurance claims from April 2010 to January 2024 for insured horses classified as SWB and born from 2010 to 2021. The initial data included 52,446 insurance numbers with the name of the horse, birth year, and identification (ID) numbers connected to the horse, i.e., SWB ID number, chip number, foreign ID number, or international Universal Equine Life Number (UELN) (Universal Equine Life Number., 2025). Horses could have several insurance numbers. For example, a horse receives a new number when changing owner or when the owner changes the type of insurance. The insurance data also included 78,825 unique insurance claim records (ICR) and 2840 different diagnosis codes.

The insurance numbers, with corresponding ICR, were matched to horses in the SWB database by the information connected to the horse (i.e., SWB ID number, chip number, foreign ID number, or international UELN number). In addition, 3453 horses without such information in the insurance data could be manually matched by name and birth year (e.g., if they had a unique name within their birth year). Horses born in 2021 were excluded because they had not had the opportunity to participate in a young horse test yet. Horses sired by an unlicensed stallion were also removed because these stallions were difficult to classify into a discipline. A data set consisting of 15,619 unique horses registered in SWB and insured in Agria, with a total of 53,168 insurance claims, remained after the data editing.

All horses were divided into discipline categories according to their sire and grandsire classification, as described by Bonow et al. (2023). Sires and grandsires were assigned to one of four categories (jumping (J), dressage (D), allround (AR), or Thoroughbred (Th)) according to breeding values, own performance, and offspring performance. Around 58 % of the insured horses belonged to the J category, 34 % to the D category and 8.6 % to the AR or Th category (Table 1). This distribution corresponds well with the same age group in the study of the SWB horse population by Bonow et al. (2023), indicating that the insurance data are representative of the population. The present study mainly considers horses in the J and D categories (N = 14,274 horses).

Table 1
Number of Swedish warmblood horses (SWB) insured by Agria, number of horses in the jumping (J), dressage (D), or allround/thoroughbred (AR/Th) category.

SWB insured by Agria				
Birth year	No of horses	No of J horses	No of D horses	No of AR/Th horses
2010	1662	941	551	170
2011	1627	914	515	198
2012	1428	777	485	166
2013	1247	727	395	125
2014	1193	694	384	115
2015	1292	764	412	116
2016	1440	847	495	98
2017	1472	883	489	101
2018	1513	871	532	110
2019	1493	881	529	83
2020	1252	736	453	63
Total	**15,619**	**9034**	**5240**	**1345**

There are two main types of insurance for horses offered by Agria: veterinary care and life insurance (Egenvall et al., 2008). Veterinary care insurance reimburses the owner for most of the costs of veterinary care, whereas life insurance reimburses the owner if the horse is euthanized or accidentally dies. Almost all horses are insured for both types. The diagnostic registry used has, in some cases, several codes for similar injuries. For example, 'serous osteoarthritis in the fetlock joint' (code: LG411) is similar to 'acute inflammatory conditions in fetlock joint' (code: LG41). These similar diagnoses were merged when investigating the most common diagnoses for veterinary care and life reimbursement.

2.2. Orthopedic disease data from insurance claims

From the insurance data, all diagnoses connected to the locomotor system (LOC) were considered. In total, there were 915 such diagnoses. These diagnoses were divided into eight subgroups, according to type and location of the injury (Table 2). The classification was performed by one of the authors, who is a clinical veterinarian and researcher specializing in the locomotor system. All LOC diagnoses were categorized into only one of the subgroups, even though some diagnoses could belong to more than one subgroup. In these cases, the diagnosis was categorized into the most obvious subgroup. Horses with a diagnosis connected to LOC were categorized according to the eight subgroups,

Table 2
Subgroups of locomotor system (LOC) diagnoses, their abbreviation, number of LOC diagnoses, and number of claims connected to LOC diagnoses for all horses (N = 15,619).

Group of LOC diagnoses	Abbreviation	No of diagnoses	No of claims
Orthopedic disease of the extremities (not acute trauma)	EXT	413	19,363
Orthopedic disease of the axial skeleton (not acute trauma)	AXI	76	4448
Osteochondrosis/ osteochondrosis dissecans	OCD	46	933
Developmental disease in limbs or hooves (other than OCD)	DEV	88	781
Traumatic orthopedic disease	TRA	213	2517
Neurologic disease	NEU	6	338
Laminitis	LAM	12	289
Infectious disease in joints or skeleton	INF	61	393
Total		915	29,062

but some horses appeared in more than one group because of different injuries sustained during the period of the study.

2.3. Statistical analysis

The proportion of horses (J and D horses, N = 14,274) tested at a young horse test or competed was calculated for each subgroup of horses (i.e., according to sex, discipline category, and test status or competition status). Comparisons of proportions within subgroups were estimated using Chi-Square tests for homogeneity in SAS (SAS., 2016). Stallions and geldings were combined into one sex category of male horses in the analyses, because many owners do not report when their stallion is gelded. However, a large majority of the SWB male horses are gelded.

The prevalence of ICR and LOC diagnoses were considered as a 1/0-trait, i.e., either the horse had at least one claim/diagnosis, or not. It was not possible to distinguish between the number of injuries for an individual, because insurance claims could refer to one specific injury with one or several return visits. To compare the prevalence of ICR and LOC diagnoses between different groups of horses, a multivariate logistic regression was used, i.e., the PROC LOGISTIC statement in SAS, with sex (male or female), birth year, discipline category (J or D), test status (1/0), and competition status (1/0) as class variables. The estimates were presented as Least Squares (LS) means. In these analyses, only J and D horses born between 2010 and 2019 that were old enough to compete were included (N = 13,085 horses).

The first decile and median of the age in years at the first insurance claim regarding a LOC diagnosis was calculated in SAS using the PROC UNIVARIATE statement. Only horses with a LOC diagnosis were included in these analyses.

Survival analysis was used to investigate the risk of having a LOC diagnosis by using the information from 'time to event' (i.e., the number of days from birth to the first LOC diagnosis). Horses without a LOC diagnosis were censored in the analysis, where the last day with available insurance data (30th of January 2024) was used as the censoring date. Horses were also censored if they were omitted from the data before the end date for other reasons, either because the owner had the insurance terminated or because the horse died for a reason other than a LOC diagnosis (without previously having a LOC diagnosis). In these cases, the date of termination of the insurance or death of the horse was used as the censoring date instead. The date of any termination of insurance performed before 2018 was unknown. In these cases, the date 31st of December 2017 was set as the censoring date. Survival curves were constructed using the Kaplan-Meier method, where the cumulative probability of survival is presented (Kaplan and Meier, 1958). This was performed by using the PROC LIFETEST statement in SAS. In this analysis, J and D horses born between 2010 and 2020 were included, except for the analysis of competition status, where J and D horses born 2010–2019 were considered. Survival curves (S(t)) were estimated for sex (male or female), discipline category (J or D), test status (1/0), competition status (1(0), and for three birth cohorts (2010, 2015, and 2020), using the strata statement. The survival curves were transformed into Cumulative Incidence Function (CIF) curves (CIF(t) = 1 – S(t)) to make interpretation easier.

3. Results

3.1. Descriptive statistics of insurance data

Approximately 56 % of the SWB horse population born from 2010 to 2020 was insured by Agria, based on statistics of born foals (Swedish Warmblood Association (SWB (SWB., (2024)). The sex distribution in the data set was even, with 51 % female and 49 % male horses. Out of 14,274 J and D horses in the data set, 5957 (42 %) had been tested at YHT or RHT (Table 3). A total of 6885 horses (53 %) born 2010–2019 had been competing until October 2023, and had at least one record from an official competition in show jumping, dressage, or eventing.

Table 3
Description of Swedish warmblood jumping and dressage horses born 2010–2020 and insured by Agria; number (N) and percent (%) of horses tested at a young horse test, that competed, that had an insurance claim record (ICR), and that had a locomotor (LOC) diagnosis.

Birth year	Tested		Competed		With ICR		With LOC diagnosis	
	N	%	N	%	N	%	N	%
2010	645	43.2	964	64.6	1073	71.9	843	56.5
2011	562	39.3	949	66.4	991	69.4	771	54.0
2012	479	38.0	759	60.1	837	66.3	659	52.2
2013	454	40.5	697	62.1	737	65.7	574	51.2
2014	402	37.3	674	62.5	703	65.2	535	49.6
2015	448	38.1	671	57.1	761	64.7	590	50.2
2016	534	39.8	729	54.3	832	62.0	612	45.6
2017	614	44.8	675	49.2	826	60.3	569	41.5
2018	639	45.6	485	34.6	798	56.9	472	33.6
2019	659	46.7	282	20.0	695	49.3	397	28.2
2020	521	43.8	-	-	473	39.8	232	19.5
Total	**5957**	**41.7**	**6885**	**52.6**	**8726**	**61.1**	**6254**	**43.8**

Approximately 20 % of the four-year-old horses (born in 2019) had been competing, whereas approximately 65 % of the 13-year-old horses (born in 2010) had been competing. Insurance claim records (ICR) had been made for 8726 horses (62 %) until January 2024 and the number of horses with a LOC diagnosis was 6254 (44 %). The proportion of insured horses with ICR increased with age, where approximately 40 % of the horses born in 2020 had an ICR, and approximately 72 % of the horses born in 2010 had an ICR. The same pattern was seen for the proportion of horses with a LOC diagnosis, with a range from 20 % (horses born 2020) to 57 % (horses born 2010) (Table 3).

More female (44.1 %) than male horses (39.3 %) participated in young horse tests ($P < 0.0001$), whereas a higher proportion of male (56.1 %) than female horses (49.3 %) competed ($P < 0.0001$) (Table 4). More D horses (48.3 %) than J horses (38.0 %) had been tested at a young horse test ($P < 0.0001$). On the other hand, a larger proportion of J horses (62.4 %) than D horses (37.5 %) had competed ($P < 0.0001$). Approximately 60 % of the tested horses had also competed, whereas only 47 % of the non-tested horses had competed ($P < 0.0001$).

The ten most common diagnoses for veterinary care in the data were the same for J and D horses, where lameness (unspecified) was the most common, followed by traumatic injuries in the skin (Table 5). Out of 2032 euthanized horses, 1924 had a life insurance (95 %). The most common cause for euthanasia was lameness (unspecified), followed by chronic osteoarthritis in the spinal joints, and ataxia (Table 6). Of the euthanized horses, approximately 50 % belonged to the J category, 40 % to the D category, and 10 % to the AR/Th category.

3.2. Prevalence of ICR and LOC diagnosis

The class variables birth year, sex, discipline category, and test status had a significant effect on the proportion of horses with a LOC diagnosis in the multivariate logistic regression model. The proportion of ICR and diagnoses connected to LOC was higher for male than for female horses ($P < 0.0001$) (Table 7). Diagnoses connected to orthopedic disease of the extremities (EXT), orthopedic disease of the axial skeleton (AXI), osteochondrosis (OCD), and neurologic disease (NEU) were more common for male horses ($P < 0.0001$ to $P < 0.05$), whereas no significant differences were seen for developmental disease in limbs or hooves (DEV), traumatic orthopedic disease (TRA), laminitis (LAM), and infectious disease in joints or skeleton (INF). The proportion of horses with an ICR and those with a LOC diagnosis was significantly higher for D horses than for J horses ($P < 0.0001$). Also, the proportion of horses with a diagnosis connected to EXT, AXI, DEV, TRA, NEU, and LAM was higher for D horses than for J horses ($P < 0.0001$ to $P < 0.01$). Tested horses had a higher proportion of ICR and LOC diagnoses than non-tested horses ($P < 0.0001$). Also, the proportion of horses with a diagnosis connected

Table 4
Distribution of horses across subgroups (sex, discipline category (jumping (J) and dressage (D) horses), test status, and competition status[a]) for all horses insured by Agria, those tested at young horse tests, and those competing, together with level of significance for differences between categories within each subgroup.

		Sex			Discipline category			Test status			Competition status[a]		
Item	All horses	Female	Male	Sign[b]	J	D	Sign[b]	Tested	Non-tested	Sign[b]	Comp	Non-comp	Sign[b]
No of horses	14,274	7309	6965	-	9034	5,24	-	5957	8317	-	6885	6200	-
Percent tested	41.7	44.1	39.3	****	38.0	48.3	****	-	-	-	47.6	34.9	****
Percent competed[a]	52.6	49.3	56.1	****	61.4	37.5	****	60.2	47.2	****	-	-	-

[a] J and D horses born in 2010–2019, N = 13,085. [b] ****P < 0.0001.

Table 5
The 10 most common diagnoses for veterinary care for jumping horses (no of insurance claims=23,481) and dressage horses (no of insurance claims=17,153), respectively [a] [a]metacarpophalangeal and metatarsophalangeal joints.

	Diagnosis in jumping horses	No	Percent	Diagnosis in dressage horses	No	Percent
1	Lameness (unspecified)	2488	10.6	Lameness (unspecified)	1752	10.2
2	Traumatic injuries, skin	1927	8.2	Traumatic injuries, skin	1454	8.5
3	Fetlock[a] joint osteoarthritis	1100	4.7	Colic	753	4.4
4	Stifle joint osteoarthritis	1049	4.5	Stifle joint osteoarthritis	734	4.3
5	Colic	896	3.8	Fetlock[a] joint osteoarthritis	697	4.1
6	Back pain (unspecified)	783	3.3	Back pain (unspecified)	562	3.3
7	Distal interphalangeal joint osteoarthritis	583	2.5	Suspensory desmitis	426	2.5
8	Suspensory desmitis	570	2.4	Distal interphalangeal joint osteoarthritis	410	2.4
9	Hoof abscess	483	2.1	Hoof abscess	360	2.1
10	Osteoarthritis, unspec. joints	337	1.4	Osteoarthritis, unspec. joints	203	1.2

Table 6
The 10 most common diagnoses for euthanasia of 2032 euthanized horses in the insurance data.

	Diagnosis	No of horses	Percent
1	Lameness (unspecified)	190	9.4
2	Chronic osteoarthritis in spinal joints	125	6.2
3	Ataxia	114	5.6
4	Colic	101	5.0
5	Overriding spinous processes (kissing spines)	98	4.8
6	Osteoarthritis, unspecified joints	53	2.6
7	Laminitis	43	2.1
8	Traumatic injuries, skin	42	2.1
9	Suspensory desmitis	32	1.6
10	Chronic osteoarthritis in fetlock[a] joint	30	1.5

[a] metacarpophalangeal and metatarsophalangeal joints

to EXT, AXI, OCD, DEV, and INF was higher for tested horses than for non-tested horses (P < 0.0001 to P < 0.05). When comparing competed and non-competed horses, no significant differences were seen between the groups regarding the proportion of horses with an ICR or LOC diagnosis. However, competed horses had diagnoses connected to the extremities (EXT) or the axial skeleton (AXI) to a higher extent than non-competed horses (P < 0.0001 to P < 0.01). On the other hand, non-competed horses were affected by DEV, TRA, NEU and LAM to a greater extent than competed horses (P < 0.0001 to P < 0.05). Probably some of the non-competed horses were not able to compete as a consequence of these diagnoses.

3.3. *Time to first LOC diagnosis*

The first decile and median age in years at first LOC diagnosis are presented in Table 8, showing higher values for diagnoses connected to EXT, AXI, and LAM than for diagnoses connected to DEV. It should be noted that the values in Table 8 only refer to horses with a diagnosis.

3.4. *Survival analysis of insurance data*

The survival analysis, including all born and insured SWB horses,

Table 7
Least squares means of proportion (in %) of horses[a] with insurance claim records (ICR), locomotor (LOC) diagnosis, and different subgroups of LOC diagnosis for groups of horses according to sex, discipline category (jumping (J) and dressage (D) horses), test status, and competition status together with level of significance for differences between categories within each group. Results are from a multivariate logistic regression model with sex, discipline category, test status, competition status, and birth year as categorical variables.

	Sex			Discipline category			Test status			Competition status		
Item	Female	Male	Sign[b]	J	D	Sign[b]	Tested	Non-tested	Sign[b]	Comp	Non-comp	Sign[b]
ICR	63.3	66.9	****	61.1	68.9	****	67.8	62.3	****	65.0	65.2	n.s
LOC	45.0	49.7	****	43.9	50.9	****	49.9	44.9	****	48.2	46.5	n.s
EXT	34.2	37.9	****	33.6	38.5	****	38.2	33.9	****	38.9	33.3	****
AXI	13.0	14.3	*	12.1	15.3	****	15.1	12.2	****	14.6	12.7	**
OCD	3.8	5.1	***	4.2	4.5	n.s	5.1	3.7	***	4.3	4.4	n.s
DEV	3.0	3.0	n.s	2.6	3.5	**	3.4	2.6	*	2.3	3.9	****
TRA	9.2	9.2	n.s	8.4	10.1	**	9.6	8.8	n.s	8.6	9.8	*
NEU	0.7	1.8	****	0.9	1.4	**	1.1	1.2	n.s	0.6	2.0	****
LAM	0.8	0.6	n.s	0.6	0.9	**	0.6	0.8	n.s	0.5	1.1	****
INF	1.6	1.7	n.s	1.6	1.7	n.s	1.9	1.4	*	1.4	1.8	n.s

EXT: Orthopedic disease of the extremities, AXI: Orthopedic disease of the axial skeleton, OCD: Osteochondrosis, DEV: Developmental disease in limbs or hooves. TRA: Traumatic orthopedic disease, NEU: Neurologic disease, LAM: Laminitis, INF: Infectious disease in joint or skeleton
[a] J and D horses born in 2010–2019 (N = 13,085)
[b] *P < 0.05, **P < 0.01, ***P < 0.001, ****P < 0.0001, n.s = not significant.

Table 8
Age in years at first locomotor (LOC) diagnosis for Swedish warmblood horses with an insurance claim for LOC diagnosis (presented as age at first decile and median), number and percent of horses with insurance claim records for LOC diagnosis and subgroups of LOC diagnoses.

Time to event	1st decile (10 %)	Median	No with LOC	Percent with LOC
Age at first LOC	1.1	4.8	6254	43.8
Age at first EXT	2.7	5.3	4806	33.7
Age at first AXI	4.0	6.2	1862	13.0
Age at first OCD	1.3	2.9	625	4.4
Age at first DEV	0.1	0.3	428	3.0
Age at first TRA	1.0	4.6	1237	8.7
Age at first NEU	1.4	4.1	191	1.3
Age at first LAM	3.2	7.2	147	1.0
Age at first INF	0.3	4.1	212	1.5

EXT: Orthopedic disease of the extremities, AXI: Orthopedic disease of the axial skeleton, OCD: Osteochondrosis, DEV: Developmental disease in limbs or hooves. TRA: Traumatic orthopedic disease, NEU: Neurologic disease, LAM: Laminitis, INF: Infectious disease in joint or skeleton

showed that the probability of having a LOC diagnosis, i.e., being diagnosed with an injury or disease in the locomotor system during the time period, was significantly affected by sex ($P < 0.0001$), discipline category ($P < 0.0001$), test status ($P < 0.0001$), competition status ($P < 0.0001$), and birth cohort ($P < 0.0001$). The risk was higher for male than for female horses, and the difference increased somewhat with age. The risk of having a LOC diagnosis was rather low for both sexes during the first 2.5 years. From approximately 3 years of age, there was a rapid increase in risk for both sexes, where male horses were at a higher risk of having a LOC diagnosis, compared with female horses (Fig. 1). The risk of having a LOC diagnosis was higher for D horses than for J horses (Fig. 2). For tested and non-tested horses, the risk of having a LOC diagnosis was almost the same for both groups during the first 3 years of age (Fig. 3). From then onwards, the risk increased for both groups, where tested horses were at a higher risk compared with non-tested horses. Non-competed horses had a higher risk of having a LOC diagnosis during the first 9 years of age, compared with competed horses (Fig. 4). At approximately 8 years of age, the curve for non-competed horses flattened out, whereas the curve for competed horses continued to increase. After 9 years of age, the curves crossed, indicating that the probability for LOC diagnoses became higher for competed horses in comparison with non-competed horses of the same age. For all these figures (Figs. 1–4), the curves were flattening out before 12 years of age, staying at a probability of around 60–70 % to have a LOC diagnosis.

In Fig. 5, the risk of having a LOC diagnosis is presented for horses born in 2010, 2015, and 2020, respectively. Because the horses in the data had different periods of possible observation time, the curves in the graph end at different time points. The figure shows that later cohorts had a steeper increase in the curve, indicating that the risk for LOC diagnoses has increased with time.

4. Discussion

We found significant differences in the prevalence of orthopedic diagnoses in insurance data between J and D horses but also between categories of other factors (sex, birth cohort, and participation in young horse tests and competition) by using multivariate logistic regression. We also illustrated the differences between categories using survival analysis. Survival analysis is a statistical method to investigate the time until a specific event occurs (Klein and Moeschberger, 2003), e.g. time to first orthopedic diagnosis. The main benefit of the method is that non-affected horses are also included in the analysis and will be censored in the data. Survival analysis has been used in previous studies when investigating disease and death in horse populations (e.g. Ross et al., 1998; Wallin et al., 2000; Árnason and Björnsdóttir, 2003).

Orthopedic diseases affecting the extremities (EXT) and the axial

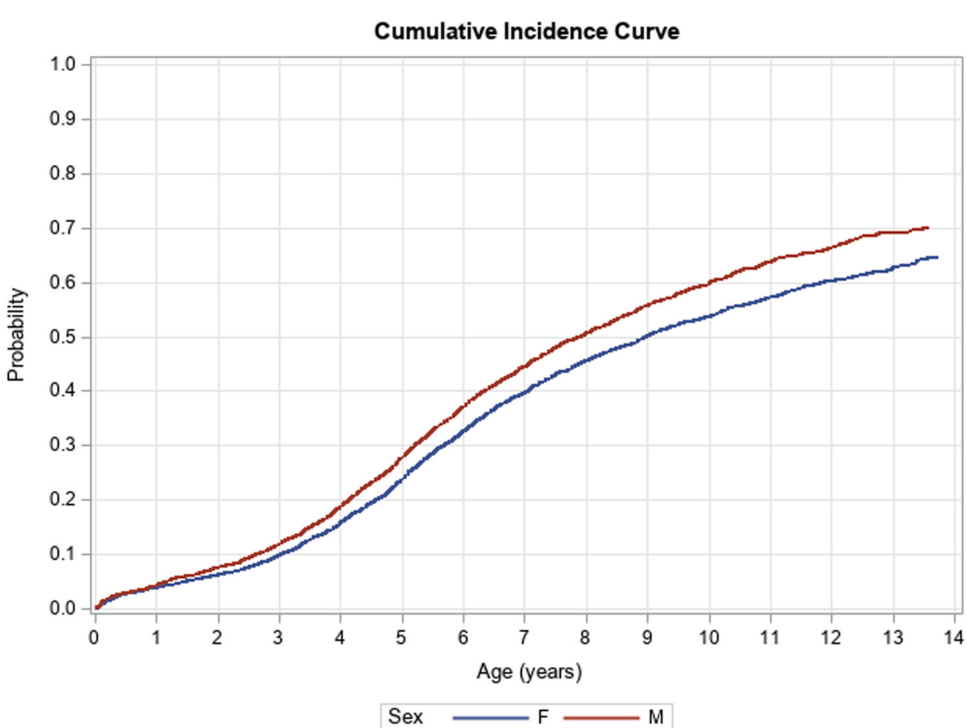

Fig. 1. The probability of having a LOC diagnosis as a function of time (Cumulative Incidence Function) for female (F) and male (M) horses, respectively. N = 7309 and n = 6965 for female and male horses, respectively. The median age of the first LOC diagnosis was 9.0 and 7.9 years for female and male horses, respectively.

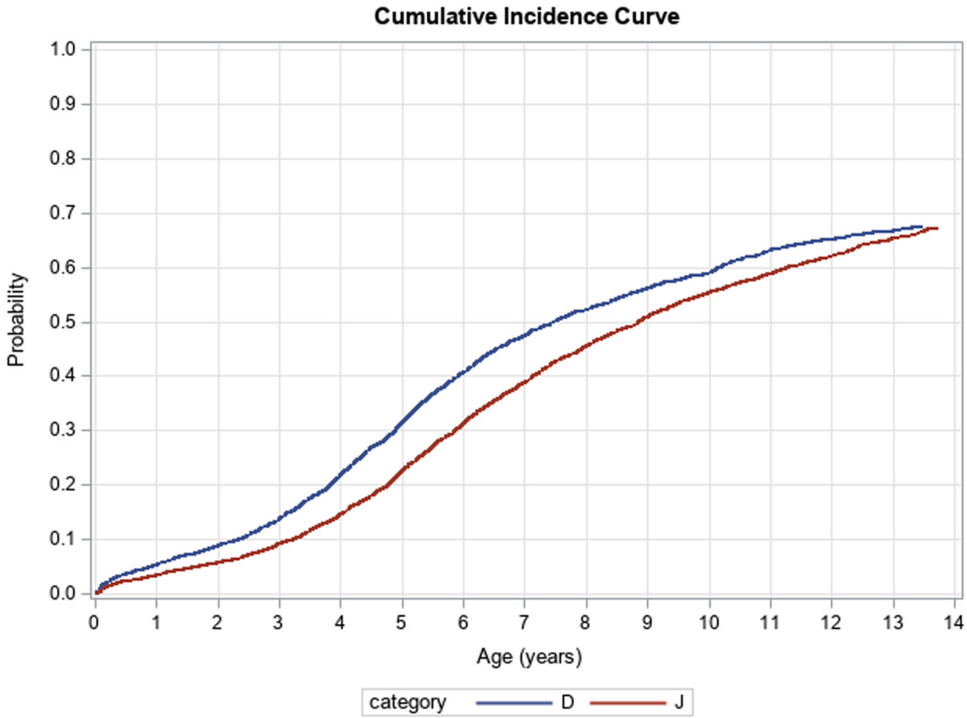

Fig. 2. The probability of having a LOC diagnosis as a function of time (Cumulative Incidence Function) for dressage (D) and jumping (J) horses, respectively. N = 5240 and n = 9034 for d and j horses, respectively. The median age of the first LOC diagnosis was 7.5 and 8.9 years for d and j horses, respectively.

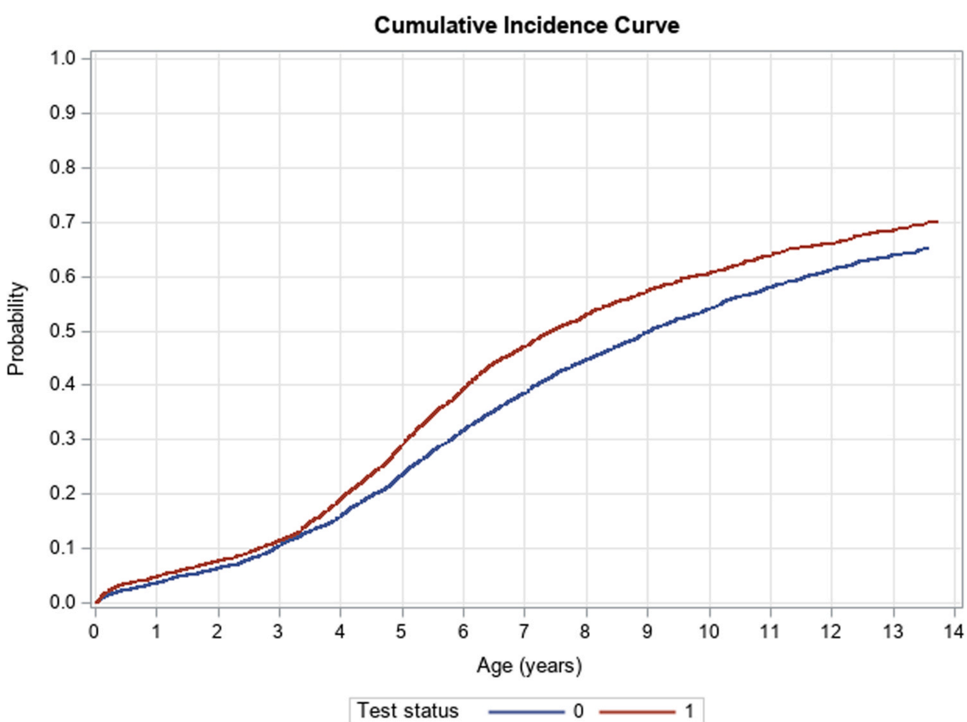

Fig. 3. The probability of having a LOC diagnosis as a function of time (Cumulative Incidence Function) for tested (1) and non-tested (0) horses, respectively. N = 5957 and n = 8317 for tested and non-tested horses, respectively. The median age of the first LOC diagnosis was 7.5 and 9.1 years for tested and non-tested horses, respectively.

skeleton (AXI), often caused by physical workload and/or by abnormalities in the conformation, are commonly associated with lameness. However, in this study, we have also considered other types of diagnoses connected to the locomotor system, i.e., diagnoses connected to OCD, DEV, TRA, NEU, LAM and INF, in order to give a broader description of locomotor diseases in warmblood horses.

4.1. *Usefulness of insurance data*

Insurance data from Agria has been used previously in Swedish

Fig. 4. The probability of having a LOC diagnosis as a function of time (Cumulative Incidence Function) for competed (1) and non-competed (0) horses, respectively. N = 6885 and n = 8317 for competed and non-competed horses, respectively. The median age of the first LOC diagnosis was 8.8 and 8.2 for competed and non-competed horses, respectively.

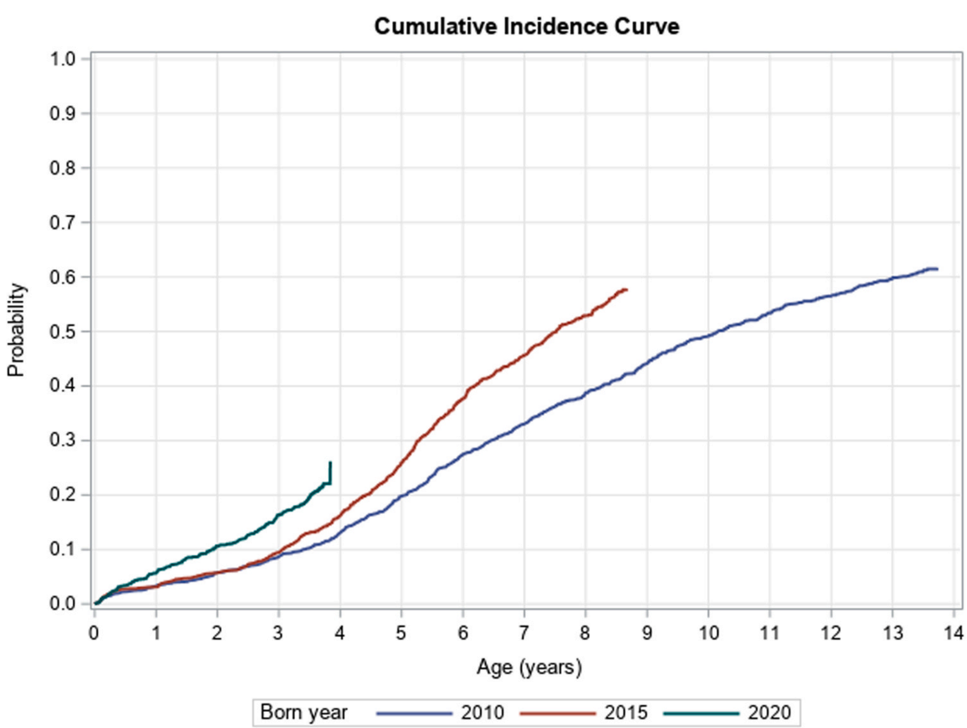

Fig. 5. The probability of having a LOC diagnosis as a function of time (Cumulative Incidence Function) for horses born in 2010, 2015, and 2020, respectively. N = 1492, n = 1176, n = 1189, respectively.

studies (Egenvall et al., 2009). Because few other countries use insurance policies to such a wide extent, the number of studies based on horse insurance date is scarce. Leblond et al. (2000) investigated mortality in 448 insured French horses in 1995, and Higuchi (2006) investigated the prevalence of colic in insured Japanese horses during a three-year period from 2001 to 2003. The insurance data used in this study may have some uncertainties, such as how many horses actually had an injury or how old the horses were when they had their first LOC injury. All horse owners may not use their insurance, even though they have one. There could be several reasons for that, for example that they do not want to have the injury registered, or they may forget or ignore to send in the receipts to the insurance company. Insured horses can have several insurance numbers in the database. Because it was not possible to match all insurance numbers in the database to unique horses, some ICR pertaining to previously matched horses could have been missed. Also, we did not know the termination dates of insurances prior to 2018, which could possibly have an impact on the result of the survival analyses. However, insurance data from Agria was previously validated with clinical records in a study by Penell et al. (2007), and the agreement was high. The same authors concluded that insurance data at least estimates the lower limit of the injury frequency.

The large number of horses in the dataset provides a good basis for drawing conclusions. Also, the proportion of J and D horses in the insurance data was in the same range as in the whole SWB population (Bonow et al., 2023), indicating that the insurance dataset was representative of the population. As much as 56 % of the SWB horse population born from 2010 to2020 was insured by Agria, based on statistics of born foals and number of insured horses.

4.2. Subgroups of LOC diagnoses

Orthopedic diseases are the most common health problem for riding horses, which has been confirmed in several studies (Egenvall et al., 2013; Murray et al., 2010; Penell et al., 2005; Wallin et al., 2000). Also in this study, the diagnosis ‘lameness (unspecified)’ was the most common diagnosis for both veterinary care (Table 5) and life reimbursement (Table 6), where approximately 10 % of the ICR belonged to this diagnosis. Also, several other more specific orthopedic diagnoses were represented in the statistics of the most common diagnoses for veterinary care for J and D horses (Table 5), e.g., osteoarthritis in the metacarpophalangeal or metatarsophalangeal (fetlock) joint, osteoarthritis in the stifle joint, and suspensory desmitis. Similar results were seen in the study by Penell et al. (2005), where the most common specific diagnosis was osteoarthritis in the fetlock.

In this study, some LOC diagnoses like ‘lameness (unspecified)’ were broad, whereas others were more specific. Because all LOC diagnoses were classified to solely one subgroup, some diagnoses may have an uncertain classification because they could possibly belong to more than one subgroup. For example, a fractured proximal phalanx could represent both acute trauma and an overuse injury. In this case, we decided to classify fractures as trauma, given that the study population is a riding horse population that would typically experience a lesser risk of stress fractures compared to a race horse population. All 915 diagnoses that were taken into account were connected to the locomotor system, but some have a stronger connection to lameness caused by physical workload or deviations in conformation, for example, most of the diagnoses connected to orthopedic diseases in the extremities (EXT) or in the axial skeleton (AXI). Some other diagnoses could be due to other reasons or unfortunate circumstances. However, we found it reasonable to include all potential LOC diagnoses in this study and separate them into these eight subgroups. It has to be noted that we have not had insight into how a veterinarian had evaluated and registered a particular disease or injury, which could possibly have influenced the results.

Orthopedic disease of the extremities (EXT) and the axial skeleton (AXI) were the most common subgroups of LOC diagnoses, where 34.2–37.9 % and 13.0–14.3 % of the horses (females and males) had a diagnosis connected to these subgroups, respectively (Table 7). These two were by far more common than the other subgroups, thus attention should be paid to reducing these. For example, more research about the etiology behind these diagnoses and targeted information to horse owners about main factors that prevent lameness would be valuable.

The first decile and median age at first diagnosis in Table 8 indicate that developmental disease in limbs or hooves (DEV) are most common in the first year of life, shown by the low decile and median age (0.1–0.3 years). Diagnoses connected to EXT and AXI had a higher first decile age (2.7 and 4.0 years, respectively) and median age (5.3 and 6.2 years, respectively), indicating that the onset of these diagnoses tends to come later in life. The median age corresponds to when most horses have been ridden and competed for a year or two, indicating that the physical strain increases the risk for these types of injuries. In the study by Egenvall et al. (2005), the highest risk for injuries was seen for horses aged 5–15 years. The authors concluded this was probably because most horses had their heaviest workload during that age, which supports our results. Also laminitis (LAM) diagnoses appear later in life, as indicated by the high decile and median age (3.2 and 7.2 years, respectively). This was also seen in studies by Polzer and Slater (1997) and Alford et al. (2001), who found that higher age was a risk factor for laminitis. The median age for first osteochondrosis (OCD) diagnosis was 2.9 years of age, which corresponds to the time when many owners x-ray their horses on a routine basis for future sales or sport career, which may explain a spike in detection at that age.

4.3. Differences between sexes

Male horses had significantly more ICR than female horses (Table 7). This was also seen in the study by Egenvall et al. (2005), where geldings had a higher incident rate for veterinary care than females. The proportion of LOC diagnosis was also significantly higher for male horses than for females, and especially for orthopedic diseases in the extremities (EXT). When using survival analysis, the median age at first LOC was 7.9 and 9.0 years for males and females, respectively (Fig. 1). Similar results were also found in the study by Penell et al. (2005), where geldings were found to have a higher risk for injuries connected to the joints. Also, in a study by Ross and Kaneene (1996), geldings and stallions were found to have a higher risk of experiencing lameness than females in the Michigan horse population. One explanation for males being more affected by lameness than females could be that geldings have no value for breeding, which was considered as one plausible reason in the mentioned studies (Egenvall et al., 2005; Penell et al., 2005; Ross and Kaneene, 1996). Some females will become brood mares early, especially if they have a high breeding value. An owner of a gelding will probably put in high effort to have the horse back as a riding horse when injured, whereas an owner of a mare with health problems may decide to use her for breeding instead. Ricard and Blouin (2011) concluded that females always had a greater relative risk than geldings or stallions to be removed from competition because they could be used for breeding instead. Also in our study, a higher proportion of male horses had been competing compared with females (43.6 % vs. 39.4 %). This was also seen in a study by Murray et al. (2006), where the proportion of geldings in elite show jumping and dressage were 58.7 % and 92.7 %, respectively. It should be noted that in our study, the estimates of proportions for sex were adjusted for competition status in the logistic regression model.

4.4. Differences between jumping and dressage horses

The proportion of horses with a LOC diagnosis was significantly higher for D horses (51 %) than for J horses (44 %) (Table 7). Similar significant differences were also seen for all subgroups, except for OCD and INF. The median age from the survival analysis for the first LOC diagnosis was 7.5 for D horses and 8.9 for J horses. There is no clear explanation for D horses having more LOC diagnoses than J horses. No previous study has investigated the difference in the prevalence of orthopedic disease in horses classified as jumping or dressage horses on a population level. Still, some studies have investigated orthopedic disease in horses competing in show jumping or dressage. In a study by Murray et al. (2006), data from 1069 horses undergoing an orthopedic evaluation between 1998 and 2003 were investigated in relation to sport discipline and performance level. Both discipline and level of performance had a significant effect on diagnosis and that horses competing in show jumping or dressage were predisposed to different types of injuries. In another study by Murray et al. (2010), risk factors for lameness in dressage horses were investigated using a questionnaire sent to members in British Dressage. The authors suggest that dressage horses have an increased risk for suspensory ligament injuries compared with other horse categories, and a plausible factor could be that a considerable load is put on these ligaments during some movements, e.g., collected trot and piaffe.

4.5. Differences between test status

Horses tested at a young horse test had significantly more LOC diagnoses than non-tested horses (Table 7). However, the survival curve (Fig. 3) shows almost no difference in risk between tested and non-tested horses during the first three years of age. From then on, the risk of having a LOC diagnosis increases more rapidly for tested horses than non-tested horses and the median age for the first LOC diagnosis was 7.5 and 9.1 years, respectively. This may be due to a pre-selection for horses tested at young horse tests, inasmuch as the owners of tested horses find them talented and also aim for a competition career. This reasoning is strengthened by the result that tested horses had competed to a higher extent than non-tested horses (60 % vs 47 %).

4.6. Differences between competition status

There was no overall significant difference in the prevalence of LOC diagnoses between competed and non-competed horses. However, there were significant differences for some of the subgroups of diagnoses. Competed horses were predisposed to orthopedic diseases in the extremities (EXT) and axial skeleton (AXI), whereas non-competed horses were predisposed to DEV, TRA, NEU, and LAM. Although our statistical model does not allow for definitive cause-effect conclusions, the results may indicate that competing horses are at a higher risk of having injuries in the extremities and the axial skeleton due to a higher workload and physical strain in comparison with horses that do not compete. Another plausible explanation could be that the owners of a competition horse may be more eager to take the horse to a veterinarian than the owners of a non-competing horse, in case of lameness. Additionally, some of the non-competed horses may not have been able to compete as a consequence of the diagnoses. For example, developmental disease in limbs or hooves (DEV) commonly affect growing horses at a young age, and some of the horses with a DEV diagnosis may not be able to compete due to the diagnosis. This may also be the circumstance for horses having an orthopedic trauma (TRA) at a young age. Neurologic diseases (NEU) usually have a severe impact on the health of the horse and often lead to euthanasia (Rech and Barros, 2015), which may explain the higher proportion NEU diagnoses for non-competed horses. Laminitis (LAM) diagnoses generally affect older horses, and commonly horses with high body condition scores (Alfred et al., 2001). An owner of a competing horse may be more focused on having their horse in a normal body condition than an owner of a non-competing horse, which may explain the higher proportion of LAM diagnoses in non-competing horses. Also, the competing horse is likely to get more exercise which would be beneficial to avoid a high body condition score.

Non-competed horses had a higher risk of having a LOC diagnosis during the first 9 years of age than competed horses (Fig. 4). Slightly before 10 years of age, the curves crossed, meaning that the risk for LOC diagnoses then was higher for competed horses, compared with non-competed horses. The lower risk for LOC diagnoses during the first years for horses that later in life were able to compete probably enabled training and preparing the horses to a higher degree, indicating a pre-selection for competition on health status in addition to talent. Horses are allowed to compete from 4 years of age, and the risk of having an LOC diagnosis started to increase at that age.

4.7. Differences between birth cohorts

The cohort of horses born in 2020 had a higher risk for LOC diagnoses at a young age compared with the cohorts of 2015 and 2010 (Fig. 5). Also, the cohort of 2015 had a higher risk for LOC diagnoses than the cohort of 2010 from around three years of age. This indicates that the risk for LOC diagnoses at a young age has increased with time. There could be several reasons for this, for example, more intense competing with young horses, more discipline-specific training and competing (meaning less variation in training), horses more sensitive to physical strain, and/or owners more eager to contact a veterinarian. Further investigation and monitoring of this development is needed, as orthopedic health in horses is a high priority due to the welfare of horse, the social license to operate equestrian sports, and economic aspects for the horse owner.

5. Conclusions

The majority of the Swedish Warmblood horse population is insured by Agria, making the insurance data a valuable resource for studying orthopedic health within this population. Almost 44 % of the insured horses had at least one locomotor diagnosis. Dressage horses were found to have a higher risk of orthopedic disease compared to jumping horses, male horses were at higher risk than female horses, and horses that had participated in a young horse test showed a higher risk than non-tested horses. While the overall prevalence of orthopedic diagnoses was similar between competed and non-competed horses, the two groups were predisposed to different subgroups of orthopedic diagnoses at different ages. Survival analysis indicated a trend toward developing orthopedic issues at a younger age. These findings highlight the need for further research and monitoring of the orthopedic health of the SWB horse population.

CRediT authorship contribution statement

Sandra Bonow: Formal analysis, Data curation, Writing – original draft, Writing – review & editing. **Elin Hernlund:** Methodology, Data curation, Writing – review & editing, Supervision. **Susanne Eriksson:** Methodology, Data curation, Writing – review & editing, Supervision. **Erling Strandberg:** Methodology, Writing – review & editing, Supervision. **Åsa Gelinder Viklund:** Conceptualization, Data curation, Methodology, Writing – review & editing, Supervision.

Declaration of Competing Interest

Åsa Gelinder Viklund has regular commitments for Swedish Warmblood Association, regarding the routine genetic evaluation.

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