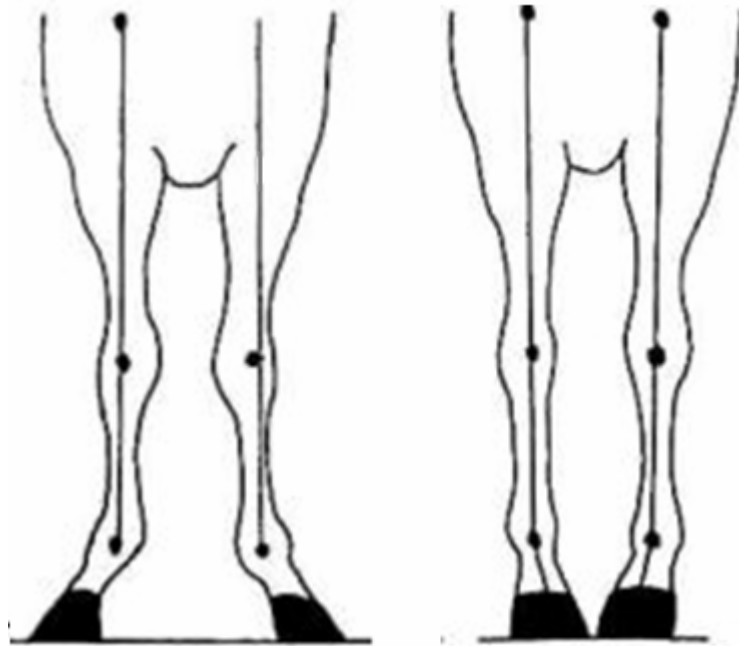


The Incidence of Angular and Flexural Limb Deformities in Standardbreds in New Zealand and the Influence on Racing Performance



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Summary

Reasons for performing the study:

There is limited information available examining conformational abnormalities in Standardbreds, and the relationship between conformation of the limbs and racing performance is controversial. However, as training is both expensive and time consuming, it would save time and money to make a selection at an early age of foals that have a greater chance of a successful racing career.

Objectives: To assess the incidence of angular and flexural limb deformities in a population of Standardbred foals in New Zealand and investigate the influence of angular and flexural limb deformities on racing performance.

Hypothesis: Horses that had angular or flexural limb deformities as foals have significantly less racing success than horses without angular or flexural limb deformities as foals.

Materials and Methods: On two Standardbred breeding farms (1296) foals were scored visually for flexural or angular limb deformities within 1 day after birth. Angular and flexural limb deformities were combined and named abnormal limb deformities (ALD). The parameters used to assess racing performance were qualifying or not, the age of qualifying, number of starts per year, prize money earned in total and prize money per start, and if exported or not. The Harness Racing New Zealand and the Australian Harness Racing Council online databases were used to obtain racing results.

Results: 178 of the 1296 foals (14.81%) had some form of angular or flexural limb deformity. There was no difference in incidence of ALD between fillies and colts. Sires did not influence the incidence of ALD in their progeny. Foals that did not have ALD were 1.5 times more likely to qualify before the age of 4 than foals that had ALD. There was no influence of ALD on total amount of prize money won, total amount of starts or total amount of prize money per start. Foals that were exported to Australia had the same incidence of ALD as the standard population, but of the foals that were sold to the U.S.A. none had any form of ALD.

Conclusions: The incidence of ALD in Standardbreds in New Zealand is 14.81%. A strong relationship between ALD and not qualifying before the age of 4 supports the theory that limb conformation is an important factor in predicting racing performance.

Potential relevance: This study gives an indication of the importance of ALD in Standardbreds and may give the owners and trainers complementary information to select their horses. It also provides a basis for further studies about the role of conformation in racing performance.

Introduction

Horse racing today is a multimillion dollar industry with racehorses being bred all over the world. Many owners and trainers want to make a selection at an early age between foals that will have a good racing career and foals that do not even have the potential to qualify. Time and money could then be saved and invested in potentially more successful foals.

Previous studies have focussed on the relationship between abnormalities on radiographs and the relationship with racing success, but many of these reports contradict each other. According to Couroucé-Malblanc *et al.*^[1], the only parameter in Standardbreds influenced by abnormal radiographic findings is the duration of the racing career, Grøndahl and Engeland^[2] reported significantly fewer starts and somewhat lower earnings for horses with OCD or fragmentation of the fetlocks and Robert *et al.*^[3] also found that radiographically detectable abnormalities in fetlock or proximal tarsus joints reduced racing aptitude. However, Alvarado *et al.*^[4], Laws *et al.*^[5] and Jørgensen *et al.*^[6] failed to detect any significant differences in racing results between horses with normal and horses with abnormal radiographs. In Thoroughbreds, Kane *et al.*^[7,8] found that starting a race before the age of 4 was one of the parameters influenced by abnormal radiographic findings and Spike-Pierce and Bramlage^[9] showed that horses with enlarged vascular canals in their sesamoids had fewer starts and lesser earnings than radiographically normal horses.

Because there are no unequivocal conclusions about the usefulness of radiographs in predicting the racing success of a foal and taking radiographs is both expensive and time-consuming, a faster, easier and cheaper way to score the limbs of a foal is needed.

Anecdotal evidence suggests that foals that have a non-straight conformation of the limbs do not race or do not appear to race with the same level of success as foals that have a straight conformation of the limbs. Two common abnormal conformational changes are angular limb deformities (AnLD) and flexural limb deformities (FLD). Angular limb deformities can be defined as lateral or medial deviations to the long axis of the limb in the frontal plane. For a foal to be born with a mild bilateral carpus valgus (lateral deviation distal to the carpus) and a toed-out appearance is considered normal by many clinicians; as the foal grows and the chest widens, the limbs straighten progressively.^[10]

Flexural limb deformities are deviations from the long axis of the limb in the sagittal plane.^[11] Most common in foals are cases where the limbs are in a state of hyperflexion, commonly referred to as “contracted tendons”. This term is incorrect because the tendons are not actually contracted, but there is disparity in the length of the musculotendonous unit relative to the length of the bone. Besides, not only the flexor tendons may be involved, but also the suspensory apparatus, the joint capsule, and surrounding fascia, skin and bone.^[12]

In Irish Thoroughbreds, an angular limb deformity incidence of 62.1% was identified by scoring the foals through visual examination on the farm first and on photographs afterwards.^[13] The relationship between conformation and racing career has been investigated and Morgan^[14] failed to detect any improvement with age in racing performance in Thoroughbred horses with straight forelimb conformation. But, in

National Hunt Racehorses, Weller *et al.*^[15] found that valgus conformation of the metacarpophalangeal joint was detrimental for racing performance.

Although Bantoiu^[16] started already in 1922 with gathering information about the conformation of Standardbreds in Germany and much research about conformation has been done later in other countries, until today no quantification of the incidence of angular and flexural limb deformities in Standardbreds in New Zealand has been reported in the literature.

The purposes of the study reported here was to score the incidence of angular limb deformities and flexural limb deformities in Standardbreds in New Zealand and examine the effect of such deformities on subsequent racing performance.

We hypothesised, on basis of clinical impression, that foals born with AnLD and FLD have significantly poorer performance on the racetrack than foals without any AnLD or FLD problems.

Hypotheses

Incidence

- There is no difference between fillies and colts in the incidence of angular and flexural limb deformities
- Sires have a significant influence on the incidence of ALD in their progeny

Racing performance

- Foals with angular or flexural limb deformities qualify less than foals without angular or flexural limb deformities
- Foals with angular or flexural limb deformities qualify at a later age than foals without angular or flexural limb deformities
- Foals with angular or flexural limb deformities earn less prize money in total than foals without angular or flexural limb deformities
- Foals with angular or flexural limb deformities start in fewer races than foals without angular or flexural limb deformities
- Foals with angular or flexural limb deformities earn less prize money per start than foals without angular or flexural limb deformities
- Foals with angular or flexural limb deformities are less likely to be exported than foals without angular or flexural limb deformities

Materials en Methods

Study population

As part of an on farm recording scheme, data of AnLD, FLD and veterinary input was recorded prospectively on two of the largest Standardbred farms in the southern Hemisphere. Farm 1 has an average of 350 foals born per year, Farm 2 an average of 300.

Foals that died before the first of September 2007 were excluded from the data to asses racing performance, but were included in the AnLD or FLD incidence dataset. Foals that were not born on the farm were excluded from the data as well, because there were no data available about the conformation of the foals within a day of birth.

Data collection

A clinical inspection of all the foals, within a day after they were born, was performed on Farm 1 by an experienced equine clinician. On the other farm, one of the birth-attendants scored the foal within a day after it was born. The foals were scored on conformation of the front- and hind legs.

On Farm 1, the conformation was determined by using the following categories:

- 1) Normal
- 2) Varus
- 3) Valgus
- 4) Contracted tendons
- 5) Non-straight conformation of the hind limbs

A foal could be ascribed to different categories. If a foal had contracted tendons and the veterinarian found it necessary to treat the foal, an injection with Oxytetracycline (Engemycin ®) was given intravenously. This was repeated 1-2 times, depending on the response of the limbs of the foal. Also, if a foal had a varus or valgus deviation and the veterinarian found it better to treat the conformational change, a periosteal strip surgery was performed. No difference has been made between horses that were treated for their limb deformity or horses that were left untreated.

On Farm 2, the conformation was subjectively described by the birth attendant, e.g. “outward”, “contracted” or “bad legs”.

AnLD and FLD were combined in all statistics as ALD (Abnormal Limb Deformities), due to the small amount of AnLD that has been found.

Performance indices

All the foals were scored on:

- qualifying or not
- age of qualifying
- total starts
- total prize money won
- total prize money won per start
- exported or not

Breeding and racing records were retrieved from the Harness Racing New Zealand online database.^[26]

Horses that were sold to Australia had records retrieved from the Australian Harness Racing Council online database^[27] and scored on the same parameters as above. A conversion from Australian Dollars to New-Zealand Dollars was made by multiplying the amount of Australian Dollars by 1.1 (Foreign Currency Indicative Rate as at 1-

dec-07). Because it was not possible to look up the results of the horses that were sold to the USA, they were excluded from calculations on the total amount of money won, total starts and total amount of money won per start.

For determining at what age the foals qualified, the racing season standards in New-Zealand were used, so that all the foals became one year older on the 1st of August. For foals sold to Australia, the same dates have been used; if not foals that were sold during a season would have a month longer to qualify or to earn money (as the season in Australia ends at the 1st of September).

Data analysis

The data of both farms were used to score the incidence of angular and flexural limb deformities. The data of Farm 1 were also used to determine if there was a difference between fillies and colts affected with ALD and to determine the relationship between angular and flexural limb deformities and poorer racing performance.

At Farm 2, data of seasons 03-04 and 04-05 were used and at Farm 1, data of 02-03 and 03-04 were used.

To assess the influence of the sire, we made groups of sires. Every sire that had produced 10 or more foals formed a single category; the sires that had produced less were all categorized as an “other” group.

SPSS v14 (Chicago, Il, USA) was used to calculate the influence of ALD on the different parameters. For detecting a difference in incidence of ALD between fillies and colts we used a binary logistic regression test, with a confidence interval of 95%. To investigate the relationship between ALD and qualification parameters, we used again a binary logistic regression test and calculated the Odds-ratio and a confidence interval of 95% to estimate the likelihood of qualifying.

For measuring the influence of ALD on the total amount of prizemoney won, total amount of starts, and total amount of prizemoney per start we performed the Kolmogorov–Smirnov test to see if the data were normally distributed. Non-parametric data were examined using a Mann-Whitney U-test to calculate the influence of ALD. The confidence interval used was again 95%.

TABLE 1. Number of foals used to calculate incidences or to assess effect of given parameter

Parameter	Nr. of foals
Incidence of ALD in Standardbreds	1296
Incidence of different sorts of ALD	92
Incidence of ALD in different sexes	713
Distribution of qualifying per age-group	333
Influence of sires on ALD	713
Qualifying with ALD vs. No ALD	713
Qualifying as a filly vs. colt	713
Total prize money won before the age of 4	336
Total starts before the age of 4	336
Total prize money per start before the age of 4	336
Exported having ALD vs. no ALD	90

Results

Incidence

The study started with 368 foals on Farm 1 in season 02-03. Nineteen of these were born dead or died as a foal, 3 foals had no brand and another 13 horses died later in life before the 1st of August 2007 (a loss of 10.5%). They were excluded from the data, and thus, for the 02-03 season, we had a total of 333 to assess racing performance.

For the 03-04 season we started with 416 foals. Fifteen of these were born dead or died as a foal, 7 foals had no brand and 14 horses were excluded from the calculations because they died later in life before the 1st of August 2007 (a loss of 9.5%). So we used 380 horses for season 03-04.

At Farm 2, 254 foals were used for season 03-04 and 329 foals for season 04-05.

A total of 1296 horses were used to score the incidence, of which 178 horses were scored with angular or flexural limb deformities and 1118 without any form of abnormal limb deformities. The average incidence of ALD per year in Standardbreds was 14.8 %, but there was large variation over the different seasons and farms.

TABLE 2: Incidence of ALD

	Farm 1 02-03	Farm 1 03-04	Farm 2 03-04	Farm 2 04-05	Average per year
ALD	53	39	19	67	44,5
No ALD	280	341	235	262	279.5
Total foals	333	380	254	329	324
Percentage ALD	15.9	10.3	7.5	25.6	14.8

Different sorts of ALD

In this study, we found that more foals are affected by flexural limb deformities than by angular limb deformities (an average of almost 30 foals per year with FLD compared to an average of 9.5 foals per year with AnLD). Although the number of foals affected by FLD is almost the same for both seasons, the number of foals affected by AnLD decreases in season 03-04.

TABLE 3: Incidence of different sorts of ALD on Farm 2

Foals can have two different conditions at the same time (i.e. contracted tendons and non straight hind limbs).

Different sorts of ALD	Fillies	colts	Total 02-03	Fillies	Colts	Total 03-04	Average per year
Contracted tendons	16	13	29	18	12	30	29.5
Varus	5	2	7	1	0	1	4
Valgus	3	6	9	1	1	2	5.5
Non-straight hind limbs	12	8	20	5	7	12	16

Difference between fillies and colts

A total of 713 foals were used to calculate the difference in incidence between colts and fillies. There was no significant difference between the sexes, with 12.2% of the fillies affected with ALD compared to 13.6 % of the colts.

TABLE 4: Distribution of ALD between fillies and colts

	ALD	No ALD	Total	Percentage ALD
Fillies	49	312	361	12.2
Colts	43	309	352	13.6

Sires vs. ALD

There was no significant sire effect on the incidence of ALD. The only sire that had a significant influence (P = 0.046) was sire nr. 15, which was a composite sire grouping of all the sires that had produced less than 10 foals.

TABLE 5: Sires and their influence on foals with ALD

	Sig.	95.0% C.I. for	
		Lower	Upper
Sire(1)	.921	.291	3.051
Sire(2)	.888	.470	2.389
Sire(3)	.824	.093	6.644
Sire(4)	.674	.282	7.082
Sire(5)	.085	.021	1.283
Sire(6)	.674	.282	7.082
Sire(7)	.363	.660	3.109
Sire(8)	.991	.209	4.887
Sire(9)	.483	.416	6.398
Sire(10)	.087	.173	1.126
Sire(11)	.531	.531	3.410
Sire(12)	.674	.282	7.082
Sire(13)	.253	.646	5.261
Sire(14)	.570	.066	4.459
Sire(15)	.046	1.015	5.814

Sire 15 stands for all sires that had produced less than 10 foals

Racing success

For assessment of racing success, we used only the foals born on Farm 1; 333 foals born in season 02-03 and 380 foals born in season 03-04.

Distribution of qualification per age-group

Only 19.8% of the foals qualified as a 2 year old. The majority of the foals qualified as a 3 year old (28.8%), and almost half of the foal crop qualified before the age of 4 (48.7%). A small percentage of the foals qualified later in life at the ages of 4 (10.8%) or 5 (1.8%). Overall, more than 60% of the foals alive at the age of 5 had obtained qualification status (61.3%).

TABLE 6: Normal percentage of qualification (based on season 02-03)

	<i>No ALD</i>	<i>ALD</i>	<i>Total</i>	<i>Percentage</i>	<i>Percentage cumulative</i>
<i>Q 2 YO</i>	58	8	66	19.8	19.8
<i>Q 3 YO</i>	83	13	96	28.8	48.7
<i>Q 4 YO</i>	32	4	36	10.8	59.5
<i>Q 5 YO</i>	6	0	6	1.8	61.3
<i>NQ</i>	101	28	129	38.7	100
<i>Total</i>	280	53	333		100

Influence of ALD on qualifying before the age of 4

There was no difference between foals with ALD and foals without ALD for qualifying before the age of 3. However, a difference was detected for qualifying before the age of 4. The percentage of the foals with ALD that qualified before the age of 4 was 39.1%, compared to 50.2 % for foals without ALD. Although it was not significant (P = 0.058) it shows that there is a tendency that foals with ALD are less likely to qualify before the age of 4 than foals without ALD.

TABLE 7: Likelihood of qualifying without ALD before the age of 4

		<i>ALD</i>	<i>No ALD</i>	<i>OR</i>	<i>P-Value</i>
Qualified as a 2 or 3 YO	Yes	36	309	1.541 (0.985-2.410)	0.058
	No	56	312		

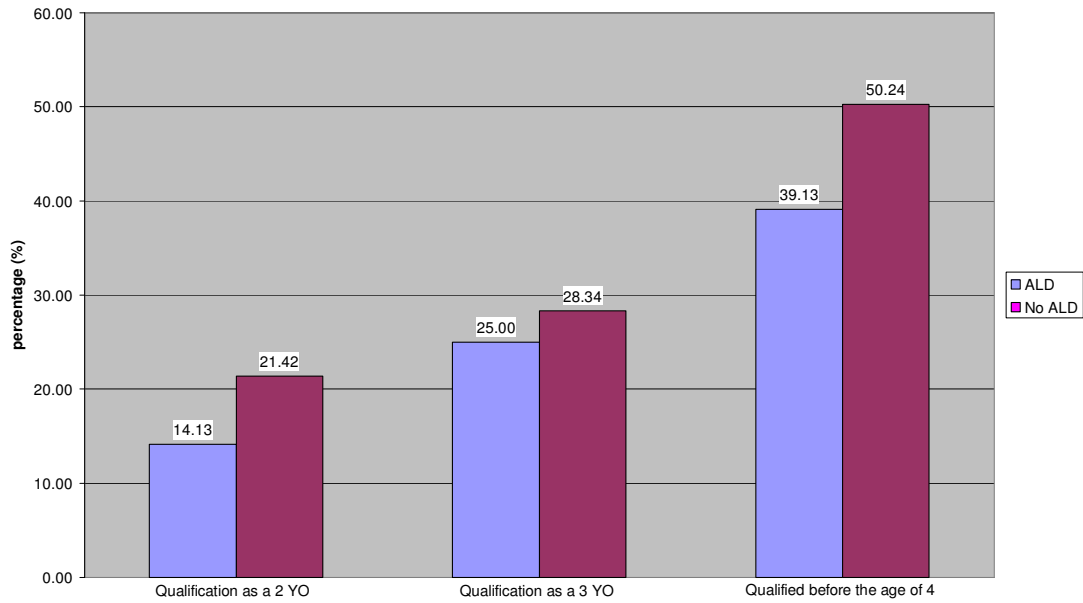


Fig.1: Distribution of qualifying before the age of 4 between ALD and No ALD

TABLE 8: Distribution of ALD between qualifiers and non-qualifiers

	Q 2YO	Q 3YO	Total Q	NQ	Total Foals	Percentage qualified
ALD	13	23	36	56	92	39.1
No ALD	133	176	309	312	621	50.2
Total	146	199	345	368	713	

Fillies vs. Colts

We used 713 foals (361 fillies, 352 colts) to determine the influence of sex on qualifying before the age of 4. The data are presented in the table below. A colt was 1.747 times more likely to qualify before the age of 4 than a filly ($P < 0.001$).

TABLE 9: Likelihood of qualifying as a colt before the age of 4

		F	C	OR	P-Value
Qualified as a 2 or 3 YO	Yes	150	195	1.747 (1.299-2.350)	< 0.001
	No	211	157		

Total prize money earned: ALD vs. no ALD before the age of 4

We collected data from 336 horses (300 without ALD, 36 with ALD) that had qualified before the age of 4. The average prize money won by foals that were scored with ALD was \$8268.29 NZD, the average prize money won by foals without ALD was \$5644.45 NZD. No significant difference ($P = 0.242$) was detected between foals with ALD and foals without ALD for the parameter “total prize money won before the age of 4”.

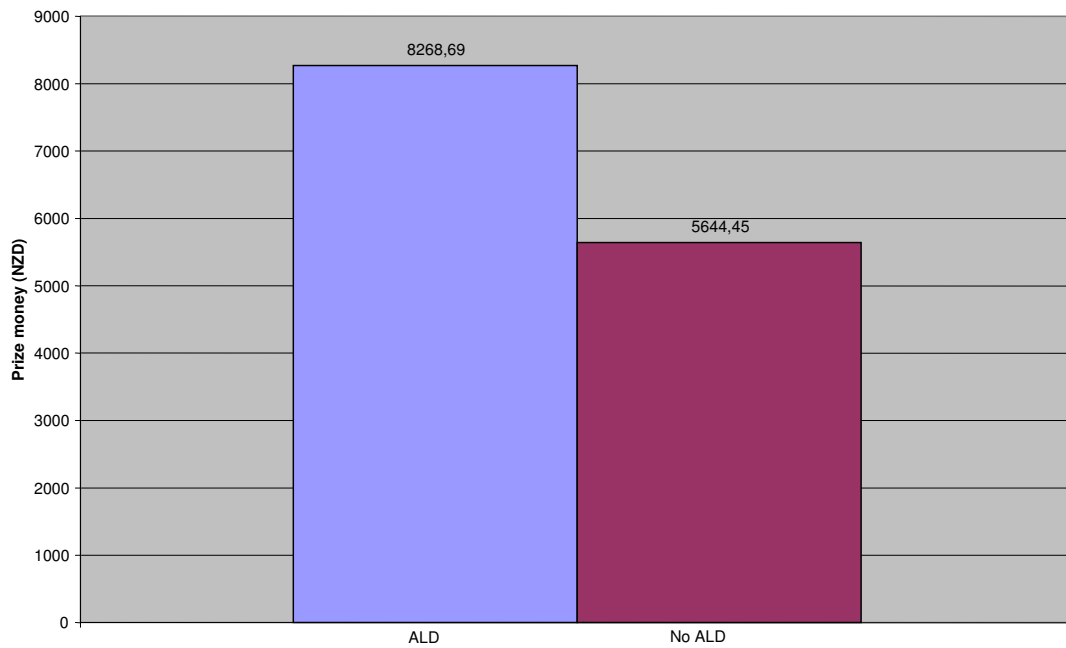


Fig. 2 Average prize money won per conformation

Total number of starts: ALD vs. no ALD before the age of 4

There was a trend that the average number of starts made by a foal with ALD before the age of 4 was less than normal, compared to the average number of starts by a foal without ALD (5.5 versus 7.2 respectively). This was not significant ($P = 0.110$).

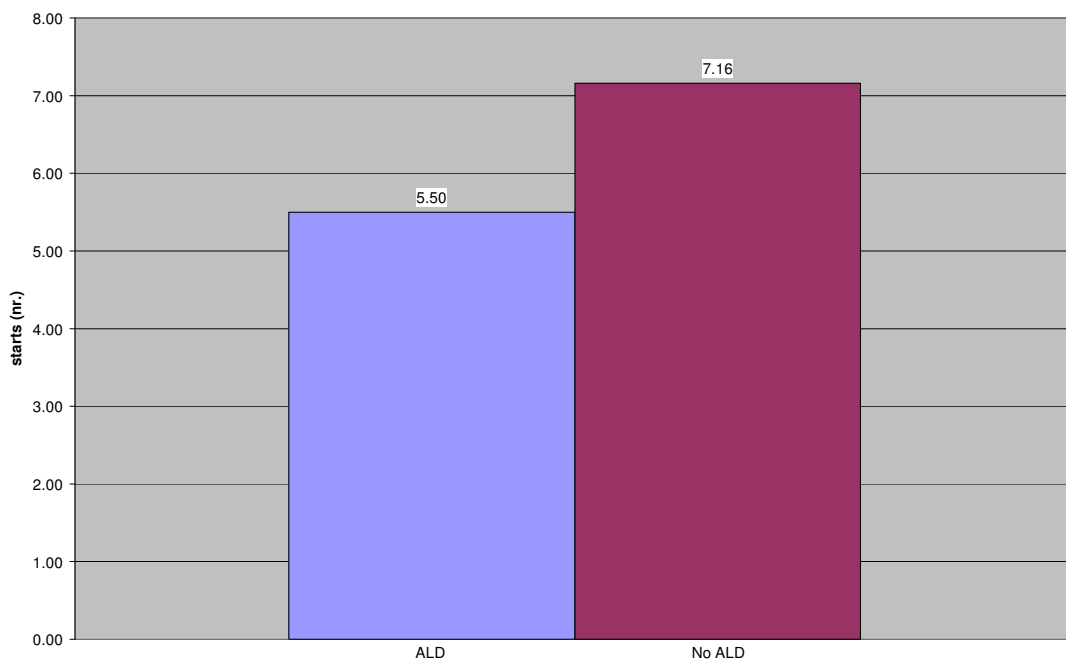


Fig. 3 Average number of starts per conformation

Total prize money per start: ALD vs. no ALD before the age of 4

The average prize money earned per start by a foal with ALD was 561.72 NZD, compared to 731.13 NZD by a foal without ALD. With a P-value of 0.292, this parameter showed no significant difference between foals that have ALD and foals that have straight limbs at birth.

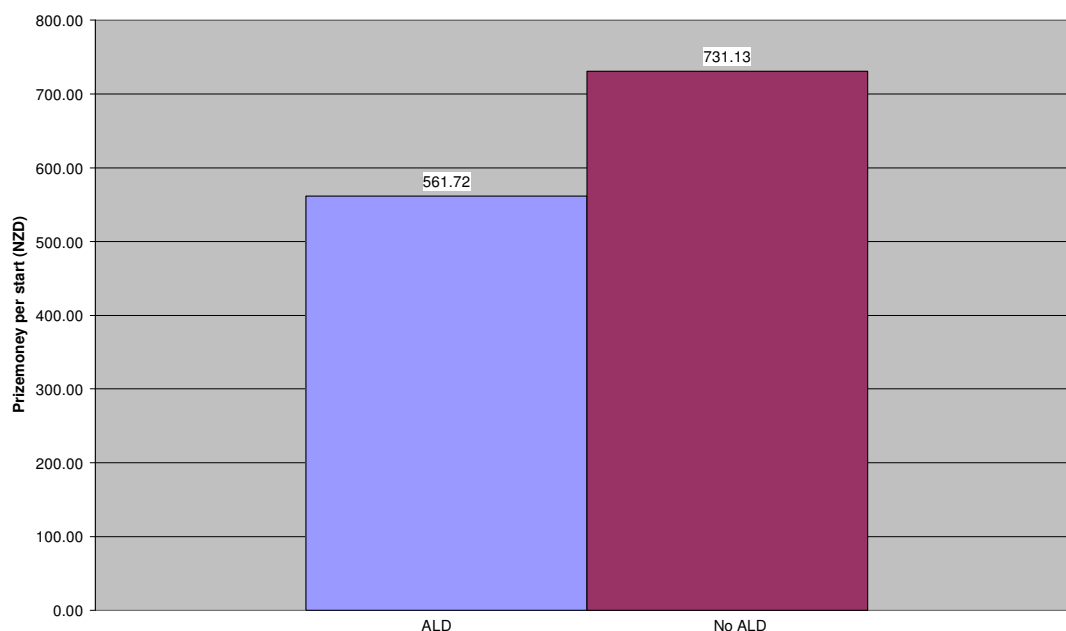


Fig. 4 Average amount of prizemoney won per start per conformation

Exported

A total of 90 horses from the 02-03 and 03-04 season were exported before 01-08-07. All the horses that have been sold to the U.S.A. had qualified in New Zealand, whereas 5 of the 79 horses (6.3%) that have been sold to Australia never qualified. None of the horses sold to the USA were recorded as having ALD, in comparison with 13.9 % with ALD that were sold to Australia. Only one of the 5 horses sold to Australia that did not qualify was scored with ALD.

TABLE 9: Exported foals with and without ALD

	ALD	No ALD	Total	Percentage with ALD
Exported to Australia	11	68	79	13.9 %
Exported to the U.S.A.	0	11	11	0 %

Discussion

Incidence

The major problem with scoring foals with abnormal limb deformities was that there was no standard form to assess the different kinds of flexural or angular limb deformities. This led to non-objective methods of measuring the conformation of the foal. Since the scoring on Farm 2 was done by different birth attendants who all had their different scoring systems and ways of describing them (not all attendants had much experience with conformation of limbs), data from Farm 2 were judged not objective enough to use in assessing racing performance. On Farm 1 this problem didn't occur because scoring of the foals was done by an experienced equine clinician. However, notwithstanding the long experience, the opinion of only one veterinarian is not very objective. A better way of scoring would be through an inspection of the foal by 2 or more experienced equine clinicians. But, because of a limited amount of time and money, this was the best solution.

Objective measurements of varus or valgus deviations, like the angle of the deviation, have been measured in previous reports^[17,18]. This was not done in this study, and therefore no data are available of the severity of the conformational change. Again, this was due to the limited amount of time and money and the quantity of the foals. Also, no data are available about the joint affected when a foal had a varus or valgus deviation. This would be important when one wants to have a precise understanding of which valgus or varus deviations are detrimental for racing performance.

Another interesting feature is that a foal that is born with a mild bilateral carpus valgus and toed-out appearance is considered normal by many clinicians. As the foal grows and the chest widens, the limb straightens progressively^[10]. In National Hunt racehorses, Weller *et al.*^[15] found that the mean deviation of front and hind limbs from the sagittal plane was 0° with a s.d. below 3°. This may have been due to the fact that that study was done with horses that had already started their racing career, horses not able to cope with the high demands of training having already been selected out.

With regards to scoring the conformation by inspection, according to Dutton *et al.*^[19] a fetlock varus is often overlooked by owners and veterinarians, possibly because of lack of observation of the foal from behind and the inherent offset position of the tarsus. In this report, all scoring on Farm 1 was done by a veterinarian who had years of experience with Standardbred foals. Due to his experience, he could assess the difference between a normal valgus deviation and an abnormal deviation and the chances that he would overlook any varus deviations were small. However, it is still possible that only the really severe valgus or varus deviations were noted, because most deviations tend to straighten in time and the veterinarian may not rate a small deviation as a problem.

No significant difference in incidence of limb deformities in this study has been found between sexes. This resembles the results of O'Donohue *et al.*^[13] in Thoroughbreds. When we look at the different sorts of ALD and sex, our study seems to be in conformity with the study from Dutton *et al.*^[19] who found a higher incidence of tarsus valgus in males (ratio 1.8:1), and with Bertone *et al.*^[20] who found a higher

incidence of carpus valgus in males (with a ratio of 1.9:1). But, as our population is small, no definitive conclusions can be made.

Racing success

The losses we found in this study were 10.5% per year and 9.5% per year respectively, which is a little bit more than Wilsher *et al.*^[21] found in Thoroughbreds, and almost triple the mortality rate of Jeffcott *et al.*^[22] (3.5%).

In this study we found that almost 20% of the foals qualified as a 2 year old. Compared to Thoroughbreds, the number of foals that race as a 2 year old is lower: Wilsher *et al.*^[21] showed that 32 % raced as a 2 year old, Bourke *et al.*^[23] reported a percentage of 32%, but Morgan *et al.*^[14] found a percentage of 66%.

For Canadian Standardbreds Alvarado *et al.*^[4] found a percentage of 64.4%. This difference in percentages can be due to the fact that the last two studies are based on American and Canadian populations of racehorses and the rules of starting a race differ in the USA and Canada from other countries.

The overall percentage of horses that qualified at some stage was 61.3%. In fact, this percentage may be even higher because the season was still going on. Jørgensen *et al.*^[6] found that 70% of his population of Standardbreds started in a race. This high percentage can be due to the fact that he only followed the horses that were radiographed in a practice because of insurance issues or as part of a sale, so there has already been a selection between “good” performers and bad performers. Grøndahl *et al.*^[2] found a percentage that resembles our finding: 60% of the Norwegian Standardbreds had started in a race. Our findings are slightly more than in the population of French Standardbreds, 57.4 %, by Courouc -Malblanc *et al.*^[1] but because in France the horses have to be qualified before they become 5 years, they had less chance to qualify than in this study. Without the foals that qualified as a 5 year old, the percentage of foals that qualified overall is almost the same (59.5%). But, a primary selection of the foals had already been made in this study because all foals contained that were in this study were already in training. No horse that died or was born dead were included in this study. If they would be included, an average of 30% of the foals would have qualified. A study by Robert *et al.*^[3] also in French Standardbreds, showed an overall-qualification percentage of 59.9%, which equals almost exactly our findings. In Thoroughbreds, Morgan *et al.*^[14] found an overall percentage of 91% of horses that had raced before reaching the age of 5. Kane *et al.*^[8] reported a percentage of 81% of horses that had started racing before the age of 4. One must keep in mind that these percentages are again based on an American population and rules of starting in a race are different than in other countries.

In this report, we used the racing season of New-Zealand as the standard season. This standard was also used for the foals that were sold to Australia and the USA. The season in Australia starts one month later than in New Zealand, i.e. the 1st of September. The racing season in the USA starts on the 1st of January. Most of the foals were sold after they had qualified, and by applying the season standards of New Zealand to every horse, there was no chance that earnings or amount of starts were influenced by the extra month the horse would have when it was sold to another country. Some of the foals were sold before they qualified and had a month shorter to qualify compared to New Zealand season standards. But, this seemed not to have any significant influence.

In previous studies, assessing the racing success of a horse has been done by using many different variables: qualifying, life-time earnings, number of wins, number of placed races, time record, fastest time of workout, longevity, mean and maximal index of trot, qualification^[1-6, 25]. In this study, we were only able to use qualifying or not, age of qualifying, total prize money won, total amount of starts, total prize money per start and exported or not as variables, due to the limited amount of data we collected.

With respect to the use of the number of starts as a parameter of racing success, we have to emphasize that this reflect rather a decision of the owners instead of being a reliable measurement of the excellence of the horse. Some owners choose carefully in which races they want to see their horse compete in, and some owners race their horse as much as possible. It is the same for the total amount of prize money won by a horse: when a horse starts in more races, it is more likely to have earned more prize money than a horse that hasn't had many starts. Dividing the total amount of prize money by the total amount of starts gives a better indication of the racing success of the horse.

In this report, we found a strong tendency that horses with ALD were less likely to qualify before the age of 4 in comparison with horses that were not affected. Bantoui^[16] noted, as early as in 1923, differences in the length of the bones and the angles of the joints to the horizontal plane between fast-pacing Standardbreds and slower trotters. However, no information about deviations in the saggital and frontal plane was recorded, and no statistical analysis had been carried out. In Thoroughbreds, Weller *et al.*^[15] found that a valgus conformation of the metacarpophalangeal joint was a significant factor detrimental for racing performance by using a computerised motion analysis system. However, Morgan *et al.*^[14] was unable to detect any improvement with age in racing performance for horses with a straight forelimb conformation. Hunt^[24] noted that for foals with congenital flexural deformities that progressively respond favourably in the first 2 weeks of life, the prognosis for future performance as an athlete is good, but there are no references available where he has based this opinion on. Studies about Standardbreds based on scoring abnormalities on radiographs, failed to detect any difference in racing performance between horses with normal radiographs and horses with abnormal radiographs^[2].

Also, in this study, we could not detect a significant difference in total amount of prize money won, total amount of starts, and total amount of prize money per start, probably due to the fact that we didn't have enough data with a lot of variation in the different groups, reducing statistical power considerably.

For determining the influence of ALD on racing success, only one stud farm was used to collect the data. It is one of the largest Standardbred breeding farms in the Southern Hemisphere, so a large dataset could be collected. However, using data from a single farm only, it is of great importance that this farm is a good representative of the total population and even then one cannot make predictions about the total population of Standardbreds. It could be that some of the conformational changes are breeding farm dependent, either by nutritional or genetical factors. By using different farms to collect the data, there could be a more representative dataset of the total population. But, by using different farms, some of the results may be biased because of different types of breeding management, e.g. some farms may be more prone to put foals with

conformational changes down, because they believe they'll never become a good racehorse.

In this study, no difference was made between horses that were treated for their limb deformity or horses that were left untreated. Although the number of horses treated for varus or valgus was low ($n = 4$) compared to the total population of horses with a varus or valgus deviation, it could have biased our findings.

The results obtained here showed that sex was an important factor on the likelihood of qualifying. This is in contradiction with the study of Wilsher *et al.*^[21], who found that in Thoroughbreds sex had no influence in running a race. This is easy to explain by the fact that fillies that do not qualify easily are withdrawn quicker because they can be used as breeding mares. Colts are not as useful and get more chances to qualify.

It would have been interesting to compare the fillies and the colts with ALD and to measure the influence of sex and ALD on racing career. We were not able to do this in this project because of the relatively low numbers of foals with ALD. The power of the test performed would have become too low, precluding the establishment of significant differences.

It would have been of interest also to compare the different sorts of AnLD, or to assess differences between ALD and FLD in their effects on the racing career of the foals. Again, this was not possible in this project because of the relatively low numbers of foals with AnLD or FLD.

Conclusion

Angular and flexural limb deformities seem to influence racing performance. The parameter most influenced by a non-straight conformation is the age at qualification: there is a tendency that foals that don't have ALD are 1.5 times more likely to qualify before the age of 4.

The results obtained in this study emphasize the importance of further studies to get a better understanding of the influences that angular and flexural limb deformities may have on racing performance.

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