THE INFLUENCE OF OSTEOCHONDROSIS (OC), IN YEARLING STANDARDBRED HORSES ON SUBSEQUENT TWO AND THREE-YEAR OLD RACING PERFORMANCE AND THE INFLUENCE OF SIRE ON RATES OF OC IN ILLINOIS STANDARDBRED HORSES

BY

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THESIS

Submitted in partial fulfillment of the requirements
for the degree of Master of Science in Animal Sciences
in the Graduate College of the
University of Illinois at Urbana-Champaign, 2015

Urbana, Illinois

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Abstract

Much of the economic impact of the equine industry is based on performance horses in racing and competitive horse shows. Owners and trainers are concerned about the soundness of their animals both because of humane issues and because it is necessary to get a return on the investment in their horses. Proper functioning and comfort in joint articulations is of prime importance. One primary concern in the racing industry over the last 50 years has been the effect of Osteochondrosis (OC) in horses and how OC affects their performance on the race track. Osteochondrosis is an orthopedic disease that involves the failure of endochondral ossification affecting the articular cartilage. This generally occurs in the early orthopedic development in juvenile horses. Due to this, owners and trainers take great interest in early orthopedic developmental abnormalities as a predictor of future lameness that could inhibit performance. There are two lesions that are most concerning to owners and trainers who are osteochondrosis (OC) and osteochondrosis dissecans (OCD). The difference between the two is that OC is the abnormal subchondral ossification affecting the cartilage and OCD involves a piece of bone falling into the joint space. Several studies have attempted to determine what predisposes horses to this disease. These studies have looked at genetic predisposition, nutrition, skeletal growth rates, and the amount of physical activity. While these studies have tried to determine the likelihood that a horse will develop OC, no work has been done to determine if the horses in Illinois who have some form of OC have had surgery to remove these abnormalities, and if such surgery might result in increased earnings compared to the horses who did not receive surgery. Also, it is important to determine if having OC abnormalities

affects the longevity of a horse's racing career or if it affects the amount of money the horse earns.

It is common practice to have yearling horses scanned using fluoroscopy for OC before training starts. Most of the horses that have some form of OC "generally have surgery to remove the abnormality before it can cause any severe damage", according to the veterinarian who conducts a vast majority of the fluoroscope exams on Illinois horses, Dr. Philip Kapraun. The scans can be done for a number of reasons such as if swelling or lameness is noted, but many owners scan horses as a routine procedure.

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Chapter 1

General Introduction

Characteristic and Origin of Osteochondrosis

Osteochondrosis (OC) is a disease of the growth cartilage that can be found in multiple species such as pigs, horses, cattle, cats, dogs, and rats (Ytrheis et al., 2007). Osteochondrosis was first described in 1887 by Konig. It has been described as the loose or semi-loose fragments in the joints that could have been caused by minimal trauma acting on an underlying lesion, mild trauma and necrosis, or severe trauma (Weeren, 2011). The etiology of osteochondrosis has many factors such as trauma, diet, increased growth, hereditary, anatomical characteristics, and a defect in the blood supply to the epiphyseal cartilage. It cannot be due to just one cause (Ytrheis et al., 2007). It has been found that osteochondrosis lesions develop much earlier than previously thought and as early as the first few months of life. This may occur during the most extreme phase of growth (Lecoco et al., 2008). Abnormalities can generally be in the early stages of life, but many lesions heal on their own and do not require surgery (Hurtig et al., 1996). There is even evidence that lesions that are comparable to OC may be present in foals from age 2-18 days (Lecoco et al., 2008). Osteochondrosis lesions occur when there is an area of cartilage that fails to undergo matrix calcification or vascular invasion preventing it from becoming bone (Ytrheis et al., 2007). During the process of growth, remodeling and ossification of the articular side of the epiphysis, which functions as a type of growth plate, there is a thin layer of articular cartilage that develops in the mature animal. This is the place at which equine OC lesions develop (Weeren, 2011). In the horse, there are three common places to find OC

from the highest to lowest in occurrence respectively, which are the tarsal, femoropatellar, or metatarsophalangeal/metacarpophalangeal joints. However, the common places to find OC do differ between breeds. Warmbloods and Standardbreds follow the mentioned pattern, but lesions in Thoroughbreds are more common in the femoropatellar joint (Weeren, 2011). There are several equine breeds that have a predisposition to developing osteochondrosis. In the Standardbred, it is thought that up to 50% of the disease is heritable but the mode of inheritance has yet to be identified (Hurtig et al., 1996). In other species of animals it has been shown to occur in different areas, such as in the pig, it is more common to see the lesions on the medial aspect and sagittal ridge of the distal condyle of the humerus or the medial condyle of the femur. However, in the dog it is more common to see OC lesions in the caudal central aspect of the humeral head as well as in 3 other different locations than in the pig. It has also been shown that medium and large sized dogs are most likely to be affected by osteochondrosis than smaller dogs as well as males more likely than females (Ytrheis et al., 2007).

Another area that researchers are evaluating as a possible cause of osteochondrosis, is nutrition and growth. There have been multiple studies to look at nutritional factors related to OC. One study looked at oral supplementation of copper to pregnant mares. Oral supplementation decreased the occurrence of OC, but injectable copper supplementation during late pregnancy did not help. This could be because the injections were given too late, and the OC lesions had already begun to develop (Lecoco et al., 2008). Another study found that copper supplementation to mares during pregnancy was associated with neonatal liver concentrations and the repair of the lesions. This finding suggested that there was a positive

effect on the repair of a lesion but not on the development of the disease as the result of copper nutrition (Weeren, 2011).

When looking at rapid growth, there have been data finding that rapid growth is not necessarily essential for the development of OCD, but can be a factor (Yrtheis et al., 2007). There has been a high incidence of OC in rapidly growing horses but not all these horses will develop lesions and even foals with moderate growth can develop lesions if they have a predisposition (Hurtig et al., 1996). The time from weaning to 12 months, is an important time to make sure the foal has adequate mineral supplementation and grows at a moderate rate to help decrease the risks of OC. Once the horse reaches 12 months, the chance of OC significantly decreases (Secombe et al., 2012). Feeding strategies to achieve steady growth in foals may help to decrease the risk of lesions. Depriving the foal of protein can cause a rapid compensatory growth spurt when it is re-fed which can lead to other problems in addition to OCD (Hurtig et al., 1996). The goal of diet modification is to slow the skeletal growth rate while still providing the appropriate levels of protein and minerals to promote proper bone development (Secombe et al., 2012). Researchers are trying to identify affected foals before a lesion occurs and develop a targeted supplement that will circumvent the defect and allow normal development.

There are many studies that have looked at exercise as a potential factor in OC, but the exact role is still far from clear. Some studies have shown that regular, not strenuous, but limited exercise reduced the risk of osteochondrosis development (Weeren, 2011, Praud, 2013.) while in another study forced exercise was found to affect the distribution of OCD lesions but not the number (Hurtig et al., 1996). When looking at the etiology of trauma on OCD

one study looked at dropping pigs at a young age from various heights to see if they had more lesions than a similar control group that was dropped. It concluded that trauma was a cause of OCD as the pigs that were dropped had more lesions than those not dropped (Ytrehus et al., 2007). Its role in the actual development of OCD appears to be very limited and does not explain why OCDs occur in specific sites (Ytrheis et al., 2007). Equine osteochondrosis probably only has a few essential causes besides direct blunt trauma to a joint causing an osteochondral fracture in a typical location (Trotter et al., 1996). However, the role of trauma could depend on the stage of the disease, and generally the trauma only has to be minimal to result in the onset of symptoms (Ytrheis et al., 2007). When looking at the causes of OCD there is little to no evidence that rapid growth, dietary factors or major trauma play a role in the cause of OCD but genetics and anatomic factors do (Ytrheis et al., 2007).

Researchers are trying to determine the genetic risk factors for OCD and one factor they are looking at is the underlying shared predisposition in horses to developing orthopedic disease in general, but they need to narrow their focus to get the underlying factors (Hurtig et al., 1996).When looking at different species like pigs, horses, and dogs there is a difference in the prevalence of OC, that shows that there is a heritable component (Ytrheis et al., 2007). There has been speculation that the cause of this diseases may lie within one or more of the genes that are necessary for the skeletal development of the cartilage and joints (Hurtig et al., 1996). In each of the joints, there are predilection sites to find OC lesions. In the tarsal joint the most common place is the cranial end of the distal intermediate ridge of the tibia. Also, OC lesions are generally bilateral in occurrence and more common in the tarsus and femoropatellar joints (Weeren, 2011). In one study, it was concluded that the inheritance of certain joint

shapes and exterior conformation increased the severities of joint lesions. This was supported by different studies that concluded that anatomic characteristics are important in the etiology of osteochondrosis (Yrtheis et al., 2007). The long-term goal is to be able to identify horses with a high genetic predisposition to this disease and through management of nutrition and exercise to essentially prevent the disease's development (Hurtig et al., 1996).

Osteochondrosis occurs when there is a disturbance in the process of endochondral ossification that results in the difference in the thickness of the epiphyseal cartilage (Weeren, 2011). Researchers have yet to determine if the primary or secondary causes of OC are molecular changes in the cartilage collagen and metabolic changes (Lecoco et al., 2008). As the horse becomes older, the areas of epiphyseal cartilage become weak as the cartilage canals regress and disappear by seven months of age (Weeren, 2011). The term Ischaemic chondronecrosis describes the condition of chondrocyte necrosis in the cartilage canals. These have been identified as the sites predilected for OC in young animals (Olstad, 2013). One study was designed to show the changes in the epiphyseal development and other potential precursors to OCD using polarized light microscopy as well as picrosirius red stain (Lecoco et al., 2008). The higher grade of extracellular matrix decreased in fetuses as they became older and even after they were born which shows that there is a substantial change in development as the normal matrix increases with time (Lecoco et al., 2008). Necrosis begins as the cartilage canals regress because the deep layers of retained cartilage plugs cannot be perfused. Areas that begin to become necrotic can become detached by biomechanical forces (Weeren, 2001). OCD are generally thought to result from physical or traumatic force acting upon a pre-existing OC lesion (Olstad, 2013). In one study using biomarkers, the growth curve was found to be very

steep during the first five months, but gradually leveled out. It was also found, using skeletal biomarkers that there was a definite change in ratio and concentration by 20-30 weeks. This is about the time when the disappearance of fetal blood supply to the cartilage causes maturation of the skeletal blood supply (Donabedian et al., 2008). One study determined that surgical transection of two adjacent radial vessels in the lateral pouch of the left femoro-patellar joint resulted in ischaemic chondronecrosis (Olstad, 2013). As this disease has a variety of factors that can play a role, it is very difficult to determine the process or origin of lesions (Weeren, 2011).

The factors of osteochondrosis have been accepted as being multifactorial involving nutrition, genetic factors, endocrine elements and biomechanics (Pieramati et al., 2003). Loss of performance and lameness in the horse is most commonly a result of osteochondrosis and palmar/plantar first phalanx osteochondral fragments (Lykken et al, 2013). There have been studies showing the effect of heredity on OCD. One study by Stromberg and Rejno observed a familiar association among the progeny of 2 stallions finding a high frequency of OCD (Pieramati et al., 2003). Prevention of these diseases many be able to be addressed through selective breeding, but there needs to be further knowledge about how heritability and genetic factors affect the likelihood of these diseases (Lykkjen et al., 2013). In the study by Lykkjen, it showed that there was a significant difference between genders on the development of OCD in the medial malleolus of the tibia. It also showed that in Norwegian Standardbreds 50.7% of the horses had one or more radiological lesions recorded. This was significantly higher than in Swedish Standardbreds (Lykkjen et al., 2012).

Conclusions

Osteochondrosis lesions are a major concern in the equine industry as it takes an economic toll on the owners and trainers as well as sets a horse back in performing its duties whether it is competing in horse shows or racing. This is a very treatable disease but can be costly to the owners if surgery is required, not including the time lost for recovery from surgery. As a result, the causes of osteochondrosis are important subjects for research. Studies have looked at factors such as trauma, diet, increased growth, heritability, anatomical characteristics and a defect in the blood supply to the epiphyseal cartilage. These studies have found little to no evidence that rapid growth, dietary factors, or major trauma play a role in the cause of OC, but that genetics and anatomic factors are major considerations. While there have been studies to determine the causes of osteochondrosis and studies to determine surgical procedures for the best outcome, there has been little research looking at the performance of racehorses after the removal of osteochondral fragments. This is an important area of study as we do not know how well horses' race after removal of OC lesions and how much money they make compared to horses that did not have any lesions to begin with. Part of this evaluation is the question of the longevity of the horse on the race track after osteochondral fragments have been removed. This is valuable information for horse owners faced with the decision regarding surgical removal of osteochondral fragments in their horses.

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Chapter 2

Relationship of Osteochondrosis in Yearling Standardbreds to Subsequent Race Earnings and Number of Starts at Two and Three Years of Age

Introduction

Osteochondrosis (OC) is an orthopedic disease involving failure of endochondral ossification of the cartilage precursor to bone (Hurtig et al., 1996). The prevalence of OC across various breeds of horses has been found to vary from 5% in Canadian draft horses (Riley et al., 1998) to 61.7% in South German Coldbloods (Wittwer et al., 2006). There have been many studies of the prevalence of osteochondrosis in many different breeds such as Standardbreds, Danish and French Trotters and Thoroughbreds. One recent study of 315 Standardbred yearlings found that 58% (n=184) presented with OC lesions (Kapraun et al., 2008). A retrospective study of 243 Danish Trotters that were radiographed prior to commencement of racing found no relationship of OC status to subsequent earnings (Jorgensen et al., 1997), however horses with multiple lesions were found to have reduced earnings and longevity. A study of 865 French Trotters found that abnormal radiographic findings in two-year-olds prior to racing resulted in reduced longevity of their racing careers (Courouce-Malblanc et al., 2006). There have been other studies that have looked at the prevalence of Osteochondrosis and the effect it has on a horse's racing career (Robert et al., 2013, Jorgensen et al., 1997).

It has become common practice to radiograph yearlings either before or after purchasing. There have been many studies done on the performance of Standardbreds with reference to Osteochondrosis. These have suggested that horses with Osteochondrosis have a poorer performance than horses that are unaffected with OCD (Roberts et al., 2013) however, the results from these studies have yet to be shown to apply to Thoroughbreds (Roberts et al., 2013). A study of Standardbred horses with fragments in the metacarpo/metatarsophalangeal joints found that there were lower earnings and fewer starts for those horses than horses without (Jorgensen et al., 1997). Thoroughbreds have a different racing career than Standardbreds as they tend to start racing earlier and have shorter racing careers (Robert et al., 2013). Such breed differences suggest that more research should be in this area. The osteochondrosis lesions tend to be different in these two breeds as well as the type of stress differs between horses racing at the trot and the canter (Roberts et al., 2013). In the study by Jorgensen (1997) there were 243 horses that were split into 6 groups with group 0 being free of OCD, group 1 had OCD in tibiotarsal joint, group 2 had OCD in metacarpo/metatarsophalangeal joint, group 3 had 2 joints with OCD, group 4 had traumatic OCD and group 5 had combined lesions. These horses were then evaluated for active racing years, earnings per year and earnings per start and were watched for their 4th, 3rd and 2nd year racing seasons. The findings in the Thoroughbreds showed different results. In Thoroughbreds, the fetlocks, then carpi, and distal part of the tarsus were affected the most. Horses with higher grades of OCD and more lesions were less likely to race, with females having a more reduced chance. The three groups come from research groups in different years. Group 1 was horses from 1997-1998, Group 2 was horses from 2002-2004 and Group 3 was horses from 1998-2000. The

difference between the groups showed that between group 1, 2, and 3, group 3 had a decreased chance of racing at age 5. It also found that Group 1 had an increased risk of, not racing at age 3. Even though, group 2 had a lower prevalence of radiographic findings than other groups there was no difference between severity and significance of radiographic findings. The percentage of horses that raced from this study was 75% at age 3. This is consistent with other studies (Roberts et al., 2013). A study looking at Standardbreds showed there was no significant difference (P=0.7) between horses with OCD and horses without when looking at the number of starts as well as no significant difference (P=0.8) between the average earnings per start and the overall average earnings (Jorgensen et al., 1997). A study of racing Thoroughbreds showed that the location of the OCD did have an impact on racing ability. Earnings were also lowered if the fragment was located at the proximal sesamoid base (Roberts et al., 2013).

The current study tests the hypothesis that yearling Standardbred horses that were found to have radiographic abnormalities related to OC will have reduced two and three-year-old earnings and starts, using previously obtained data.

Materials and Methods

Eight hundred and nineteen yearling Standardbreds, 354 born in 2005 and 465 born in 2006 were used. Each horse had fluoroscopic radiograph examinations of stifles, hocks, front and rear fetlocks and knees performed by the same veterinarian, trained in the detection of osteochondrosis with the fluoroscope and over 20 years' experience. All horses were examined

by the request of their owners prior to race training and independent of clinical signs of lameness. The number of starts, 2 and 3-year-old earnings, and the OC status were recorded for each horse. Horses that were free of lesions were assigned a score of "zero" and horses that had radiographically detectable lesions were assigned a score of "one".

Fluoroscopy is an imaging technique that uses real-time images of internal structures of patients through the use of a fluoroscope. A fluoroscope uses an X-ray source and a fluorescent screen between which the tissue or joint, in this case, is. This can then be partnered with a video camera so that the image can be on a screen. This procedure is commonly used for observing the gastrointestinal tract or for orthopedic surgery. This method is especially helpful in determining the OC status as the movement can be in skeletal structures and joints. It also allows for an infinite number of angles to be.

The determination of association between the OC status and starts was done using Chi-square analysis. The statistics were computed using PROC FREQ in SAS version 9.2. Comparisons of the distribution of earnings by the OC status were computed using PROC TTEST in SAS Version 9.2.

Results

Of the 819 horses, 462 were determined to be free of Osteochondrosis while 357 had some form of OC. Table 1 shows the relationship of starters versus non-starters according to the OCD status. Among the horses without lesions, 75% made at least one start compared to 70% of horses with lesions. Based on using Chi-square test there was not a significant association between the OCD status and starts ($p=0.1048$).

Table 1: Race starters according to the OCD status

OCD_Status	Starts		
Frequency **Row Pct**	**0**	**1**	**Total**
0	115 24.89%	347 75.11%	462
1	107 29.97%	250 70.03%	357
Total	222	597	819

Statistic	DF	Value	Prob
Chi-Square	1	2.6305	0.1048

Table 2 compares the number of starts for horses according to the OCD status. Table 2 also shows the 95% confidence limit for the means, the Standard Deviation and the range of values observed. Even though, the horses without lesions had a higher average number of starts than compared to the horses with lesions the difference was not statistically significant (p=0.1909), computed using Proc T-Test.

Table 2: Number of starts for horses without and with lesions

OCD_Status	Mean	95% CL Mean		Std Dev	Minimum	Maximum
0	14.7381	13.5179	15.9583	13.3460	0	48.0000
1	13.5154	12.1478	14.8830	13.1388	0	49.0000

t test	DF	t Value	Pr > |t|
	817	1.31	0.1909

Table 3 shows two-year-old earnings for horses according to the OCD status. Table 3 also shows the 95% confidence limit for the means, the Standard Deviation and the range of values observed for all horses in the data set. The difference of $3,436 in earnings was not statistically significant (p=0.1725), as the range of earnings values for horses both with and without lesions was quite large, with many horses in both groups having zero earnings while a few horses in each group had earnings of several hundred thousand dollars.

Table 3 Two-Year-old earnings of horses without and with lesions

OCD_Status	Mean	95% CL Mean		Std Dev	Minimum	Maximum
0	$9,695	$5,927	$13,462	$41,209	0	$628,880
1	$6,259	$3053	$9,464	$30,802	0	$483,995

Table 3 continued:

t test	DF	t Value	Pr > |t|
	816.14	1.37	0.1725

Table 4 shows the mean earnings for the three-year-olds, the 95% confidence limit for the means, the Standard Deviation and the range of values observed for all horses in the data set. The mean earnings for 3-year-old horses with lesions were actually higher than the earnings for 3-year-old horses without lesions in this data set. The small difference of $1,881 was not significantly different (p=0.6802) between groups, however.

Table 4: Mean earning of three-year-old horses without and with lesions

OCD_Status	Mean	95% CL Mean		Std Dev	Minimum	Maximum
0	$12,515.4	$9,702	$15,328	$30,768	0	$436,666
1	$14,396.1	$5,882	$22,910	$81,795	0	$1,502,395

t test	DF	t Value	Pr > |t|
	434.1	-0.41	0.6802

Table 5 shows the mean combined earnings for two and three-year-olds, the 95% confidence limit for the means, the Standard Deviation and the range of values observed for all horses in the data set. The slight numerical advantage in earnings of $1,555 for horses without OCD lesions was not statistically significant (p=0.7872).

Table 5 Earnings for two and three-year-old years combined, without and with lesions

OCD_Status	Mean	95% CL Mean		Std Dev	Minimum	Maximum
0	$22,210	$16,413	$28,008	$63,415	0	$761,068
1	$20,655	$10,925	$30,385	$93,479	0	$1,606,728

t test	DF	t Value	Pr > |t|
	596.01	0.27	0.7872

Discussion

The results of this study found that there was no significant difference (P>.05) between the racing careers of horses with or without OCD lesions. This result has been found in other studies as well, confirming that more research needs to be done. A study by Jorgensen (1997) using Standardbreds showed there was no significant difference (P>.05) between horses with OCD and horses without when looking at average earnings per start, and average earnings (Jorgensen et al., 1997). A study by Robert (2006) on French Trotters found that horses with

multiple lesions did tend to have reduced earnings as well as a shorter racing career when compared to horses with only one lesion. It also suggested that genetics, racing ability, pain tolerance, temperament and conformation also play a role in a horse's racing career. It also found that 84% of horses that had poor performance were suffering from more than one problem (Roberts et al., 2006). We classified horses without lesions with a 0 and horses with lesions with a number 1. We did not look at the severity or number of lesions in the horses just looked at if they had them. If we would have looked at the number and even possibly the location, we may have had better statistical power in detecting differences. However, we were limited to the notation of the qualitative descriptions of lesions in our study.

The evaluation of 2-year-old earnings found that the horses without lesions made on average $9,695 and horses with lesions made on average $6,259. While this appeared to be a big difference, it was not significantly different (P>.05). One possible reason that horses with lesions made numerically less money could be that the horses may have had surgery to remove their OCDs, so they may have missed part or all of the two year old racing year to heal from surgery. In one study, horses that have gone through surgery have been found to perform successfully after surgery, and just as well as horses that did not have lesions (Robert et al., 2006).

The evaluation of 3-year-old earnings found the seemingly paradoxical result that horses with lesions actually made more money than the horses without lesions. Although this finding contradicted our hypothesis that both 2 and 3 year old Standardbred racehorses would have reduced earnings if OCD was found during yearling evaluations, it is possible that fewer starts at two (we didn't break out 2 year old starts and 3 year old starts separately), for any reason, is

beneficial for earning power at age three. Additionally, a single horse having an OCD lesion as a yearling was represented with over $1.5 million in earnings at three years of age, and that horse had a significant impact on the mean earnings of the horses in the OCD group, as well as the standard deviation and 95% confidence limit.

Another study found that horses with grades of 4-8 or more findings (radiographic abnormalities) were less likely to race at age 2, although most of those horses raced at age 3 (Robert et al., 2013). Another study done by Robert (2006) found that 4 out of 5 horses that had surgery to remove an osteochondral fragment in the fetlock went on to race successfully, which is also consistent with a study done by Whitton (1994) that found 80% of horses went on to improve their performance after having arthroscopic surgery. It further found that lesions in the carpus or the distal tarsus were unlikely to influence the early racing career, whereas if the lesions were in the fetlock or proximal tarsus joints, it significantly decreased racing success. Another study found that the removal of OCD lesions may only be beneficial in horses that show lameness and swelling (Jorgensen et al., 1997).

It is possible that our data set, identifying horses only as having radiographically detectable OCD lesions or not, lacked the specificity of lesion types to detect differences in racing performance. For example, studying subsets of horses having specific subtypes of stifle, hock or fetlock lesions may have found a greater relationship between lesions and racing performance (Couroure-Malblanc et al., 2006). Furthermore, all of the horses in this study were radiographed by one veterinarian with most examined in Northern Illinois, hence the diversity of the horse population may not have represented the population of Standardbred horses in

the US or North America. A larger number of racehorses representing more sires lines might have better reflected the genetic influences on this disease. It is possible that if horses from all over the country had OCD status determined, and were followed throughout their racing careers, then a different result may have been found for racing success beyond ages 2 and 3 years. The current study attempted to determine differences in racing performance of young horses as related to the OCD status as yearlings before their racing careers began. Information that was lacking in the current study, that would have been helpful, was the subsequent veterinary treatment of horses found to have OCD lesions at an early age. If most of the horses with lesions in the data set had surgery to remove OCDs that fact alone could obscure many differences that may have been found otherwise, if no surgery were performed. Due to this consideration, a subsequent chapter summarizes our findings from a survey of Standardbred horse owners possessing yearlings with OCD lesions. The purpose of the survey was to estimate the rate of surgery among horses found to have OCD lesions.

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Chapter 3

Influence of Sire on Osteochondrosis in Illinois Yearling Standardbreds

Introduction

The etiology of Osteochondrosis has many factors such as trauma, diet, increased growth, hereditary, anatomical characteristics, and a defect in the blood supply to the epiphyseal cartilage. It cannot be limited to just one cause (Ytrehus et al., 2007). The loss of performance and lameness in the horse is most commonly caused by Osteochondrosis and palmar/plantar osteochondral fragments (Lykkjen et al., 2013). A single sire can produce up to 70% OC affected foals and making those foals twice as likely to have offspring that develop OC (McCoy et al., 2013). When looking at different species such as pigs, horses, and dogs, there is a difference in the prevalence of OCD demonstrating a heritable component (Ytrehus et al., 2007), when looking at certain breeds of pigs and certain breeds of horses, such as the Standardbreds, Warmbloods, Thoroughbreds and French Trotters. Genome-wide Association (GWA) studies have examined specific locations of OC manifestations along with looking at the overall occurrence of OC in commercial pigs (McCoy et al., 2013). To date, no specific gene or alleles have been identified as an underlying risk (McCoy et al., 2013). The knowledge of how heritability and genetic factors affect the likelihood of these diseases may be achieved through the examination of selective breeding (Lykkjen et al., 2013). In one study, it was concluded that the inheritance of certain joint shapes and exterior conformation increased the severities of joint lesions. This was supported by different studies that concluded that anatomic characteristics are important in the etiology of osteochondrosis (Ytrehus et al., 2007). Another

approach is through identifying the genetic risk factors through techniques such as genome-wide association and candidate gene approach (McCoy et al., 2013). There have been studies that found an effect of heredity on OCD. One study by Stromberg and Rejno (1978) observed a familiar association among the progeny of two stallions finding a high frequency of OCD. Another study done found that heredity had a large impact on prevalence, severity and location of OCD but showed no relation between increased growth rate and OCD (Ytrehus et al., 2007). Another study also found that females tended to have shorter racing career than males. As soon as their racing performance dropped they were retired to become broodmares (Robert et al., 2013). However another study did not find an effect on outcome when looking at lineage, age, sex and heterozygosity (Lykkjen et al., 2013). When looking at all the causes of OCD there is little to no evidence that rapid growth, major trauma or dietary factors play a role in the cause of OCD but genetics and anatomic factors have been implicated (Ytrheis et al., 2007).

In our current study, we hypothesized that sire would be a significant factor in determining which horses had OCD lesions.

Materials and Methods

There were 818 offspring of 191 sires in the data set that were initially evaluated to determine differences in OCD rates according to sire. Horses that were free of lesions were assigned a "zero". Horses with lesions were assigned a "one". There were three kinds of tests used to see if a sire had a significant effect on OCD occurrence. These tests were the Likelihood Ratio test, Score test, and Wald test. However, the estimation was found to be unstable when

using all the observations, which included many stallions represented by only single offspring. The observations were then run again using sires with more than two observations to see if it would give a more accurate result as there were many sires with only one observation. This decreased the number of observations to 729. Again, the same three statistical tests were used. However, the estimations were still unstable for this case so the observations were again decreased to sires with more than three observations. This allowed the estimation to stabilize. So the final numbers of observations used were 603 offspring of a total of 45 sires.

Results

Using all the observations the p-values for the three tests, Likelihood Ratio test, Score Test, and Wald test are shown in Table 1.

Table 6: P-values of tests for differences in OCD rates of offspring of all sires

Test	P-Values
Likelihood Ratio test	0.0173
Score test	0.6764
Wald test	1.0000

In Table 6 the p-value for the Likelihood Ratio test shows that Sire had a significant effect ($P<.05$) on OCD occurrence in the yearling standardbreds whereas the other two tests show that there was no significance effect ($P>.05$). Although the Likelihood Ratio Test using all

the observations found that the effect of the sire was significant, it cannot be trusted based on the other two tests not finding a significant effect. This could have resulted because there were many sires that had only one observation, causing the estimation to be unstable, as these sires do not have adequate observations to be dependable.

To try and correct this unstableness, the sires with more than two observations were used. In Table 7 the p-values for the three tests were recalculated using only sires with more than two offspring.

Table 7: Sires with more than two observations

Test	**P-Values**
Likelihood Ratio test	0.1623
Score test	0.6376
Wald test	1.0000

The p-values for these tests using only sires with more than 2 observations found that there was no evidence that Sire had an effect on OCD occurrence, however this estimation was still unstable due to the wide range of p-values among the three tests.

Table 8: Sires with more than three observations

Test	P-Values
Likelihood Ratio test	0.8260
Score test	0.8975
Wald test	0.9809

The tests were run again for Sires that had more than three observations and the estimation then stabilized. However, the p-values for all three tests ranged from 0.82 to 0.98 which means the three tests did not find any evidence of Sire related with OCD occurrence in the data set that was available to us for the current study.

Discussion

This study did not find any relation between sires and the heritability of osteochondrosis. We might have found different results if we had a greater number of offspring for each sire. The prevalence of sires in this data set with just a few offspring each was a bit of a surprise since many Standardbred stallions are bred to up to 140 mares per season nationwide. For this reason, it appears that the horses evaluated for OCD in this study included quite a few "home breds" that were not the result of major large-scale breeding programs.

In studies like these, the long-term goal is to be able to determine the horses with a high genetic predisposition to this disease, so that management of other risk factors such as nutrition and exercise may help to prevent the disease's development (Hurtig et al., 1996). The study by Lykkjen (2013) used 1,217 horses with a total of 22 sires, and found that there was a significant effect ($P<.05$) on heritability which implicated the role of genetics in the pathogenesis of palmar/plantar first phalanx osteochondral fragments. That study had the advantage of having more observations per sire than in our current study, and also focused more on a particular type of osteochondral defect that has been found to be more consistently associated with lameness. There are several equine breeds that have predispositions to osteochondrosis but in the Standardbred industry it has been found that up to 50% of the disease is thought to be inherited but the genetic defect has yet to be identified (Hurtig et al., 1996). One study found that up to 70% of foals of a single sire can be affected with OC (McCoy et al., 2013). Another study by Stromberg and Rejno observed a familial association among the progeny of 2 stallions finding a high frequency of OCD. One study speculated that the cause of this disease may lie within one or more of the genes that are important in the skeletal development in the cartilage and joints (Hurtig et al., 1996). To determine which genes are the risk factors there are two different approaches being used. They are Genome-wide approach and candidate gene approach (McCoy et al., 2013). These two approaches have identified several promising regions, but they have their limitations (McCoy et al., 2013). The etiology of Osteochondrosis has many factors such as trauma, diet, increased growth, hereditary, anatomical characters and a defect in the blood supply to the epiphyseal cartilage. It cannot be limited to just one cause (Ytrheis et al., 2007). The risk factors of Osteochondrosis in horses and

pigs is anywhere between 14% and 52% when looking at genetic factors with these species (McCoy et al., 2013). Another study found that horses that are deficient in copper were diagnosed with bone disorders but if the mares were supplemented with copper in the late stages of pregnancy the foals had a lower incidence of OCD (Hurtig et al., 1996). By determining horses that are predisposed to develop OCD, they can be managed so that if surgery is required it can be done early enough to allow the horse to go on to perform very well (Hurtig et al., 1996). As improvements in next-generation technology improves, as study in this field is ongoing, pathways and genes will be identified in different livestock species which will in turn further studies in humans as well (McCoy et al., 2013).

In the current study, we may have had better results had we looked at specific lesions that cause lameness instead of just looking to see if the horse did or did not have lesions. It may have also helped if we only looked at stallions that had a large number of offspring, so we had a bigger, less diverse data set. Unfortunately, we were very limited in our resources as we looked at data from only one veterinarian who scanned horses mainly in Northern Illinois.

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Chapter 4 - Appendix

Follow-up survey of horse owners with yearlings having fluoroscopically-detected radiographic abnormalities

Due to uncertainties related to the surgical status of horses represented in chapter 3 ("Relationship of Osteochondrosis in Yearling Standardbreds to Subsequent Race Earnings and Number of Starts at Two and Three Years of Age"), we devised a survey to try to estimate the percentage of horses with OCD lesions that had surgery to remove them. We thought this information might help us to determine if this variable may have affected the outcome of their racing careers.

The survey contained five questions (Figure 1) but as question 4 and 5 were not independent of each other the responses to these two questions were combined into three categories. These categories are shown in Figure 2. The first three questions were not statistically analyzed but confirmed what we stated in the earlier chapters that horses are routinely scanned for OCDs. The answers to question one indicated that while there were some horses that were scanned for reasons such as inflammation (13%), swelling (12%) or boggy joints (7%), the majority were scanned because it was routine procedure (64%). There were 4% that wrote other as the reason for the scan, but did not give any specifics. This was again confirmed in question three where 83% of the horses were scanned as a routine procedure. The answers to question two showed that 53% of the horses had no symptoms before the scan. Only 19% showed swelling, 18% had pain, and only 10% had inflammation.

The average number of starts and subsequent earnings over a four year period were compared for these three groups of horses using Analysis of Variance (ANOVA). We had access to a longer record of racing information in this smaller group of horses and decided to use all of the racing observations available. A total of 361 surveys were mailed to the owners of horses identified in chapter 3 as having fluoroscopically-detected radiographic lesions. Of those 361 mailed surveys, 80 were returned, with 78 total horses represented in the returned surveys. There were two surveys that were returned saying that they did not know the reasoning behind the scanned, so they were excluded.

Figure 1: Survey Form

1) Why did you have your horse scanned?

   Routine Procedure Swelling Other:_____

   Boggy Joins Pain

2) Was there pain, swelling or inflammation that was noticed before the scan? Circle all that apply.

   Pain Inflammation

   Swelling

3) Was the scan part of routine procedure?

   Yes No

4) Was surgery recommended?

   Yes No

5) Was surgery performed?

   Yes No

Figure 2 Summary Statistics

Surgery recommendation/action	N Obs	Variable	N	Mean	Std Dev*	Minimum	Maximum
Not Recommended	22	FourYr_To_Date_Starts	22	11.14	19.34	0.00	72.00
		SubsequentEarnings	22	10083.32	29363.73	0.00	130640.00
Recommended but not Done	7	FourYr_To_Date_Starts	7	11.43	18.35	0.00	47.00
		SubsequentEarnings	7	5362.43	9225.87	0.00	24855.00
Recommended and Done	49	FourYr_To_Date_Starts	49	7.47	17.18	0.00	78.00
		SubsequentEarnings	49	11406.29	35428.11	0.00	175240.00

The mean number of starts was lower among the horses for whom surgery was recommended and done compared to the other two groups (7 versus 11), but the horses for whom surgery was recommended and not done had the lowest mean earnings ($5,362 versus $10,083 and $11,406).

Differences between the groups related to surgical recommendations and actions were not significant (P>.05), as the standard deviations were quite large compared to the means.

One category that was difficult to characterize was “surgery not recommended”. The recommendation of no surgery for some horses with radiographic abnormalities was made by the Veterinarian, based in his expertise and experience in risk and benefits assessment of surgical intervention with lesions. Most of the recommendations of no surgery were based upon the assessment that the likelihood of minor lesions causing significant lameness was small (based on interview with Dr. Philip Kapraun, DVM). Eighty-eight percent of the horses

represented in the survey results had surgery. Assuming that the high percentage of survey responders closely represent the percentage of owners performing surgery in the entire data set, then the fact that most of the horses with OC in our data set likely had surgical intervention may have obscured possible effects of OC on performance parameters measured in this study.

For the survey results to be more conclusive, a larger group of horses that were recommended for surgery but did not have surgery would have been desirable. This might help to determine if the preexisting lesions had a significant impact on their racing careers. The results might have been more conclusive if the groups had more equal numbers of horses to compare these results better. However, the picture that develops from studying this population of race horses suggests that the vast majority of horses with OC have surgical intervention, which may obscure differences in performance between affected and non-affected horses that could have been detected otherwise. Although the results of this study found no significant differences in subsequent racing performance of horses with or without OC lesions as yearlings, it was anticipated that there might be significant "noise" from the detrimental effects of various sources of exercise intolerance related to various body systems. These other sources of exercise intolerance could include respiratory, cardiovascular and muscular systems as well as other parts of the skeletal system including soft tissues such as suspensory ligaments and digital flexor tendons.