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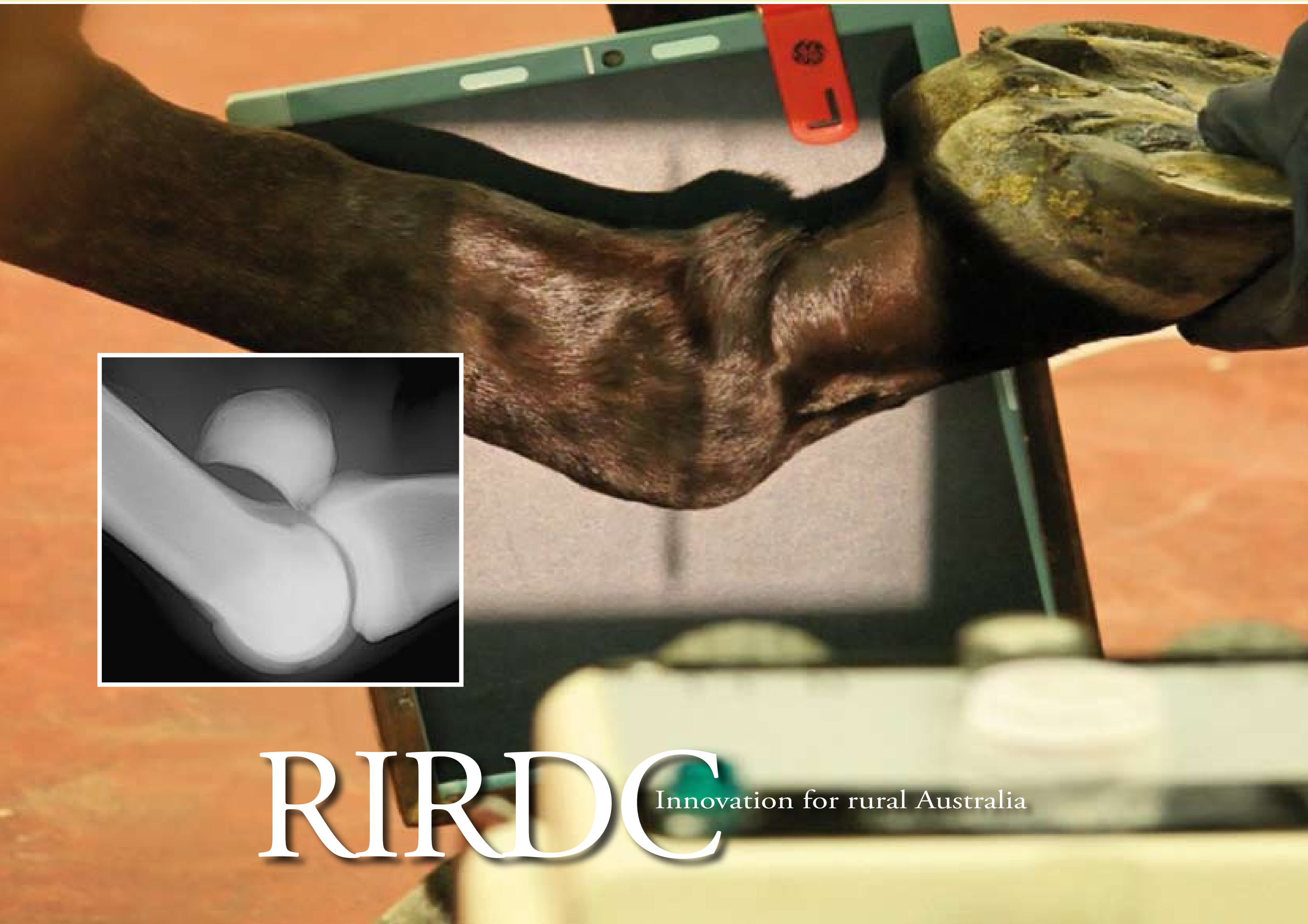
A Prospective Study of Presale Radiographs of Thoroughbred Yearlings

RIRDC Publication No. 09/082



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A Prospective Study of Presale Radiographs of Thoroughbred Yearlings

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July 2009

RIRDC Publication No 09/082
RIRDC Project No PRJ-000615

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ISBN 1 74151 882 2
ISSN 1440-6845

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Electronically published by RIRDC in July 2009
Print-on-demand by Union Offset Printing, Canberra at www.rirdc.gov.au
or phone 1300 634 313

Foreword

Thoroughbred yearling sales are an important part of the racing industry. In 2003, 76.4% of the $218 million grossed from sale of Thoroughbred horses was from the sale of yearlings. Previous studies have shown that purchasing a yearling as a potential future racehorse is a high risk investment. Orthopaedic disease and musculoskeletal injuries are common causes of economic loss within the racing industry. Radiograph repositories were introduced to Australian Thoroughbred yearling sales in 2003. The effectiveness of a pre-purchase radiographic examination is limited by the quality of that examination and the experience of the person interpreting the radiographs. To the best of the authors' knowledge there have been no studies investigating inter-and intra-radiologist agreement for reporting of abnormal findings on pre-sale radiographs of yearlings or outlining the common mistakes made when radiographing horses based on examination of a large number of radiographs. Radiograph repositories have provided an opportunity for research into orthopaedic lesions in Thoroughbred yearlings. Studies from the USA investigating orthopaedic abnormalities in yearling Thoroughbreds have found some associations with decreased race performance. However there have been limitations in the assessment of some abnormalities due to low reported prevalence. The prevalence and effect of orthopaedic lesions in Thoroughbred yearlings under Australian conditions is not known.

There were 2401 sets of radiographs obtained from the repository systems of auction sales in Australia in 2003. Radiographs were reviewed by one of four veterinary specialist radiologists. Racing performance at 2 and 3 years of age was obtained from the relevant racing authority. This data was used to assess the economics of investing in a thoroughbred yearling, the agreement within and between radiologists for radiograph interpretation, the quality of radiographs submitted to repositories in 2003, and the prevalence and effect on race performance of radiographic lesions.

The findings from this study will benefit veterinarians who undertake pre-purchase examination of yearlings, buyers and sellers of yearlings, sales companies, racing authorities and equine researchers.

This study demonstrated associations between sale price and all measures of race performance at 2 and 3 years of age. The probability of recouping the combined estimated costs and purchase price in the first two years of racing is 5.1% indicating that the yearling market must be determined by factors other than expected returns from racing. It is important for policy making and the survival of the racing industry that racing authorities investigate all the factors that determine the yearling market.

Agreement within and between radiologists was substantial or better for larger lesions identified on radiographs, but repeatability tended to be fair or slight for more subtle lesions, and those where categorisation was difficult to define. Care should be taken when interpreting the findings of studies that rely on radiographic categorisation of lesions where repeatability is low. There is a need for the standardisation of radiographic interpretation based on easily recognisable factors.

Poor positioning of radiographs was the most common cause of poor quality images. Care in positioning is especially important for maximising radiographic quality.

Large numbers of orthopaedic lesions were identified on radiographs submitted to yearling radiograph repositories in Australia in 2003. The prevalence of individual lesions was similar to those previously reported.

A number of associations between lesions observed on radiographs of Thoroughbred yearlings and race performance were identified. Large osteochondrosis lesions of the sagittal ridge of hind fetlocks are associated with poorer performance. It is also possible that stifle osteochondrosis lesions and subchondral cystic lesions, as well as forelimb sesamoid abnormalities (fracture, lucency and modelling) are associated with poorer performance. Due to the small number of observed cases for some radiographic lesions conclusions regarding their effect on race performance could not be made. Further investigation of the effect of these lesions on race performance is needed. This study only

assessed the effect of lesions on race performance at 2 and 3 years of age. The long term effect of the observed lesions on race career is not known.

This research was funded by Rural Industries Research and Development Corporation and Racing Victoria Limited.

This report, an addition to RIRDC's diverse range of over 1800 research publications, forms part of our Equine R&D program, which aims to assist in developing the Australian horse industry and enhancing its export potential.

Most of RIRDC's publications are available for viewing, downloading or purchasing online at www.rirdc.gov.au. Purchases can also be made by phoning 1300 634 313.

Peter O'Brien
Managing Director
Rural Industries Research and Development Corporation

Acknowledgments

This research was jointly funded by RIRDC and Racing Victoria Limited. The authors thank Dr James Gilkerson for instigating collection of the radiographs used in the study, and owners and veterinarians who gave permission for radiographs to be made available. Magic Millions Pty Ltd and William Inglis and Sons Ltd supported the study by sending the radiographs from the repositories. A number of overseas race clubs made performance data available.

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What the report is about

This report describes a detailed examination of the quality of radiographs submitted to the first year of radiographic repositories at yearling sales in Australia, the repeatability of their interpretation, the prevalence of orthopaedic lesions identified by radiography, and the relationship between the lesions identified and future performance. The economic return for an investment in a yearling after its first 2 years of racing is also examined.

Who is the report targeted at?

The target audience includes veterinarians who examine yearlings and their radiographs at yearling sales, buyers and sellers of yearlings, sales companies, racing authorities and equine researchers.

Background

Radiograph repositories were introduced to decrease the number of radiographic examinations performed on horses and the number of disputes arising from the sale of horses with pre-existing problems. A high prevalence of orthopaedic lesions is observed on radiographs of yearlings. There is limited information on the quality of radiographs taken for sale repositories, the repeatability of interpretation of those radiographs, or the effect of lesions identified on future race performance.

Aims/objectives

This study aims to assess:

- the economics of investing in a Thoroughbred yearling;
- the quality of radiographs submitted to the repository system in Australia in 2003;
- the prevalence of radiographically-detectable orthopaedic lesions in Thoroughbred yearlings in Australia; and
- the value of radiographs, taken at yearling age, to detect orthopaedic lesions, for predicting future race performance.

Methods used

The selected sales were eight of the eleven premier Thoroughbred yearling auctions held by Magic Millions Pty Ltd and William Inglis and Son Ltd in Australia in 2003. A total of 2401 sets of radiographs were examined by one of four specialist radiologists.

Race performance data was collected by identifying the horse's racing name from the relevant Stud Books, and accessing race records from race club databases.

Radiologist agreement was determined by Kappa statistics and negative and positive agreement. Associations between radiographic findings and race performance were determined using logistic regression, analysis of covariance and negative binomial regression.

Results/key findings

An association between sale price and race performance at 2 and 3 years of age was demonstrated. With increasing sale price category there is an increased chance of earning back the estimated costs of training and a decreased chance of earning back the purchase price.

The probability of recouping the combined estimated costs and purchase price in the first 2 years of racing is 5.1%. The yearling market must be determined by factors other than expected returns from racing.

Large numbers of lesions were identified on radiographs submitted to yearling radiographic repositories in Australia in 2003.

In approximately half of the radiographic sets examined the requirements of the repository system were not met due to non-diagnostic or missing radiographs. Care in positioning of Flexed LM views of the fore fetlocks, LM views of the hind fetlocks and DMPaLO views of the carpus is especially important for maximising radiographic quality.

There was good intra- and inter-observer agreement for larger lesions identified on radiographs, but agreement was not good for more subtle lesions, and those where categorisation was difficult to define. Care should be taken when interpreting the findings of studies that rely on radiographic categorisation of lesions where agreement is low.

A number of associations between lesions observed on radiographs of Thoroughbred yearlings and race performance were identified. Large osteochondrosis lesions of the sagittal ridge of hind fetlocks are associated with poorer performance. It is also possible that stifle osteochondrosis lesions and subchondral cystic lesions, as well as forelimb sesamoid abnormalities (fracture, lucency and modelling) are associated with poorer performance. Conclusions on the effect of some lesions on race performance could not be made due to small numbers of observed instances. This study only assessed the effect of lesions on race performance at 2 and 3 years of age. The long-term effect of the observed lesions on race career is not known.

Implications and Recommendations

Some orthopaedic abnormalities were identified as being associated with poor performance. For this reason radiography is an important part of any pre-purchase examination. The repository system could be improved if issues such as poor film quality and consistency of interpretation could be resolved.

It is important for policy making and the survival of the racing industry that racing authorities investigate all the factors that determine the yearling market.

Care in positioning radiographs will result in the greatest improvement in quality of radiographs submitted to repositories.

Many studies utilise race performance as a measure of success for analysis. Incorporation of a horse value as a confounding factor may be of value in studies where the horse population is of varied quality.

There is a need for the standardisation of radiographic interpretation based on easily recognisable factors.

Further investigation of radiographic findings that occur in only a small number of cases is required to determine their affect on racing performance.

The long term effect of radiographically-observed orthopaedic disease in Thoroughbred horses needs to be established.

Introduction

Summary

This Introduction is divided into the following sections:

- The Thoroughbred industry in Australia
- Horse sales
- Radiograph repositories at auction sales, and
- Orthopaedic disease

The Thoroughbred Industry

Thoroughbred breeding and racing in Australia is a multi-billion dollar industry. In a report released in 2001 by the Rural Industries Research and Development Corporation, it was estimated that the Thoroughbred industry contributed $1.22 billion to the Australian Gross Domestic Product. Gambling on Thoroughbred racing was estimated to provide $452 million in Government revenue, and Thoroughbred breeding and racing contributed an estimated $1600 million in taxes to State and Federal Governments (Anon 2001; Gordon 2001).

Many people are involved in the Thoroughbred industry through employment and/or participation in the sport. Horse racing is Australia’s oldest national sport and is the second most popular sport as measured by attendances (Anon 2001). During the 1999/2000 race season, an estimated 5.2 million spectators attended the 3050 race meetings held across Australia (Anon 2001; Gordon 2001). The Thoroughbred breeding and racing industries provide over 249,000 full- or part-time jobs. In 2003, there were approximately 11,200 breeders, 133,000 racehorse owners, 6500 trainers, 1500 jockeys and 454 race clubs registered with the relevant governing bodies (Anon 2001; Ross 2003).

Horse Sales

Horse sales are an important component of the Thoroughbred industry (Beeman *et al.* 1992). It is estimated that there are 150 Thoroughbred auctions throughout Australia each year (Gordon 2001). These auctions consist of weanling, yearling, ready-to-run, racehorse, broodmare and mixed sales. Sale of Thoroughbred horses through public auction results in an approximate 8% turnover of ownership each year (Gordon 2001). In the 2002/03 season, 7167 Thoroughbreds were sold at auction. Sale of these horses grossed in excess of $218 million (Ross 2003).

Yearling Auction Sales

Yearling sales are the largest of the above-mentioned sale types, both in number of horses sold and gross sales. In 2001, 18,163 Australian Stud Book-registered foals were born. In the 2002/03 season, 4057 of these foals were sold as yearlings at auction sales. The top selling yearling was a brown colt by Sunday Silence which sold for $1.7 million at the Australian Easter Yearling Sale. Sale of yearlings in the 2002/2003 season totalled $166.5 million, with the average sale price being $41,000 (Ross 2003).

Purchasing a Yearling

Purchase of a yearling as a potential racehorse is a high-risk investment. Many problems can occur after purchase and prior to arrival at the racetrack. When a horse finally commences racing, its performance may be poor. In the United States, one study showed that 19% of 1162 premium yearlings sold at auction had not started in a race by the end of their 3-year-old year (Kane *et al.* 2003a). In the only Australian study to profile the expected race performance and earnings of Thoroughbreds it was reported that during the first year of racing 39.5% of 1804 horses followed earned no money and 86.9% did not earn enough to cover estimated training costs (More 1999). However racing prize money is not the only means by which horses can generate a return on money invested in their purchase. Many have successful breeding careers although some prior success on the track is generally required.

So why does a buyer take such risks in purchasing a yearling, rather than purchasing a racehorse that has proven ability on the track? The explanation is essentially one of expense. Proven racehorses attract a premier price. For example, Savabeel, the winner of the Cox Plate in 2004, was purchased as a yearling in 2003 for $400,000. It was reported that after the Cox Plate win the trainer was offered in excess of $30 million for the horse (Wilson 2004).

Pre-purchase Examination at Auction Sales

Prospective owners and trainers undertake pre-purchase examinations to ensure that they are purchasing a yearling with racing ability that is sound and will continue to stay sound once training and racing commence. This is particularly important as orthopaedic disorders and musculoskeletal injuries are well-known causes of economic loss within the racing industry (Bailey *et al.* 1997; Jeffcott *et al.* 1982; More 1999; Pool and Meagher 1990).

Pedigree Evaluation

Prior to the commencement of a sale, prospective buyers obtain a copy of the sales catalogue. The catalogue provides detailed pedigree information for each of the yearlings to be sold. The potential buyer examines the pedigree information and selects yearlings of interest for further inspection.

Yearling Examination

Buyers and trainers are given the opportunity to examine the yearlings prior to the commencement of the sale. Yearlings are inspected for growth potential, conformational problems, gross abnormalities, gait, temperament and evidence of behavioural disorders such as weaving or wind-sucking. If the yearling passes this initial evaluation the buyer will then consider further assessment by a veterinarian (Martin *et al.* 2003).

Veterinary Examination

Veterinary examinations can vary from a simple clinical examination to more complicated diagnostic procedures. In a clinical examination the veterinarian auscultates the heart on both sides of the chest to check for abnormalities such as arrhythmias. The eyes are examined for such problems as corneal damage. The legs and hooves are checked for heat, swelling, decreased joint mobility or scarring, which might indicate previous surgery or injury. The yearling is walked in-hand to allow the veterinarian to examine the gait and overall symmetry (Anderson *et al.* 2004; Beeman 1987; Mair 1998; Martin *et al.* 2003; Teigland 1992).

Following the clinical examination, the veterinarian discusses any findings with the potential buyer and a decision is then made as to whether to proceed with further diagnostic procedures. The extent of further veterinary examination requested depends heavily on the

expected price of the horse (Anderson *et al.* 2004; Dart *et al.* 1992; Goble 1992; van Hoogmoed *et al.* 2003). The most common procedures performed are endoscopy of the upper airway and radiography of the limbs. Endoscopy allows examination of the upper airways to detect abnormalities such as left laryngeal hemiplegia and epiglottic entrapment. Radiographs may be performed based on the clinical findings of the examining veterinarian or of predetermined areas based on sites known to be commonly affected by lesions. Ultrasonography of tendons and ligaments may also be requested. Blood samples can be taken to screen for anti-inflammatory drugs that may mask symptoms of injury or lameness (Anderson *et al.* 2004; Mair 1998; Teigland 1992; van Hoogmoed *et al.* 2003).

Radiography in the Yearling Pre-purchase Examination

For more than 30 years Thoroughbred yearlings at public auction sales have undergone pre- or post-sale radiographic evaluation (Soule 1987). However such radiographic examinations have in the past had limitations and difficulties (Howard *et al.* 1992; Teigland 1992).

The cost of pre-purchase examination of a yearling was borne by a potential buyer. If a buyer was interested in multiple horses these examinations could become a costly exercise. For this reason buyers did not want to share their findings with other potential buyers. To help decrease the cost, some sales allowed buyers to undertake a radiographic examination immediately post-sale and before the animal had left the sales grounds. If an abnormality was detected the buyer was permitted to cancel the sale or mediate with the vendor. This protocol frequently resulted in disputes between the vendor and buyer (Howard *et al.* 1992; Martin *et al.* 2003; Teigland 1992).

Pre-purchase radiographic examination of yearlings at the sales was undesirable for vendors as repetitive examinations risked injury to the yearling or handler and repeated sedation resulted in an extended period of time when inspection of the yearling was not possible. Also, radiation doses to staff and horses concerned the industry as it was not uncommon for some yearlings to be radiographed on multiple occasions (Martin *et al.* 2003).

Of course, detection and interpretation of radiographic lesions have been known to influence sale prices and/or sale outcomes. Some vendors refused to allow radiographic examination of their yearlings but this was at the risk of losing potential buyers (Dart *et al.* 1992; Howard *et al.* 1992; van Hoogmoed *et al.* 2003).

The Radiograph Repository System

Radiograph repositories were introduced to decrease the number of radiographic examinations performed on horses and the number of disputes arising from sale of horses with pre-existing problems.

A radiograph repository is an area set up by a sales company for storage of radiographs submitted by vendors and for subsequent viewing by veterinarians at the request of potential buyers. Sales companies control the submission and viewing of radiographs submitted into their repositories (Anderson *et al.* 2004; Magic Millions Pty Ltd 2003; Martin *et al.* 2003; William Inglis & Son Ltd 2003).

Submission of radiographs into the repository is entirely voluntary. In 2003 a standard set of radiographs cost approximately $1000, an expense borne by the vendor. It is usually this cost and the expected sale price of the yearling that determines whether or not a vendor will submit radiographs to the repository (Martin *et al.* 2003).

Introduction of the Radiograph Repository

The yearling sale radiograph repository was first introduced at the Keeneland Sales, USA in 1996 (Martin *et al.* 2003). In 2002, the Hong Kong Jockey Club introduced a 42-radiographic view requirement for all horses being imported into Hong Kong (Anon 2002). This meant that a yearling at auction would need to have passed a 42-view radiographic examination before a potential Hong Kong buyer would consider purchasing the horse. In the same year, New Zealand Bloodstock officially implemented a radiograph repository requiring submission of 34 views, or 42 views if the horse was expected to be sold to Hong Kong (Anon 2004).

The Repository System in Australia

Australia introduced the radiograph repository to its auction sales in 2003. As in New Zealand, 34 views were required for submission, with eight additional views if a horse was aimed at the Hong Kong market (Magic Millions Pty Ltd 2003; William Inglis & Son Ltd 2003).

In its first year of introduction in Australia, 2847 radiograph sets were submitted into the repositories at the William Inglis Melbourne Premier, Sydney Classic, Australian Easter, Sires Produce and Scone yearling sales, and the Magic Millions Conrad Jupiters, Adelaide Premier and Perth Premier yearling sales. At an average cost of $1000 per set, vendors spent in excess of $2.8 million to provide this facility for buyers. Of the 2847 radiograph sets submitted, potential buyers viewed approximately 55% and approximately 10% of sets were viewed on five or more separate occasions.

Australia's Radiograph Repository Requirements

In 2003, the requirements, as recommended by the Australian Equine Veterinary Association, for radiograph repositories at William Inglis and Magic Millions sales were as follows (Magic Millions Pty Ltd 2003; William Inglis & Son Ltd 2003).

- Radiographs to be taken within 42 days prior to the sale.
- Radiographs to be submitted to the repository no later than four days prior to commencement of the sale.
- All films to be clearly marked with the name of the veterinarian or clinic undertaking the examination, the date x-rays were taken, the dam's name, the year of birth, sex, brands and lot number.
- A report divulging any orthopaedic surgery undertaken prior to the sale to be included for William Inglis sales, but is a voluntary inclusion for Magic Millions sales.
- Radiographs available to be inspected only by veterinarians registered in the State in which the sale is being held.
- A minimum of 34 views, to a maximum of 42 views, to be submitted (Table 1).

Table 1. Radiographic views required for submission of radiographs into the repository system in Australia. Each view is taken of both the left and right limb.

Joint	View
Fore feet	lateromedial (LM)
Knees	dorso20^o-30^o medial-palmarolateral oblique (DMPaLO)
	dorso30^o-40^o lateral-palmaromedial oblique (DLPaMO)
	flexed lateromedial (Flexed LM)
Fore fetlocks	dorsopalmar elevated 20^o (DPa)
	dorso30^o medial-palmarolateral oblique (DMPaLO)
	dorso30^o lateral-palmaromedial oblique (DLPaMO)
	flexed lateromedial (Flexed LM)
Hind fetlocks	dorsoplantar elevated 30^o (DPl)
	dorso30^o medial-plantarolateral oblique (DMPlLO)
	dorso30^o lateral-plantaromedial oblique (DLPlMO)
	lateromedial (LM)
Hocks	dorso65^o medial-plantarolateral oblique (DMPlLO) or plantaro25^o lateral-dorsomedial oblique (PlLDMO)
	dorso20^o lateral-plantaromedial oblique (DLPlMO)
	lateromedial (LM)
Stifles	lateromedial (LM)
	caudocranial (CdCr) or caudo20^o lateral-craniomedial oblique (CdLCrMO)
Additional views required for Hong Kong protocol:	
Fore feet	dorsopalmar upright (DPa up)
Hocks	dorso45^o lateral-plantaromedial oblique (DLPlMO)
Knees	dorsopalmar (DPa)
	dorsoproximal-dorsodistal oblique flexed (Flexed DPrDDiO)

How Many Radiographic Views?

Opinions on the minimum number of radiographic views required for adequate pre-purchase examination of horses vary from 32 to 82 views covering fore and hind feet, fore and hind fetlocks, fore and hind cannon bones, knees, hocks and stifles (Anderson *et al.* 2004; Martin *et al.* 2003; Park 2000; Poulos 1992; Teigland 1992).

Ideally, radiographic views should allow adequate visualisation of the anatomical features of the joint or area being evaluated that are most likely to be affected by pathological changes. This is best achieved by correct positioning of the X-ray film, and by optimising film quality and exposure which affect spatial resolution and contrast latitude (Butler *et al.* 2000; Park 2000). Slight variations in positioning and quality of radiographs may lead to artefacts or conceal significant abnormalities (Hance and Morehead 2000; Meagher 2001; Park 2000).

Outlined below are the anatomical features that can be observed on each of the 34 views required for the repository system in Australia. Detailed information on each of the radiographic views can be found in *Adams' Lameness in Horses* (Adams 2002) or *Clinical Radiology of the Horse* (Butler *et al.* 2000).

Fore Foot

The LM view of the fore foot should allow adequate visualisation of the second and third phalanx (Adams 2002; Butler *et al.* 2000).

Fore/Hind Fetlock

The flexed LM view of the fore fetlocks and LM view of the hind fetlocks allow examination of the sagittal ridge of the third metacarpal/metatarsal bone, dorsal and palmar/plantar aspects of the third metacarpal/metatarsal bone, proximal first phalanx and the fetlock joint space. The DPa/DPl views of the fore and hind fetlocks are required for examination of the fetlock joint space, the distal aspect of the third metacarpal/metatarsal bones, the proximal first phalanx and the distal aspect of the proximal sesamoid bones. The oblique views of the fore and hind fetlocks are used for examination of the dorsomedial/lateral and palmar/plantar medial/lateral aspects of the joint and proximal sesamoid bones (Adams 2002; Butler *et al.* 2000; Colon 2004).

Carpus

The DLPaMO view of the carpus allows visualisation of the dorsal aspect of the radial carpal bone. The DMPaLO view of the carpus is used for examination of the dorsal aspect of the intermediate carpal bone. The flexed LM view of the carpus allows evaluation of the distal aspect of the radius and the proximal and distal aspects of the radial and intermediate carpal bones (Adams 2002; Butler *et al.* 2000; Colon 2004).

Tarsus

The DMPlLO view of the tarsus is used for examination of the distal intermediate ridge of the tibia, the dorsolateral aspect of the lateral trochlear ridge of the talus, and the tarsometatarsal and intertarsal joints. The DLPlMO view of the tarsus is required for evaluation of the medial malleolus and the medial trochlear ridge of the talus and the joint space between them. The distal intermediate ridge of the tibia, tarsometatarsal joint, distal intertarsal joint and medial trochlear ridge of the tarsus are examined using a LM view (Adams 2002; Butler *et al.* 2000; Colon 2004).

Stifle

The patella, lateral and medial trochlear ridges of the femur, femoral condyles and the proximal aspect of the tibia can be evaluated on a LM view of the stifle. The CdCr view of the stifle allows examination of the medial and lateral condyles of the femur (Adams 2002; Butler *et al.* 2000; Colon 2004).

Orthopaedic Lesions

Developmental orthopaedic disease (DOD) is a well-known problem in young thoroughbred horses. This term encompasses a variety of conditions, including osteochondritis dissecans (OCD), subchondral bone cysts or osseous cyst-like lesions (OCLL), epiphysitis, cervical vertebral malformation (wobbler syndrome), angular limb deformities and flexural deformities (Hintz 1987; Rose 1997). DOD is of great concern to both the breeder and prospective buyer due to potential effects on sale price and race career. Other orthopaedic problems of equal concern include juvenile degenerative joint disease (jDJD), sesamoiditis, fractures and hoof disorders (Anderson *et al.* 2004; Butler et al. 2000; Martin *et al.* 2003).

There are three potential contributors to an orthopaedic lesion in a yearling: traumatic injury, genetic predisposition or environmental influence. Some heritable orthopaedic disorders have been found in Standardbred, warmblood and pony breeds. However, as far as the authors are aware, no such heritability has been demonstrated in Thoroughbreds. Environmental factors that may contribute to orthopaedic disorders include nutrition (both pre- and post-natally), exercise, season, ground hardness, rapid growth after illness or may include change in diet, body mass or administration of steroids. Traumatic injury to the limbs may directly result in the occurrence of an orthopaedic lesion. However, injury that results in abnormal limb loading to the supporting limb may also lead to the development of orthopaedic disease (Hintz 1987; Rose 1997).

Osteochondritis dissecans (OCD)

OCD involves osteochondral flap or fragment formation of cartilage and subchondral bone within a joint. OCD is a manifestation of osteochondrosis. In horses, OCD occurs most commonly in the stifle, hock and shoulder joints (Adams 2002).

Subchondral Bone Cysts or Osseous Cyst-Like Lesions (OCLL)

OCLL are considered also to occur as a result of osteochondrosis. They are cystic lesions that occur in subchondral bone. Subchondral bone is the bone found beneath cartilage. OCLL in horses are found most commonly in the stifle, knee and fetlock joints (Adams 2002).

Osteophytes and Enthesiophytes

Osteophytes and enthesiophytes are bony growths. Osteophytes and enthesiophytes occur due to joint inflammation or subchondral bone damage. Osteophytes can occur on any bone surface within a joint space, however enthesiophytes only occur at sites of insertion of soft tissue structures, including muscles and ligaments, into the bone. Osteophytes and enthesiophytes occur most commonly in the knee, fetlock and hock joints in horses (Adams 2002).

Sesamoiditis

Sesamoiditis literally means inflammation of the sesamoid bones. In horses, the proximal sesamoid bones of the fetlock become inflamed, may be demineralised and have osteophyte and/or enthesiophyte formation. This is a result of overloading of the bone and often involves the suspensory ligaments and distal sesamoidean ligaments as well. Sesamoiditis can occur in both the fore and hind fetlocks (Adams 2002).

Fractures and Fragments

Fractures and fragments (chip fractures) usually occur due to traumatic force. They can occur in any bone. Fragments are most commonly seen in the knee and fetlock joints (Adams 2002).

Club Feet

Club feet are considered to be those that have a foot axis greater than or equal to 60^{o}. They can occur in fore or hind feet (Adams 2002) and their cause is unknown.

Prevalence of Orthopaedic Lesions in Thoroughbred Yearlings

A number of overseas studies have documented the prevalence of orthopaedic lesions in Thoroughbred yearlings. To date, there have been no such studies in Australia.

In an Irish study of 1711 Thoroughbreds from birth to 18 months of age, 67% of animals had some form of developmental orthopaedic disease (O'Donohue *et al.* 1992). This study was a survey of a number of prominent stud farms and no details of radiographic examination of the horses was reported.

In a retrospective study of routine radiographs from 582 yearlings sold in the United States, Howard *et al.* (1992) reported that hind and fore fetlocks were most commonly affected by orthopaedic disorders, followed by tarsi, stifles, feet and carpi. These authors did not state which radiographic views were taken. Prevalence was also reported as a percentage of limbs affected, not as a percentage of horses, thereby failing to provide a true indication of the prevalence of lesions within this population.

In a detailed study reporting prevalence of radiographically detectable orthopaedic lesions in 1162 Thoroughbred yearlings sold at auction in the United States, Kane *et al.* (2003b) reported the following as the most common radiographic changes detected:

- In the fore fetlocks, flattening of the distal palmar condyles of the third metacarpus was found to be present in 40.9% of yearlings.
- In the hind fetlocks, a semicircular notch in the dorsal aspect of the distal third metatarsus was detected in 27.1% of yearlings.
- Approximately 79% of the yearlings studied had two or more irregular vascular channels in the fore or hind proximal sesamoid bones.
- In the carpi, a circular lucency in the ulnar carpal bone was present in 20.1% of the yearlings.
- In the hock, 17.5% of yearlings had osteophytes or enthesiophytes in the distal intertarsal or tarsometatarsal joints.
- Osteitis was the most common fore foot change, occurring in 11% of the yearlings.

Yearlings that were radiographed were in the top tier of yearlings presented for sale at auction during the four-year study period, therefore the prevalence data reported Kane *et al*. (2003b) may only be relevant for yearlings of equivalent quality. It should also be noted that the age range of the yearlings radiographed was not reported. Since the ages of the yearlings presented for sale can vary from 13 to 19 months depending upon foaling and sale dates, then if radiographic examinations are undertaken the full six weeks prior to sale, the age at time of radiographic examination can range from 11.5 to 17.5 months.

Lesion Significance

Lesions can be classified as occult (an underlying pathological process is occurring but cannot yet be detected radiographically; although they may be detected by more sensitive techniques

such as scintigraphy or by post-mortem histology), clinically normal variations in anatomical structures, incidental findings, clinically significant but currently unassociated with clinical signs, or clinically significant and associated with clinical signs (Anderson *et al.* 2004; Beeman *et al.* 1992; Kane *et al.* 2000; Kane *et al.* 2003b).

Only four studies have been published that provide a quantitative assessment of the effect that orthopaedic lesions detected by radiography in Thoroughbreds at yearling age may have on future race performance (Beard *et al.* 1994; Cohen *et al.* 2006; Kane *et al.* 2003a; Spike-Pierce and Bramlage 2003). All of these studies were undertaken in the USA.

In the early 1990s Beard *et al*. (1994) compared the race performance of 64 yearlings known to have osteochondrosis of the tarsocrural joint to that of a control group consisting of 277 of their siblings. The 64 yearlings that were diagnosed as having osteochondrosis of the tarsocrural joint all had arthroscopic surgery to remove fragments prior to commencing racing. Yearlings that had undergone surgery were found to be less likely to race at 2 years of age than the control group of siblings. Due to the small number of horses involved in the study the authors were not able to determine if yearlings undergoing surgery had significantly different race performance ability than control animals.

In a radiographic study of the proximal sesamoid bones of 487 Thoroughbred yearlings, Spike-Pierce and Bramlage (2003) found that yearlings with more than two irregular vascular channels (greater than 2 mm wide with abnormal margins) present in the proximal sesamoid bones had a statistically significant decrease in the number of race starts and earnings at 2 and 3 years of age compared to control horses.

Following on from the study of prevalence of orthopaedic lesions, Kane *et al*. (2003a) analysed the race performance at 2 and 3 years of age of the 1162 yearlings radiographed. The following lesions were found to have an effect on race performance:

- moderate or extreme palmar supracondylar lysis of the third metacarpus
- enthesiophyte formation on the fore proximal sesamoids
- proximal dorsal fragmentation of first phalanx in the fore fetlocks, and
- dorsal medial intercarpal joint disease.

In the most recent available study abnormal radiographic findings from 348 yearlings and race performance at 2 and 3 years of age were analysed (Cohen *et al.* 2006). No associations between the presence of abnormal radiographic findings and reduced race performance were found.

Conclusions

Obtaining radiographic examinations of yearlings for submission to the radiograph repository system costs vendors millions of dollars each year. Given the unknown value of radiographs taken at yearling age in predicting future racing performance, is this money being well spent? To date, studies reporting the prevalence and effect of orthopaedic disorders in young Thoroughbred horses have only occurred overseas. The prevalence and effect of orthopaedic lesions in young Thoroughbreds under Australian conditions is unknown. There are numerous studies investigating racetrack fatalities and breakdowns in the UK, USA and Australia. Comparison of these studies shows that the type and frequency of musculoskeletal injury varies between the different countries. Given this, it could be expected that the prevalence of orthopaedic disorders in Thoroughbred yearlings and the effect that these lesions have on racing performance may also differ from that shown overseas.

In order to address the issues facing the Thoroughbred Industry in Australia this study aimed to assess:

- the economics of investing in a Thoroughbred yearling;
- the quality of radiographs submitted to the repository system in Australia in 2003;
- the prevalence of radiographically detectable orthopaedic lesions in Thoroughbred yearlings in Australia, and
- the value of radiographs, taken at yearling age to detect orthopaedic lesions, for predicting future race performance.

The Study Population

Summary

The aim of this section is to describe the study population. Details and sources of data compiled are outlined. Signalment, sale and race performance results for the study population are collated.

Materials and Methods

Horse Population

Horses included in the study comprised Thoroughbreds foaled in Australia or New Zealand in 2001, which were subsequently entered into selected yearling sales in Australia in 2003.

Yearling Sales

Selected sales were eight of the eleven premier Thoroughbred yearling auctions held by Magic Millions Pty Ltd and William Inglis and Son Ltd in Australia in 2003 (Table 2).

Table 2. Details of yearling sales held by Magic Millions Pty Ltd and William Inglis and Son Ltd in 2003

Sale ID	Yearling Sale	Date of Sale	Bloodstock Company
A	Conrad Jupiters	9, 10, 11, 12 & 14 January 2003	Magic Millions Pty Ltd
B	Classic	19, 20 & 21 January 2003	William Inglis and Son Ltd
C	Premier/Premier II	10, 11 & 13 February 2003	William Inglis and Son Ltd
D	Adelaide	24, 25, 26 & 29 February 2003	Magic Millions Pty Ltd
E	Perth Premier	11, 12 & 14 March 2003	Magic Millions Pty Ltd
F	Australian Easter	22, 23 & 24 April 2003	William Inglis and Son Ltd
G	Sires' Produce	27 April 2003	William Inglis and Son Ltd
H	Scone	18 May 2003	William Inglis and Son Ltd

Horse Identifying Information

Catalogues for each sale were obtained from the relevant sales company (Magic Millions Pty Ltd 2004; William Inglis and Son Ltd 2004) and used to obtain identifying information for each horse. Information collated included sale identity, sale date, lot number, sex, colour, foaling date, sire, dam, grandsire, vendor and Thoroughbred incentive scheme nomination. Age, in years, at time of sale was calculated by subtracting the foaling date from the date of sale.

Duplicate Sale Entries

In cases where a horse was entered into more than one sale, duplicate entries were removed. Selection for removal was on the basis of sale result, i.e., if the horse was sold at one sale, but passed-in or withdrawn at another sale, the record for the sold result was retained and other records were deleted. In the case of a horse that was entered on more than one occasion and not sold at any sale, the first sale entry was kept.

Sale Results

Results for each sale were acquired from the relevant sales company website (Magic Millions Pty Ltd 2004; William Inglis and Son Ltd 2004) allowing recording of the following information for each horse: sale result (sold, passed-in or withdrawn from sale), purchase price, passed-in price (last highest bid recorded), reserve price (for passed-in horses only) and purchaser.

Radiographs

A set of radiographs was considered to be complete if it contained the minimum 34 views as required for repository admission (Table 1). The lot number of horses which had a radiographic set submitted to the repository was obtained from the relevant sales company (Magic Millions Pty Ltd 2004; William Inglis and Son Ltd 2004). Post sale, radiograph sets from repository systems at the eight yearling sales were forwarded to The University of Melbourne Equine Centre for this study. Forwarding of radiographs to the Equine Centre was undertaken by the sales companies after obtaining permission from the veterinary establishment submitting the radiographs to the repository. Radiograph sets were catalogued by cross-matching with sales catalogue information to confirm horse identification provided on radiographs. Each set of radiographs was provided with a unique identification number. Details recorded from radiograph sets included the date of radiographic examination, veterinary establishment submitting the radiographic set, number of radiographs present, and presence of surgical report. Age, in years, at time of radiographic examination was calculated by subtracting foaling date from the date of radiographic examination.

Identification of Registration for Racing Purposes

Yearling sale catalogue information was cross-matched with The Australian Stud Book (2005) for Australian-born horses, and The New Zealand Stud Book (2005) for New Zealand-born horses, to determine if horses had been registered for racing purposes. The relevant stud book was also used to check if the horse had been exported from Australia.

Race Performance

Race performance records were retrieved for the 2-year-old (1 August 2003 to 31 July 2004) and the 3-year-old race seasons (1 August 2004 to 31 July 2005). Race performance for the combined 2 and 3-year-old seasons (1 August 2003 to 31 July 2005) was then calculated by adding the retrieved race performance records from the 2 and 3-year-old race seasons together. Information that was recorded included registration number, registration date, trainer, trainer changes, date of trainer change, gelding reported, date of first start, number of race starts, number of first, second and third places attained, and prize money earned. For those horses that raced, their age (in years) at first race start, number of places, percentage of starts placed and prize money per start were then calculated. Age (in years) at first race start was calculated by subtracting the foaling date from the date of first start. Number of places was the sum of first, second and third places attained. The percentage of starts placed was

calculated by dividing the number of places by number of starts and multiplying by 100. Prize money earned divided by number of starts gives prize money per start.

Australian Race Horses

Race performance information for horses racing in Australia was retrieved from Racing Information Services Australia Pty Ltd i-ris© database (2005).

Exported Race Horses

Race performance information for horses that were exported was retrieved from the relevant racing association (Beijing Jockey Club 2005; Cust 2006; Ito 2006; Korean Racing Authority 2006; Magboo 2006; Neal 2006; New Zealand Thoroughbred Racing Inc 2005; The Hong Kong Jockey Club 2005; Wanklin 2006; Webbey 2006). All overseas prize money earned was converted into Australian dollars (Anon 2006).

Data Collation

All data were entered into a Microsoft® Office Access 2003 (Microsoft Corporation, USA) database.

Statistical Analysis

Results are reported as means (median; range) unless otherwise stated.

Comparison of Horses With/Without Radiograph Sets Sent to The University of Melbourne Equine Centre

Statistically significant differences between horses that had radiographic sets forwarded for inclusion in the study and those that had not, were determined on the basis of sex, sale result and starting a race at 2 or 3 years of age, using a Fisher's exact test (Petrie 2006). A Mann-Whitney test (Petrie 2006) was used to determine statistically significant differences between horses that had radiographic sets made available to The University of Melbourne and those that had not, on the basis of age at sale, market price (purchase or passed-in price), age at first race start, prize money earned, number of starts, number of places, percentage starts placed and mean prize money per start. All race performance results analysed were for the combined 2 and 3-year-old seasons. A two-sided P-value of <0.05 was considered statistically significant. SPSS[Error! Reference source not found.] was used to calculate the Fisher's exact test and Mann-Whitney test.

Results

Study Population

Sale Entries

There were 3905 entries into the eight yearling sales. Of these, 75 were duplicate entries, which were removed from the database as previously described, leaving 3830 horses for analysis (Table 3).

Horse Signalment

A total of 3687 (96.3%) horses were Australian-born, with the remaining 143 foaled in New Zealand. At the time of sale there were 2193 (57.2%) colts, 1634 (42.7%) fillies and 3 (0.1%) geldings. The mean age at time of sale was 1.40 years (1.39; 1.10 – 1.80) (Table 3).

Sale Results

There were 2773 (72.4%) horses sold, 786 (20.5%) passed-in at sale and 271 (7.1%) withdrawn from sale. The mean market price (sale price and passed-in price) was $50,721 (27,750; 0 – 1,700,000) (Table 3).

Table 3. Details of horse signalment and sale results for each of the eight yearling sales

Sale ID	No. of Entries	No. of Horses	Sex (%) C	Sex (%) F	Sex (%) G	Mean Age at Sale (median; range)	Sale Result(%) S	Sale Result(%) PI	Sale Result(%) WD	Mean Market Price (median; range)
A	969	951	561 (59.0)	390 (41.0)	0	1.3 (1.3; 1.1 – 1.5)	724 (76.1)	164 (17.4)	63 (8.3)	53,299 (47,500; 1000 – 900,000)
B	515	492	262 (53.2)	230 (46.8)	0	1.3 (1.3; 1.1 - 1.5)	334 (67.9)	133 (27.0)	25 (5.1)	26,896 (20,000; 0 – 180,000)
C	580	577	334 (57.9)	243 (42.1)	0	1.4 (1.4; 1.2 – 1.5)	405 (70.2)	120 (20.8)	52 (9.0)	34,295 (27,500; 0 – 260,000)
D	523	515	293 (56.9)	221 (42.9)	1 (0.2)	1.4 (1.4; 1.2 – 1.6)	342 (66.4)	125 (24.3)	48 (9.3)	24,623 (18,000; 1000 – 310,000)
E	438	438	266 (60.7)	172 (39.3)	0	1.4 (1.4; 1.2 – 1.6)	321 (73.3)	80 (18.3)	37 (8.4)	18,960 (15,000; 1000 – 150,000)
F	524	524	294 (56.1)	230 (43.9)	0	1.6 (1.6; 1.4 – 1.7)	380 (72.5)	118 (22.5)	26 (5.0)	133,133 (90,000; 10,000 – 1,700,000)
G	150	143	76 (53.1)	67 (46.9)	0	1.5 (1.5; 1.4 – 1.7)	98 (68.5)	33 (23.1)	12 (8.4)	21,053 (19,000; 2000 – 65,000)
H	206	190	107 (56.3)	81 (42.6)	2 (1.1)	1.6 (1.6; 1.4 – 1.8)	169 (88.9)	13 (6.8)	8 (4.2)	11,722 (9000; 1000 – 67,500)

C = colt, F = filly, G = gelding
S = sold, PI = passed-in, WD = withdrawn

Radiograph Data

A total of 2832 horses had radiograph sets submitted to repository systems at the yearling sales. From these, 2401 (84.8%) radiograph sets were forwarded to The University of Melbourne Equine Centre for this study (Table 4).

Radiograph sets were submitted by 65 veterinary establishments. The mean number of radiograph sets taken by veterinary clinics was 36.9 (8; 0 – 565). Of the 2401 radiographic sets catalogued for the study, 2320 (96.1%) had 34 radiographs present. There were 52 (2.2%) radiographic sets with a surgical report present. The mean age at time of radiographic examination was 1.3 years (1.3; 0.9 – 1.8). Details of the number of radiographic sets submitted to repositories, forwarded to The University of Melbourne for this study, and age of horse at time of radiographic examination for each of the eight yearling sales are outlined in Table 4 below.

Table 4. Details of radiographic sets for each of the eight yearling sales

Sale ID	Number of Radiograph Sets in Repository	Number of Radiograph Sets Available for Study	Mean Age at Radiograph (median; range)
A	707	651	1.2 (1.2; 0.9 – 1.4)
B	435	351	1.3 (1.3; 1.1 – 1.5)
C	502	477	1.3 (1.3; 1.1 – 1.5)
D	429	300	1.3 (1.3; 1.1 – 1.5)
E	145	102	1.4 (1.4; 1.2 – 1.6)
F	507	428	1.5 (1.5; 1.3 – 1.7)
G	99	79	1.5 (1.4; 1.1 – 1.6)
H	24	24	1.6 (1.6; 1.5 – 1.8)

Identification of Registration for Racing Purposes

As at 31 July 2005, 3570 (93.2%) of the 3830 horses were registered for racing purposes.

Exported Horses

At the end of the 3-year-old race season on 31 July 2005, 414 (10.8%) horses had been exported from Australia. There were 23 horses that were exported from Australia and then exported onward to another country. During the 2 year study period, 35 exported horses were imported back into Australia. Horses were exported to eleven countries: one to China, 93 to Hong Kong, eight to Japan, six to Korea, 44 to Macau, 82 to Malaysia, 88 to New Zealand, 15 to the Philippines, 67 to Singapore, 31 to South Africa and three to the United States of America.

Race Performance

2-year-old Race Performance

At the end of the 2-year-old race season 1411 (36.8%) horses had started in at least one race. The mean age at first race start, for horses having their first start during the 2-year-old race season, was 2.5 years. During the 2-year-old race season horses that started had a mean of 2.9 race starts, 0.3 places and had 28% of starts resulting in a first, second or third place. Mean earnings of starters was $15,025, with a mean prize money per start of $3463.

3-year-old Race Performance

During the 3-year-old race season 2792 (72.9%) horses had started in at least one race. The mean age at first race start, for horses having their first start during the 3-year-old race season was 3.2 years. Horses racing during the 3-year-old season had a mean of 6.2 race starts, 1.5 places and 29.8% of starts resulted in a place. The mean prize money earned by starters was $21,347 and the mean prize money per start was $2789.

2 and 3-year-old Race Performance

During the first 2 years of racing, from the 1 August 2003 to 31 July 2005, 1459 (66.5%) of the colts were reported as being gelded. The mean number of trainer changes during the 2 year period was 1.4 (1; 1 - 6).

At the end of the first 2 years of racing, 2898 (75.7%) horses had started in at least one race. The mean age at first race start was 2.9 years. During the 2 and 3-year-old race season horses had a mean of 7.4 race starts, 1.9 places and 29.3% of race starts resulted in a place. Starters racing during the 2 and 3-year-old season had mean earnings of $28,008, with a mean of $2895 earned per race start (Table 5).

Table 5. Race performance results for the 2, 3 and combined 2 and 3-year-old race seasons for the study population group. Mean (median; range) reported.

	2-year-old Race Season (n=1411)	3-year-old Race Season (n=2792)	2 and 3-year-old Race Season (n=2898)
Age at First Start (years)	2.5 (2.5; 1.9 – 3.0)	3.2 (3.2; 2.7 – 4.0)	2.9 (2.9; 1.9 – 4.0)
No. of Race Starts	2.9 (2; 1 – 14)	6.2 (6; 1 – 28)	7.4 (7; 1 – 38)
No. of Places	0.3 (0; 0 – 8)	1.5 (1; 0 – 19)	1.9 (1; 0 – 20)
Percentage of Starts Placed	28.0 (14; 0 – 100)	29.8 (25; 0 – 100)	29.3 (27; 0 – 100)
Prize Money Earned (Aus$)	15,025.15 (1000; 0 – 3,109,400)	21,347.93 (4550; 0 – 2,682,960)	28,008.10 (5480; 0 – 3,470,325)
Prize Money Per Race Start (Aus$)	3463.13 (367; 0 – 444,200)	2789.75 (750; 0 – 268,296)	2895.23 (796; 0 – 242,836)

Comparison of Horses With/Without Radiographic Sets Sent to The University of Melbourne Equine Centre

There were 2401 (84.8%) horses with radiographic sets sent to The University of Melbourne for study and 431 (15.2%) radiographed horses whose radiographs were not sent for this study.

Horse Signalment

There were 1406 (58.6%) colts and 995 (41.4%) fillies in the radiograph study group. The horses without radiographs sent for study consisted of 260 (60.3%) colts, 170 (39.4%) fillies and 1 (0.2%) gelding. There was no difference in percentage of colts and fillies for horses with radiographs sent or not sent for this study (P=0.111).

The mean age at time of sale for horses with radiographs sent for study and those horses were radiographs not sent for study was 1.40 years. There was a significant difference in the distribution of age at the time of sale for study horses and non-study horses (P=0.030).

Sale Results

Sale results of study horses were 1867 (77.8%) sold, 510 (21.2%) passed-in and 24 (1.0%) withdrawn from sale. Non-study horses sale results were 302 (70.1%) sold, 122 (28.3%) passed-in and 7 (1.6%) withdrawn from sale. Study horses were more likely to be sold and less likely to be passed-in compared to non-study horses (P=0.002).

The mean market price of study horses was $61,337 in comparison to non-study horses for which the mean market price was $57,463. There was a statistically significant difference in the distribution of market price for study and non-study horses (P<0.001), with study horses having a higher mean market price.

2 and 3-year-old Race Performance

A total of 1894 (78.9%) study horses started in at least one race during the 2 and 3-year-old race seasons. There were 328 (76.1%) non-study horses starting in at least one race during the first 2 years of racing. There was no difference between percentage of horses starting in at least one race for study and non-study horses (P=0.203). The mean age at first race start for study and non-study horses was 2.9 years. There was no difference between the age at first race start of study and non-study horses (P=0.161).

The mean number of race starts of study and non-study horses was six. Study horses had a mean of 2.6 race places, whilst non-study horses had a mean of 2.4 places. The mean percentage of race starts placed of study horses was 25% compared to non-study horses having a mean 22% of race starts resulting in a place being attained. There was no difference in distribution of the number of race starts (P=0.189), the number of race places attained (P=0.063) or percentage of race starts resulting in a place (P=0.058) for study and non-study horses.

The mean prize money earned in the first 2 years of racing for study horses was $26,355 and for non-study horses was $18,771. There was no difference between the distributions of prize money earned of study and non-study horses (P=0.119). The mean prize money earned per race start for study horses was $2689 and for non-study horses was $2134. There was no significant difference between the earnings per race start during the 2 and 3-year-old race seasons of study and non-study horses (P=0.117).

Table 6. Comparison of sale results and race performance at 2 and 3 years old of horses with/without radiographs forwarded for this study

		Study (n=2401)	Non-Study (n=431)	P-value
Sex (%)	C	1406 (58.6)	260 (60.3)	0.111
	F	995 (41.4)	170 (39.4)	
	G	0	1 (0.2)	
Mean Age at Sale (years) (median; range)		1.39 (1.37; 0.99 – 1.80)	1.40 (1.40; 1.15 – 1.71)	0.030
Sale Result (%)	S	1867 (77.8)	302 (70.1)	0.002
	PI	510 (21.2)	122 (28.3)	
	WD	24 (1.0)	7 (1.6)	
Mean Market Price ($) (median; range)		61,337 (37,500; 0 – 1,700,000)	57,463 (30,000; 1000 – 1,000,000)	<0.001
Starters (%)		1894 (78.9)	328 (76.1)	0.203
Mean Age at First Start (years) (median; range)		2.9 (2.9; 1.9 – 4.0)	2.9 (3.0; 1.9 – 4.0)	0.161
Mean Number of Starts (median; range)		6 (5; 0 – 30)	6 (5; 0 – 28)	0.189
Mean Number of Places (median; range)		2.6 (0; 0 – 20)	2.4 (0; 0 – 10)	0.063
Mean Per cent of Starts Placed (median; range)		25 (20; 0 – 100)	22 (14; 0 – 100)	0.058
Mean Prize Money Earned ($) (median; range)		26,355 (260; 0 – 3,470,325)	18,771 (1370; 0 – 697,950)	0.119
Mean Prize Money per Start (median; range)		2689 (440; 0 – 242,836)	2134 (249; 0 – 46,530)	0.117

Discussion

Each year large numbers of Thoroughbred yearlings are sold at auction. In recent years there have been several studies that consider the effect of abnormal radiographic findings detected during pre-sale examination of Thoroughbred yearlings on future race performance (Cohen *et al.* 2006; Kane *et al.* 2003a; Robert *et al.* 2003; Spike-Pierce and Bramlage 2003). In addition there are studies that investigate causes of wastage within the Thoroughbred industry (Bailey *et al.* 1997; Jeffcott *et al.* 1982; More 1999; Wilsher *et al.* 2006). By outlining the study population, comparisons to these published studies can be made. Potential bias within the sample of radiographs provided for this study must also be established.

Study Population

The mean market price of the 2830 horses in this study was approximately $9000 higher than the mean purchase price reported for the 4057 yearlings that were sold at auction in 2003 (Ross 2003). The market price reported in this study includes sale and passed-in price whereas the

mean price reported in the Australian Racing Fact Book by Ross (2003) was for sold yearlings only. The mean price of yearlings sold at auction in this study was approximately $14,000 higher than the $41,000 reported by Ross (2003) for the same year. The higher mean market and purchase prices reported here are consistent with the study population coming from selected yearling sales. These sales tended to be the premier yearling sales held in each state, potentially resulting in the study population consisting of higher quality horses than the overall population of yearlings sold that year.

In a study aimed at profiling race career and factors affecting performance in the 1990's in Queensland, Australia, 50.7% of the 1804 horses followed had their first race start as 2-year-olds (More 1999). This percentage of 2-year-old first time starters is considerably higher than the 36.8% reported in this study. The number of 2-year-old horses racing in Australia has decreased by approximately 20% in the 10 years since the horses followed by More (1999) raced as 2-year-olds (Ross 2003). The mean number of race starts as a 2-year-old is lower in this study than reported previously (More 1999). However the percentage of horses that first race as 3-year-olds and the mean number of starts at 3 was comparable to that reported by More (1999). Kane *et al*. (2003a) reported that 81% of yearlings followed started in at least one race in the first 2 years of racing, which is comparable to the 75.7% of starters in this study.

Horses With/Without Radiographic Sets Sent to The University of Melbourne Equine Centre

The lack of statistically significant differences between horses that had radiographs forwarded for study and those that did not shows that a representative sample of radiographed horses was obtained. The distribution of sex and all measures of racing performance for study and non-study horses were equivalent. Although there was a statistically significant difference in age at time of sale of radiographed and non-radiographed horses it is unlikely to be of biological importance. The statistical difference in sale result and market price of study and non-study horses is probably due to the percentage of horses passed-in in each group. Non-study horses were more likely to be passed-in at sale. Veterinarians and owners may have been reluctant to forward radiographs from passed-in horses as they may have been required to sell the horse post-auction.

Conclusions

The higher mean market price of the population group may indicate that results from this study are only applicable to horses equivalent to those entered into premier yearling sales.

The difference in 2-year-old race performance of horses in this study and the study by More (1999) in the late 1990's warrants further investigation. In recent years it is believed that the Thoroughbred industry in Australia has increased the pressure of horses to perform at a young age, yet it would appear that the number of 2-year-olds racing may be less.

The sample of horses for which radiographic examinations were received for study at The University of Melbourne is a representative sample.

Associations between Sale Price of Thoroughbred Yearlings and Race Performance at 2 and 3 Years Old

Introduction

Thoroughbred breeding and racing in Australia is a multi-million dollar industry (Anon 2001; Gordon 2001). Horse sales are a core component of the industry. Approximately 150 Thoroughbred auctions are held across Australia each year. These auctions consist of weanling, yearling, ready-to-run, racehorse, broodmare and mixed sales, and are estimated to result in an 8% turnover of ownership each year (Gordon 2001). The largest of these auctions are yearling sales, both in number of horses sold and gross sales. There were 7167 Thoroughbreds sold at auction during the 2002/2003 season, of which 56.6% were yearlings. Sale of the 7167 horses grossed $218 million, of which 76.4% was from the sale of yearlings (Ross 2003).

Auctions are operated on a 'buyer beware' system, so it is in the interest of the buyer to ensure they have appropriately investigated their purchase (Anderson *et al.* 2004; Beeman *et al.* 1992; Howard *et al.* 1992). Buyers study pedigrees, examine yearlings and enlist the services of expert veterinarians in order to purchase a successful racehorse and minimise their financial risk. Veterinary examination is particularly important as orthopaedic disorders are a well-known cause of economic loss within the racing industry (Bailey *et al.* 1997; Jeffcott *et al.* 1982; More 1999; Pool and Meagher 1990).

Purchasing a yearling as a potential future racehorse is a high-risk investment. In a study in the United States in the 1990's, 19% of yearlings studied had not raced by the end of their 3-year-old year (Kane *et al.* 2003a). That study aimed to identify the number and effect of radiographically detectable orthopaedic lesions in yearlings presented for sale. Yearlings in that study were in the top tier of those entered for auction during the study period. An earlier Australian study to profile the race performance and earnings of Thoroughbreds reported that 39.5% of horses followed earned no money, and 86.9% earned insufficient monies to cover estimated training costs in the first year of racing (More 1999).

The price paid for a yearling is generally reflective of the pedigree, sex, size, growth potential, gait, conformation, and temperament of the animal, as well as the presence of behavioural disorders or veterinary abnormalities. But does purchase price reflect the racing potential of the yearling? Despite the millions of dollars invested and the obvious risks involved in such purchases there is little published information examining the economics of investing in a yearling as a potential future racehorse. This study aims to assess associations between the purchase price of Thoroughbred yearlings and race performance in the first 2 years.

Horses

The 2773 horses that were sold at auction as described in "The Study Population" section were all included in analysis in this section.

Sale Data

As previously described, in “The Study Population”, sale data was retrieved from the relevant bloodstock sales company (Magic Millions Pty Ltd 2004; William Inglis and Son Ltd 2004).

Purchase Price Categories

Purchase price was divided into five categories: 1) $0 – 10,000; 2) $10,001 - 20,000; 3) $20,001 – 50,000; 4) $50,001 – 100,000 and 5) greater than $100,000. These groups were chosen as it was considered that they represented the most likely potential spending categories of purchasers, and they approximated the quintiles for purchase price.

Race Data

Race performance data for the 2 and 3-year-old race seasons was compiled as described in “The Study Population”.

Estimated Costs

The cost of keeping a racehorse during the first 2 years of racing was estimated at $40,000 by adding averaged costs per month (as quoted by companies syndicating horses of similar value) to the average sale price of the study population group (Delbridge Racing 2005; Hancox Bloodstock Pty Ltd 2005; Ken King Thoroughbreds 2005).

Statistical Analysis

Results are reported as means (median; range) unless otherwise stated.

Associations between the proportion of horses in each sale price category starting in at least one race, earning any prize money, earning prize money greater than the estimated cost of keep, earning prize money greater than their purchase price, or earning prize money greater than the combined estimated cost of keep and purchase price, were determined using a Fisher’s exact test (Petrie 2006). Relationships between the distributions of number of starts and prize money earned for each of the five sale price categories were determined using a Kruskal-Wallis test (Petrie 2006). All race performance results are for the combined 2 and 3-year-old race seasons and include starters and non-starters. A two-sided P-value of <0.05 was considered statistically significant. SPSS (SPSS Inc, Chicago, Illinois, USA) was used to calculate the Fisher’s exact test and the Kruskal-Wallis test.

Results

Horse Signalment

There were 1641 (59.2%) colts, 1130 (40.8%) fillies and 2 (0.1%) geldings. During their 2 and 3-year-old years 1428 (87%) of the colts were reported as having been gelded. The mean age at time of sale was 1.4 years (1.4; 1.0 – 1.8).

Sale Results

The mean purchase price for the 2773 horses was $55,298 (1000 – 1,700,000; 30,000). Horses purchased at the eight yearling sales grossed $153,343,000.

Table 7. Horse signalment and purchase price for each of the five sale price categories

Sale Price Category	Sex (%) C	Sex (%) F	Sex (%) G	Mean Age At Sale (years) (median; range)	Mean Purchase Price ($) (median; range)
$0 - 10,000 n=511	264 (51.7)	245 (47.9)	2 (0.4)	1.4 (1.4; 1.1 – 1.8)	6621.82 (7000; 1000 – 10,000)
$10,001 - 20,000 n=523	312 (59.7)	211 (40.3)	0	1.4 (1.4; 1.1 – 1.8)	15,855.16 (16,000; 10,500 – 20,000)
$20,001 - 50,000 n=906	559 (61.7)	347 (38.3)	0	1.4 (1.4; 1.1 – 1.8)	34,704.19 (34,000; 21,000 – 50,000)
$50,001 - 100,000 n=498	315 (63.3)	183 (36.7)	0	1.4 (1.4; 1.1 – 1.7)	74,372.49 (72,500; 51,000 – 100,000)
>$100,000 n=335	191 (57.0)	144 (43.0)	0	1.5 (1.5; 1.2 – 1.7)	218,470.10 (170,000; 102,500 – 1,700,000)

Identification of Registration for Racing Purposes

At the end of the 3-year-old race season, 2650 (95.6%) horses had been registered for racing purposes.

Exported Horses

A total of 356 (12.8%) horses were exported as at 31 July 2005. Horses were exported as follows: 1 to China, 71 to Hong Kong, 7 to Japan, 6 to Korea, 37 to Macau, 69 to Malaysia, 73 to New Zealand, 10 to Philippines, 51 to Singapore, 28 to South Africa, 2 to the United States of America. There were 18 horses that were exported from Australia and then again to another country, and 31 horses that were imported back into Australia.

Overall Race Results

Of the 2773 sold horses a total of 2206 (79.6%) started in at least one race during their 2 and 3-year-old years. The mean age at first race start was 2.8 years (2.8; 1.9 – 4.0). The mean number of race starts was 7.5 (6; 1 – 30) for a mean of 2.6 places (2; 0 – 20) and 30.2% of starts placed (29; 0 – 100). The mean prize money earned was $30,724 (6500; 0 – 3,470,325) and prize money per start was $3167 (887; 0 – 242,836). Over the 2 year racing period horses earned a total $67,594,857 in prize money.

In total, 1705 (61.5%) horses earned some prize money, 311 (11.2%) earned enough money to cover estimated costs during the first 2 years of racing, 400 (14.4%) earned enough money to recoup their purchase price, and 142 (5.1%) earned enough money to cover the combined estimated costs and purchase price.

Table 8. Mean number of race starts, mean prize money earned and percentage of horses that started, earned any prize money, earned prize money greater than the estimated costs, their purchase price and combined estimated costs/purchase price during the first 2 years of racing for each sale price category.

Sale Price Category	Starters (%)	Mean No. of Race Starts (median; range)	Mean Prize Money Earned ($) (median; range)	Prize Money > $0 (%)	Prize Money > Est. Cost (%)	Prize Money > Purchase Price (%)	Prize Money > Est. Cost + Purchase Price (%)
$0 - 10,000	371	5.2	9647.22	237	19	121	14
n=511	(72.6)	(4; 0 – 27)	(0; 0 – 1,429,202)	(46.4)	(3.7)	(23.7)	(2.7)
$10,001 - 20,000	396	5.7	10,624.71	287	29	85	26
n=523	(75.7)	(5; 0 – 38)	(806; 0 – 449,914)	(54.9)	(5.5)	(16.3)	(5.0)
$20,001 - 50,000	738	6.3	17386.42	594	92	117	48
n=906	(81.5)	(6; 0 – 27)	(3200; 0 – 730,305)	(65.6)	(10.2)	(12.9)	(5.3)
$50,001 - 100,000	471	6.5	45,370.53	347	92	56	35
n=498	(83.7)	(6; 0 – 22)	(7775; 0 – 3,470325)	(69.7)	(18.5)	(11.2)	(7.0)
>$100,000	284	6.1	56,204.12	240	79	21	19
n=335	(84.8)	(6; 0 – 20)	(8900; 0 – 2,760,460)	(71.6)	(23.6)	(6.3)	(5.7)
P-value	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	0.030

Associations between Purchase Price and Race Performance

Starting in a Race

There was a significant positive association between percentage of horses starting a race and sale price category (P<0.001). As sale price category increased, there was an increased chance of horses starting in a race (Figure 1).

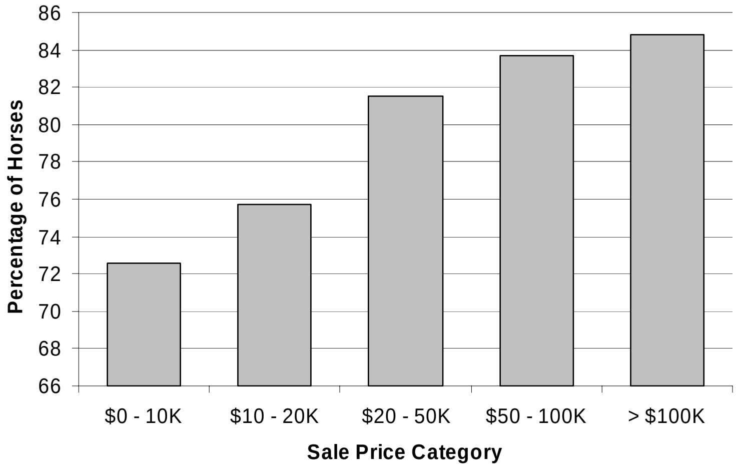

Figure 1. Percentage of horses in each sale price category starting in at least one race during the first 2 years of racing.

Number of Race Starts

There was a significant association between median number of race starts and sale price category (P<0.001). With increasing sale price category the number of race starts a horse was likely to have during its first 2 years of racing increased (Figure 2).

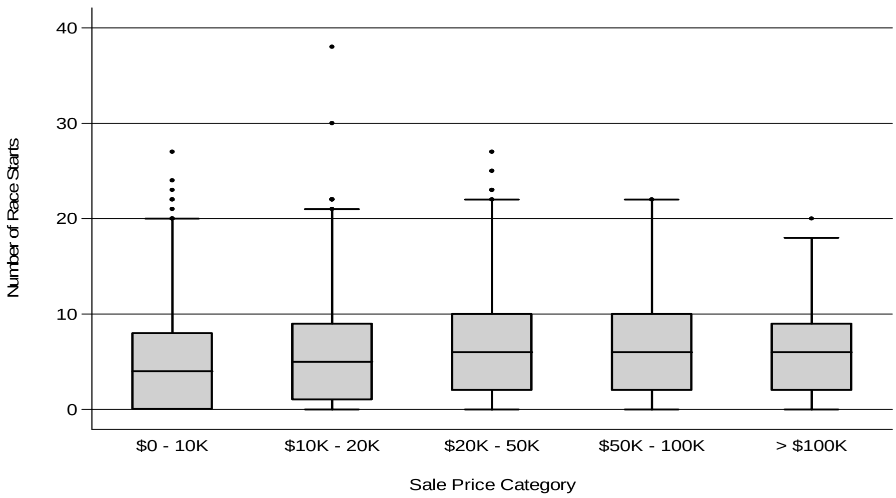

Figure 2. Box plot showing distribution of the number of race starts in the first 2 years of racing for each of the sale price categories.

Prize Money Earned

There was a significant association between median prize money earned during the 2 and 3-year-old race seasons and sale price category (P<0.001). As the purchase price increased the chance of earning any prize money at 2 and 3 years of age increased (Figure 3).

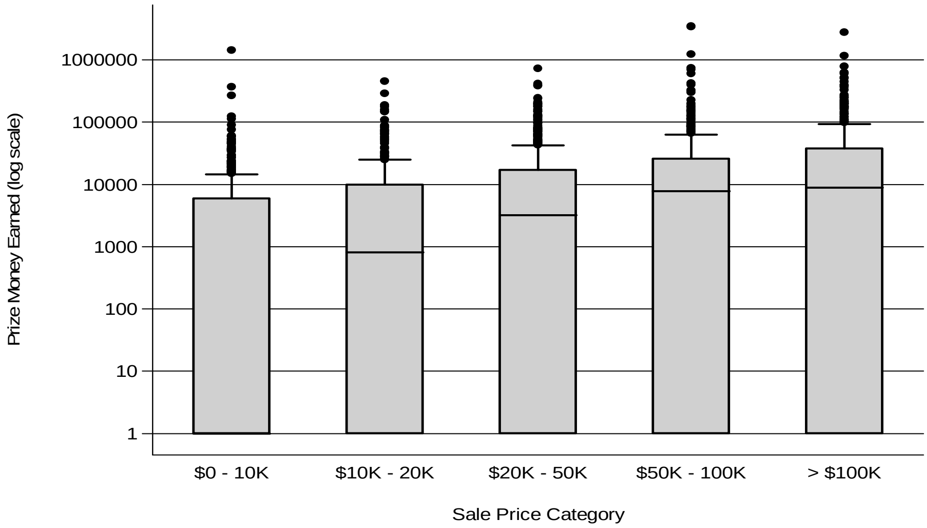

Figure 3. Box plot, on a log scale, showing distribution of the prize money earned in the first 2 years of racing for each of the sale price categories.

Prize Money Earned Greater Than $0

There was a positive association between percentage of horses earning any prize money and sale price category (P<0.001). As the purchase price increased the chances of earning any prize money at 2 and 3 years of age increased (Figure 4).

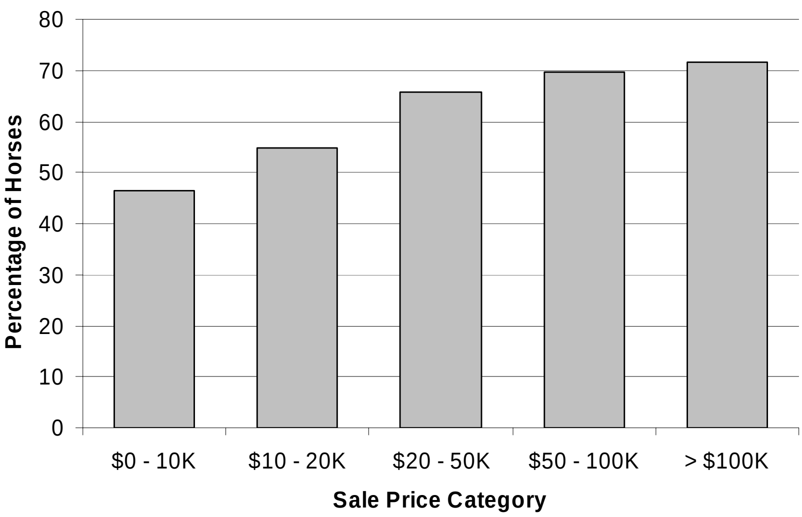

Figure 4. Percentage of horses in each sale price category earning prize money in during their 2 and 3-year-old race season.

Prize Money Earned Greater Than Estimated Costs

There was a significant association between the percentage of horses earning prize money greater than the estimated costs of the first 2 years of racing and their sale price category

(P<0.001). With increasing sale price category there was an increased chance of earning more than the $40,000 in estimated costs (Figure 5).

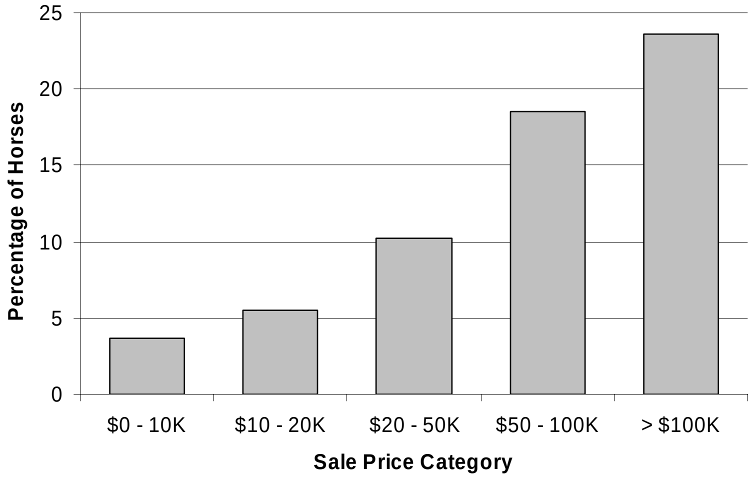

Figure 5. Percentage of horses in each sale price category earning prize money greater than the estimated costs incurred during the first 2 years of racing.

Prize Money Earned Greater Than Purchase Price

There was a statistically significant association between proportion of horses earning prize money greater than their purchase price and sale price category (P<0.001). The chance of earning prize money greater than the purchase price, in the first 2 years of racing, decreased as sale price category increased (Figure 6).

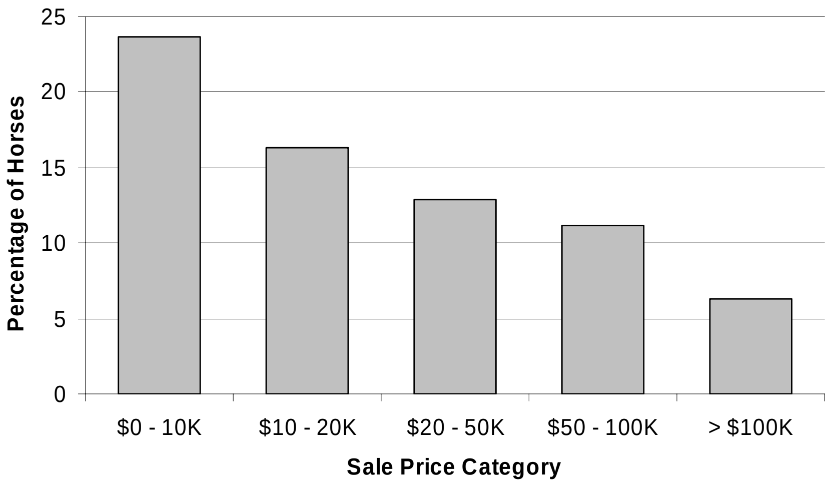

Figure 6. Percentage of horses earning prize money, at 2 and 3 years old, greater than their purchase price for each sale price category.

Prize Money Earned Greater Than Combined Estimated Costs and Purchase Price

There was a statistically significant association between the proportion of horses earning prize money, during the first 2 years of racing, greater than the combined estimated costs and purchase price and their sale price category (P=0.030). As purchase price increased from $0 to $100,000 the chance of a horse earning the combined estimated costs and purchase price

increased. Over $100,000 the chance decreased to approximately that of horses in the $20,001 to $50,000 category (Figure 7).

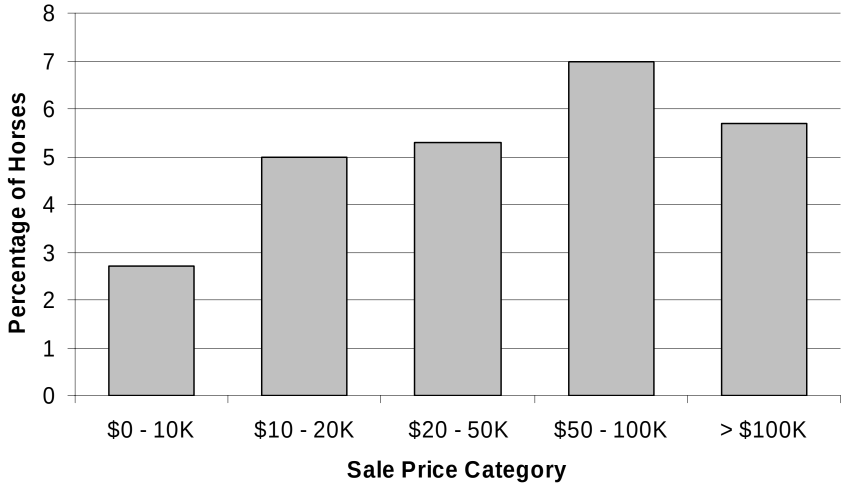

Figure 7. Percentage of horses earning prize money greater than the combined estimated costs and purchase price in each sale price category.

Discussion

Given the millions of dollars invested in the purchase of Thoroughbred yearlings as potential future racehorses each year, the high risk of these investments, and the common use of racing performance as an outcome in equine research, examination of the relationship between purchase price and race performance is warranted. It is important to stress that this study only analyses income from the first 2 years of racing. It does not consider potential future earnings from racing, breeding or on-sale. Future breeding potential is an important factor when evaluating horses for sale. The top-selling yearling earned almost $600,000 from only seven starts. However the top money earner was purchased for only $80,000 and earned almost $3.5 million in only 16 starts. Only 44% of the total cost of $153,343,000 of all horses in this study was returned as prize money. The total prize pool available for these horses to win from 1 August 2003 to 31 July 2005 is not known.

Purchase price had a significant effect on all measures of race performance and earnings. With increasing sale price category, the likelihood of starting a race, the mean number of race starts at 2 and 3 years of age, the number of horses earning prize money, and total prize money earned increased. This may confirm buyers' ability to select better horses but other reasons are also possible. Thus buyers paying higher prices could be more motivated to race their purchase, or more expensive horses may go to more proven trainers who have the ability to achieve maximum racing performance for a longer duration from the horse.

A total of 79.6% of yearlings in this study went on to race. This is similar to the figure reported by Kane *et al*. (2003a) in a study of 1162 Thoroughbred yearlings in the USA. That study aimed to assess associations between orthopaedic lesions and race performance at 2 and 3 years of age. In a study assessing causes of wastage in the UK, Wilsher *et al*. (2006) reported that 39% of 537 2-year-olds in training and 24% of 456 3-year-olds in training did not race.

The mean number of starts amongst horses in this study was 7.5. Wilsher *et al*. (2006) reported the mean number of starts for 2-year-olds in training as 2.0 and for 3-year-olds in training as 4.0. The number of race starts of the 1162 yearlings followed by Kane *et al*. (2003a) were not reported.

In this study 38.5% of horses earned no money during the first 2 years of racing. More (1999) reported that 39% of the 1567 2-year-old horses followed in Queensland earned no money and in a study of 537 2-year-old horses in training in the UK Wilsher *et al*. (2006) reported that 64% earned no money.

With an increasing sale price, the chance of a horse earning back the $40,000 estimated cost of keeping the horse for the first 2 years increased, however, only 11.2% of horses managed to earn greater than that amount. In a study investigating wastage in Thoroughbred horses in the UK, Wilsher *et al*. (2006) reported that only 5% of 2-year-olds and 17% of 3-year-olds were able to earn back the estimated costs of training. In an Australian study aimed at profiling the racing career of Thoroughbred horses, More (1999) reported that 13% of 2 years old recouped their training costs through prize money earned. The estimated cost of keeping a horse for the 2 year period was obtained for the mean purchase price of $55,000. It is possible that the cost of keep would have been less than this amount for cheaper horses and more than this amount for more expensive horses depending upon the buyer's choice of trainer. For example it is unlikely that a yearling purchased for $10,000 would be placed with the same trainer as one that was purchased for $500,000, however this data was not available.

As sale price category increased the chance of a buyer earning back the cost of the yearling decreased. Horses purchased within the $0 to $10,000 category were, on average, almost four times more likely to earn back their purchase price than those purchased for more than $100,000.

The $50,001 to $100,000 category had the highest proportion of horses earning back the combined purchase price and estimated costs. However, only 7% of horses within that category earned prize money in excess of the combined costs, so purchasers are still unlikely to make a return on their investment within the first 2 years.

Conclusions

With increasing sale price category there is an increased chance of earning back the estimated costs of $40,000 and a decreased chance of earning back the purchase price.

Amongst all horses studied only 5.1% recouped the combined estimated costs and purchase price in the first 2 years of racing.

Many studies utilise race performance as a measure of success for analysis. Incorporation of horse value as a confounding factor may be of use in studies where the horse population is of varied quality.

This study only analyses income from the first 2 years of racing, and does not consider potential future earnings from racing, breeding or on-sale.

Inter- and Intra-Radiologist Agreement for Reporting of Radiographic Quality and Orthopaedic Findings

Introduction

Radiologists and veterinarians are frequently required to interpret radiographic examinations of clinical cases for potential abnormalities. With the introduction of radiograph repositories to auction sales in Australia and other leading Thoroughbred breeding countries there is increased pressure upon veterinarians to interpret pre-sale radiographic examinations and make a decision regarding a horse's potential future racing performance. Horses presented for sale at auction usually have no obvious signs of clinical abnormality to help the veterinarian in interpreting the radiographs. Veterinarians are therefore frequently looking for any abnormal radiographic findings, and are often required to make a decision regarding the importance of these lesions based on personal experience. The ability of a radiologist or veterinarian to interpret the pre-sale radiographs is a significant factor when weighing up any abnormal radiographic findings. To the best of the authors' knowledge there have been no published studies reporting inter- and intra-radiologist agreement for reporting of abnormal radiographic findings on pre-sale radiographs of Thoroughbred yearlings.

Materials and Methods

Number of Radiographic Sets to be Read

The number of radiograph sets to be read for a required 95% confidence interval width of ≤ 0.2, assuming a lesion prevalence of 30% and a kappa-statistic of 0.8 was calculated as 167 (Shoukri 2004).

Random Selection of Radiographic Sets

The identification numbers of the 167 sets to be read were selected using a random number generator (www.random.org/sform.html 5/4/2005). The 167 sets of radiographs were chosen from the first 800 of the 2401 sets of radiographs catalogued.

Radiograph Reporting

The randomly selected sets of radiographs were read twice by four specialist veterinary radiologists. There was approximately 12 months between the first and second readings of radiologist A, six months between readings for radiologist B and three weeks between readings for radiologists C and D.

Radiograph Quality

The quality of all radiographs was assessed, by one of four veterinary specialist radiologists, based on the following possible flaws.

Movement

Movement of the horse, radiographic plate and/or radiographic beam resulting in blurring of the radiographic image.

Exposure

A radiographic image was considered to be over-exposed if the margins of bones could not be reliably assessed with the use of a bright light and/or if examination of soft tissue was not possible. Under-exposure of the radiographic image was considered to have occurred when the internal trabecular detail and subchondral bone could not be assessed.

Positioning

A positioning flaw was recorded if any part of the area of interest was not visible because it was outside of the field of view, obscured by overlying structures, or distorted due to poor alignment of the X-ray beam, limb and/or radiographic plate.

Labelling and Markers

A labelling flaw was recorded if the film did not meet the repository requirements (Table 1), if the placement of radiographic markers resulted in the inability to identify the radiographic view, and/or if labels or markers obscured the radiographic image.

Processing

Any problems associated with the processing of the film were recorded including roller marks, fixative residue, inadequate fixing and dark room artefact.

Grading

All radiographs were assessed as: 1) no flaws present, 2) flaws present resulting in the film being less than ideal but still diagnostic, and 3) flaws rendering the film non-diagnostic.

An individual radiograph could have multiple flaws; it could be graded as less than ideal for more than one flaw or be graded less than ideal for one flaw and be deemed non-diagnostic for another.

Film Quality Groupings for Analysis

Based on preliminary data indicating that radiographs of the flexed lateromedial fore fetlock, lateromedial hind fetlock, and the dorsomedial palmarolateral oblique view of the carpus were most commonly being reported as non-diagnostic due to positioning flaws, these results were used for agreement analysis. Positioning flaws resulting in the flexed lateromedial fore fetlock (FF FlexLM), lateromedial hind fetlock (HF LM) or dorsomedial palmarolateral carpus (C DMPaLO) being considered non-diagnostic (ND) were grouped as present or absent for agreement analysis.

Orthopaedic Lesion Reporting

Radiographs were reviewed by one of four veterinary specialist radiologists for radiographically-detectable orthopaedic abnormalities as outlined below. All findings were recorded separately for the left and right limbs and for medial and lateral proximal sesamoid bones. Modelling in any joint was defined as proliferative bone growth that changed the bone surface contour.

Fore Feet

A foot was considered to be upright (club) if the foot axis was 60^{o} or more. This angle was measured using the dorsal hoof wall; in cases where this was not possible, due to radiograph quality, the dorsal cortex of the third phalanx was used. The presence of modelling on the dorsal and dorsodistal surfaces of P3, and any osteophytes of the distal interphalangeal joint (P2/P3) were recorded. Any fracture of third phalanx was recorded.

Fore and Hind Fetlocks

In the fore and hind fetlocks defects of the sagittal ridge of the third metacarpus/tarsus were identified. Defects were graded according to the length observed on the flexed lateromedial view in the fore fetlocks and the lateromedial view in the hind fetlocks. The presence of a fragment on the distal aspect of the third metacarpal bone was recorded for the fore fetlocks only. Fragments of the dorsal proximal first phalanx and palmar/plantar first phalanx were reported. Palmar/plantar fragments of the first phalanx were further categorised as articular or non-articular based on their position. In the fore fetlocks palmar supracondylar lysis of the third metacarpus, defined as increased convexity of the bone surface immediately proximal to the articular surface, was reported as present or absent. Modelling on the dorsal surface of the first phalanx was recorded in the fore fetlocks only.

Fore and Hind Sesamoids

Vascular channels present in the lateral and medial proximal sesamoid bones were graded according to type and number present, as described by Spike-Pierce and Bramlage (2003). A regular channel was considered to be linear and less than 2 mm in width and an irregular channel was abnormally shaped and greater than 2 mm in width. Number and type of vascular channels were recorded and horses where then grouped on the basis of having one or two regular vascular channels, three or more regular vascular channels, one or two irregular vascular channels, or three or more irregular vascular channels. Presence of modelling on any surface, lucency within, and fracture of, the sesamoid bones was recorded as present or absent.

Carpi

Fragment, osteophyte or enthesiophyte of any area of the carpi were recorded as present or absent. Fragment, osteophyte or enthesiophyte of the radial carpal and/or third carpal bone were grouped. The presence of an OCLL in the ulnar carpal bone was recorded. First and fifth carpal bones were recorded as present or absent.

Tarsi

OCD, defined as any osteochondral fragment, flap or change in contour of the distal intermediate ridge of the tibia, medial or lateral malleoli of the tibia, or medial or lateral trochlear ridges of the talus, were recorded as present or absent. Osteophytes of the tarsocrural, intertarsal and tarsometatarsal joints were recorded as present or absent. Any fracture of the tarsi was recorded as present or absent.

Stifles

OCD of the lateral or medial trochlear ridges of the femur, and of the patella were recorded. OCD of the trochlear ridges was graded by length as observed on the lateromedial view of the stifle. OCD of the patella was recorded as present or absent. OCLL of the medial condyle of the femur were graded by depth as observed on the caudocranial view of the stifle. Fracture of the patella was recorded as present or absent.

Orthopaedic Findings Grouping for Analysis

Radiographically-detectable orthopaedic lesions were grouped as present or absent for agreement analysis. Fore foot, fore fetlock, carpus, hind fetlock, tarsus, stifle and additional lesion groupings are outlined in Table 9 to Table 15 below.

Table 9. Fore foot lesion groupings.

Fore Foot Lesion	Abbreviated
Club foot	FFootClub
Modelling dorsal aspect third phalanx	FFootOsteoDorsal
Modelling toe of third phalanx	FFootOsteoToe

Table 10. Fore fetlock lesion groupings.

Fore Fetlock Lesion	Abbreviated
Sagittal ridge defect and/or fragment third metacarpal	FFSRDPresent
Fragment dorsoproximal aspect first phalanx	FFFragProxP1
Fragment proximopalmar aspect first phalanx	FFFragPalmP1
Lateral and/or medial sesamoid vascular channel	FFSesVCPresent
Lateral and/or medial sesamoid vascular channel ≤ 2 mm wide (regular)	FFSesVCLTE2
Lateral and/or medial sesamoid vascular channel > 2 mm wide (irregular)	FFSesVCGT2
Lateral and/or medial sesamoid modelling	FFSesModelling
Lateral and/or medial sesamoid cystic lesion	FFSesCyst
Lateral and/or medial sesamoid fracture	FFSesFrac

Table 11. Carpus lesion groupings.

Carpus Lesion	Abbreviated
Osteophyte and/or enthesiophyte	CarpOsteoEnth
Osseous cyst-like lesion (OCLL) ulnar carpal bone	CarpOCLLUlnar
First and/or fifth carpal bone	CarpC1C5

Table 12. Hind fetlock lesion groupings.

Hind Fetlock Lesion	Abbreviated
Sagittal ridge defect third metatarsal	HFSRDPresent
Fragment dorsoproximal aspect first phalanx	HFFragProxP1
Fragment proximoplantar aspect first phalanx	HFFragPlantP1
Lateral and/or medial sesamoid vascular channel	HFSesVCPresent
Lateral and/or medial sesamoid vascular channel ≤ 2 mm wide (regular)	HFSesVCLTE2
Lateral and/or medial sesamoid vascular channel > 2 mm wide (irregular)	HFSesVCGT2
Lateral and/or medial sesamoid modelling	HFSesModelling
Lateral and/or medial sesamoid cystic lesion	HFSesCyst
Lateral and/or medial sesamoid fracture	HFSesFrac

Table 13. Tarsus lesion groupings.

Tarsus Lesion	Abbreviated
Osteochondrosis (OCD) distal intermediate ridge tibia and/or medial/lateral malleolus tibia	TarOCDDIRTMall
OCD medial/lateral trochlear ridge talus	TarOCDTroch
Osteophyte talocalcaneal-centroquatral and/or centrodistal joints	TarOsteoTCCD
Osteophyte tarsometatarsal joint	TarOsteoTMT

Table 14. Stifle lesion groupings.

Stifle Lesion	Abbreviated
OCD medial/lateral trochlear ridge femur and/or patella	StifleOCDPresent
OCD medial/lateral trochlear ridge femur and/or patella ≤ 20 mm long	StifleOCDLTE20
OCD medial/lateral trochlear ridge femur and/or patella 21 to 40 mm long	StifleOCD21to40
OCD medial/lateral trochlear ridge femur and/or patella > 40 mm long	StifleOCDGT40
OCLL medial condyle femur	StifleOCLLPresent
OCLL medial condyle femur ≤ 6 mm deep	StifleOCLLLTE6
OCLL medial condyle femur > 6 mm deep	StifleOCLLGT6

Table 15. Additional lesion groupings.

Lesion	Abbreviated
OCD in any joint	OCDPresent
OCD in any joint ≤ 20 mm deep	OCDLTE20
OCD in any joint > 20 mm deep	OCDGT20
Fracture and/or fragment in any joint	FracFrag
Osteophyte and/or enthesiophyte in any joint	OsteoEnth

Statistical Analysis

The kappa-statistic (K) (Cohen 1960), percentage of positive agreement and percentage of negative agreement (Cicchetti and Feinstein 1990) for intra-radiologist agreement between readings 1 and 2 were calculated. Combined inter-radiologist kappa-statistic for Radiologist A, B, C and D (RA, RB, RC and RD) reading 1 and RA, RB, RC and RD reading 2 were determined (Fleiss 2003). The percentage of positive agreement and percentage of negative agreement for inter-radiologist agreement for RA and RB, RA and RC, RA and RD, RB and RC, RB and RD and RC and RD for reading 1 and reading 2 were calculated. The mean percentage of positive agreement and mean percentage of negative agreement for the six combinations of reading 1 and reading 2 are reported.

The kappa-statistic was interpreted as follows: <0.20 slight agreement, 0.20 to 0.40 fair agreement, 0.41 to 0.60 moderate agreement, 0.61 to 0.80 substantial agreement and >0.8 almost perfect agreement (Dohoo *et al.* 2003). The percentage of positive agreement is the percentage of concurring "present" ratings of all "present" ratings, and is calculated by: $2a / (2a+b+c)$ where a = the number of "present - present" pairs; b = the number of "present – absent" pairs and c = the number of "absent – present" pairs. The percentage of negative agreement is the concordant "absent" ratings as a percentage of all "absent" ratings, and is calculated by $2d / (2d+b+c)$ where d = the number of "absent – absent" pairs (Cicchetti and Feinstein 1990). The percentage of positive and negative agreements are not influenced by the prevalence of the lesion, however kappa varies with the prevalence. SPSS was used to calculate the kappa statistic, WinPepi (Abramson 2004) to calculate the percentage of positive and negative agreement, and Stata (StataCorp, College Station, Texas, USA) was used to estimate the combined inter-radiologist kappa statistic.

Results

Film Quality

There were 12 radiographs missing from the 167 sets examined, leaving 5666 radiographs for examination for flaws affecting film quality. Flexed lateromedial views of the fore fetlock were most commonly considered non-diagnostic. Lateromedial views of the hind fetlock and dorsomedial palmarolateral views of the carpus were the next most commonly considered to be non-diagnostic (Table 16). Each of these three radiographic views was most frequently considered to be non-diagnostic due to incorrect positioning flaws (data not shown).

Table 16. Number of radiographs considered non-diagnostic for any flaw by Radiologist A, B, C and D readings 1 and 2 for each radiographic view.

Joint	View	n	Radiologist A Read 1 (n)	Radiologist A Read 2 (n)	Radiologist B Read 1 (n)	Radiologist B Read 2 (n)	Radiologist C Read 1 (n)	Radiologist C Read 2 (n)	Radiologist D Read 1 (n)	Radiologist D Read 2 (n)
Fore Foot	LM	334	2	1	2	2	3	2	1	1
Fore Fetlock	FlexLM	334	81	82	73	67	83	60	72	81
	DLPaMO	334	19	27	5	13	6	4	4	5
	DMPaLO	334	6	21	6	14	9	2	4	4
	DPa	334	1	1	4	6	15	3	2	0
Carpus	FlexLM	334	1	2	4	1	1	4	0	0
	DLPaMO	334	14	13	1	4	4	4	1	1
	DMPaLO	333	33	39	7	10	16	3	0	0
Hind Fetlock	LM	334	9	14	73	56	125	60	110	109
	DLPlMO	334	23	36	4	12	9	2	1	1
	DMPlLO	333	7	38	15	12	20	10	10	7
	DPl	334	2	0	4	12	14	4	0	2
Tarsus	LM	334	4	4	9	2	15	14	1	1
	DMPlLO	330	11	19	6	3	15	9	1	2
	DPl	334	9	21	8	0	8	12	1	0
Stifle	LM	332	14	7	12	17	12	4	1	0
	CdCr	330	14	13	11	29	12	11	5	6
Total Radiographs		5666	250	338	244	260	367	208	214	220

Intra-radiologist

Moderate to almost perfect agreement was observed within radiologists when grading film quality for flexed lateromedial views of the fore fetlock joints and fair to almost perfect agreement for lateromedial views of the hind fetlock joints. Only slight to fair agreement within radiologists was observed when grading film quality for dorsomedial palmarolateral views of the carpus.

Table 17. Measures of agreement for film quality of Radiologist A reading 1 and reading 2 (n=167).

View	Read 1 Present Read 2 Present	Read 1 Present Read 2 Absent	Read 1 Absent Read 2 Present	Read 1 Absent Read 2 Absent	Kappa-statistic (K)	Positive Agreement (%)	Negative Agreement (%)
FF FlexLM	48	7	8	104	0.80	86.5	93.3
HF LM	4	2	8	153	0.42	44.4	96.8
C DMPaLO	10	11	26	120	0.29	35.1	86.6

Table 18. Measures of agreement for film quality of Radiologist B reading 1 and reading 2 (n=167).

View	Read 1 Present Read 2 Present	Read 1 Present Read 2 Absent	Read 1 Absent Read 2 Present	Read 1 Absent Read 2 Absent	Kappa-statistic (K)	Positive Agreement (%)	Negative Agreement (%)
FF FlexLM	38	6	9	114	0.77	83.5	93.8
HF LM	26	23	12	106	0.46	59.8	85.8
C DMPaLO	1	4	6	156	0.14	16.7	96.9

Table 19. Measures of agreement for film quality of Radiologist C reading 1 and reading 2 (n=167).

View	Read 1 Present Read 2 Present	Read 1 Present Read 2 Absent	Read 1 Absent Read 2 Present	Read 1 Absent Read 2 Absent	Kappa-statistic (K)	Positive Agreement (%)	Negative Agreement (%)
FF FlexLM	34	19	4	110	0.66	74.7	90.5
HF LM	38	49	5	75	0.37	58.5	73.5
C DMPaLO	1	8	1	157	0.16	18.2	97.2

Table 20. Measures of agreement for film quality of Radiologist D reading 1 and reading 2 (n=167).

View	Read 1 Present Read 2 Present	Read 1 Present Read 2 Absent	Read 1 Absent Read 2 Present	Read 1 Absent Read 2 Absent	Kappa-statistic (K)	Positive Agreement (%)	Negative Agreement (%)
FF FlexLM	48	3	6	110	0.87	94.6	96.1
HF LM	67	7	7	86	0.83	91.6	92.5
C DMPaLO	0	0	0	167	Not Applicable	Not Applicable	100.0

Inter-radiologist

When grading flexed lateromedial views of the fore fetlocks for incorrect positioning flaws there was only slight agreement observed between radiologists. Substantial agreement was observed between radiologists for grading of incorrect positioning of the lateromedial hind fetlock views. Only fair agreement was observed between radiologists for incorrect positioning of the dorsomedial palmarolateral views of the carpus.

Table 21. Measures of agreement for film quality of Radiologist A, B, C and D reading 1.

View	Total Cases (n)	Kappa-statistic (K)	Positive Agreement (%)	Negative Agreement (%)
FF FlexLM	167	0.15	84.0	93.0
HF LM	167	0.77	43.8	79.2
C DMPaLO	167	0.31	30.5	94.6

Table 22. Measures of agreement for film quality of Radiologist A, B, C and D reading 2.

View	Total Cases (n)	Kappa-statistic (K)	Positive Agreement (%)	Negative Agreement (%)
FF FlexLM	167	0.05	77.9	91.1
HF LM	167	0.69	46.9	83.3
C DMPaLO	167	0.34	12.6	91.7

Orthopaedic Findings

Intra-radiologist

Almost perfect agreement was observed within radiologists for the presence of extra carpal bones (Table 23 to Table 26). Almost perfect to substantial agreement was observed for osteochondrosis lesions greater than 20 mm in depth and/or 21-40 mm in length, osseous cyst- like lesions of the ulnar carpal bone (Figure 8) and of the stifle, fore fetlock sagittal ridge defects and for plantar fragments of the first phalanx of the hind fetlock joints.

Fair or only slight agreement for at least one radiologist where the prevalence for the lesion was between 20 and 147 out of 167 was observed for osteophytes and enthesiophytes at all locations, fore fetlock vascular channels greater than 2 mm (Figure 12), fore and hind sesamoid cysts, intertarsal and tarsometatarsal osteophytes (Figure 9).

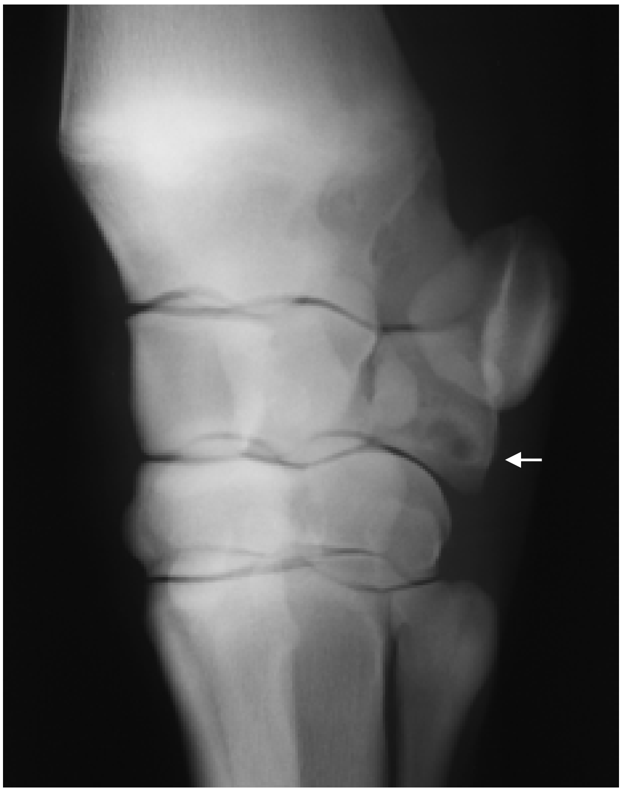

Figure 8. A dorsolateral palmaromedial oblique view of a carpus showing an example of an osseous cyst-like lesion present in the ulnar carpal bone. There was substantial to almost perfect agreement observed within and between radiologists for identifying this radiographic finding.

Table 23. Measures of agreement for orthopaedic findings of Radiologist A reading 1 and reading 2 (n=167).

Finding	Read 1 Present Read 2 Present	Read 1 Present Read 2 Absent	Read 1 Absent Read 2 Present	Read 1 Absent Read 2 Absent	Kappa-statistic (K)	Positive Agreement (%)	Negative Agreement (%)
				Almost Perfect			
CarpC1C5	43	1	3	120	0.94	95.6	98.4
HFFragPlantP1	9	3	0	155	0.85	85.7	99.0
CarpOCLLUlnar	22	0	7	138	0.84	86.3	97.5
				Substantial			
FFSRDPresent	38	9	4	116	0.80	85.4	94.7
StifleOCD21to40	5	2	1	159	0.76	76.9	99.1
StifleOCDPresent	8	5	2	154	0.75	76.2	98.4
StifleOCLLPresent	10	6	2	149	0.69	71.4	97.4
FracFrag	20	13	1	133	0.69	74.1	95.0
StifleOCLLLTE6	7	5	1	150	0.68	70.0	98.0
FFFragPalmP1	1	1	0	165	0.66	66.7	99.7
HFSRDPresent	1	1	0	165	0.66	66.7	99.7
HFFragProxP1	3	3	0	161	0.66	66.7	99.1
TarOCDTroch	1	1	0	165	0.66	66.7	99.7
TarOsteoTCCD	3	0	3	161	0.66	66.7	99.1
OCDPresent	11	8	2	146	0.66	68.8	96.7
TarOsteoTMT	6	5	1	155	0.65	66.7	98.1
OCDGT20	10	9	2	146	0.61	64.5	96.4
				Moderate			
FFootOsteoDorsal	10	11	2	144	0.57	60.6	95.7
FFSesModelling	5	6	1	155	0.57	58.8	97.8
FFootClub	4	6	0	157	0.56	57.1	98.1
FFSesFrac	2	3	0	162	0.56	57.1	99.1
HFSesVCGT2	24	18	7	118	0.56	65.8	90.4
TarOCDDIRTMall	2	1	2	162	0.56	57.1	99.1
FFSesCyst	13	13	7	134	0.50	56.5	93.1
OsteoEnth	28	23	12	104	0.47	61.5	85.6
				Fair			
FFSesVCPresent	158	6	1	2	0.37	97.8	36.4
FFSesVCGT2	18	32	5	111	0.37	77.7	85.7

HFSesVCPresent	128	13	15	11	0.34	90.1	44.0
StifleOCDLTE20	2	5	2	158	0.34	36.4	97.8
HFSesVCLTE2	125	14	17	11	0.30	89.0	41.5
OCDLTE20	1	5	0	161	0.28	28.6	98.5
CarpOsteoEnth	2	5	5	155	0.25	28.6	96.9
			Slight				
HFSesCyst	2	5	10	150	0.17	21.1	95.2
FFSesVCLTE2	147	8	9	2	0.14	94.5	19.0
StifleOCDGT40	0	2	0	165	0.00	0.0	99.4
FFootOsteoToe	0	1	1	165	-0.01	0.0	99.4
FFFragProxP1	0	3	1	163	-0.01	0.0	98.8
HFSesModelling	0	2	3	162	-0.01	0.0	98.5
StifleOCLLGT6	0	1	1	161	-0.01	0.0	99.4
HFSesFrac	0	4	2	161	-0.02	0.0	98.2

For some findings the total number may not equal 167 due to missing radiographs

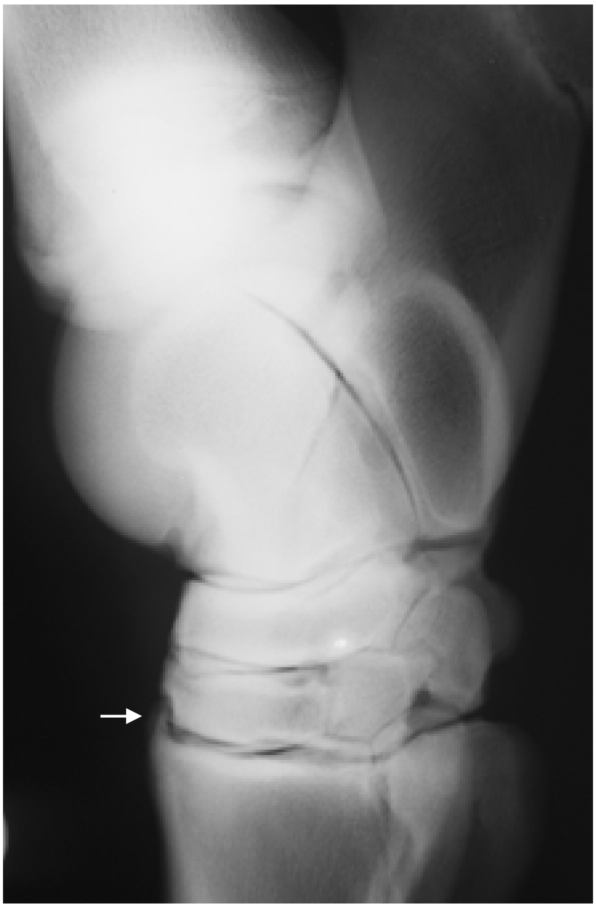

Figure 9. A lateromedial view of a left tarsus showing osteophytes of the tarsometatarsal joint. Within radiologist agreement was substantial for three out of four radiologists and fair for the remaining radiologist, but between radiologist the observed agreement was only fair.

Table 24. Measures of agreement for orthopaedic findings of Radiologist B reading 1 and reading 2 (n=167).

Finding	Read 1 Present Read 2 Present	Read 1 Present Read 2 Absent	Read 1 Absent Read 2 Present	Read 1 Absent Read 2 Absent	Kappa-Statistic (K)	Positive Agreement (%)	Negative Agreement (%)
			Almost Perfect				
FFFragPalmP1	1	0	0	166	1.00	100.0	100.0
StifleOCDGT40	1	0	0	163	1.00	100.0	100.0
StifleOCLLLTE6	1	0	0	154	1.00	100.0	100.0
StifleOCLLGT6	3	0	0	152	1.00	100.0	100.0
CarpC1C5	43	2	4	118	0.91	93.5	87.8
HFFragPlantP1	9	2	1	155	0.85	85.7	99.0
OCDGT20	6	1	1	143	0.85	85.7	99.3
			Substantial				
CarpOCLLUlnar	29	6	9	123	0.74	79.5	94.3
StifleOCDPresent	6	2	3	156	0.69	70.6	98.4
FFSesFrac	2	2	0	163	0.66	66.7	99.4
TarOCDDIRTMall	4	4	0	159	0.66	66.7	98.8
StifleOCD21to40	2	2	0	160	0.66	66.7	99.4
FFSRDPresent	49	14	14	90	0.64	77.8	86.5
StifleOCLLPresent	8	4	4	151	0.64	66.7	97.4
HFSesVCGT2	20	7	11	129	0.62	69.0	93.5
HFSRDPresent	5	1	5	156	0.61	62.5	98.1
			Moderate				
HFSesVCPresent	108	19	8	32	0.59	88.9	70.3
HFSesVCLTE2	104	20	9	34	0.58	87.8	70.1
FFSesVCLTE2	155	3	4	5	0.57	97.8	58.8
OCDPresent	11	9	4	143	0.57	62.9	95.7
FracFrag	17	9	10	131	0.57	64.2	93.2
FFSesVCPresent	157	3	3	4	0.55	98.1	57.1
FFSesVCGT2	21	15	10	121	0.53	62.7	90.6
HFFragProxP1	1	1	1	164	0.49	50.0	99.4
FFootOsteoDorsal	17	5	24	121	0.44	54.0	89.3
			Fair				
FFSesModelling	1	1	2	163	0.39	40.0	99.1
FFootClub	4	9	3	151	0.36	40.0	96.2

FFootOsteoToe	4	4	8	151	0.36	40.0	96.2
TarOsteoTMT	17	15	23	112	0.33	47.2	85.5
OsteoEnth	54	16	45	52	0.29	63.9	63.0
TarOsteoTCCD	6	4	19	138	0.28	25.8	92.3
TarOCDTroch	1	4	1	161	0.27	28.6	98.5
HFSesCyst	1	5	1	160	0.24	25.0	98.2
				Slight			
CarpOsteoEnth	2	6	10	149	0.15	20.0	94.9
FFFragProxP1	0	1	0	166	0.00	0.0	99.7
HFSesModelling	0	3	0	164	0.00	0.0	99.1
StifleOCDLTE20	0	0	2	162	0.00	0.0	99.4
OCDLTE20	0	0	1	150	0.00	0.0	99.7
FFSesCyst	0	4	4	159	-0.02	0.0	97.5
HFSesFrac	0	6	4	157	-0.03	0.0	96.9

For some findings the total number may not equal 167 due to missing radiographs

Figure 10. A dorsomedial plantarolateral oblique view of the tarsus showing an example of an osteochondrosis fragment of the distal intermediate ridge of the tibia. The agreement within and between radiologists for the reporting of this finding ranged from moderate to substantial.

Table 25. Measures of agreement for orthopaedic findings of Radiologist C reading 1 and reading 2 (n=167).

Finding	Read 1 Present Read 2 Present	Read 1 Present Read 2 Absent	Read 1 Absent Read 2 Present	Read 1 Absent Read 2 Absent	Kappa-statistic (K)	Positive Agreement (%)	Negative Agreement (%)
			Almost Perfect				
StifleOCDGT40	2	0	0	165	1.00	100.0	100.0
CarpC1C5	45	2	3	117	0.93	94.7	97.9
StifleOCD21to40	5	1	1	160	0.83	83.3	99.4
			Substantial				
FFSRDPresent	62	8	9	88	0.79	87.9	91.2
StifleOCLLLTE6	6	2	1	156	0.79	80.0	99.0
FFootOsteoToe	10	2	3	152	0.78	80.0	98.4
CarpOCLLUlnar	26	1	11	129	0.77	81.3	95.6
StifleOCLLPresent	8	2	4	153	0.71	72.7	98.1
StifleOCDPresent	6	2	3	156	0.69	70.6	98.4
HFSesVCLTE2	132	5	10	20	0.67	94.6	72.7
OCDGT20	8	3	4	142	0.67	69.6	97.7
FFootClub	2	2	0	163	0.66	66.7	99.4
TarOsteoTMT	66	5	24	72	0.66	82.0	83.2
HFSesVCPresent	132	6	10	19	0.65	94.3	70.4
FFSesVCGT2	20	3	14	126	0.64	70.2	93.7
HFSesVCGT2	20	5	12	130	0.64	70.2	93.9
FFSesFrac	4	3	2	158	0.60	61.5	98.4
HFFragPlantP1	4	3	2	158	0.60	61.5	98.4
TarOsteoTCCD	15	9	7	136	0.60	65.2	94.4
			Moderate				
HFSRDPresent	16	11	6	134	0.59	65.3	94.0
FracFrag	16	9	8	134	0.59	65.3	94.0
OCDPresent	15	10	8	134	0.56	62.5	93.7
TarOCDTroch	4	5	1	157	0.55	57.1	98.1
OCDLTE20	4	3	4	147	0.51	47.1	97.2
OsteoEnth	97	10	26	34	0.50	84.3	65.4
HFSesFrac	1	1	1	164	0.49	50.0	99.4
StifleOCLLGT6	1	0	2	162	0.49	50.0	99.4
CarpOsteoEnth	8	12	4	143	0.45	50.0	94.7
TarOCDDIRTMall	4	5	4	154	0.44	47.1	97.2
			Fair				
HFFragProxP1	1	1	2	163	0.39	40.0	99.1

HFSesCyst	11	7	18	131	0.39	46.8	91.3
FFootOsteoDorsal	14	15	15	123	0.37	48.3	89.1
FFSesCyst	16	10	31	110	0.30	43.8	84.3
FFSesVCPresent	160	1	5	1	0.24	98.2	25.0
FFSesVCLTE2	156	2	4	1	0.23	98.1	25.0
				Slight			
FFSesModelling	2	7	7	151	0.18	22.2	95.6
FFFragProxP1	0	0	2	165	0.00	0.00	99.4
FFFragPalmP1	0	0	1	166	0.00	0.00	99.7
HFSesModelling	0	2	3	162	-0.01	0.00	98.5
StifleOCDLTE20	0	1	2	164	-0.01	0.00	99.1

For some findings the total number may not equal 167 due to missing radiographs

Figure 11. A lateromedial view of a right fore fetlock showing an example of a fragment of the proximal dorsal aspect of the first phalanx. Agreement within and between radiologists when identifying this abnormality was slight.

Table 26. Measures of agreement for orthopaedic findings of Radiologist D reading 1 and reading 2 (n=167).

Finding	Read 1 Present Read 2 Present	Read 1 Present Read 2 Absent	Read 1 Absent Read 2 Present	Read 1 Absent Read 2 Absent	Kappa-statistic (K)	Positive Agreement (%)	Negative Agreement (%)
				Almost Perfect			
FFSesModelling	1	0	0	166	1.00	100.0	100.0
FFSesFrac	2	0	0	165	1.00	100.0	100.0
StifleOCD21to40	4	0	0	162	1.00	100.0	100.0
CarpC1C5	46	2	0	119	0.97	97.9	99.2
HFFragPlantP1	6	1	0	160	0.92	92.3	99.7
StifleOCDPresent	6	0	1	160	0.92	92.3	99.7
CarpOCLLUlnar	39	1	6	121	0.89	91.8	97.2
OCDGT20	7	0	2	156	0.87	87.5	99.4
StifleOCLLLTE6	3	1	0	161	0.85	85.7	99.7
StifleOCLLGT6	3	1	0	161	0.85	85.7	99.7
OCDPresent	9	0	3	155	0.85	85.7	99.0
HFSRDPresent	4	1	5	157	0.83	57.1	98.1
FracFrag	10	4	0	153	0.82	83.3	98.7
				Substantial			
StifleOCLLPresent	6	4	0	157	0.74	97.6	98.7
TarOsteoTMT	34	12	5	116	0.73	80.0	93.2
FFSRDPresent	53	9	4	101	0.68	89.1	94.0
FFSesVCGT2	37	10	13	107	0.67	76.3	90.3
FFSesVCPresent	165	1	0	1	0.66	99.7	66.7
CarpOsteoEnth	1	1	0	165	0.66	66.7	99.7
TarOCDDIRTMall	2	0	2	163	0.66	66.7	99.4
TarOCDTroch	1	0	1	165	0.66	66.7	99.7
StifleOCDGT40	1	0	1	164	0.66	66.7	99.7
HFSesVCPresent	144	6	5	12	0.65	96.3	68.6
HFSesVCLTE2	137	10	7	13	0.65	94.2	60.5
OsteoEnth	59	15	16	77	0.62	79.2	83.2
FFootOsteoDorsal	10	1	10	146	0.61	64.5	96.4
				Moderate			
HFSesVCGT2	35	8	13	111	0.55	76.9	91.4
FFootOsteoToe	7	7	9	144	0.41	46.7	94.7
				Fair			

FFSesVCLTE2	163	1	2	1	0.39	99.1	40.0
TarOsteoTCCD	2	6	1	158	0.35	36.4	97.8
				Slight			
HFFragProxP1	0	2	0	165	0.00	0.0	99.4
HFSesModelling	0	2	8	157	-0.02	0.0	96.9
HFSesFrac	0	6	10	151	-0.05	0.0	95.0
FFootClub	0	0	0	167	Not Applicable	Not Applicable	100.0
FFFragProxP1	0	0	0	167	Not Applicable	Not Applicable	100.0
FFFragPalmP1	0	0	0	167	Not Applicable	Not Applicable	100.0
FFSesCyst	0	0	0	167	Not Applicable	Not Applicable	100.0
HFSesCyst	0	0	0	167	Not Applicable	Not Applicable	100.0
StifleOCDLTE20	0	0	0	166	Not Applicable	Not Applicable	100.0
OCDLTE20	0	0	0	165	Not Applicable	Not Applicable	100.0

For some findings the total number may not equal 167 due to missing radiographs

Inter-radiologist

There was almost perfect agreement between radiologists on the presence of extra carpal bones (Table 27 to Table 28). Almost perfect to substantial agreement was shown for osseous cyst-like lesions of the stifle greater than 6 mm in depth, and stifle osteochondrosis lesions greater than 20 mm in length.

Radiologists showed substantial agreement on the presence or absence of all osteochondrosis lesions greater than 20 mm deep, and the presence or absence of fracture fragments. For more specific lesions there was substantial agreement on the presence or absence of sagittal ridge defects, palmar P1 fragments and sesamoid fractures in the fore fetlocks, plantar P1 fragments in the hind fetlocks, osteochondrosis of the distal tibia (Figure 10), and osseous cyst-like lesions in the ulnar carpal bones (Figure 8).

Moderate agreement was shown for the presence or absence of an osteochondrosis lesion. For specific lesions there was moderate agreement for the presence or absence of sesamoid vascular channels (Figure 12).

Fair to slight agreement for lesions with a prevalence of between 20 and 147 out of 167 for at least one radiologist was shown for osteophytes and enthesiophytes at any site, fore fetlock sesamoid vascular channels greater than 2, fore and hind fetlock sesamoid cystic lesions, hind fetlock sagittal ridge defects, and osteophytes of the tarsometatarsal (Figure 9) and centrodistal joints.

Table 27. Measures of agreement for orthopaedic findings of Radiologists A, B, C and D reading 1.

Finding	Total Cases (n)	Kappa-statistic (K)	Positive Agreement (%)	Negative Agreement (%)
		Almost Perfect		
StifleOCDGT40	164	1.00	100.0	100.0
CarpC1C5	167	0.93	95.3	98.2
StifleOCD21to40	164	0.91	91.7	99.8
		Substantial		
HFFragPlaP1	167	0.80	81.7	98.9
StifleOCDPresent	167	0.75	77.5	98.7
CarpOCLLUlnar	167	0.73	77.9	95.0
FFSRDPresent	167	0.71	81.6	89.7
HFFragProxP1	167	0.66	65.0	99.3
StifleOCLLGT6	161	0.66	63.4	99.4
OCDGT20	154	0.64	70.6	97.7
FracFrag	167	0.64	69.3	94.7
FFSesFrac	167	0.62	100.0	100.0
StifleOCLLPresent	167	0.61	63.5	97.2
		Moderate		
StifleOCLLLTE6	161	0.59	54.4	98.4
HFSesVCGT2	167	0.54	63.4	90.5
OCDPresent	167	0.53	58.9	94.9
TarOCDDIRTMall	167	0.50	53.3	98.3
HFSesVCPresent	167	0.41	90.1	51.1
HFSesVCLTE2	167	0.41	89.8	54.2
		Fair		
FFSesVCGT2	165	0.39	53.1	85.4
FFootOsteoDorsal	167	0.38	45.6	92.3
TarOsteoTMT	167	0.34	47.1	83.8
FFSesVCPresent	167	0.30	98.2	29.8
TarOsteoTCCD	167	0.29	32.9	95.2
FFootOsteoToe	167	0.27	31.8	96.1
OsteoEnth	167	0.27	59.0	66.3
FFSesVCLTE2	165	0.26	96.7	30.6
HFSRDPresent	167	0.26	36.5	95.4

FFFragPalP1	167	0.22	13.3	99.7
TarOCDTroch	167	0.22	30.2	98.0
		Slight		
FFootClub	167	0.16	44.5	78.6
FFFragProxP1	167	0.16	10.0	99.5
CarpOsteoEnth	167	0.13	16.9	91.9
FFSesModelling	167	0.11	19.8	96.9
HFSesCyst	167	0.11	9.5	95.9
OCDLTE20	154	0.09	3.3	98.3
FFSesCyst	167	0.05	7.5	91.9
StifleOCDLTE20	164	0.01	0.0	98.9
HFSesModelling	167	-0.01	0.0	98.7
HFSesFrac	167	-0.03	0.0	97.2

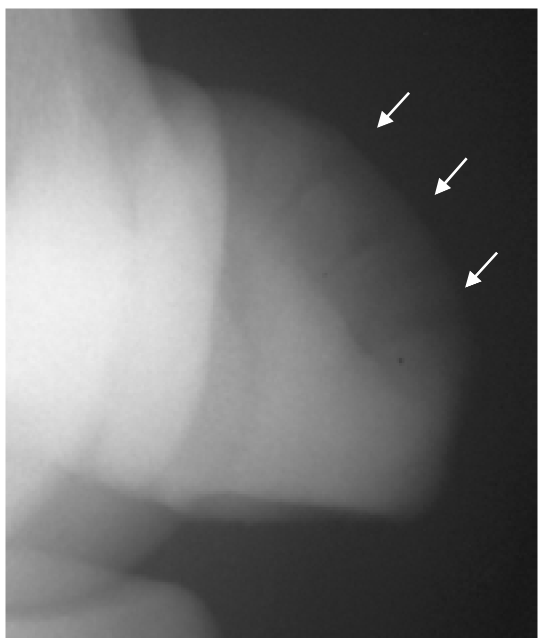

Figure 12. A section of a dorsomedial oblique view of the fore fetlock. There are several irregular vascular channels in the medial proximal sesamoid. Agreement within radiologists was only fair or slight, and between radiologist agreement was moderate.

Table 28. Measures of agreement for orthopaedic findings of Radiologists A, B, C and D reading 2.

Finding	Total Cases (n)	Kappa-statistic (K)	Positive Agreement (%)	Negative Agreement (%)
		Almost Perfect		
CarpC1C5	167	0.92	94.5	97.8
StifleOCLLGT6	159	0.90	83.4	99.9
		Substantial		
HFFragPlaP1	167	0.79	78.6	99.0
CarpOCLLUlnar	167	0.75	80.6	94.4
FFSRDPresent	167	0.73	81.8	90.4
TarOCDDIRTMall	167	0.73	75.0	99.2
OCDGT20	160	0.71	72.0	98.3
FFFragPalP1	167	0.67	50.0	99.9
StifleOCDPresent	167	0.67	68.9	98.4
FFSesFrac	167	0.66	75.0	99.4
StifleOCLLLTE6	159	0.61	55.8	98.9
		Moderate		
StifleOCLLPresent	167	0.59	61.6	97.5
OCDPresent	167	0.59	63.7	95.5
FracFrag	167	0.56	60.3	94.5
StifleOCD21to40	166	0.53	54.2	98.8
HFSesVCGT2	167	0.52	62.6	89.8
HFSesVCLTE2	167	0.44	88.5	53.0
HFSesVCPresent	167	0.43	89.7	54.3
StifleOCDGT40	166	0.42	33.4	99.6
FFootOsteoDorsal	167	0.41	50.2	90.8
		Fair		
TarOCDTroch	167	0.39	45.7	99.1
FFSesVCLTE2	164	0.38	97.9	35.5
FFSesModelling	167	0.37	37.7	98.2
FFSesVCGT2	164	0.36	49.3	86.8
FFootClub	167	0.29	44.1	98.6
HFSRDPresent	167	0.29	29.7	95.5
FFSesVCPresent	167	0.26	97.9	30.6
TarOsteoTCCD	167	0.25	27.4	93.6

FFootOsteoToe	167	0.24	25.5	91.9
HFFragProxP1	167	0.24	17.8	99.1
TarOsteoTMT	167	0.21	37.2	79.9
		Slight		
OsteoEnth	167	0.16	55.9	56.2
StifleOCDLTE20	166	0.15	10.3	98.9
CarpOsteoEnth	167	0.10	12.4	95.7
OCDLTE20	160	0.09	3.6	98.4
FFSesCyst	167	0.08	11.9	89.8
HFSesCyst	167	0.03	4.9	93.6
FFFragProxP1	167	-0.01	10.0	99.5
HFSesModelling	167	-0.02	0.0	97.9
HFSesFrac	167	-0.03	0.0	97.2

For some findings the total number may not equal 167 due to missing radiographs

Discussion

Radiography has been used for the diagnosis of equine orthopaedic conditions for over 40 years (Wheat and Rhode 1964). It is commonly used as part of a pre-purchase examination (Dart *et al.* 1992; van Hoogmoed *et al.* 2003), and survey radiographs submitted to a repository are now an important part of many Thoroughbred yearling sales (Kane *et al.* 2003a; Kane *et al.* 2003b). The use of a diagnostic technique is reliant on an understanding of its sensitivity and specificity, and agreement of interpretation. The interpretation of radiographs is subjective, and there is potential for disagreement both between and within observers making interpretations. Despite this, there are few studies examining the agreement of interpretation of equine radiographs (Labens *et al.* 2007; Morgan *et al.* 2006; Weller *et al.* 2001).

The kappa statistic is frequently used as a measure of agreement where data are categorical as in the current study. Low kappa values need to be interpreted with care as the analysis is highly prevalence-dependent. Where the prevalence of a lesion is very low or very high the kappa value can be misleading. For this reason low kappas were only regarded as reliable where the prevalence was between 20 and 147 out of 167.

The quality of a radiographic image directly affects its usefulness as a diagnostic tool. Any variation in film quality may result in abnormalities being missed (Hance and Morehead 2000; Meagher 2001; Park 2000). There was considerable variation in the number of views considered non-diagnostic, for any of the possible flaws, both within and between radiologists. It was expected that there would be varied agreement for reporting of film quality. Assessing a radiographic image as perfect, less than perfect or non-diagnostic is subjective and is likely to be an individual decision, based on personal preferences and experience.

The variation of moderate to almost perfect agreement within radiologists to slight agreement between radiologists for flexed lateromedial views of the fore fetlock is not surprising. This image is primarily used to view the sagittal ridge of the third metacarpus and even small changes in positioning can affect the image for this purpose. Although it is also used to examine the dorsal

and palmar aspects of the first phalanx, and the sesamoid bones, viewing of these areas is less affected by changes in positioning. Therefore an image may be non-diagnostic for viewing the sagittal ridge, but diagnostic for viewing all other areas of the joint. It is then an individual decision to regard the radiograph as non-diagnostic or not.

A standing lateromedial view is not performed for the specific purpose of viewing the sagittal ridge, but as a flexed lateral view of the hind fetlock is not included in the yearling protocol it must be used for this purpose. The interpretation of a film as not diagnostic may depend on the radiologist's desire to view the sagittal ridge. This could be determined by what is seen on other views and is therefore likely to vary.

The dorsomedial palmarolateral oblique view is taken to view the dorsolateral aspect of the carpus. As there is no obvious landmark in this region the judgement as to whether the appropriate area of the dorsal surface is visible is subjective and therefore prone to variability. The fair to slight within- and between-radiologist agreement for non-diagnostic dorsomedial palmarolateral oblique views of the carpus supports this expectation, however the number of non-diagnostic films was low, so analyses may not be reliable.

The overall number of non-diagnostic views reported, and variation in the observed agreement within and between radiologists for non-diagnostic views, may have an affect on the agreement of interpretation of radiographic changes. The radiographic images used for this study were those submitted to repository systems at Australian sales in 2003. For this reason radiologists were asked to examine the radiographic sets as they would have been examined by veterinarians at the sale repository. If radiographic sets with missing or non-diagnostic films were excluded the observed agreement for radiographic findings may have improved.

Inter- and intra-radiologist agreement was similar for most lesion categories. This indicates that experience or expertise is less likely to be a factor in radiographic interpretation and that it is more likely a function of the process of interpretation itself. Hind fetlock sagittal ridge defects were an exception. Each radiologist was consistent in identifying them but there was poor agreement between radiologists. This was not the case for fore fetlock sagittal ridge lesions were there was substantial to almost perfect agreement within and between radiologists. This demonstrates the value of the flexed lateromedial view which is only required for the forelimb and not the hindlimb. If defects in the sagittal ridge are more difficult to identify without a flexed lateral view both intra- and inter-radiologist agreement would be low. However it appears that there is a difference between radiologists in their awareness of the ability to identify these lesions on other views. Further investigation of the need for a well-positioned flexed lateral view of the hind fetlock is required.

Lesions that showed substantial or better levels of agreement both within and between radiologists were generally of a larger size. These included deep and extensive osteochondrosis lesions, fracture fragments, osseous cyst-like lesions in the stifle and ulnar carpal bone, and extra carpal bones. Consistency of identification of larger lesions seems logical. However Engh *et al.* (2002) found lesion size was not a factor in inter-observer agreement for evaluation of radiographic osteolytic lesions around human hip prostheses. Large fractures are identified consistently on radiographs but smaller and non-displaced fractures are less consistently identified (Morgan *et al.* 2006). The site of smaller fracture fragments has also been shown to affect agreement between observers. Morgan *et al.* (2006) demonstrated moderate inter observer agreement for palmar/plantar first phalanx fragments in a small number of cadaver limbs, and only fair agreement for dorsal first phalanx fragments. The effect of site was difficult to assess in the current study due to the low prevalence of dorsal first phalanx fragments. Morgan *et al.*

(2006) also found moderate agreement between observers for sesamoid fractures which was similar to the present study.

Radiologists were less consistent when identifying periarticular modelling, smaller and shallower osteochondrosis lesions, and sesamoid changes. In all but one radiographic projection Labens *et al.* (2007) found osteophytes less reliable than other radiographic indicators of osteoarthritis of the distal tarsal joints when read by a number of observers. Attempting to classify a continuous variable like periarticular modelling as either present or absent will result in inconsistency, particularly if a good definition of each category is not available. Modelling may be particularly prone to this problem as it is not always considered an abnormality at some sites and therefore there is the potential for inconsistency between observers on the amount and type of modelling classified as normal.

Sesamoid changes are a continuum that is difficult to categorise, as shown in the present study. Not only were vascular channels difficult to repeatably categorise, but there was also a large variation between radiologists in the classification of cysts. The current study used the system described by Kane *et al.* (2003b) and Spike-Pierce and Bramlage (2003) to categorise vascular channels. In neither of these studies was agreement analysis performed, and the authors are not aware of any previous verification of this technique. Many vascular channels are close to 2 mm and accurately estimating their diameter subjectively is difficult. Digital radiographs may allow an objective measurement of channels, provided calibration for magnification is performed.

Conclusions

This is the first study to examine the agreement of interpretation of a large number of radiographic findings at a number of sites. There was substantial or better intra- and inter-observer agreement for larger lesions, but agreement was not good for more subtle lesions and those where categorisation was difficult to define. This demonstrates the need for the standardisation of radiographic interpretation based on easily recognisable factors. Further studies are required to examine the radiographic agreement of interpretation of lesions that had a low prevalence in the current study. This study also demonstrates that care should be taken when interpreting the findings of studies that rely on radiographic categorisation of lesions where agreement is low.

An Assessment of the Quality of Radiographs Submitted to Yearling Sale Repositories in Australia in 2003

Introduction

Radiographic techniques in the horse are well described (Adams 2002; Butler *et al.* 2000; Quick and Rendano 1977; Quick and Rendano 1978; Quick and Rendano 1979; Rendano 1977a; Rendano 1977b; Rendano and Quick 1978; Rendano and Watrous 1979; Smallwood *et al.* 1985). Since the introduction of repositories to auction sales there have been publications making specific recommendations for radiographing yearlings for the repository system (Colon 2004; Hance and Morehead 2000; Martin 1998). These publications tend to be based on the personal experiences of the authors. To date, there are no studies outlining the common mistakes made when radiographing horses based on examinations of large numbers of radiographs. The aim of this study was to assess the quality of radiographs submitted to repository systems in Australia in 2003, report the findings and make recommendations on how best to improve radiographic quality.

Materials and Methods

Radiograph Sets

Radiographic sets were comprised of the 2401 sets described in "The Study Population" section of this report.

Radiograph Quality

The quality of all radiographs was assessed, by one of four veterinary specialist radiologists, as described in the "Inter- and Intra-Radiologist Agreement for Reporting of Radiographic Quality and Orthopaedic Findings" section of this report.

Grading

All radiographs were assessed as: 1) no flaws present, 2) flaws present resulting in the film being less than ideal but still diagnostic, and 3) flaws rendering the film non-diagnostic.

An individual radiograph could have multiple flaws; it could be graded as less than ideal for more than one flaw or be graded less than ideal for one flaw and be deemed non-diagnostic for another.

Statistical Analysis

Numbers and percentages of each of the possible flaws are reported for each radiographic view.

Results

There were 2401 radiographic sets examined for radiographic flaws. There were 337 radiographs missing from these sets, resulting in a total of 81,297 radiographs to be examined for flaws affecting the radiographic image quality.

Non-diagnostic Radiographs

Overall 3.8% (3109/81297) of all radiographs were considered to be non-diagnostic. Incorrect positioning was the most commonly reported flaw associated with radiographs being classified as non-diagnostic (3.0%, 2432/81297). The radiographic views that were most commonly assessed as non-diagnostic due to incorrect positioning flaws were Flexed LM views of the fore fetlock (14.9%, 707/4757), LM views of the hind fetlock (12.3%, 585/4769) and DMPaLO oblique views of the carpus (4.6%, 218/4776). Between 1% and 4.5% of DLPaMO, DMPaLO and DPa views of the fore fetlock, Flexed LM and DLPaMO views of the carpus, DLPlMO, DMPlLO and DPl views of the hind fetlock, LM, DMPlLO and DPl views of the tarsus and LM and CdCr views of the stifle were found to be non-diagnostic. The LM views of the fore foot were least likely to be classed as non-diagnostic (<1%).

Less than Ideal Radiographs

There were 30.2% (24512/81297) of radiographs assessed as having flaws resulting in their being less than ideal but still diagnostic. Over-exposure was the most commonly reported flaw resulting in radiographs being considered as less than ideal (17.7%, 14357/81297). Over-exposure resulted in LM views of the stifle (34.1%, 1631/4784) and DMPaLO (27.5%, 1315/4788) and DLPaMO (27.2%, 1300/4786) views of the fore fetlock being considered less than ideal. Additionally, positioning flaws were commonly responsible for radiographs being classed as less than ideal (14.6%, 11864/81297). The DMPaLO (45.6%, 2177/4776) views of the carpus and LM (43.2%, 2072/4794) views of the tarsus were most commonly considered to be less than ideal due to incorrect positioning. The LM views of the fore foot were least frequently considered to be less than ideal (16.2%, 777/4786).

Radiographic Set

In total 51.1% (1227/2401) of radiograph sets examined were incomplete due to missing radiographs and/or one or more radiographs being reported as non-diagnostic. There were 45.6% (1094/2401) of radiograph sets submitted that were complete with one or more radiographs reported as less than ideal. A complete set of radiographs with no flaws reported occurred in 3.3% (80/2401) of sets examined.

Table 29. Number and percentage of flaws resulting in radiographic views being deemed non-diagnostic.

Joint	View	Number of Radiographs Assessed	Movement (%)	Over Exposure (%)	Under Exposure (%)	Positioning (%)	Label (%)	Processing (%)
Fore Foot	LM	4786	0	1 (0.02)	0	8 (0.2)	0	10 (0.2)
Fore Fetlock	Flexed LM	4757	9 (0.2)	22 (0.5)	1 (0.02)	707 (14.9)	0	10 (0.2)
	DLPaMO	4786	1 (0.02)	9 (0.2)	1 (0.02)	54 (1.1)	33 (0.7)	11 (0.2)
	DMPaLO	4788	0	9 (0.2)	0	18 (0.4)	32 (0.7)	15 (0.3)
	DPa	4789	0	0	12 (0.3)	22 (0.5)	0	15 (0.3)
Carpus	Flexed LM	4789	14 (0.3)	6 (0.1)	4 (0.1)	24 (0.5)	0	7 (0.1)
	DLPaMO	4797	1 (0.02)	1 (0.02)	2 (0.04)	62 (1.3)	0	9 (0.2)
	DMPaLO	4776	4 (0.1)	1 (0.02)	5 (0.1)	218 (4.6)	0	9 (0.2)
Hind Fetlock	LM	4768	2 (0.04)	7 (0.1)	8 (0.1)	585 (12.3)	1 (0.02)	13 (0.3)
	DLPlMO	4788	1 (0.02)	5 (0.1)	1 (0.02)	88 (1.8)	30 (0.6)	14 (0.3)
	DMPlLO	4791	0	4 (0.1)	0	54 (1.1)	29 (0.6)	15 (0.3)
	DPl	4785	0	3 (0.1)	24 (0.5)	27 (0.5)	0	15 (0.3)
Tarsus	LM	4794	0	0	5 (0.1)	117 (2.4)	2 (0.04)	11 (0.2)
	DMPlLO	4787	3 (0.1)	2 (0.1)	4 (0.1)	145 (3.0)	2 (0.1)	13 (0.2)
	DLPlMO	4778	1 (0.02)	3 (0.06)	10 (0.2)	174 (3.6)	1 (0.02)	16 (0.3)
Stifle	LM	4784	2 (0.04)	43 (0.9)	18 (0.4)	69 (1.4)	0	19 (0.4)
	CdCr	4754	22 (0.5)	10 (0.2)	28 (0.6)	60 (1.3)	0	36 (0.8)
Total Flaws			60 (0.1)	126 (0.2)	123 (0.2)	2432 (3.0)	130 (0.2)	238 (0.3)

LM = lateromedial, Flexed LM = flexed lateromedial, DLPaMO = dorsolateral-palmaromedial oblique, DMPaLO = dorsomedial-palmarolateral oblique, DLPlMO = dorsolateral-plantarolateral oblique, DMPlLO = dorsomedial-plantarolateral oblique, DPl = dorsoplantar, CdCr = caudocranial

Table 30. Number and percentage of flaws resulting in radiographic images being deemed less than ideal

Joint	View	Number of Radiographs Assessed	Movement (%)	Over Exposure (%)	Under Exposure (%)	Positioning (%)	Label (%)	Processing (%)
Fore Foot	LM	4786	12 (0.3)	470 (9.8)	103 (2.2)	192 (4.0)	8 (0.2)	77 (1.6)
Fore Fetlock	Flexed LM	4757	48 (1.0)	951 (20.0)	25 (0.5)	666 (14.0)	11 (0.2)	74 (1.6)
	DLPaMO	4786	12 (0.3)	1300 (27.2)	40 (0.8)	231 (4.8)	28 (0.6)	77 (1.6)
	DMPaLO	4788	7 (0.1)	1315 (27.5)	29 (0.6)	222 (4.6)	25 (0.6)	74 (1.5)
	DPa	4789	5 (0.1)	590 (12.3)	169 (3.5)	456 (9.5)	9 (0.2)	75 (1.6)
Carpus	Flexed LM	4789	162 (3.4)	473 (9.9)	107 (2.2)	224 (4.7)	6 (0.1)	83 (1.7)
	DLPaMO	4797	34 (0.7)	836 (17.4)	24 (0.5)	290 (6.0)	11 (0.2)	80 (1.7)
	DMPaLO	4776	41 (0.9)	607 (12.7)	271 (5.7)	2177 (45.6)	9 (0.2)	78 (1.6)
Hind Fetlock	LM	4768	11 (0.2)	647 (13.6)	78 (1.6)	951 (19.9)	10 (0.2)	80 (1.7)
	DLPlMO	4788	10 (0.2)	866 (18.1)	70 (1.5)	302 (6.3)	21 (0.4)	80 (1.7)
	DMPlLO	4791	15 (0.3)	886 (18.5)	55 (1.1)	311 (6.5)	22 (0.5)	79 (1.6)
	DPl	4785	4 (0.1)	443 (9.3)	227 (4.7)	360 (7.5)	12 (0.3)	79 (1.7)
Tarsus	LM	4794	47 (1.0)	986 (20.6)	144 (3.0)	2072 (43.2)	9 (0.2)	87 (1.8)
	DMPlLO	4787	60 (1.3)	1083 (22.6)	88 (1.8)	1881 (39.3)	9 (0.2)	87 (1.8)
	DLPlMO	4778	30 (0.6)	456 (9.5)	299 (6.3)	972 (20.3)	6 (0.1)	88 (1.8)
Stifle	LM	4784	18 (0.4)	1631 (34.1)	142 (3.0)	417 (8.7)	9 (0.2)	98 (2.0)
	CdCr	4754	103 (2.2)	817 (17.2)	178 (3.7)	140 (2.9)	2 (0.04)	102 (2.1)
Total Flaws			619 (0.8)	14357 (17.7)	2049 (2.5)	11864 (14.6)	207 (0.3)	1398 (1.7)

LM = lateromedial, Flexed LM = flexed lateromedial, DLPaMO = dorsolateral-palmaromedial oblique, DMPaLO = dorsomedial-palmarolateral oblique, DLPlMO = dorsolateral-plantarolateral oblique, DMPlLO = dorsomedial-plantarolateral oblique, DPl = dorsoplantar, CdCr = caudocranial

Discussion

This study identified significant problems associated with the quality of radiographs submitted to repositories in 2003. It should be noted that this was the first year of operation of the repository system in Australia and problems were inevitable given the sudden demand for this service. However, this study is invaluable in identifying specific problems, and therefore allowing recommendations to be made that will greatly improve radiographic quality within the repository system and within everyday clinical practice.

The quality of a radiographic image directly affects its usefulness as a diagnostic tool. Even the slightest variation in radiographic quality can lead to artefact or allow significant abnormalities to be missed. Radiographs submitted to the repository system should provide an accurate and honest representation of the yearling. If veterinarians are provided poor quality repository radiographs, they are then unable to provide appropriate recommendations, leading to a lack of confidence by potential buyers.

Non-diagnostic Radiographs

Overall 78% (2432/3109) of the non-diagnostic radiographs were due to flaws in positioning. Flaws associated with movement, exposure and labelling were each responsible for less than 5% of the non-diagnostic radiographs and processing flaws for 7.6% of the non-diagnostic radiographs. It is clear from these results that positioning is the most common cause of non-diagnostic radiographs. Previously published reports on sales radiographs have only reported commonly observed flaws in positioning (Colon 2004; Hance 2006a; Hance 2006b; Hance 2006c; Hance 2006d; Hance and Morehead 2000; Martin 1998).

Flexed Lateromedial View of the Fore Fetlock

The flexed LM view of the fore fetlock was most commonly graded as non-diagnostic. Poor mediolateral and proximodistal orientation were common positioning flaws encountered when examining flexed LM fore fetlock views (Figure 13). Poor or no flexion was also a common reason (20.2%, 143/707) for flexed LM views of the fore fetlocks being deemed non-diagnostic. The sagittal ridge of the third metacarpus should be clearly visible and the proximal sesamoid bones and condyles of the third metacarpus must be superimposed.

Poor positioning of Flexed LM views of the fore fetlock may occur when the handler inadvertently moves the limb in a medial or lateral direction instead of holding it directly under the horse. If the radiographer does not allow for this movement and assumes that the limb is being held correctly positioning errors can occur.

Lateromedial Hind Fetlock

Poor mediolateral orientation was the most common positioning flaw associated with LM views of the hind fetlocks being deemed non-diagnostic (Figure 14). Incorrect mediolateral positioning of LM views of the hind fetlock are most likely to occur when a horse tends to stand toe-out. It is important that the radiographer allows for this or corrects the horse's stance.

Dorsomedial Palmarolateral Oblique View of the Carpus

The DMPaLO views of the carpus were frequently deemed non-diagnostic due to poor lateromedial positioning and were commonly considered to be either too close to DP (Figure 15) or too close to LM (Figure 16). An angle too close to DP obscures the dorsolateral aspect of the joint, a common site for osteophytes and fragments.

Figure 13. Example of a flexed lateromedial view of a fore fetlock deemed non-diagnostic due to incorrect mediolateral and proximodistal orientation. Note the sagittal ridge of the third metacarpus cannot be clearly identified and the proximal sesamoid bones and condyles of the third metacarpus are not superimposed.

Figure 14. Example of a lateromedial view of a hind fetlock found to be non-diagnostic due to inaccurate mediolateral orientation. As with the Flexed LM fore fetlock view, the sagittal ridge is not clearly identifiable and the sesamoids and condyles are not superimposed.

Figure 15. Example of a non-diagnostic DMPaLO view of the carpus with incorrect lateromedial orientation. The angle of this view was considered to be too close to DP.

Figure 16. Example of a non-diagnostic DMPaLO view of the carpus with incorrect lateromedial orientation resulting in the image being deemed to be too close to LM.

Quality radiographic examinations are vital to the sale of yearlings. It is understood that yearlings are young, unbroken and sometimes fractious animals, which can make radiographic examination difficult. In cases where a particular view cannot be obtained, due to the safety of the animal and/or handlers, a letter detailing this should be submitted with the radiographs. However this should not excuse the submission of poor quality radiographic images. It cannot be over-emphasised that unsatisfactory radiographs should be discarded and repeat radiographic examinations undertaken.

Conclusions

Each of the radiographic views required for the repository system are views that may be taken during a regular clinical examination. These recommendations are relevant not only for veterinarians undertaking radiographic examinations of yearlings for the repository system, but are equally important for everyday clinical practice.

In approximately half of the radiographic sets examined the requirements of the repository system were not met due to non-diagnostic or missing radiographs. Care in positioning of Flexed LM views of the fore fetlocks, LM views of the hind fetlocks and DMPaLO views of the carpus is especially important for maximising radiographic quality.

The radiographs examined in this study were from the first year of the repository system. Anecdotal evidence suggests that the quality has improved, but this has not been confirmed. Examination of the quality of radiographs currently being submitted to the repository system should be undertaken to determine if an on-going quality assurance program is required. This would ensure that the required standard of radiographic examination of yearlings is maintained. Examination of all radiographs would be logistically and financially difficult. A quality assurance program could consist of an expert review panel examining independent reports on the radiographic quality of an appropriate random selection of radiographs. Recommendations for improvement of radiographic quality could then be made to individual practices and/or the veterinary industry.

Prevalence of orthopaedic findings in radiographs submitted to yearling sale repositories in Australia in 2003

Introduction

Radiograph repositories were first introduced to auction sales in the USA in 1996 and to Australian sales in 2003. The radiograph repository system provides an additional resource to purchasers as a part of a detailed pre-purchase examination that encompasses pedigree, physical and veterinarian examination. Veterinarians examining the radiographs are limited by a lack of knowledge of the prevalence and potential clinical effects of observed abnormalities.

Whilst there have been several studies (Alvarado *et al.* 1989; Carlsten *et al.* 1993; Courouce-Malblanc *et al.* 2006; Grondahl 1991; Hardy *et al.* 1991; Jorgensen *et al.* 1997; Sandgren 1988; Sandgren *et al.* 1993) examining some specific radiographic abnormalities in Standardbreds, there is limited information available regarding the prevalence of radiographically detected orthopaedic lesions in Thoroughbred yearlings. In a study of 582 yearlings radiographed pre- or post-sale in Kentucky, Howard *et al.* (1992) reported that fore and hind fetlocks were most commonly affected by radiographic abnormalities and feet and carpi were affected the least. Kane *et al.* (2003b) reported similar findings in a study of 1127 Thoroughbred yearlings. In both studies the majority of fetlock changes were associated with vascular channels in the proximal sesamoids. In a study that assessed the effect of radiographic changes in the proximal sesamoid bones of yearlings with racing performance, 17.7% of horses studied had abnormally shaped linear defects (Spike-Pierce and Bramlage 2003). In the most recent study of abnormal radiographic findings of Thoroughbred yearlings Cohen *et al.* (2006) did not report radiographic changes in the proximal sesamoids of either the fore or hindlimbs. To the best of the authors' knowledge there have been no detailed studies of radiographic changes in Thoroughbred yearlings in Australia.

This study aims to report the prevalence of orthopaedic findings in the fore feet, fore fetlocks, carpi, hind fetlocks, tarsi and stifles of Thoroughbred yearlings from radiographs submitted to repository systems at auction sales in Australia in 2003.

Materials and Methods

Radiograph Sets

Radiographic sets comprised of the 2401 sets described in "The Study Population" section of this report.

Reporting of Orthopaedic Findings

Radiographs were reviewed for orthopaedic findings by one of four veterinary radiologists as outlined in the "Inter- and Intra-Radiologist Agreement for Reporting of Radiographic Quality and Orthopaedic Findings" section of this report.

Statistical Analysis

Number and percentage of each orthopaedic finding in the left and right limbs, and in the horse itself is reported here. If a finding was present in both the left and right limb, classification at the horse level was by the most severe change.

Results

Overall

A total of 7 (0.3%) horses did not have any abnormal radiographic findings. If vascular channel findings are excluded (as some consider these to be normal) 329 (13.7%) horses did not have an abnormal finding reported in any joint radiographed. Fore and hind proximal sesamoid bones were the areas most commonly affected, with 97% and 88% reported as having abnormal findings respectively. Excluding vascular channels, 15% of fore and hindlimb proximal sesamoids had abnormal radiographic findings reported. A total of 44% of horses had abnormal radiographic findings reported in the tarsi. Fore fetlocks were affected by abnormalities in 41% of horses and hind fetlocks affected in 21% of horses. The carpi had radiographic abnormalities reported in 29% of horses. Radiographic abnormalities were reported in the fore foot of 24% of horses studied. Only 10% of horses had a radiographic abnormality reported in the stifle.

Fore Feet

Modelling of the dorsal surface and at the toe of the third phalanx were the most commonly occurring findings in the fore foot (Figure 17). Approximately a third of horses with modelling of the dorsal aspect of the third phalanx had a bilateral occurrence. Club foot, osteophyte at the dorsal aspect of the distal interphalangeal joint, and fracture of the third phalanx occurred in less than 3% of horses (Table 31). Findings tended to be unilateral with bilateral findings in approximately a quarter of horses with club foot, modelling of the toe of the third phalanx, osteophyte at the second and third phalanx interface and fracture of the third phalanx.

Table 31. Prevalence of radiographically detectable orthopaedic findings in the fore feet of Thoroughbred yearlings (n=2401).

Finding	Category	Left Fore		Right Fore		Horse	
		n	%	n	%	n	%
Club	Present	32	1.3	42	1.7	60	2.5
	Absent	2369	98.7	2359	98.3	2341	97.5
Modelling dorsal P3	Present	239	10.0	236	9.8	347	14.5
	Absent	2162	90.0	2165	90.2	2054	85.5
Modelling toe P3	Present	86	3.6	98	4.1	146	6.1
	Absent	2315	96.4	2303	95.9	2255	93.9
Osteophyte P2/P3	Present	15	0.6	9	0.4	20	0.8
	Absent	2386	99.4	2392	99.6	2381	99.2
Fracture P3	Present	3	0.1	6	0.2	7	0.3
	Absent	2398	99.9	2395	99.8	2394	99.7

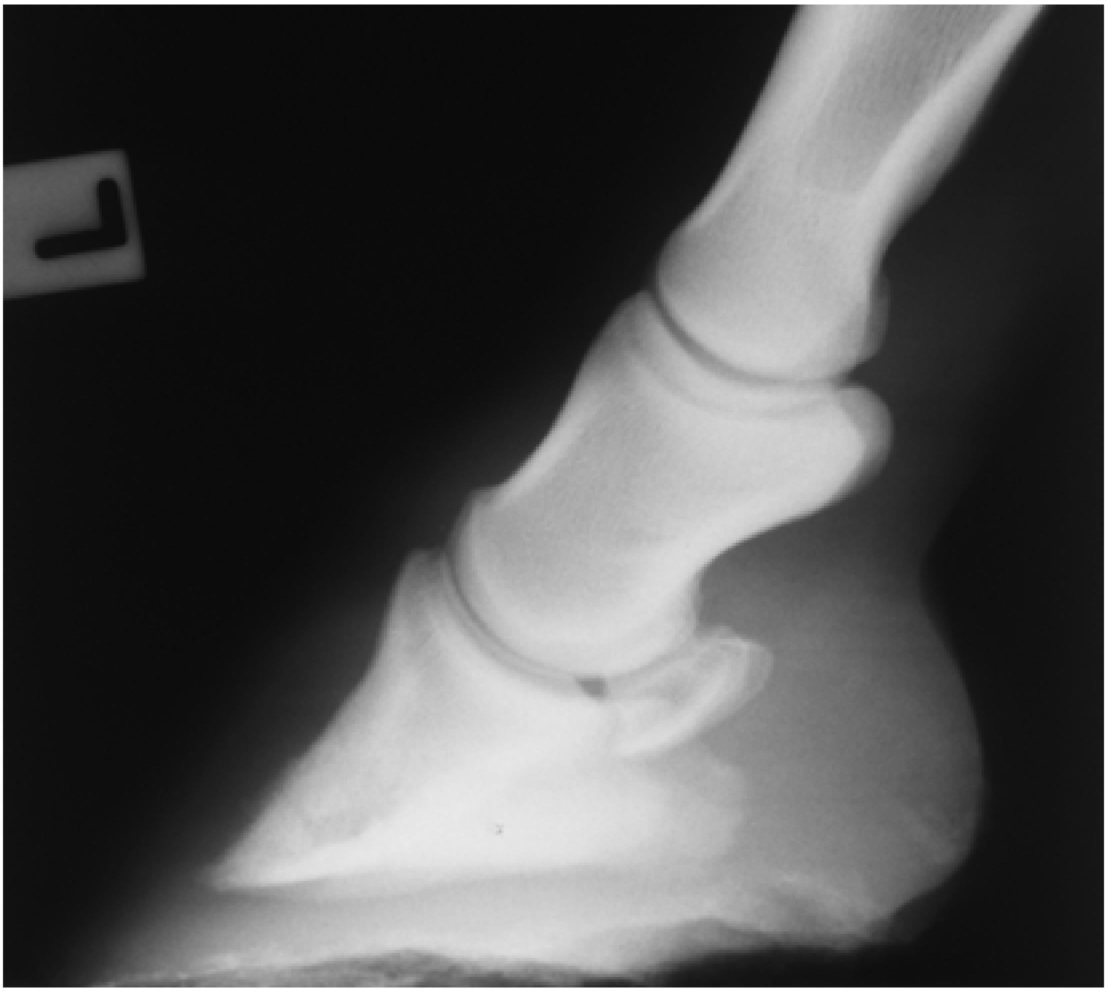

Figure 17. A Lateromedial view of the fore foot. There is modelling on the dorsal and dorsodistal surfaces of the third phalanx. Modelling of the dorsal aspect of the third phalanx was the most commonly observed abnormality in the fore foot.

Fore Fetlocks and Proximal Sesamoids

A defect of the sagittal ridge of the third metacarpus (Figure 18) was the most commonly occurring fore fetlock finding, being present in 37.1% of horses, with 428 of the 890 affected horses having bilateral occurrence. All other findings occurred in less than 1% of the population studied (Table 32). A fragment at the distal aspect of the third metacarpus (5 of 6 horses), fragment proximal dorsal first phalanx (14 of 18 horses) and modelling of the dorsal first phalanx (15 of 18 horses) tended to occur unilaterally. All occurrences of fragments of the palmar aspect of the first phalanx and palmar supracondylar lysis of the third metacarpus were unilateral.

Approximately 97% of horses had vascular channels present in the fore proximal sesamoids (Figure 19). Of those horses affected a quarter were considered to have vascular channels with irregular margins. A total of 58.3% of horses had vascular channels occurring in all four fore proximal sesamoids. Modelling, lucency and fracture of the proximal sesamoids tended to occur unilaterally, and tended to occur more frequently in medial sesamoids (Table 33).

Table 32. Prevalence of radiographically detectable orthopaedic findings in the fore fetlocks of Thoroughbred yearlings (n=2401).

Finding	Category	Left Fore		Right Fore		Horse	
		n	%	n	%	n	%
Defect sagittal ridge MCIII	≤ 5 mm length	44	1.8	67	2.8	67	2.8
	6 – 10 mm length	274	11.4	261	10.9	315	13.1
	> 10 mm length	236	9.8	228	9.5	344	14.3
	Present – no size	112	4.7	96	4.0	164	6.8
	Absent	1735	72.3	1749	72.8	1511	62.9
Fragment MCIII	≤ 5 mm length	3	0.1	1	0.1	4	0.2
	6 – 10 mm length	0	0.0	0	0.0	0	0.0
	> 10 mm length	1	0.1	1	0.1	1	0.1
	Present – no size	0	0.0	1	0.1	1	0.1
	Absent	2397	99.8	2398	99.7	2395	99.6
Fragment proximal dorsal P1	Present	9	0.4	13	0.5	18	0.7
	Absent	2392	99.6	2388	99.5	2383	99.3
Fragment palmar P1	Articular	2	0.1	1	0.1	3	0.1
	Non-articular	2	0.1	2	0.1	4	0.2
	Present – no category	0	0.0	2	0.1	2	0.1
	Absent	2397	99.8	2396	99.7	2392	99.6
Palmar supracondylar lysis MCIII	Present	2	0.1	0	0.0	2	0.1
	Absent	2399	99.8	2401	100.0	2399	99.9
Modelling dorsal P1	Present	7	0.3	14	0.6	18	0.7
	Absent	2394	99.7	2387	99.4	2383	99.3

Table 33. Prevalence of radiographically detectable orthopaedic findings in the fore proximal sesamoid bones of Thoroughbred yearlings (n=2401).

Finding	Category	Left Fore				Right Fore				Horse	
		Lateral		Medial		Lateral		Medial			
		n	%	n	%	n	%	n	%	n	%
Vascular channels	1 - 2 regular	1383	57.6	1342	55.9	1392	58.0	1365	56.9	1026	42.7
	> 2 regular	236	9.8	416	17.3	237	9.9	437	18.2	694	28.9
	1 - 2 irregular	177	7.4	226	9.4	187	7.8	211	8.8	508	21.2
	> 2 irregular	14	0.6	30	1.2	25	1.0	28	1.2	86	3.6
	Present – no category	32	1.3	26	1.1	23	1.0	35	1.5	15	0.6
	Absent	559	23.3	361	15.1	537	22.3	325	13.4	72	3.0
Modelling	Present	20	0.8	33	1.4	18	0.7	40	1.7	91	3.8
	Absent	2381	99.2	2368	98.6	2383	99.3	2361	98.3	2310	96.2
Lucency	Present	80	3.3	127	5.3	72	3.0	117	4.9	283	11.8
	Absent	2321	96.7	2274	94.7	2329	97.0	2284	95.1	2118	88.2
Fracture	Present	6	0.2	17	0.7	5	0.2	12	0.5	35	1.5
	Absent	2395	99.8	2384	99.3	2396	99.8	2389	99.5	2366	98.5

Figure 18. A flexed lateromedial view of the fore fetlock with a defect of the sagittal ridge of the third metacarpus. This was the most common abnormality reported in the fore fetlock.

Figure 19. A dorsomedial oblique view of the fore fetlock. There are several irregular vascular channels in the medial proximal sesamoid. Vascular channels were the most common finding in the fore and hind proximal sesamoid bones.

Carpi

Presence of first and/or fifth carpal bones (Figure 20) was the most common radiographic finding in the carpi with almost one third of horses having these bones present, and almost 70% of these horses having bilateral occurrence. An osseous cyst-like lesion was present in the ulnar carpal bone of 534 (22%) horses and tended to be found unilaterally (413 of 534 horses) (Table 34). All other findings occurred in less than 4% of the study population. Only 3 of 18 horses had fragments occurring bilaterally. Osteophytes and enthesiophytes were found unilaterally in 72% and 80% of horses with these abnormalities, respectively.

Table 34. Prevalence of radiographically detectable orthopaedic findings in the carpi of Thoroughbred yearlings (n=2401).

Finding	Category	Left Fore		Right Fore		Horse	
		n	%	n	%	n	%
Fragment	Present	12	0.5	9	0.4	18	0.7
	Absent	2389	99.5	2392	99.6	2383	99.3
Osteophyte	Present	50	2.1	51	2.1	79	3.3
	Absent	2351	97.9	2350	97.9	2322	96.7
Enthesiophyte	Present	35	1.5	40	1.7	62	2.6
	Absent	2366	98.5	2361	98.3	2339	97.4
OCLL ulnar carpal bone	Present	306	12.7	349	14.5	534	22.2
	Absent	2095	87.3	2052	85.5	1867	77.8
First and fifth carpal bones	Present	630	26.2	625	26.0	741	30.9
	Absent	1771	73.8	1776	74.0	1660	69.1

Figure 20. Example of a first carpal bone seen on the dorsolateral palmaromedial oblique view of the carpus. This was the most common finding in the carpus.

Hind Fetlocks and Proximal Sesamoids

A fragment of the plantar aspect of the first phalanx was the most common finding in the hind fetlocks (Figure 21) with 6% of horses having this abnormality present. Fragments at the plantar and proximal dorsal aspects of the first phalanx tended to occur unilaterally with less than 9% of cases occurring bilaterally. A defect of the sagittal ridge of the third metatarsus was found in 7.5% of horses with approximately a quarter of those affected having bilateral lesions (Table 35).

Vascular channels were present in the hind proximal sesamoids of 87% of horses, of which 30% were considered to have irregular borders. A total of 27% of horses affected had vascular channels present in all four hind proximal sesamoid bones. Sesamoid modelling, cystic lucency and fractures of the hind sesamoid bones tended to occur unilaterally. Cystic lucency tended to occur more frequently in the medial sesamoids (Table 36).

Table 35. Prevalence of radiographically detectable orthopaedic findings in the hind fetlocks of Thoroughbred yearlings (n=2401).

Finding	Category	Left Hind		Right Hind		Horse	
		n	%	n	%	n	%
Defect sagittal ridge MCTII	≤ 5 mm length	19	0.8	20	0.8	32	2.3
	6 – 10 mm length	14	0.6	20	0.8	27	1.1
	> 10 mm length	8	0.3	8	0.3	18	0.7
	Present – no size	48	2.0	52	2.2	82	3.4
	Absent	2312	96.3	2301	95.8	2242	92.5
Fragment proximal P1 dorsal	Present	31	1.3	26	1.1	53	2.2
	Absent	2370	98.7	2375	98.9	2348	97.8
Fragment plantar P1	Articular	48	2.0	27	1.1	66	2.7
	Non-articular	41	1.7	40	1.7	78	3.2
	Present – no category	4	0.2	4	0.2	6	0.2
	Absent	2308	96.1	2330	97.0	2251	93.9

Figure 21. A dorsolateral plantaromedial oblique view of the hind fetlock. There is a large of fragment of the plantar first phalanx. This was the most common hind fetlock abnormality observed.

Table 36. Prevalence of radiographically detectable orthopaedic findings in the hind proximal sesamoids of Thoroughbred yearlings (n=2401).

Finding	Category	Left Fore				Right Fore				Horse	
		Lateral		Medial		Lateral		Medial			
		n	%	n	%	n	%	n	%	n	%
Vascular channels	1 - 2 regular	1095	45.6	945	39.4	1054	43.9	952	39.7	1093	45.5
	> 2 regular	166	6.9	184	7.7	180	7.5	185	1.7	383	16.0
	1 - 2 irregular	154	6.4	272	11.3	163	6.8	242	10.1	542	22.6
	> 2 irregular	22	0.9	15	0.6	16	0.7	27	1.1	71	3.0
	Present – no category	12	0.5	29	1.2	17	0.7	30	1.2	12	0.5
	Absent	952	39.7	956	39.8	971	40.4	965	40.2	300	12.4
Modelling	Present	35	1.5	36	1.5	41	1.7	28	1.2	96	4.0
	Absent	2366	98.5	2365	98.5	2365	98.3	2375	98.8	2305	96.0
Cystic lucency	Present	56	2.3	85	3.5	68	2.8	89	3.7	238	9.9
	Absent	2345	97.7	2316	96.5	2333	97.2	2312	96.3	2163	90.1
Fracture	Present	11	0.5	10	0.4	10	0.4	12	0.5	41	1.7
	Absent	2390	99.5	2391	99.6	2391	99.6	2389	99.5	2360	98.3

Tarsi

Osteophyte formation of the tarsometatarsal joint was the most commonly observed abnormality in the tarsi, with 35% of horses affected. Almost 40% of horses with osteophytes of the tarsometatarsal joint had the abnormality in both limbs. Osteophytes were present at the centrodistal joint in 10% of horses, with almost 30% of those affected having this abnormality bilaterally. OCD of the distal intermediate ridge of the tibia occurred in 3% of horses. Of those horses affected a quarter had the abnormality bilaterally. The medial trochlear ridge of the talus was affected by OCD in 2% of horses, and a quarter of those had OCD at this site in both limbs. Osteophyte formation of the talocalcaneal-centroquatral joint, and OCD of the medial malleolus of the tibia, the lateral malleolus of the tibia and the lateral trochlear ridge of the talus all occurred in less than 2% of horses and tended to be unilateral. Only one horse had a fracture reported in both tarsi (Table 37).

Table 37. Prevalence of radiographically detectable orthopaedic finding in the tarsi of Thoroughbred yearlings (n=2401)

Finding	Category	Left Fore		Right Fore		Horse	
		n	%	n	%	n	%
OCD distal intermediate ridge tibia	Present	58	2.4	45	1.9	82	3.4
	Absent	2343	97.6	2356	98.1	2319	96.6
OCD medial malleolus tibia	Present	10	0.4	12	0.5	20	0.8
	Absent	2391	99.6	2389	99.5	2381	99.2
OCD lateral malleolus tibia	Present	6	0.2	7	0.3	12	0.5
	Absent	2395	99.8	2394	99.7	2389	99.5
OCD medial trochlear ridge talus	Present	35	1.5	37	1.5	57	2.4
	Absent	2366	98.5	2364	98.5	2344	97.6
OCD lateral trochlear ridge talus	Present	18	0.7	22	0.9	39	1.6
	Absent	2383	99.3	2379	99.1	2362	98.4
Osteophyte talocalcaneal-centroquatral joint	Present	18	0.7	18	0.7	33	1.4
	Absent	2383	99.3	2383	99.3	2368	98.6
Osteophyte centrodistal joint	Present	170	7.1	156	6.5	253	10.5
	Absent	2231	92.9	2245	93.5	2148	89.5
Osteophyte tarsometatarsal joint	Present	597	24.9	578	24.1	849	35.4
	Absent	1804	75.1	1823	75.9	1552	64.6
Fractures	Present	1	0.1	1	0.1	1	0.1
	Absent	2400	99.9	2400	99.9	2400	99.9

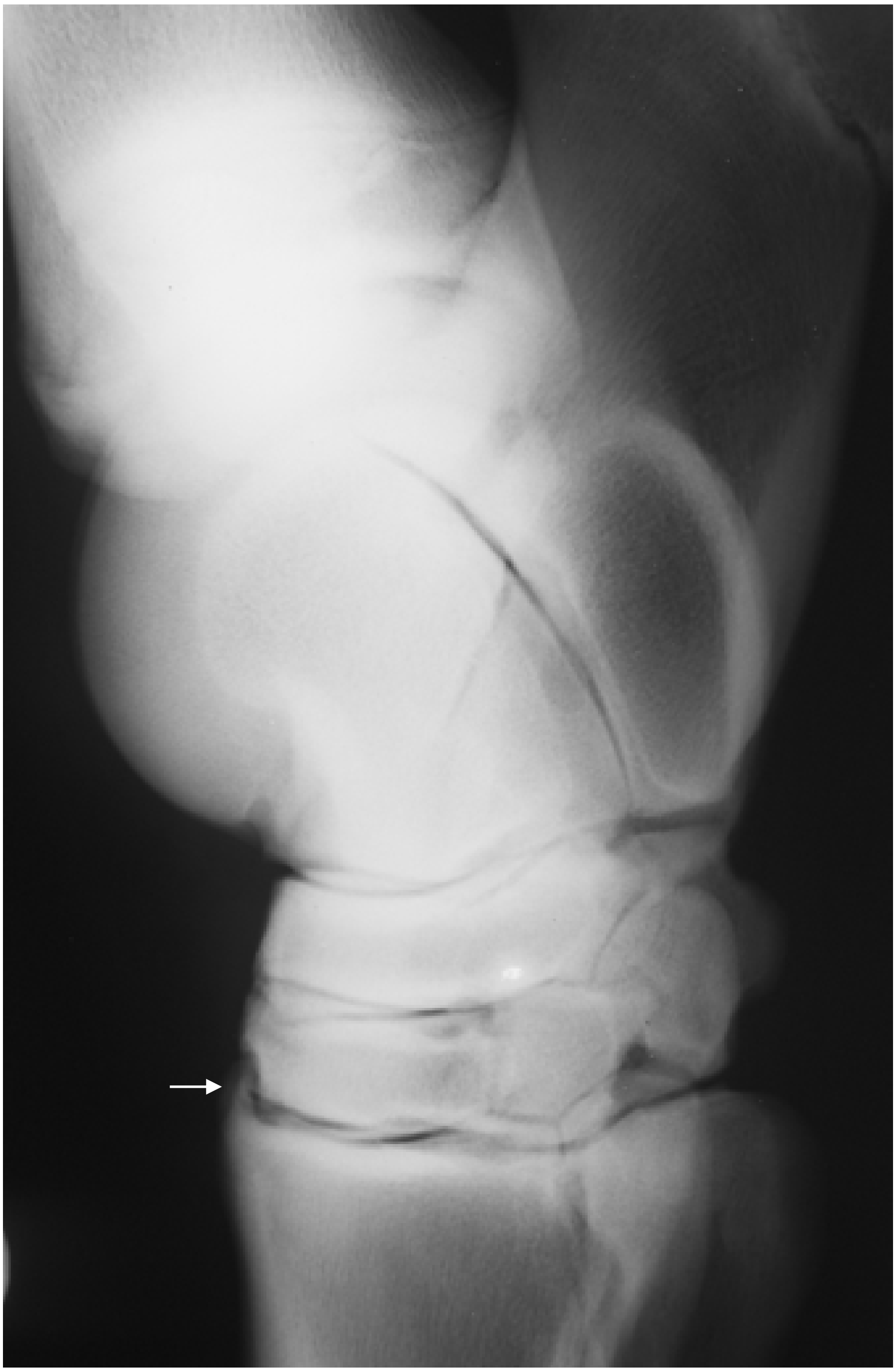

Figure 22. A lateromedial view of a left tarsus with osteophyte formation involving the tarsometatarsal joint. This was the most common abnormality reported in the tarsus.

Stifles

OCLL in the medial condyle of the femur was the most commonly occurring lesion in the stifle and was reported in 5.6% of horses (Figure 23). Of the 134 horses with OCLL present in the medial condyle, 23 had lesions bilaterally, 23 had a lesion present in the left limb only and 88 had a lesion in the right limb only. OCD of the lateral trochlear ridge of the femur was present in almost 4% of horses and of those horses affected 27% had bilateral occurrence. OCD of the medial trochlear ridge of the femur, OCD of the patella and fracture of the patella occurred in less than 1% of horses and all cases were unilateral (Table 38).

Table 38. Prevalence of radiographically detectable orthopaedic findings in the stifles of Thoroughbred yearlings (n=2401).

Finding	Category	Left Fore		Right Fore		Horse	
		n	%	n	%	n	%
OCD lateral trochlear ridge femur	≤20 mm length	31	1.3	24	1.0	43	1.8
	21-40 mm length	21	0.9	21	0.9	33	1.4
	>40 mm length	5	0.2	10	0.4	12	0.5
	Present - no size	2	0.1	2	0.1	3	0.1
	Absent	2342	97.5	2344	97.6	2310	96.2
OCD medial trochlear ridge femur	≤20 mm length	6	0.2	4	0.2	10	0.4
	21-40 mm length	2	0.1	0	0	2	0.1
	>40 mm length	1	0.1	0	0	1	0.1
	Present – no size	0	0.0	1	0.1	1	0.1
	Absent	2392	99.6	2396	99.7	2387	99.3
OCD patella	Present	2	0.1	1	0.1	3	0.1
	Absent	2399	99.9	2400	99.9	2398	99.9
OCLL medial condyle femur	≤6 mm depth	31	1.3	69	2.9	87	3.6
	>6 mm depth	5	0.2	17	0.7	21	0.9
	Present – no size	10	0.4	25	1.0	26	1.1
	Absent	2355	98.1	2290	95.4	2267	94.4
Fracture patella	Present	2	0.1	0	0	2	0.1
	Absent	2399	99.9	2401	100	2399	99.9

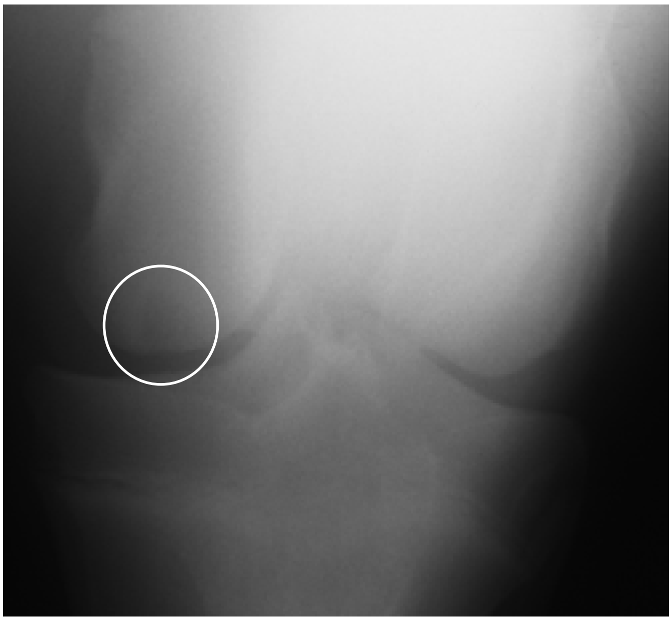

Figure 23. Example of an osseous cyst-like lesion in the medial condyle of the femur seen on the caudocranial view of the stifle. This was the most common abnormality observed in the stifles.

Discussion

The introduction of radiograph repositories to auction sales has provided a resource for research into radiographic abnormalities in Thoroughbred yearlings. Two previous studies have reported radiographic changes in Thoroughbred yearlings from pre- and post-sale radiographic examinations in the USA (Howard *et al.* 1992; Kane *et al.* 2003b). Details of specific radiographic views taken of each joint were not reported by Howard *et al*. (1992) whereas Kane *et al*. (2003b) included radiographic examination of joints similar to those required by repository systems, with the exception of the stifle (LM view only) and the fore foot (included DP). In the most recent study from the USA, Cohen *et al.* (2006) reported radiographic changes in 348 Thoroughbred yearlings using repository radiographs. This report is the first major study of radiographic findings in Thoroughbred yearlings presented for sale in Australia.

A comparison was made of yearlings for which radiographs were made available to this study and those in "The Study Population section of this report". There were no statistically significant differences that were believed to be important across all measures of signalment, sale or race performance, therefore it is considered that a representative sample of radiographs was obtained for this study.

The mean market price ($61,337 includes purchase and passed-in values) of horses studied is approximately $20,000 higher than the average yearling sale price reported for that year ($41,000 only for those horses sold at auction) (Ross 2003). In this study and that of Kane et al. (2003b) horses that have radiographs submitted to repositories have a higher mean market price than those that do not. Yearlings presented for sale tend to be free from clinical signs of injury or lameness; presale screening of radiographs may prompt withdrawal of horses with lesions that sellers consider would affect sale price. Also a number of yearlings undergo surgery prior to sale, as evidenced by the surgery reports submitted with radiographs in this study. For these reasons it is possible that the prevalence of lesions reported in this study is lower than would be expected in the general population of Thoroughbred yearlings.

Differences in prevalence data between studies could be due to a number of reasons. There may be a true difference in incidence of the abnormality due to management practices in young growing horses between populations. Conditions such as osteochondrosis have a multifactorial pathogenesis and therefore feeding and housing practices are likely to affect prevalence. Other conditions may be affected by the amount of exercise young growing horses are exposed to, and the surface on which they are exercising. Radiographic factors will also have a major influence on prevalence, for example, the views performed and the quality of the radiographs. Finally, interpretation of radiographs is subjective and this will result in variability in reporting both between and within examiners.

Fore Feet

Howard *et al*. (1992) examined radiographs of 259 feet (131 left and 128 right) and Kane *et al*. (2003b) examined radiographs of the fore feet of 300 horses; fore feet were not examined by Cohen *et al*. (2006) as the USA repository systems do not require radiographic images of the fore feet. This study reports radiographic changes in the fore feet of 2401 horses.

The most common fore foot findings reported in this and other studies was modelling of the third phalanx. Almost 19% of horses in this study had modelling on the dorsal surface and/or the toe of the third phalanx, which is higher than reported by others (Howard *et al*. (1992), 2%; Kane *et al*. (2003b), 11%). The definition for modelling used in this study only included proliferative changes to the dorsal surface and toe of the fore foot. Osteitis, the term used by Kane *et al*. (2003b) and Howard *et al*. (1992), includes proliferative changes and lysis of the third phalanx.

There were 74 club feet affecting 60 horses reported in this study compared to a single observation by Howard *et al*. (1992). There were no reports of this finding by Kane *et al*. (2003b), however this abnormality was not outlined in their categorisation of radiographic changes in the fore foot, so it is unclear if it was not reported or not observed.

Fractures or fragmenting of the third phalanx was observed in 0.3% of horses, which is lower than reported by Kane *et al*. (2003b) and Howard *et al*. (1992) which reported 5% and 0.8% of horses affected, respectively. Kane *et al*. (2003b) observed rotation of the third phalanx in one horse, and Howard et al. (1992) in four feet; no such changes were observed in horses in the current study.

There were 20 horses reported with osteophytes of the distal interphalangeal joint (P2/P3) and this was not reported by others (Howard *et al.* 1992; Kane *et al.* 2003b).

Fore Fetlocks and Sesamoids

The prevalence of defects of the sagittal ridge of the third metacarpus of the fore fetlock was approximately 10% higher in this study than that reported by Kane *et al.* (2003b), and approximately 30% higher than those reported by Cohen *et al.* (2006) and Howard *et al.* (1992). Reasons for the higher reported prevalence are not known. Defects of the sagittal ridge are best seen on a flexed lateromedial view. This view was a part of the radiographic examination of the fore fetlock in this study and those of Cohen *et al*. (2006) and Kane *et al*. (2003b). Although this study reports lesion prevalence by the length of the abnormality, regardless of its type (flattening, lucency, fragmentation), similar guidelines were used for identification of sagittal ridge defects by both Kane *et al.* (2003b) and Cohen *et al.* (2006). The classification used by Howard *et al.* (1992) was 'OCD', and varied from small defects to large defects with fragments.

Proportions of horses with proximal dorsal or palmar fragmentation of the first phalanx were similar to those previously reported (Cohen *et al.* 2006; Howard *et al.* 1992; Kane *et al.* 2003b). The observed prevalence of fragments of the distal third metacarpus in this study is similar to that reported by Kane et al. (2003b).

Kane *et al.* (2003b) observed palmar supracondylar lysis in 4.8% of horses, but in this study the abnormality was only reported in two horses. There were no cases of palmar supracondylar lysis reported by Howard *et al.* (1992) or Cohen *et al.* (2006). Detecting a change in contour of a surface is very subjective however Kane *et al.* (2003b) reported the finding as severe in 2% of cases.

The prevalence of vascular channels is widely reported, and across all studies they are the most commonly observed finding in the sesamoid bones. Vascular channels that are considered to be irregular (>2 mm wide with abnormal or ill-defined borders) were observed in 24.8% of horses; this is considerably higher than that reported by Howard *et al.* (1992), whose categorisation of the abnormality was 'large linear defects >1 mm wide with ill-defined borders'. Kane *et al.* (2003b) identified 79.1% of horses with irregular vascular channels. In a study of 487 horses identifying changes in proximal sesamoid bones and associations with performance, approximately 8% of horses had irregular vascular channels in the forelimbs (Spike-Pierce and Bramlage 2003). An irregular vascular channel had a similar definition in this study compared to that reported by Kane *et al*. (2003b) and Spike-Pierce and Bramlage (2003), i.e., a "linear lucency with nonparallel sides/abnormal borders and >2 mm in width". Subjective measurement of a vascular channel to categorise it into greater than or less than 2 mm in width may explain the large variations in frequency of these changes between studies.

Modelling of the fore proximal sesamoid bones was observed in 3.8% of horses, compared to 1.3% enthesiophytes and 0.3% osteophytes observed by Kane *et al.* (2003b). Howard *et al.* (1992) observed modelling of the sesamoid bones in 1.3% of 1018 forelimbs examined. In this study modelling was defined as proliferative change in the articular surface of the sesamoid bones, so included both osteophytes and enthesiophytes, a similar definition was used by Howard *et al.* (1992). Changes in the

contour of the abaxial border were identified by Spike-Pierce and Bramlage (2003), however the number of cases were not reported.

Fractures of the sesamoid bones occurred in similar proportions to that reported previously (Howard *et al.* 1992; Kane *et al.* 2003b) although Spike-Pierce and Bramlage (2003) reported no sesamoid fractures. Lucency within the proximal sesamoid bones was observed in 11.8% of horses; this is similar to that reported by Kane *et al.* (2003b). Lucency in the sesamoid bones was not reported by Howard *et al.* (1992) and lucent changes reported by Spike-Pierce and Bramlage (2003) were at the abaxial border, not within the sesamoid bone. Cohen *et al.* (2006) did not report any abnormal radiographic findings in the sesamoid bones in their study of 348 sale yearlings.

Carpi

The most common finding in the carpi was presence of first and fifth carpal bones (30.9% of horses). First carpal bones are usually observed in approximately 30% of horses (Butler *et al.* 2000). First and fifth carpal bones are considered a vestigial remnant.

Osseous cyst-like lesions were observed in the ulnar carpal bone of 22.2% of horses; this is approximately the same as that reported by Kane *et al*. (2003b), but much higher than the reported 0.1% of carpi reported by Howard *et al*. (1992). The proportion of horses observed with fragments of the carpus is similar to that previously reported (Howard *et al.* 1992; Kane *et al.* 2003b). Kane *et al.* (2003b) reported four horses with fracture of the accessory carpal bone; in the current study only two horses were observed with fragmenting of the accessory carpal bone. Osteophytes were present in the carpi of 3.3% of horses, compared to 1.7 % and 0.7% of horses reported by Kane *et al.* (2003b) and Howard *et al.* (1992), respectively. Enthesiophytes were observed in 2.6% of horses, but were not reported by either Kane *et al.* (2003b) or Howard *et al.* (1992). Enthesiophytes of the radial and/or third carpal bone were categorised under 'dorsal medial carpal disease' by Kane *et al.* (2003b). 'Dorsal medial carpal disease' also included thickening of the dorsal cortex of the radial carpal bone, and fragmenting or modelling of the third and radial carpal bones; its presence was reported in 2.7% of horses (Kane *et al.* 2003b). There were no abnormal radiographic findings reported in the carpi of 348 yearlings studied by Cohen *et al.* (2006).

Hind Fetlocks and Sesamoids

Defects of the sagittal ridge of the third metatarsus were observed in 7.5% of horses studied. This is higher than the 1.8% observed by Kane *et al.* (2003b), and similar to the 8.0% of horses observed by Cohen *et al.* (2006). There were no defects of the sagittal ridge reported by Howard *et al.* (1992). The definition of changes to the sagittal ridge were similar in this study to that used by Kane *et al*. (2003b) and Cohen *et al*. (2006).

The proportion of horses observed with fragment of the proximal dorsal first phalanx is similar to those previously reported (Cohen *et al.* 2006; Howard *et al.* 1992; Kane *et al.* 2003b). This study reported 6.1% of horses to have fragments of the plantar aspect of the first phalanx. This proportion is similar to that reported by Kane *et al*. (2003b), but double that observed by Cohen *et al*. (2006) and triple the number seen in hind fetlocks by Howard *et al*. (1992). Definitions for reporting fragments of plantar first phalanx were similar, and the same radiographic views were available to radiologists in this study and that of Cohen *et al*. (2006). The radiographic views for reporting were not outlined by Howard *et al*. (1992). That study examined pre and post-sale radiographs and horses were less likely to have hind fetlock radiographic examinations undertaken compared to fore fetlock and carpi examinations.

Irregular vascular channels were reported in the hind proximal sesamoid bones of 25.6% of horses. Kane et al. (2003b) reported irregular vascular channels in 77.8% of horses, Spike-Pierce and Bramlage (2003) 11.7% of horses, and Howard et al. (1992) 10.9% of hind fetlocks examined. As with vascular channels in the fore proximal sesamoid bones, similar definitions for reporting were used in

all studies, so differences in the observed prevalence may be due to the subjective nature of measuring changes in channel width or may simply be differences in the populations due to sampling or region.

Modelling of the articular surface of the proximal sesamoid bones of the hindlimb was observed in 4.0% of horses examined. This is approximately 2.5% higher than previously reported in Thoroughbred yearlings (Howard *et al.* 1992; Kane *et al.* 2003b). The prevalence of lucency within the hind proximal sesamoid bones was approximately 6% lower than that reported by Kane *et al*. (2003b). There were no reports of lucency observed in the hind sesamoids by Howard *et al*. (1992), and those reported by Spike-Pierce and Bramlage (2003) were on the abaxial surface not within the sesamoid. Fracture of the hind sesamoids was reported in 1.7%, 2.5% and 2.9% of horses in this study, Kane *et al*. (2003b) and Howard *et al*. (1992), respectively.

Tarsi

The reported number of cases of OCD in the distal intermediate ridge of the tibia was similar to those previously reported (Cohen *et al.* 2006; Howard *et al.* 1992; Kane *et al.* 2003b). OCD lesions were observed on the medial malleolus of the tibia in 0.8% of horses and the lateral malleolus of the tibia in 0.5% of horses. Howard *et al*. (1992) reported 0.7% of tarsi examined had OCD in the medial malleolus, but no cases on the lateral malleolus. Neither Cohen *et al*. or Kane *et al*. (2003b) reported changes to the medial or lateral malleoli. The observed proportions of horses with OCD present on the medial and lateral trochlear ridges of the talus are similar to those previously reported (Cohen *et al.* 2006; Howard *et al.* 1992; Kane *et al.* 2003b).

Kane *et al*. (2003b) reported a considerably lower number of horses with osteophyte presence in the centrodistal joint and tarsometatarsal joints than was observed in this study. The reported number of cases for both joints was combined, so it is difficult to ascertain the exact differences in proportions compared to what was observed in the current study. There were no reported cases of osteophyte of the talocalcaneal-centroquatral joint made by Kane *et al*. (2003b), and Cohen *et al*. (2006) did not report osteophytes in any joint of the tarsus. Howard *et al*. (1992) observed osteophytes of the tarsometatarsal joint in 2.3% of tarsi examined, which is considerably lower than the 24.5% of tarsi affected in this study.

Stifles

The observed prevalence of OCD in the medial and lateral trochlear ridges of the femur of horses in this study is similar to that previously reported (Cohen *et al.* 2006; Howard *et al.* 1992; Kane *et al.* 2003b). Osseous cyst-like lesions in the medial condyle of the femur were observed in 5.6% of horses, which is similar to that reported by Cohen *et al*. (2006). No cases of osseous cyst-like lesions were reported by Kane *et al*. (2003b); we note that the radiographic examinations of the stifle in that study did not include a caudocranial view of the stifle, which is generally required to observe this abnormality. There were no cases of osseous cyst-like lesions in the medial condyle of the femur reported by Howard *et al*. (1992), but details of radiographic examinations were not provided for that study.

There were three horses observed with OCD of the patella, and two horses observed with fracture of the patella. Fragmentation of the patella was reported in one horse by Kane *et al*. (2003b) and was not reported by either Cohen *et al*. (2006) or Howard *et al.* (1992).

General Summary

Radiographic findings with similar observed prevalences in this study to prevalences previously reported were:

- Fragment proximal dorsal first phalanx in the fore fetlock
- Fragment palmar first phalanx in the fore fetlock
- Fracture of the fore proximal sesamoid bones
- Fragment of the carpus
- OCLL of the ulnar carpal bone
- First and fifth carpal bone presence
- Fragment proximal dorsal first phalanx of the hind fetlock
- Fracture of the hind proximal sesamoid bones
- OCD of the distal intermediate ridge of the tibia
- OCD of the medial malleolus of the tibia
- OCD of the medial or lateral trochlear ridges of the talus
- OCD of the medial or lateral trochlear ridge of the femur
- OCD or fracture of the patella, and
- Osseous cyst-like lesions of the medial condyle of the femur

Radiographic findings observed in this study at higher prevalences than those previously reported were:

- Club fore foot
- Modelling of the first phalanx
- Defect of the sagittal ridge of the third metacarpus and third metatarsus
- Modelling of the fore or hind proximal sesamoid bones
- Osteophyte in the carpi, and
- Osteophyte of the centrodistal and tarsometatarsal joints

Radiographic findings observed in this study at lower prevalences than those previously reported were:

- Fracture of the third phalanx
- Palmar supracondylar lysis of the third metacarpus
- Lucency in the fore or hind proximal sesamoid bones

Radiographic findings that were reported in this study, but had not previously been reported in Thoroughbred yearlings were:

- Osteophyte of the distal interphalangeal joint (P2/P3)
- OCD lateral malleolus of the tibia
- Osteophyte of the talocalcaneal-centroquatral joint

Conclusions

The results of this study may only be applicable to yearlings that are radiographed for sale purposes. A high proportion of horses were identified as having some kind of abnormal orthopaedic finding and veterinarians examining radiographs at sale should expect to see some instances on radiographs. The observed prevalence of most lesions was similar to those previously reported in Thoroughbred yearlings.

Associations of orthopaedic findings in radiographs submitted to yearling sale repositories in Australia in 2003 with racing performance at 2 and 3 years old

Introduction

Radiograph repositories were introduced to Australian Thoroughbred yearling sales in 2003. As part of a pre-purchase assessment veterinarians are able to examine a set of radiographs of a yearling on behalf of a potential buyer. To do this effectively veterinarians need to know what influence any radiographic changes will have on future performance. However, veterinarians have limited information on which to base these recommendations.

Studies of associations between radiographic findings in yearlings and subsequent performance need to be large so that adequate numbers of each lesion are accumulated for analysis. Cohen *et al.* (2006) found no significant associations between radiographic findings and performance in 348 yearlings, but numbers were too low in most lesion groups to draw any conclusions. Kane *et al.* (2003a) examined radiographs from 1162 Thoroughbred yearlings and identified four lesions that were significantly associated with poorer performance, and five lesions that were definitely not associated with performance measures. For the remainder not enough cases were observed for interpretation. To our knowledge no similar studies have been performed in Australasia.

Our aim was to examine radiographic findings in Thoroughbred yearlings presented to Australian yearling sales and determine any associations with subsequent racing performance at 2 and 3 years of age in a large population of horses.

Materials and Methods

Horses

The horses assessed in this section were those for which radiographic sets were forwarded to The University of Melbourne Equine Centre as outlined in "The Study Population" section of this report.

Market Price

All horses that were sold at auction were assigned the value of their purchase price. Horses that were passed-in at auction were assigned the value of the last highest bid recorded. Horses that were withdrawn from the sale were removed from the analyses, as no value was available to assign to these horses.

Radiograph Sets

Radiographic sets were comprised of the 2401 sets described in "The Study Population" section of this report. Sets from horses withdrawn from sale were excluded.

Surgery Reports

Any surgery report that was submitted with the radiographs was reviewed and the affected joint or joints and reason for surgery recorded. The conditions of sale for William Inglis and Son Ltd (2003)

sales stipulated that a surgery report be submitted, whereas surgery reports were voluntary for Magic Millions Ltd (2003) sales.

Orthopaedic Findings

Radiographically-detectable orthopaedic lesions were reported by radiologists as outlined in the "Inter- and Intra-Radiologist Agreement for Reporting of Radiographic Quality and Orthopaedic Findings" section of this report.

Radiographically-detectable orthopaedic lesions were grouped for analysis. If a finding was present in both the left and right limb, classification for grouping was by the most severe change. Groupings of radiographic findings for the fore foot, fore fetlock, carpus, hind fetlock, tarsus, stifle and additional lesion groupings are outlined in Table 39 toTable 46 below.

Table 39. Grouping of radiographic findings in the fore feet.

Radiographic Change	Category
Club foot	Present
	Absent
Modelling dorsal third phalanx	Present
	Absent
Modelling of toe third phalanx	Present
	Absent

Table 40. Grouping of radiographic findings in the fore fetlocks.

Radiographic Change	Category
Defect sagittal ridge third metacarpus	Present
	Absent
Defect sagittal ridge third metacarpus	≤ 5 mm length
	6 to 10 mm length
	> 10 mm length
	Absent
Fragment proximal dorsal first phalanx	Present
	Absent
Fragment palmar first phalanx	Present
	Absent

Table 41. Grouping of radiographic findings in the fore proximal sesamoid bones.

Radiographic Change	Category
Vascular channels	1 - 2 regular
	> 2 regular
	1 - 2 irregular
	> 2 irregular
	Absent
Modelling	Present
	Absent
Cystic lucency	Present
	Absent
Fracture	Present
	Absent

Table 42. Grouping of radiographic changes in the carpi.

Radiographic Change	Category
Modelling	Present
	Absent
Any change radial carpal and/or third carpal bones	Present
	Absent
OCLL ulnar carpal bone	Present
	Absent
First and/or fifth carpal bones	Present
	Absent

Table 43. Grouping of radiographic findings in the hind fetlocks.

Radiographic Change	Category
Defect sagittal ridge third metatarsus	Present
	Absent
Defect sagittal ridge third metatarsus	≤ 5 mm length
	6 to 10 mm length
	> 10 mm length
	Absent
Fragment proximal dorsal first phalanx	Present
	Absent
Fragment plantar first phalanx	Present
	Absent
Fragment plantar first phalanx	Articular
	Non-articular
	Absent

Table 44. Grouping of radiographic findings in the hind proximal sesamoids.

Radiographic Change	Category
Vascular channels	1 - 2 regular
	> 2 regular
	1 - 2 irregular
	> 2 irregular
	Absent
Modelling	Present
	Absent
Cystic lucency	Present
	Absent
Fracture	Present
	Absent

Table 45. Grouping of radiographic findings in the tarsi.

Radiographic Change	Category
OCD distal intermediate ridge tibia and/or medial/lateral malleolus tibia	Present
	Absent
OCD medial/lateral trochlear ridge talus	Present
	Absent
Osteophyte talocalcaneal-centroquatral and/or centrodistal joints	Present
	Absent
Osteophyte tarsometatarsal joint	Present
	Absent

Table 46. Grouping of radiographic findings in the stifle.

Radiographic Change	Category
OCD medial/lateral trochlear ridge femur and/or patella	Absent
	Present
Osteochondritis dissecans medial/lateral trochlear ridge femur and/or patella	Absent
	≤ 20 mm length
	21 to 40 mm length
	> 40 mm length
Osseous cyst-like lesions medial condyle femur	Absent
	Present
Osseous cyst-like lesions medial condyle femur	Absent
	≤ 6 mm deep
	> 6 mm deep

Race Data

Race performance data for the 2 and 3-year-old race seasons were compiled as described in "The Study Population" section of this report.

Outcomes that were considered for analyses were days from sale to first race start, starting in a race at 2 or 3 years, starting in a race at 2 and 3 years, number of race starts, number of race places, having 7 or more race starts (the mean number of race starts for the population), having two or more race places (the mean number of places for the population), percentage of starts placed, total prize money earned, prize money per race start, earning any prize money, earning prize money greater than $40,000 (the

estimated cost of keep for 2 years) as described in the "Associations between Sale Price of Thoroughbred Yearlings and Race Performance at 2 and 3 Years Old" section of this report), and earning prize money greater than the market price.

Statistical Analysis

Screening of radiographic abnormalities against continuous outcomes (total prize money earned, prize money per start, percentage of starts placed) was with analysis of covariance (Petrie 2006). Screening of count data (number of starts and number of places) was with negative binomial regression (Hilbe 2007). Logistic regression (Hosmer 2000) was used for screening of binomial outcomes (starting in a race at 2 or 3 years, starting in a race at 2 and 3 years, earning any prize money, earning prize money greater than $40,000, earning prize money greater than market price). Total prize money earned and prize money per race start were log transformed, as they were not normally distributed. All outcomes are for the 2 and 3-year-old race years combined. All analyses are for all horses (starters and non-starters) except for the parameters: days from sale to first race start, percentage of starts placed, and prize money per race start, where analyses were for starters only. Log transformed market price was forced into all analyses. Stata statistical package was used for all analyses.

Results are reported as means (median; range) unless otherwise indicated. A radiographic lesion was defined as not having a significant association with poorer performance if the 95% confidence interval (95%CI) for the odds ratio (OR), relative risk (IRR), or geometric mean ratio (GM ratio) did not include 0.5, or the 95% confidence interval for the difference in mean days from sale to first start did not include 90 days, or the 95% confidence interval for the difference in percentage of starts placed did not include -15%. A 2-sided P-value of <0.05 was considered statistically significant.

Results

Horse signalment

There were 2401 horses for which radiographic data sets were forwarded to The University of Melbourne Equine Centre for this study. Of these, 1867 (77.8%) horses were sold at auction, 510 (21.2%) were passed-in at auction, and 24 (1.0%) were withdrawn from the sale. The latter 24 horses were removed from the analyses in this section. In addition, full race performance data were not obtainable for four horses that were passed-in at sale; these horses were also removed from the analyses. The remaining 2373 horses were included in the analyses.

Of these horses, 1392 (58.7%) were colts and 981 (41.3%) were fillies. During the first 2 years of racing 981 (70.5%) horses were gelded.

Market Price

The mean purchase price paid for horses that were sold at auction was $66,984 (40,000; 1000 – 1,700,000). The mean highest bid recorded for passed-in horses was $40,820 (27,500; 1000 – 475,000).

Overall performance results

There were 1874 (79.0%) horses that started in at least one race during their 2 and 3-year-old season. A total of 878 (37.0%) horses started in at least one race at 2 years old and one race at 3 years old. The mean biological age at first race start was 2.9 years (2.8; 1.9 – 3.9). The mean number of days from sale to first race start was 553.8 (542; 163 – 1244). The mean number of race starts was 5.9 (5; 0 – 30). Mean number of race placings was 2.1 (1; 0 – 15). Mean percentage of starts resulting in a place was 31.2 (30; 0 – 100). The mean total prize money earned was $26,267 (2600; 0 – 3,470,325), with a

mean prize money per race start of $3378 (967; 0 – 242,836). There were 806 (34%) horses that had seven or more race starts and 815 (34.3%) horses that had two or more race placings. In total, 1477 (62.2%) horses earned some prize money, 277 (11.7%) earned more than $40,000 and 301 (12.7%) horses earned enough money to cover their purchase or passed-in value.

Significant Lesions

Lesions associated with reduced performance

The only radiographically-identified lesion associated with reduced performance in more than two of the outcomes assessed was the presence of a defect greater than 10 mm in length in the sagittal ridge of the metatarsus (Figure 24, Table 35). Affected horses (n=18) had a greater time to first race (147 days, 95%CI 476.7– 246.7), were less likely to start (OR 0.10, 95%CI 0.0 – 0.7), had fewer starts as 2 and 3-year-olds (IRR 0.47, 95%CI 0.3 – 0.8), were less likely to win any prize money (OR 0.29, 95%CI 0.1 – 0.8) and won less total prize money than unaffected horses (GM ratio 0.09, 95%CI 0.0 – 0.7) (Table 68 to 76).

A mild stifle OCD lesion (Figure 25) was the only other lesion to be associated with reduced performance in more than one performance category. Horses with OCD lesions of the stifle that were 20 mm or less in length took longer to make their first start (66 days, 95%CI 12.5 – 119.5) and were less likely to place two or more times (OR 0.48, 95%CI 0.2 – 1.0) (Table 82 to 86).

Modelling of the borders of the proximal sesamoid bones of the forelimbs (Figure 26) was associated with a reduced chance of starting a race as a 2 or 3-year-old (OR 0.61, 95%CI 0.4 – 1.0), and there were trends for less prize money earned, decreased numbers of starts, and a reduced chance of winning any prize money and prize money greater than market price (Table 52 to 56).

Sesamoid fractures in the fore fetlock (Figure 27) were associated with a decreased chance of starting a race at 2 and 3 years (OR 0.39, 95%CI 0.2 – 1.0) (Table 57).

Sesamoid cysts of the fore fetlock were associated with increased days to first start (24.5 days, 95%CI 0.5 – 48.5) and there was a trend for decreased chance of starting a race at 2 and 3 years of age (Table 57).

Osseous cyst-like lesions of the medial condyle of the distal femur that were greater than 6 mm in depth were associated with a decreased chance of starting a race at 2 and 3 years of age (OR 0.20, 95%CI 0.0 – 0.9) (Table 82). An upright front foot was associated with increased number of days to first start (50.5 days, 95%CI 1.2 – 99.9) (Table 47).

Figure 24. A lateromedial view of the right hind fetlock showing an example of a large irregular defect of the sagittal ridge of the third metatarsus.

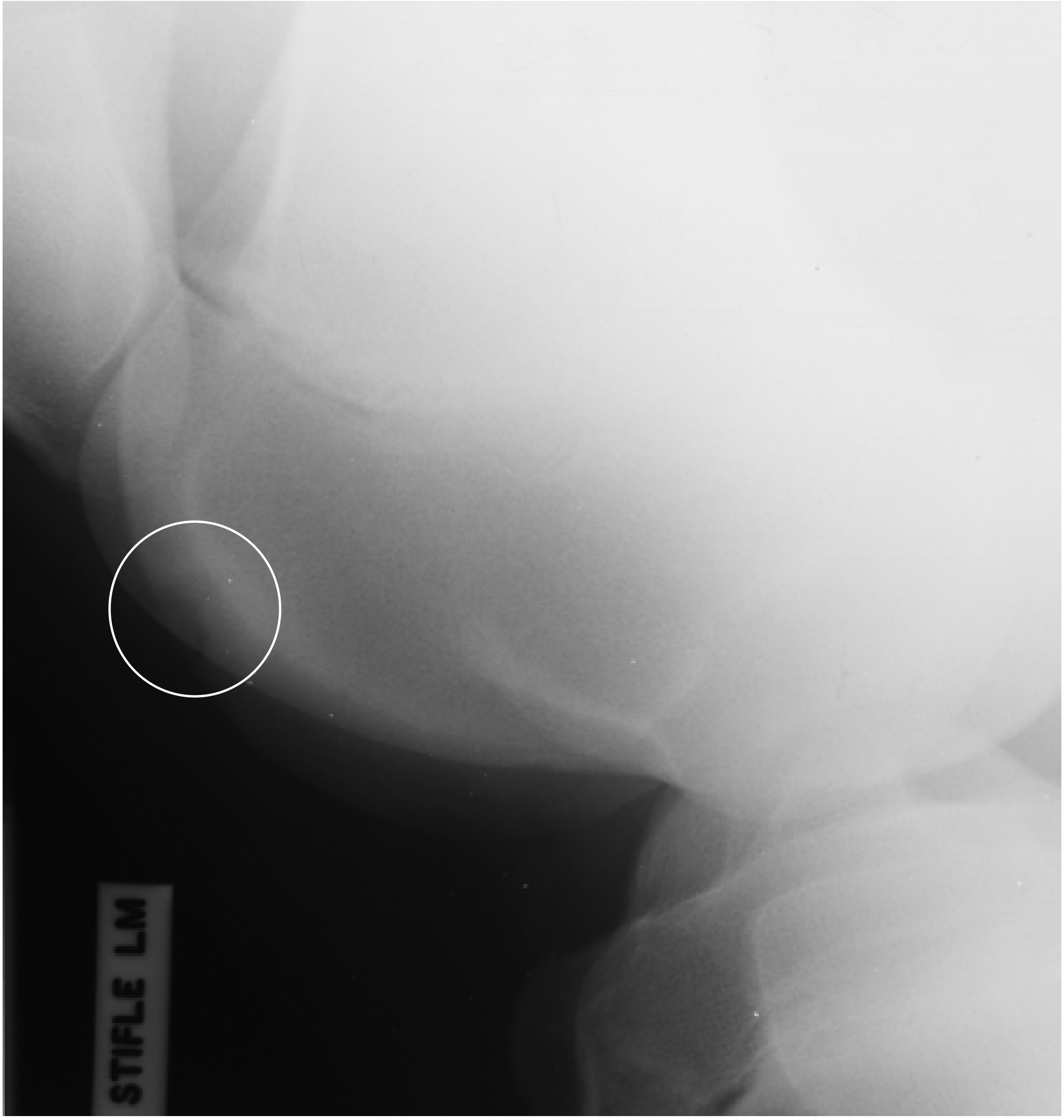

Figure 25. Example of an osteochondrosis fragment of the lateral trochlear ridge of the tibia seen on the lateromedial view of the stifle.

Figure 26. A dorsomedial palmarolateral oblique view of the fore fetlock showing modelling of the medial proximal sesamoid bone.

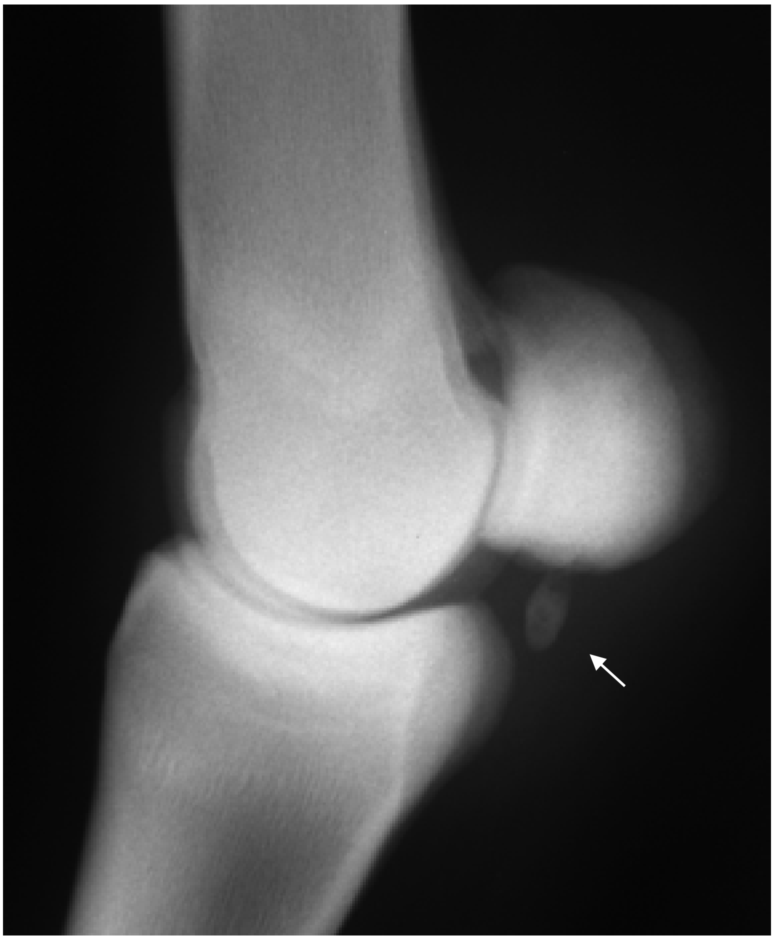

Figure 27. A lateromedial view of the fore fetlock showing a basilar fracture of the medial proximal sesamoid bone.

Lesions with no association with performance or associated with improved performance

A number of radiographically-detected lesions were observed with a high enough frequency to be able to conclude that they had no effect on performance, and some of these were associated with improved performance.

Horses with greater than two irregular vascular channels in sesamoid bones of forelimbs had an increased chance of placing greater than two times (OR 1.97, 95%CI 1.0 – 3.8) when compared to horses with no vascular channels (Table 59). Horses with one or two regular or irregular vascular channels, or more than two regular vascular channels in the hind fetlock joints had a greater number of places (IRR 1.22, 95%CI 1.0 – 1.5; IRR 1.28, 95%CI 1.0 – 1.6; IRR 1.24, 95%CI 1.0 – 1.5) and an increased chance of starting greater than seven times (OR 1.33, 95%CI 1.0 – 1.8; OR 1.43, 95%CI 1.0 – 2.0; OR 1.36, 95%CI 1.0 – 1.8). Horses with one or two regular or irregular vascular channels in the hind proximal sesamoids had an increased chance of placing on two or more occasions (OR 1.41, 95%CI 1.1 – 1.9; OR 1.38, 95%CI 1.0 – 1.9). Horses with any number of regular vascular channels in the hind sesamoids had an increased chance of earning more than the estimated cost of keep (OR 1.83, 95%CI 1.1 – 3.0; OR 2.11, 1.2 – 3.7; OR 1.63, 95%CI 0.9 – 2.8; OR 2.32, 95% CI 1.0 – 5.3;) and earning more than their market price (OR 1.77, 95%CI 1.1 – 2.7; OR 2.01, 95%CI 1.2 – 3.3; OR 1.81, 95%CI 1.1 – 2.9; OR 2.64 95%CI 1.3 – 5.5). Modelling in the hind sesamoids also resulted in an increased chance of earning more than $40,000, the estimated cost of keep (OR 1.87, 95%CI 0.8 – 1.8). Sesamoid fractures of the hindlimbs were associated with increased prize money per start (GM ratio 3.89, 95%CI 1.3 – 11.8) (Table 72 to 76).

Modelling on the dorsal aspect of the third phalanx was associated with increased prize money per start (GM ratio 1.57, 95%CI 1.1 – 2.3), and an increased chance of earning more than market price (OR 1.42, 95%CI 1.0 – 2.0) (Table 50 to 51).

The presence of an osseous cyst-like lesion of the ulnar carpal bone was associated with an increased chance of starting a race at 2 and 3 years of age (OR 1.29, 95%CI 1.1 – 1.6), earning more prize money (GM ratio 1.70, 95%CI 1.1 – 2.6), starting seven or more times (OR 1.23, 95%CI 1.0 – 1.5), earning some prize money (OR 1.27, 95%CI 1.0 – 1.6) and greater than $40,000 (OR 1.41, 95%CI 1.1 – 1.9). Modelling of the dorsal aspect of the carpus was associated with a greater number of places (IRR 1.32, 1.0 – 1.7) (Table 62 to 66).

Other radiographic findings that were observed with adequate numbers to be confident that they had no effect on performance included the presence or absence of a sagittal ridge defect in the forelimbs, the presence of a first or fifth carpal bone, lucency within the hind sesamoid bones, plantar fragments of the proximal phalanx in hind fetlock joints, more than two regular vascular channels in the fore proximal sesamoids, and osteophytes of the talocalcaneal-centroquatral, centrodistal and tarsometatarsal joints.

Lesions where confidence intervals were too wide in one or two performance outcomes, to allow assessment but which had no significant association with performance in all others, were modelling of the toe of the third phalanx, defects of the sagittal ridge of the fore fetlock greater than 6 mm, any regular (or more than two irregular) vascular channels in the fore sesamoids, and OCLL of the medial femoral condyle greater than 6 mm in depth (Table 87 and 88).

Lesions for which no conclusion can be drawn

Confidence intervals for dorsal and palmar first phalanx fragments in fore fetlock joints and large osteochondrosis lesions of the stifle were too wide in multiple performance categories to be able to draw any conclusions (Table 87 and 88).

Although it was possible to conclude that they had no effect on race start indices, it was not possible to draw conclusions on prize money indices for dorsal first phalanx fragments in the hind fetlock, radial and third carpal bone changes, and OCLL of the distal femur greater than 6 mm in diameter (Table 87 and Table 88).

Surgery reports

Surgery reports were supplied with the radiographs for 52 horses. The most commonly reported surgery was arthroscopy for stifle osteochondrosis (20 cases), followed by arthroscopy for tarsocrural osteochondrosis (15 cases) and hind fetlock arthroscopy to remove osteochondral fragments at various sites (14 cases).

Unfortunately there were not enough surgery cases reported to do a meaningful statistical analysis.

Table 47. Radiographic findings in the fore foot and associations with starting a race at 2 or 3 years of age and starting a race at 2 and 3 years of age for all horses, and number of days from sale to first race start for starters only. All models include log market price.

		Start a Race at 2 or 3 Years Old					Start a Race at 2 and 3 Years Old					Days from Sale to First Start				
		Yes n (%)	No n (%)	OR	95% CI	P	Yes n (%)	No n (%)	OR	95% CI	P	n (%)	Mean (Median; Range)	Difference	95% CI	P
Club	Present	46 (78.0)	13 (22.0)	1.01	0.5 - 1.9	0.98	20 (33.9)	39 (66.1)	0.92	0.5 - 1.6	0.75	46 (2.4)	585.5 (586; 277 - 877)	50.5	1.2 - 99.9	0.04
	Absent	1828 (79.0)	486 (21.0)				858 (37.1)	1456 (62.9)				1828 (97.6)	530.4 (525; 163 - 931)			
Modelling Dorsal P3	Present	268 (77.9)	76 (22.1)	0.92	0.7 - 1.2	0.55	129 (37.5)	215 (62.5)	1.02	0.8 - 1.3	0.89	268 (14.3)	526.2 (532; 171 - 924)	-5.6	-27.5 - 16.2	0.61
	Absent	1606 (79.2)	423 (20.8)				749 (36.9)	1280 (63.1)				1606 (85.7)	532.6 (526; 163 - 931)			
Modelling Toe P3	Present	115 (79.3)	30 (20.7)	0.99	0.7 - 1.5	0.98	57 (39.3)	88 (60.7)	1.09	0.8 - 1.5	0.63	115 (6.1)	514.1 (528; 186 - 823)	-17.3	-49.1 - 14.5	0.29
	Absent	1759 (78.9)	469 (21.1)				821 (36.8)	1407 (63.2)				1759 (93.9)	532.9 (526; 163 - 931)			

Table 48. Radiographic findings in the fore foot and associations with number of race starts and number of places for all horses, and percentage of starts placed for starters only. All models include log market price.

		Number of Starts					Number of Places				Percent of Starts Placed				
		n (%)	Mean (Median; Range)	IRR	95% CI	P	Mean (Median; Range)	IRR	95% CI	P	n (%)	Mean (Median; Range)	Difference	95% CI	P
Club	Present	59	5.4	0.92	0.7 - 1.2	0.53	1.9	0.94	0.7 - 1.4	0.74	46	33.7	3.7	-4.0 - 11.4	0.34
		(2.5)	(5; 0 - 17)				(1; 0 - 11)				(2.4)	(33; 0 - 100)			
	Absent	2314	5.9				2.1				1828	31.1			
		(97.5)	(5; 0 - 30)				(1; 0 - 15)				(97.6)	(30; 0 - 100)			
Modelling Dorsal P3	Present	344	6.3	1.07	1.0 - 1.2	0.28	2.3	1.10	0.9 - 1.3	0.22	268	32.7	1.6	-1.8 - 5.0	0.35
		(14.5)	(6; 0 - 30)				(1; 0 - 13)				(14.3)	(31; 0 - 100)			
	Absent	2029	5.8				2.0				1606	30.9			
		(85.5)	(5; 0 - 27)				(1; 0 - 15)				(85.7)	(30; 0 - 100)			
Modelling Toe P3	Present	145	5.6	0.95	0.8 - 1.1	0.54	2.0	0.96	0.8 - 1.2	0.73	115	31.1	0.8	-4.2 - 5.8	0.76
		(6.1)	(5; 0 - 19)				(1; 0 - 9)				(6.1)	(29; 0 - 100)			
	Absent	2228	5.9				2.1				1759	31.1			
		(93.9)	(5; 0 - 30)				(1; 0 - 15)				(93.9)	(30; 0 - 100)			

Table 49. Radiographic findings in the fore foot and associations with number of starts being seven or more and number of places being two or more amongst all horses. All models include log market price.

		Starts ≥ 7					**Places ≥ 2**				
		Yes n (%)	No n (%)	OR	95% CI	P	Yes n (%)	No n (%)	OR	95% CI	P
Club	Present	18 (30.5)	41 (69.5)	0.86	0.5 - 1.5	0.60	20 (33.9)	39 (66.1)	1.05	0.6 - 1.8	0.86
	Absent	788 (34.1)	1526 (65.9)				795 (34.4)	1519 (65.6)			
Modelling Dorsal P3	Present	122 (35.5)	222 (64.5)	1.08	0.9 - 1.4	0.54	125 (36.3)	219 (63.7)	1.10	0.9 - 1.4	0.45
	Absent	684 (33.7)	1345 (66.3)				690 (34.0)	1339 (66.0)			
Modelling Toe P3	Present	44 (30.3)	101 (69.7)	0.83	0.6 - 1.2	0.33	47 (32.4)	98 (67.6)	0.89	0.6 - 1.3	0.51
	Absent	762 (34.2)	1466 (65.8)				768 (34.5)	1460 (65.5)			

Table 50. Radiographic findings in the fore foot and associations with prize money earned for all horses and prize money per race start for starters only. All models include log market price.

		Prize Money Earned ($)					**Prize Money per Start ($)**				
		n (%)	GMean (Median; Range)	GM Ratio*	95% CI	P	n (%)	GMean (Median; Range)	GM Ratio*	95% CI	P
Club	Present	59 (2.5)	417 (4175; 0 - 414,975)	1.77	0.5 - 5.8	0.35	46 (2.4)	120 (1092; 0 - 27,665)	1.85	0.7 - 4.7	0.20
	Absent	2314 (97.5)	316 (2600; 0 - 3,470,325)				1828 (97.6)	91 (967; 0 - 242,836)			
Modelling Dorsal P3	Present	344 (14.5)	447 (3534; 0 - 1,232,985)	1.45	0.9 - 2.5	0.17	268 (14.3)	120 (1058; 0 - 112,090)	1.57	1.1 - 2.3	0.03
	Absent	2029 (85.5)	295 (2500; 0 - 3,470,325)				1606 (85.7)	87 (938; 0 - 242,836)			
Modelling Toe P3	Present	145 (6.1)	282 (2200; 0 - 1,168,300)	0.79	0.4 - 1.7	0.54	115 (6.1)	85 (750; 0 - 106,209)	0.83	0.5 - 1.5	0.53
	Absent	2228 (93.9)	316 (2600; 0 - 3,470,325)				1759 (93.9)	91 (977; 0 - 242,836)			

*GM ratio is the ratio of the geometric means

Table 51. Radiographic findings in the fore foot and associations with earning any prize money, earning prize money greater than the estimated cost of training ($40,000) and earning prize money greater than the market price for all horses. All models include log market price.

		Prize Money > $0					Prize Money > $40,000					Prize Money > Market Price				
		Yes n (%)	No n (%)	OR	95% CI	P	Yes n (%)	No n (%)	OR	95% CI	P	Yes n (%)	No n (%)	OR	95% CI	P
Club	Present	40 (67.8)	19 (32.2)	1.41	0.8 - 2.5	0.23	3 (5.1)	56 (94.9)	0.51	0.2 - 1.6	0.26	4 (6.8)	55 (93.2)	0.43	0.2 - 1.2	0.11
	Absent	1437 (62.1)	877 (37.9)				274 (11.8)	2040 (88.2)				297 (12.8)	2017 (87.2)			
Modelling Dorsal P3	Present	225 (65.4)	119 (34.6)	1.16	0.9 - 1.5	0.23	52 (15.1)	292 (84.9)	1.40	1.0 – 2.0	0.05	55 (16.0)	289 (84.0)	1.42	1.0 – 2.0	0.03
	Absent	1252 (61.7)	777 (38.3)				225 (11.1)	1804 (88.9)				246 (12.1)	1783 (87.9)			
Modelling Toe P3	Present	89 (61.4)	56 (38.6)	0.93	0.7 - 1.3	0.67	19 (13.1)	126 (86.9)	1.06	0.6 - 1.8	0.83	16 (11.0)	129 (89.0)	0.90	0.5 - 1.5	0.69
	Absent	1388 (62.3)	840 (37.7)				258 (11.6)	1970 (88.4)				285 (12.8)	1943 (87.2)			

Table 52. Radiographic findings in the fore fetlock and associations with starting a race at 2 or 3 years of age and starting a race at 2 and 3 years of age for all horses, and number of days from sale to first race start for starters only. All models include log market price.

		Start a Race at 2 or 3 Years Old					Start a Race at 2 and 3 Years Old					Days from Sale to First Start				
		Yes n (%)	No n (%)	OR	95% CI	P	Yes n (%)	No n (%)	OR	95% CI	P	n (%)	Mean (Median; Range)	Difference	95% CI	P
Defect Sagittal Ridge MCIII	Present	690 (78.5)	189 (21.5)	0.96	0.8 - 1.2	0.70	332 (37.8)	547 (62.2)	1.06	0.9 - 1.3	0.52	690 (36.8)	529.0 (523; 171 - 922)	-4.6	-20.4 - 11.2	0.57
	Absent	1184 (79.3)	310 (20.7)				546 (36.5)	948 (63.5)				1184 (63.2)	533.3 (528; 163 - 931;)			
Defect Sagittal Ridge MCIII	≤ 5 mm length	49 (71.0)	20 (29.0)	0.66	0.4 - 1.1	0.13	20 (29.0)	49 (71.0)	0.73	0.4 - 1.2	0.24	49 (2.8)	575.8 (562; 247 - 885)	39.5	-8.6 - 87.7	0.11
	6 – 10 mm length	248 (80.5)	60 (19.5)	1.10	0.8 - 1.5	0.53	115 (37.3)	193 (62.7)	1.05	0.8 - 1.4	0.71	248 (31.2)	538.5 (531; 176 - 922)	3.5	-19.6 - 26.5	0.77
	> 10 mm length	270 (79.2)	71 (20.8)	0.99	0.7 - 1.3	0.92	129 (37.8)	212 (62.2)	1.05	0.8 - 1.3	0.71	270 (15.4)	523.3 (518; 184 - 878)	-9.0	-31.2 - 13.3	0.43
	Absent	1184 (79.3)	310 (20.7)				546 (36.5)	948 (63.5)				1184 (67.6)	533.3 (528; 163 - 931)			
Fragment Proximal Dorsal P1	Present	14 (77.8)	4 (22.2)	0.92	0.3 - 2.8	0.88	6 (33.3)	12 (66.7)	0.84	0.3 - 2.3	0.73	14 (0.7)	583.7 (584; 331 - 775)	55.5	-33.2 - 144.2	0.22
	Absent	1860 (79.0)	495 (21.0)				872 (37.0)	1483 (63.0)				1860 (99.3)	531.3 (526; 163 - 931)			
Fragment Palmar P1	Present	7 (77.8)	2 (22.2)	0.99	0.2 - 4.8	0.99	3 (33.3)	6 (66.7)	0.89	0.2 - 3.6	0.87	7 (0.4)	549.1 (539; 333 - 815)	12.6	-112.6 - 137.8	0.84
	Absent	1867 (79.0)	497 (21.0)				875 (37.0)	1489 (63.0)				1867 (99.6)	531.6 (526; 163 - 931)			

Table 53. Radiographic findings in the fore fetlock and associations with number of race starts and number of places for all horses, and percentage of starts placed for starters only. All models include log market price.

		Number of Starts					Number of Places				Percent of Starts Placed				
		n (%)	Mean (Median; Range)	IRR	95% CI	P	Mean (Median; Range)	IRR	95% CI	P	n (%)	Mean (Median; Range)	Difference	95% CI	P
Defect Sagittal Ridge MCIII	Present	879 (37.0)	5.9 (5; 0 - 23)	1.01	0.9 - 1.1	0.80	2.1 (1; 0 - 14)	1.05	0.9 - 1.2	0.44	690 (36.8)	31.4 (31; 0 - 100)	0.5	-2.0 - 2.9	0.72
	Absent	1494 (63.0)	5.9 (5; 0 - 30)				2.0 (1; 0 - 15)				1184 (63.2)	31.0 (30; 0 - 100)			
Defect Sagittal Ridge MCIII	≤ 5 mm length	69 (3.1)	5.1 (4; 0 - 19)	0.87	0.7 - 1.1	0.29	1.9 (0; 0 - 8)	0.93	0.7 - 1.3	0.69	49 (2.8)	29.0 (27; 0 - 100)	-1.2	-8.7 - 6.3	0.75
	6 – 10 mm length	308 (13.9)	6.1 (5; 0 - 21)	1.05	0.9 - 1.2	0.45	2.1 (1; 0 - 14)	1.07	0.9 - 1.3	0.43	248 (31.2)	31.2 (33; 0 - 100)	0.6	-3.0 - 4.19	0.75
	> 10 mm length	341 (15.4)	5.8 (6; 0 - 22)	0.99	0.9 – 1.1	0.94	2.1 (1; 0 - 11)	1.01	0.9 - 1.2	0.89	270 (15.4)	32.3 (29; 0 - 100)	1.0	-2.5 - 4.5	0.58
	Absent	1494 (67.5)	5.9 (5; 0 - 30)				2.0 (1; 0 - 15)				1184 (67.6)	31.0 (30; 0 - 100)			
Fragment Proximal Dorsal P1	Present	18 (0.8)	5.8 (4; 0 - 20)	0.98	0.6 - 1.6	0.94	2.2 (2; 0 - 8)	1.06	0.6 - 2.0	0.86	14 (0.7)	33.9 (34; 0 - 75)	2.0	-11.8 - 15.9	0.77
	Absent	2355 (99.2)	5.9 (5; 0 - 30)				2.1 (1; 0 - 15)				1860 (99.3)	31.1 (30; 0 - 100)			
Fragment Palmar P1	Present	9 (0.4)	4.8 (5; 0 - 12)	0.82	0.4 - 1.7	0.59	1.8 (1; 0 - 6)	0.92	0.4 - 2.4	0.86	7 (0.4)	36.1 (30; 0 - 67)	6.2	-13.3 - 25.7	0.53
	Absent	2364 (99.6)	5.9 (5; 0 - 30)				2.1 (1; 0 - 15)				1867 (99.6)	31.1 (30; 0 - 100)			

Table 54. Radiographic findings in the fore fetlock and associations with number of starts being seven or more and number of places being two or more amongst all horses. All models include log market price.

		Starts ≥ 7					Places ≥ 2				
		Yes n (%)	No n (%)	OR	95% CI	P	Yes n (%)	No n (%)	OR	95% CI	P
Defect Sagittal Ridge MCIII	Present	300 (34.1)	579 (65.9)	1.01	0.9 - 1.2	0.89	322 (36.6)	557 (63.4)	1.18	1.0 - 1.4	0.06
	Absent	506 (33.9)	988 (66.1)				493 (33.0)	1001 (67.0)			
Defect Sagittal Ridge MCIII	≤ 5 mm length	22 (31.9)	47 (68.1)	0.92	0.6 - 1.5	0.75	24 (34.8)	45 (65.2)	1.12	0.7 - 1.9	0.65
	6 – 10 mm length	108 (35.1)	200 (64.9)	1.06	0.8 - 1.4	0.67	117 (38.0)	191 (62.0)	1.27	1.0 - 1.6	0.07
	> 10 mm length	113 (33.1)	228 (66.9)	0.96	0.8 - 1.2	0.78	123 (36.1)	218 (63.9)	1.13	0.9 - 1.5	0.32
	Absent	506 (33.9)	988 (66.1)				493 (33.0)	1001 (67.0)			
Fragment Proximal Dorsal P1	Present	4 (22.2)	14 (77.8)	0.55	0.2 - 1.7	0.30	7 (38.9)	11 (61.1)	1.20	0.5 - 3.1	0.70
	Absent	802 (34.1)	1553 (65.9)				808 (34.3)	1547 (65.7)			
Fragment Palmar P1	Present	2 (22.2)	7 (77.8)	0.56	0.1 - 2.7	0.47	3 (33.3)	6 (66.7)	1.02	0.3 - 4.1	0.98
	Absent	804 (34.0)	1560 (66.0)				812 (34.3)	1552 (65.7)			

Table 55. Radiographic findings in the fore fetlock and associations with prize money earned for all horses and prize money per race start for starters only. All models include log market price.

		Prize Money Earned ($)					Prize Money per Start ($)				
		n (%)	GMean (Median; Range)	GM Ratio*	95% CI	P	n (%)	GMean (Median; Range)	GM Ratio*	95% CI	P
Defect Sagittal Ridge MCIII	Present	879 (37.0)	295 (2841; 0 - 1,232,985)	0.91	0.6 - 1.4	0.63	690 (36.8)	85 (1017; 0 - 112,090)	0.94	0.7 - 1.3	0.68
	Absent	1494 (63.0)	331 (2550; 0 - 3,470,325)				1184 (63.2)	95 (944; 0 - 242,836)			
Defect Sagittal Ridge MCIII	≤ 5 mm length	69 (3.1)	151 (600; 0 - 441,846)	0.53	0.2 - 1..6	0.27	49 (2.8)	51.29 (804; 0 - 49094)	0.33	0.1 - 2.5	0.28
	6 – 10 mm length	308 (13.9)	339 (3155; 0 - 741,250)	1.12	0.7 – 2.0	0.69	248 (31.2)	98 (970; 0 - 73,640)	1.22	0.4 - 3.4	0.71
	> 10 mm length	341 (15.4)	339 (3125; 0 - 1,232,985)	0.99	0.6 - 1.7	0.96	270 (15.4)	98 (1106; 0 - 112,090)	0.96	0.4 - 2.6	0.93
	Absent	1494 (67.5)	331 (2550; 0 - 3,470,325)				1184 (67.6)	95 (944; 0 - 242,836)			
Fragment Proximal Dorsal P1	Present	18 (0.8)	209 (3050; 0 - 197,375)	0.63	0.1 - 5.3	0.67	14 (0.7)	69 (1052; 0 - 9869)	0.66	0.1 - 3.6	0.63
	Absent	2355 (99.2)	316 (2600; 0 - 3,470,325)				1860 (99.3)	91 (967; 0 - 242,836)			
Fragment Palmar P1	Present	9 (0.4)	363 (2000; 0 - 63,173)	1.50	0.1 - 30.9	0.79	7 (0.4)	110 (1000; 0 - 10,529)	1.71	1.3 - 17.8	0.66
	Absent	2364 (99.6)	316 (2600; 0 - 3,470,325)				1867 (99.6)	91 (967; 0 - 242,836)			

*GM ratio is the ratio of the geometric means

Table 56. Radiographic findings in the fore fetlock and associations with earning any prize money, earning prize money greater than the estimated cost of training ($40,000) and earning prize money greater than the market price for all horses. All models include log market price.

		Prize Money > $0					Prize Money > $40,000					Prize Money > Market Price				
		Yes n (%)	No n (%)	OR	95% CI	P	Yes n (%)	No n (%)	OR	95% CI	P	Yes n (%)	No n (%)	OR	95% CI	P
Defect Sagittal Ridge MCIII	Present	539 (61.3)	340 (38.7)	0.95	0.8 - 1.1	0.52	92 (10.5)	787 (89.5)	0.84	0.6 - 1.1	0.20	112 (12.7)	767 (87.3)	1.00	0.8 - 1.3	0.97
	Absent	938 (62.8)	556 (37.2)				185 (12.4)	1309 (87.6)				189 (12.7)	1305 (87.3)			
Defect Sagittal Ridge MCIII	≤ 5 mm length	37 (53.6)	32 (46.4)	0.72	0.4 - 1.2	0.18	6 (8.7)	63 (91.3)	0.76	0.3 - 1.8	0.54	8 (11.6)	61 (88.4)	0.83	0.4 - 1.8	0.64
	6 – 10 mm length	196 (63.6)	112 (36.4)	1.07	0.8 - 1.4	0.63	28 (9.1)	280 (90.9)	0.75	0.5 - 1.1	0.17	37 (12.0)	271 (88.0)	0.90	0.6 - 1.3	0.58
	> 10 mm length	214 (62.8)	127 (37.2)	0.98	0.8 - 1.3	0.89	38 (11.1)	303 (88.9)	0.85	0.6 - 1.2	0.39	49 (14.4)	292 (85.6)	1.19	0.8 - 1.7	0.32
	Absent	938 (62.8)	556 (37.2)				185 (12.4)	1309 (87.6)				189 (12.7)	1305 (87.3)			
Fragment Proximal Dorsal P1	Present	10 (55.6)	8 (44.4)	0.74	0.3 - 1.9	0.53	3 (16.7)	15 (83.3)	1.51	0.4 - 5.4	0.53	2 (11.1)	16 (88.9)	0.90	0.2 – 4.0	0.89
	Absent	1467 (62.3)	888 (37.7)				274 (11.6)	2081 (88.4)				299 (12.7)	2056 (87.3)			
Fragment Palmar P1	Present	6 (66.7)	3 (33.3)	1.32	0.3 - 5.3	0.69	1 (11.1)	8 (88.9)	1.21	0.2 - 9.9	0.86	2 (22.2)	7 (77.8)	1.77	0.4 - 8.7	0.48
	Absent	1471 (62.2)	893 (37.8)				276 (11.7)	2088 (88.3)				299 (12.6)	2065 (87.4)			

Table 57. Radiographic findings in the fore proximal sesamoids and associations with starting a race at 2 or 3 years of age and starting a race at 2 and 3 years of age for all horses, and number of days from sale to first race start for starters only. All models include log market price.

		Start a Race at 2 or 3 Years Old					Start a Race at 2 and 3 Years Old					Days from Sale to First Start				
		Yes n (%)	No n (%)	OR	95% CI	P	Yes n (%)	No n (%)	OR	95% CI	P	n (%)	Mean (Median; Range)	Difference	95% CI	P
Vascular Channels	1 - 2 regular	807 (79.6)	207 (20.4)	1.31	0.8 - 2.2	0.31	373 (36.8)	641 (63.2)	1.12	0.7 - 1.8	0.64	807 (43.1)	529.7 (527; 166 - 924)	-32.9	-75.8 - 10.1	0.13
	> 2 regular	547 (79.6)	140 (20.4)	1.24	0.7 - 2.1	0.41	249 (36.2)	438 (63.8)	1.05	0.7 - 1.7	0.83	547 (29.2)	532.8 (530; 166 - 931)	-26.2	-70.0 - 17.6	0.24
	1 - 2 irregular	385 (76.8)	116 (23.2)	1.11	0.7 - 1.9	0.70	196 (39.1)	305 (60.9)	1.24	0.8 - 2.0	0.39	385 (20.5)	528.3 (521; 163 - 908)	-34.5	-79.1 - 10.1	0.13
	> 2 irregular	71 (83.5)	14 (16.5)	1.79	0.8 - 3.8	0.13	31 (36.5)	54 (63.5)	1.14	0.6 - 2.1	0.68	71 (3.8)	534.9 (513; 176 - 897)	-32.2	-89.2 - 24.8	0.27
	Absent	64 (74.4)	22 (25.6)				29 (33.7)	57 (66.3)				64 (3.4)	564.2 (584; 237 - 922)			
Modelling	Present	63 (70.0)	27 (30.0)	0.61	0.4 – 1.0	0.04	29 (32.2)	61 (67.8)	0.81	0.5 - 1.3	0.35	63 (3.4)	519.7 (521; 176 - 898)	-12.3	-54.7 - 30.0	0.57
	Absent	1811 (79.3)	472 (20.7)				849 (37.2)	1434 (62.8)				1811 (96.6)	532-1 (513; 163 - 897)			
Lucency	Present	214 (79.1)	64 (23.0)	0.90	0.7 - 1.2	0.47	88 (31.7)	190 (68.3)	0.78	0.6 - 1.0	0.07	214 (11.4)	554.7 (566; 212 - 911)	24.5	0.5 - 48.5	0.04
	Absent	1660 (79.2)	435 (20.8)				790 (37.7)	1305 (62.3)				1660 (88.6)	528.7 (524; 163 - 931)			
Fracture	Present	23 (69.7)	10 (30.3)	0.65	0.3 - 1.4	0.26	6 (18.2)	27 (81.8)	0.39	0.2 – 1.0	0.04	23 (1.2)	572.0 (575; 277 - 844)	35.7	-33.7 - 105.1	0.31
	Absent	1851 (79.1)	489 (20.9)				872 (37.3)	1468 (62.7)				1851 (98.8)	531.2 (525; 163 - 931)			

Table 58. Radiographic findings in the fore proximal sesamoids and associations with number of race starts and number of places for all horses, and percentage of starts placed for starters only. All models include log market price.

		Number of Starts					Number of Places				Percent of Starts Placed				
		n (%)	Mean (Median; Range)	IRR	95% CI	P	Mean (Range; Median)	IRR	95% CI	P	n (%)	Mean (Median; Range)	Difference	95% CI	P
Vascular Channels	1 - 2 regular	1014 (42.7)	5.9 (5; 0 - 30)	1.09	0.9 - 1.4	0.46	2.0 (1; 0 - 15)	1.12	0.8 - 1.5	0.49	807 (43.1)	30.0 (29; 0 - 100)	-4.6	-11.2 - 2.1	0.18
	> 2 regular	687 (28.9)	6.0 (5; 0 - 25)	1.10	0.9 - 1.4	0.45	2.2 (1; 0 - 15)	1.16	0.8 - 1.6	0.37	547 (29.2)	32.9 (33; 0 - 100)	-2.5	-9.3 - 4.3	0.47
	1 - 2 irregular	501 (21.1)	5.7 (5; 0 - 24)	1.05	0.8 - 1.4	0.69	2.0 (1; 0 - 13)	1.06	0.8 - 1.5	0.71	385 (20.5)	30.5 (29; 0 - 100)	-4.0	-10.9 - 3.0	0.26
	> 2 irregular	85 (3.6)	6.2 (6; 0 - 27)	1.16	0.8 - 1.6	0.38	2.2 (1; 0 - 8)	1.24	0.8 - 1.9	0.31	71 (3.8)	32.5 (29; 0 - 100)	-0.9	-9.8 - 8.0	0.85
	Absent	86 (3.6)	5.4 (5; 0 - 22)				1.8 (1; 0 - 11)				64 (3.4)	34.1 (31; 0 - 100)			
Modelling	Present	90 (3.8)	4.9 (4; 0 - 23)	0.82	0.7 - 1.0	0.10	1.8 (1; 0 - 11)	0.86	0.6 - 1.2	0.32	63 (3.4)	32.2 (30; 0 - 100)	1.1	-5.5 - 7.7	0.75
	Absent	2283 (96.2)	5.9 (5; 0 - 30)				2.1 (1; 0 - 15)				1811 (96.6)	31.1 (30; 0 - 100)			
Lucency	Present	278 (11.7)	5.9 (5; 0 - 30)	0.91	0.8 - 1.0	0.16	1.9 (1; 0 - 12)	0.92	0.8 - 1.1	0.37	214 (11.4)	31.9 (30; 0 - 100)	1.2	-2.5 – 5.0	0.52
	Absent	2095 (88.3)	5.4 (4; 0 - 22)				2.1 (1; 0 - 15)				1660 (88.6)	31.1 (30; 0 - 100)			
Fracture	Present	33 (1.4)	4.3 (3; 0 - 16)	0.73	0.5 - 1.1	0.10	1.3 (1; 0 - 5)	0.65	0.4 - 1.1	0.10	23 (1.2)	31.3 (31; 0 - 100)	1.5	-9.4 - 12.3	0.79
	Absent	2340 (98.6)	5.9 (5; 0 - 30)				2.1 (1; 0 - 15)				1851 (98.8)	31.2 (30; 0 - 100)			

Table 59. Radiographic findings in the fore proximal sesamoids and associations with number of starts being seven or more and number of places being two or more amongst all horses. All models include log market price.

		Starts ≥ 7					**Places ≥ 2**				
		Yes n (%)	No n (%)	OR	95% CI	P	Yes n (%)	No n (%)	OR	95% CI	P
Vascular Channels	1 – 2 regular	676 (66.7)	338 (33.3)	1.29	0.8 - 2.1	0.31	339 (33.4)	675 (66.6)	1.42	0.9 - 2.4	0.17
	> 2 regular	439 (63.9)	248 (36.1)	1.44	0.9 - 2.4	0.15	251 (36.5)	436 (63.5)	1.56	0.9 - 2.6	0.09
	1 - 2 irregular	337 (67.3)	164 (32.7)	1.25	0.8 - 2.1	0.39	169 (33.7)	332 (66.3)	1.44	0.9 - 2.4	0.17
	> 2 irregular	53 (62.4)	32 (37.6)	1.56	0.8 – 3.0	0.17	34 (40.0)	51 (60.0)	1.97	1.0 - 3.8	0.04
	Absent	62 (72.1)	24 (27.9)				22 (25.6)	64 (74.4)			
Modelling	Present	25 (27.8)	65 (72.2)	0.74	0.5 - 1.2	0.21	29 (32.2)	61 (67.8)	0.91	0.6 - 1.4	0.69
	Absent	781 (34.2)	1502 (65.8)				786 (34.4)	1497 (65.6)			
Lucency	Present	89 (32.0)	189 (68.0)	0.91	0.7 - 1.2	0.48	86 (30.9)	192 (69.1)	0.86	0.7 - 1.1	0.26
	Absent	717 (34.2)	1378 (65.8)				729 (34.8)	1366 (65.2)			
Fracture	Present	7 (21.2)	26 (78.8)	0.52	0.2 - 1.2	0.13	9 (27.3)	24 (72.7)	0.76	0.4 - 1.7	0.49
	Absent	799 (34.1)	1541 (65.9)				806 (34.4	1534 (65.6)			

Table 60. Radiographic findings in the fore proximal sesamoids and associations with prize money earned for all horses and prize money per race start for starters only. All models include log market price.

		Prize Money Earned ($)					Prize Money per Start ($)				
		n (%)	GMean (Median; Range)	GM Ratio*	95% CI	P	n (%)	GMean (Median; Range)	GM Ratio*	95% CI	P
Vascular Channels	1 - 2 regular	1014 (42.7)	282 (2400; 0 - 3,470,325)	1.06	0.4 – 3.0	0.91	807 (43.1)	81 (867; 0 - 216,895)	0.75	0.3 - 1.7	0.48
	> 2 regular	687 (28.9)	437 (4080; 0 - 3,399,700)	1.36	0.5 - 3.8	0.56	547 (29.2)	117 (1164; 0 - 242,836)	1.03	0.5 - 2.3	0.94
	1 - 2 irregular	501 (21.1)	257 (2200; 0 - 604,175)	0.98	0.3 - 2.8	0.97	385 (20.5)	78 (1014; 0 - 73,640)	0.87	0.4 - 2.0	0.74
	> 2 irregular	85 (3.6)	537 (5200; 0 - 287,350)	2.48	0.6 - 9.8	0.20	71 (3.8)	141 (1050; 0 - 26,500)	1.30	0.5 - 3.8	0.63
	Absent	86 (3.6)	234 (1375; 0 - 730,305)				64 (3.4)	72 (867; 0 - 216,895)			
Modelling	Present	90 (3.8)	123 (850; 0 - 321,742)	0.39	0.2 - 1.0	0.06	63 (3.4)	44 (822; 0 - 45,963)	0.72	0.3 - 1.6	0.41
	Absent	2283 (96.2)	331 (2650; 0 - 3,470,325)				1811 (96.6)	93 (973; 0 - 242,836)			
Lucency	Present	278 (11.7)	229 (1465; 0 - 1,232,985)	0.76	0.4 - 1.4	0.36	214 (11.4)	74 (954; 0 - 112,090)	0.93	0.6 - 1.5	0.73
	Absent	2095 (88.3)	331 (2640; 0 - 3,470,325)				1660 (88.6)	93 (974; 0 - 242,836)			
Fracture	Present	33 (1.4)	198 (650; 0 - 50,671)	0.80	0.2 - 3.9	0.78	23 (1.2)	71 (1102; 0 - 10,134)	1.82	0.5 - 6.8	0.37
	Absent	2340 (98.6)	316 (2600; 0 - 3,470,325)				1851 (98.8)	91 (967; 0 - 242,836)			

*GM ratio is the ratio of the geometric means

Table 61. Radiographic findings in the fore proximal sesamoids and associations with earning any prize money, earning prize money greater than the estimated cost of training ($40,000) and earning prize money greater than the market price for all horses. All models include log market price.

		Prize Money > $0					Prize Money > $40,000					Prize Money > Market Price				
		Yes n (%)	No n (%)	OR	95% CI	P	Yes n (%)	No n (%)	OR	95% CI	P	Yes n (%)	No n (%)	OR	95% CI	P
Vascular Channels	≤ 2 regular	620 (61.1)	394 (38.9)	0.85	0.5 - 1.4	0.50	111 (10.9)	903 (89.1)	2.27	0.8 - 6.4	0.12	131 (12.9)	883 (87.1)	2.10	0.9 - 4.9	0.09
	> 2 regular	444 (64.6)	243 (35.4)	0.93	0.6 - 1.5	0.77	96 (14.0)	591 (86.0)	2.63	0.9 - 7.4	0.07	82 (11.9)	605 (88.1)	2.14	0.9 - 5.1	0.09
	≤ 2 irregular	300 (59.9)	201 (40.1)	0.81	0.5 - 1.3	0.38	58 (11.6)	443 (88.4)	2.46	0.9 - 7.0	0.09	68 (13.6)	433 (86.4)	2.24	0.9 - 5.4	0.07
	> 2 irregular	58 (68.2)	27 (31.8)	1.25	0.7 - 2.4	0.50	8 (9.4)	77 (90.6)	2.16	0.6 - 7.5	0.23	14 (16.5)	71 (83.5)	2.48	0.9 - 6.9	0.08
	Absent	55 (64.0)	31 (36.0)				4 (4.7)	82 (95.3)				6 (7.0)	80 (93.0)			
Modelling	Present	47 (52.2)	43 (47.8)	0.67	0.4 - 1.0	0.05	9 (10.0)	81 (90.0)	0.85	0.4 - 1.7	0.66	6 (6.7)	84 (93.3)	0.47	0.2 - 1.1	0.08
	Absent	1430 (62.6)	853 (37.4)				268 (11.7)	2015 (88.3)				295 (12.9)	1988 (87.1)			
Lucency	Present	165 (59.4)	113 (40.6)	0.90	0.7 - 1.2	0.40	32 (11.5)	246 (88.5)	1.06	0.7 - 1.6	0.79	29 (10.4)	249 (89.6)	0.74	0.5 - 1.1	0.14
	Absent	1312 (62.6)	783 (37.4)				245 (11.7)	1850 (88.3)				272 (13.0)	1823 (87.0)			
Fracture	Present	20 (60.6)	13 (39.4)	1.02	0.5 - 2.1	0.96	3 (9.1)	30 (90.9)	0.96	0.3 - 3.2	0.94	5 (15.2)	28 (84.8)	1.08	0.4 - 2.8	0.88
	Absent	1457 (62.3)	883 (37.7)				274 (11.7)	2066 (88.3)				296 (12.6)	2044 (87.4)			

Table 62. Radiographic findings in the carpi and associations with starting a race at 2 or 3 years of age and starting a race at 2 and 3 years of age for all horses, and number of days from sale to first race start for starters only. All models include log market price.

		Start a Race at 2 or 3 Years Old					Start a Race at 2 and 3 Years Old					Days from Sale to First Start				
		Yes n (%)	No n (%)	OR	95% CI	P	Yes n (%)	No n (%)	OR	95% CI	P	n (%)	Mean (Median; Range)	Difference	95% CI	P
Modelling	Present	101 (80.8)	24 (19.2)	1.18	0.7 - 1.9	0.49	52 (41.6)	73 (58.4)	1.27	0.9 - 1.8	0.21	101 (5.4)	536.6 (521; 196 - 876)	1.2	-32.7 - 35.1	0.95
	Absent	1773 (78.9)	475 (21.1)				826 (36.7)	1422 (63.3)				1773 (94.6)	531.4 (527; 163 - 931)			
Change Radial / Third Carpal Bones	Present	53 (77.9)	15 (22.1)	0.98	0.6 - 1.8	0.95	23 (33.8)	45 (66.2)	0.90	0.5 - 1.5	0.67	53 (2.8)	568.8 (582; 196 - 876)	33.6	-12.5 - 79.7	0.15
	Absent	1821 (79.0)	484 (21.0)				855 (37.1)	1450 (62.9)				1821 (97.2)	530.6 (526; 163 - 931)			
OCLL Ulnar	Present	430 (81.3)	99 (18.7)	1.22	1.0 - 1.6	0.12	220 (41.6)	309 (58.4)	1.30	1.1 - 1.6	0.01	430 (22.9)	521.7 (508; 166 - 908)	-13.8	-31.6 - 4.7	0.15
	Absent	1444 (78.3)	400 (21.7)				658 (35.7)	1186 (64.3)				1444 (77.1)	534.7 (533; 163 - 931)			
First / Fifth Carpal Bones	Present	584 (79.9)	147 (20.1)	1.10	0.9 - 1.4	0.37	268 (36.7)	463 (63.3)	0.99	0.8 - 1.2	0.93	584 (31.2)	528.7 (522; 174 - 924)	-6.1	-22.6 - 10.4	0.47
	Absent	1290 (78.6)	352 (21.4)				610 (37.1)	1032 (62.9)				1290 (68.8)	533.1 (530; 163 - 931)			

Table 63. Radiographic findings in the carpi and associations with number of race starts and number of places for all horses, and percentage of starts placed for starters only. All models include log market price.

		Number of Starts					Number of Places				Percent of Starts Placed				
		n (%)	Mean (Median; Range)	IRR	95% CI	P	Mean (Median; Range)	IRR	95% CI	P	n (%)	Mean (Median; Range)	Difference	95% CI	P
Modelling	Present	125 (5.3)	6.6 (5; 0 - 23)	1.13	0.9 - 1.4	0.20	2.6 (1; 0 - 13)	1.32	1.0 - 1.7	0.03	101 (5.4)	34.1 (35; 0 - 100)	4.1	-1.2 - 9.3	0.13
	Absent	2248 (94.7)	5.9 (5; 0 - 30)				2.0 (1; 0 - 15)				1773 (94.6)	31.0 (30; 0 - 100)			
Change Radial / Third Carpal Bones	Present	68 (2.9)	5.8 (5; 0 - 23)	0.99	0.8 - 1.3	0.10	2.3 (1; 0 - 13)	1.13	0.8 - 1.6	0.47	53 (2.8)	32.6 (33; 0 - 100)	2.7	-4.5 - 9.9	0.47
	Absent	2305 (97.1)	5.9 (5; 0 - 30)				2.1 (1; 0 - 15)				1821 (97.2)	31.1 (30; 0 - 100)			
OCLL Ulnar	Present	529 (22.9)	6.2 (6; 0 - 24)	1.06	1.0 - 1.2	0.26	2.2 (1; 0 - 12)	1.09	1.0 - 1.3	0.22	430 (22.9)	32.7 (33; 0 - 100)	2.1	-0.7 – 5.0	0.14
	Absent	1844 (77.7)	5.8 (5; 0 - 30)				2.0 (1; 0 - 15)				1444 (77.1)	30.7 (29; 0 - 100)			
First / Fifth Carpal Bones	Present	731 (30.8)	6.0 (5; 0 - 24)	1.02	0.9 - 1.1	0.69	1.9 (1; 0 - 12)	0.92	0.8 - 1.0	0.19	584 (31.2)	29.4 (25; 0 - 100)	-2.2	-4.8 - 0.4	0.10
	Absent	1642 (69.2)	5.9 (5; 0 - 30)				2.1 (1; 0 - 15)				1290 (68.8)	32.0 (33; 0 - 100)			

Table 64. Radiographic findings in the carpi and associations with number of starts being seven or more and number of places being two or more amongst all horses. All models include log market price.

		Starts ≥ 7					Places ≥ 2				
		Yes n (%)	No n (%)	OR	95% CI	P	Yes n (%)	No n (%)	OR	95% CI	P
Modelling	Present	46 (36.8)	79 (63.2)	1.15	0.8 - 1.7	0.47	52 (41.6)	73 (58.4)	1.45	1.0 - 2.1	0.05
	Absent	760 (33.8)	1488 (66.2)				763 (33.9)	1485 (66.1)			
Change Radial / Third Carpal Bones	Present	20 (29.4)	48 (70.6)	0.81	0.5 - 1.4	0.44	24 (35.3)	44 (64.7)	1.09	0.7 - 1.8	0.74
	Absent	786 (34.1)	1519 (65.9)				791 (34.3)	1514 (65.7)			
OCLL Ulnar	Present	199 (37.6)	330 (62.4)	1.23	1.0 - 1.5	0.04	190 (35.9)	339 (64.1)	1.11	0.9 - 1.4	0.34
	Absent	607 (32.9)	12.7 (67.1)				625 (33.9)	1219 (66.1)			
First / Fifth Carpal Bones	Present	249 (34.1)	482 (65.9)	1.01	0.8 - 1.2	0.92	247 (33.8)	484 (66.2)	0.98	0.8 - 1.2	0.83
	Absent	557 (33.9)	1085 (66.1)				568 (34.6)	1074 (65.4)			

Table 65. Radiographic findings in the carpi and associations with prize money earned for all horses and prize money per race start for starters only. All models include log market price.

		Prize Money Earned ($)					Prize Money per Start ($)				
		n (%)	GMean (Median; Range)	GM Ratio*	95% CI	P	n (%)	GMean (Median; Range)	GM Ratio*	95% CI	P
Modelling	Present	125 (5.3)	372 (3360; 0 - 1,232,985)	1.41	0.6 - 3.2	0.42	101 (5.4)	102 (1143; 0 - 27,665)	1.17	0.6 - 2.2	0.64
	Absent	2248 (94.7)	316 (2400; 0 - 3,470,325)				1773 (94.6)	91 (958; 0 - 242,836)			
Change Radial / Third Carpal Bones	Present	68 (2.9)	174 (1922; 0 - 173,050)	0.65	0.2 – 2.0	0.44	53 (2.8)	56 (967; 0 - 242,836)	0.69	0.3 - 1.6	0.39
	Absent	2305 (97.1)	324 (2600; 0 - 3,470,325)				1821 (97.2)	93 (750; 0 - 106,209)			
OCLL Ulnar	Present	529 (22.9)	468 (3360; 0 - 1,232,985)	1.70	1.1 - 2.6	0.02	430 (22.9)	126 (1010; 0 - 112,090)	1.37	1.0 - 1.9	0.08
	Absent	1844 (77.7)	282 (2400; 0 - 3,470,325)				1444 (77.1)	83 (940; 0 - 242,836)			
First / Fifth Carpal Bones	Present	731 (30.8)	288 (2550; 0 - 1,232,985)	0.93	0.6 - 1.4	0.72	584 (31.2)	95 (850; 0 - 112,090)	0.83	0.6 - 1.1	0.23
	Absent	1642 (69.2)	331 (0; 0 - 3,470,325)				1290 (68.8)	126 (1000; 0 - 242,836)			

*GM ratio is the ratio of the geometric means

Table 66. Radiographic findings in the carpi and associations with earning any prize money, earning prize money greater than the estimated cost of training ($40,000) and earning prize money greater than the market price for all horses. All models include log market price.

		Prize Money > $0					Prize Money > $40,000					Prize Money > Market Price				
		Yes n (%)	No n (%)	OR	95% CI	P	Yes n (%)	No n (%)	OR	95% CI	P	Yes n (%)	No n (%)	OR	95% CI	P
Modelling	Present	78 (62.4)	47 (37.6)	1.06	0.7 - 1.6	0.75	75 (14.2)	454 (85.8)	1.21	0.7 - 2.1	0.51	24 (19.2)	101 (80.8)	1.58	1.0 - 2.5	0.06
	Absent	1399 (62.2)	849 (37.8)				202 (11.0)	1642 (89.0)				277 (12.3)	1971 (87.7)			
Change Radial / Third Carpal Bones	Present	38 (55.9)	30 (44.1)	0.80	0.5 - 1.3	0.38	6 (8.8)	62 (91.2)	0.85	0.4 – 2.0	0.70	9 (13.2)	59 (86.8)	0.97	0.5 – 2.0	0.92
	Absent	1439 (62.4)	866 (37.6)				271 (11.8)	2034 (88.2)				292 (12.7)	2013 (87.3)			
OCLL Ulnar	Present	350 (66.2)	179 (33.8)	1.27	1.0 - 1.6	0.02	75 (14.2)	454 (85.8)	1.41	1.1 - 1.9	0.02	78 (14.7)	451 (85.3)	1.23	0.9 - 1.6	0.15
	Absent	1127 (61.1)	717 (38.9)				202 (11.0)	1642 (89.0)				223 (12.1)	1621 (87.9)			
First / Fifth Carpal Bones	Present	452 (61.8)	279 (38.2)	1.00	0.8 - 1.2	0.97	76 (10.4)	655 (89.6)	0.87	0.7 - 1.2	0.35	82 (11.2)	649 (88.8)	0.79	0.6 - 1.0	0.09
	Absent	1025 (62.4)	617 (37.6				201 (12.2)	1441 (87.8)				219 (13.3)	1423 (86.7)			

Table 67. Radiographic findings in the hind fetlock and associations with starting a race at 2 or 3 years of age and starting a race at 2 and 3 years of age for all horses, and number of days from sale to first race start for starters only. All models include log market price.

		Start a Race at 2 or 3 Years Old					Start a Race at 2 and 3 Years Old					Days from Sale to First Start				
		Yes n (%)	No n (%)	OR	95% CI	P	Yes n (%)	No n (%)	OR	95% CI	P	n (%)	Mean (Median; Range)	Difference	95% CI	P
Defect Sagittal Ridge MTIII	Present	122 (76.7)	37 (23.3)	0.89	0.6 - 1.3	0.56	61 (38.4)	98 (61.6)	1.09	0.8 - 1.5	0.63	122 (6.5)	524.8 (520; 176 - 922)	-9.4	-40.3 - 21.6	0.55
	Absent	1752 (79.1)	462 (20.9)				817 (36.9)	1397 (63.1)				1752 (93.5)	532.2 (527; 163 - 931)			
Defect Sagittal Ridge MTIII	≤ 5 mm length	27 (84.4)	5 (15.6)	1.45	0.6 - 3.8	0.45	14 (43.8)	18 (56.2)	1.35	0.7 - 2.7	0.40	27 (1.5)	518.1 (509; 217 - 885)	-16.2	-80.3 – 48.0	0.62
	6 – 10 mm length	22 (81.5)	5 (18.5)	1.22	0.5 - 3.3	0.69	10 (37.0)	17 (63.0)	1.04	0.5 - 2.3	0.93	22 (1.2)	544.9 (544; 267 - 799)	11.1	-59.9 – 82.0	0.76
	> 10 mm length	11 (61.1)	7 (38.9)	0.41	0.2 - 1.06	0.06	1 (5.6)	17 (94.4)	0.10	0.0 - 0.7	0.02	11 (0.6)	677.5 (661; 558 - 883)	146.7	46.7 - 246.7	0.004
	Absent	1752 (79.1)	462 (20.9)				817 (36.9)	1397 (63.1)				1752 (96.7)	532.2 (527; 163 - 931)			
Fragment Proximal Dorsal P1	Present	45 (84.9)	8 (15.1)	1.57	0.7 - 3.4	0.25	18 (34.0)	35 (66.0)	0.90	0.5 - 1.6	0.72	45 (2.4)	561.7 (573; 248 - 861)	27.1	-22.8 – 77.0	0.29
	Absent	1829 (78.8)	491 (21.2)				860 (37.1)	1460 (62.9)				1829 (97.6)	531.0 (525; 163 - 931)			
Fragment Plantar P1	Present	120 (80.5)	29 (19.5)	1.14	0.8 - 1.7	0.54	63 (42.3)	86 (57.7)	1.29	0.9 - 1.8	0.13	120 (6.4)	517.6 (522; 225 - 892)	-16.9	-48.1 - 14.3	0.29
	Absent	1754 (78.9)	470 (21.1)				815 (36.6)	1409 (63.4)				1754 (93.6)	532.7 (527; 163 - 931)			

Table 68. Radiographic findings in the hind fetlock and associations with number of race starts and number of places for all horses, and percentage of starts placed for starters only. All models include log market price.

		Number of Starts					Number of Places				Percent of Starts Placed				
		n (%)	Mean (Median; Range)	IRR	95% CI	P	Mean (Median; Range)	IRR	95% CI	P	n (%)	Mean (Median; Range)	Difference	95% CI	P
Defect Sagittal Ridge MTIII	Present	159 (6.7)	5.8 (5; 0 - 21)	0.99	0.8 - 1.2	0.92	2.2 (1; 0 - 9)	1.09	0.9 - 1.4	0.47	122 (6.5)	33.0 (33; 0 - 100)	2.5	-2.4 - 7.3	0.32
	Absent	2214 (93.3)	5.9 (5; 0 - 30)				2.1 (1; 0 - 15)				1752 (93.5)	31.0 (30; 0 - 100)			
Defect Sagittal Ridge MTIII	≤ 5 mm length	32 (1.4)	6.4 (6; 0 - 16)	1.09	0.8 - 1.6	0.64	2.3 (2; 0 - 8)	1.18	0.7 - 1.9	0.50	27 (1.5)	30.7 (30; 0 - 80)	0.2	-9.8 - 10.2	0.97
	6 – 10 mm length	27 (1.2)	5.9 (5; 0 - 18)	1.00	0.7 - 1.5	1.0	2.5 (2; 0 - 9)	1.18	0.7 - 2.0	0.53	22 (1.2)	37.9 (44; 0 - 80)	7.3	-3.8 - 18.4	0.20
	> 10 mm length	18 (0.8)	2.8 (1; 0 - 11)	0.47	0.3 - 0.8	0.01	1.2 (0; 0 - 5)	0.57	0.3 - 1.2	0.12	11 (0.6)	28.0 (33; 0 - 80)	-3.4	-19.0 - 12.3	0.67
	Absent	2214 (96.6)	5.9 (5; 0 - 30)				2.1 (1; 0 - 15)				1752 (96.7)	31.0 (30; 0 - 100)			
Fragment Proximal Dorsal P1	Present	53 (2.2)	6.3 (6; 0 - 17)	1.07	0.8 - 1.4	0.64	1.9 (1; 0 - 11)	0.92	0.6 - 1.4	0.66	45 (2.4)	23.2 (20; 0 - 80)	-7.3	-15.1 - 0.5	0.07
	Absent	2320 (97.8)	5.9 (5; 0 - 30)				2.1 (1; 0 - 15)				1829 (97.6)	31.4 (30; 0 - 100)			
Fragment Plantar P1	Present	149 (6.3)	6.0 (6; 0 - 21)	1.02	0.9 - 1.2	0.83	2.0 (1; 0 - 11)	0.99	0.8 - 1.3	0.92	120 (6.4)	27.4 (25; 0 - 100)	-3.6	-8.4 - 1.3	0.15
	Absent	2224 (93.7)	5.9 (5; 0 - 30)				2.1 (1; 0 - 15)				1754 (93.6)	31.4 (30; 0 - 100)			

Table 69. Radiographic findings in the hind fetlock and associations with number of starts being seven or more and number of places being two or more amongst all horses. All models include log market price.

		Starts ≥ 7					Places ≥ 2				
		Yes n (%)	No n (%)	OR	95% CI	P	Yes n (%)	No n (%)	OR	95% CI	P
Defect Sagittal Ridge MTIII	Present	61 (38.4)	98 (61.6)	1.23	0.9 - 1.7	0.22	65 (40.9)	94 (59.1)	1.39	1.0 - 1.9	0.05
	Absent	745 (33.6)	1469 (66.4)				750 (33.9)	1464 (66.1)			
Defect Sagittal Ridge MTIII	≤ 5 mm length	14 (43.8)	18 (56.2)	1.54	0.8 - 3.1	0.23	15 (46.9)	17 (53.1)	1.76	0.9 - 3.6	0.11
	6 – 10 mm length	9 (33.3)	18 (66.7)	0.99	0.5 - 2.2	0.99	12 (44.4)	15 (55.6)	1.63	0.8 - 3.5	0.21
	> 10 mm length	3 (16.7)	15 (83.3)	0.39	0.1 - 1.4	0.14	5 (27.8)	13 (72.2)	0.74	0.3 - 2.1	0.57
	Absent	745 (33.6)	1469 (66.4)				750 (33.9)	1464 (66.1)			
Fragment Proximal Dorsal P1	Present	20 (37.7)	33 (62.3)	1.19	0.7 - 2.1	0.54	15 (28.3)	38 (71.7)	0.78	0.4 - 1.4	0.42
	Absent	786 (33.9)	1534 (66.1)				800 (34.5)	1520 (65.5)			
Fragment Plantar P1	Present	54 (36.2)	95 (63.8)	1.12	0.8 - 1.6	0.53	48 (32.2)	101 (67.8)	0.93	0.7 - 1.3	0.67
	Absent	752 (33.8)	1472 (66.2)				767 (34.5)	1457 (65.5)			

Table 70. Radiographic findings in the hind fetlock and associations with prize money earned for all horses and prize money per race start for starters only. All models include log market price.

		Prize Money Earned ($)					Prize Money per Start ($)				
		n (%)	GMean (Median; Range)	GM Ratio*	95% CI	P	n (%)	GMean (Median; Range)	GM Ratio*	95% CI	P
Defect Sagittal Ridge MTIII	Present	159 (6.7)	302 (3100; 0 - 1,232,985)	1.04	0.5 - 2.2	0.92	122 (6.5)	87 (1186; 0 - 112,090)	1.22	0.7 - 2.2	0.51
	Absent	2214 (93.3)	316 (2550; 0 - 3,470,325)				1752 (93.5)	91 (963; 0 - 242,836)			
Defect Sagittal Ridge MTIII	≤ 5 mm length	32 (1.4)	468 (4850; 0 - 216,824)	1.58	0.3 - 7.9	0.57	27 (1.5)	91 (913; 0 - 15,487)	1.06	0.3 - 3.6	0.92
	6 – 10 mm length	27 (1.2)	575 (5964; 0 - 161,950)	2.17	0.4 - 12.30	0.38	22 (1.2)	123 (1594; 0 - 24,883)	1.72	0.5 - 6.61	0.42
	> 10 mm length	18 (0.8)	30 (0; 0 - 273,000)	0.09	0.0 - 0.7	0.03	11 (0.6)	155 (838; 0 - 39,000)	0.29	0.0 - 1.9	0.20
	Absent	2214 (96.6)	316 (2550; 0 - 3,470,325)				1752 (96.7)	91 (963; 0 - 242,836)			
Fragment Proximal Dorsal P1	Present	53 (2.2)	240 (2700; 0 – 150,050)	0.87	0.3 - 3.1	0.83	45 (2.4)	69 (578; 0 - 10,866)	0.56	0.2 - 1.4	0.22
	Absent	2320 (97.8)	316 (2600; 0 - 3,470,325)				1829 (97.6)	91 (973; 0 - 242;836)			
Fragment Plantar P1	Present	149 (6.3)	295 (2400; 0 - 173,050)	1.02	0.5 - 2.2	0.95	120 (6.4)	81 (690; 0 - 21,131)	0.82	0.5 - 1.5	0.51
	Absent	2224 (93.7)	316 (2600; 0 - 3,470,325)				1754 (93.6)	93 (976; 0 - 242,836)			

*GM ratio is the ratio of the geometric means

Table 71. Radiographic findings in the hind fetlock and associations with earning any prize money, earning prize money greater than the estimated cost of training ($40,000) and earning prize money greater than the market price for all horses. All models include log market price.

		Prize Money > $0					Prize Money > $40,000					Prize Money > Market Price				
		Yes n (%)	No n (%)	OR	95% CI	P	Yes n (%)	No n (%)	OR	95% CI	P	Yes n (%)	No n (%)	OR	95% CI	P
Defect Sagittal Ridge MTIII	Present	95 (59.7)	64 (40.3)	0.92	0.7 - 1.3	0.63	19 (11.9)	140 (88.1)	1.10	0.7 - 1.8	0.70	24 (15.1)	135 (84.9)	1.18	0.7 - 1.9	0.49
	Absent	1382 (62.4)	832 (37.6)				258 (11.7)	1956 (88.3)				277 (12.5)	1937 (87.5)			
Defect Sagittal Ridge MTIII	≤ 5 mm length	21 (65.6)	11 (34.4)	1.18	0.6 - 2.5	0.67	4 (12.5)	28 (87.5)	1.20	0.4 - 3.5	0.74	7 (21.9)	25 (78.1)	1.96	0.8 - 4.6	0.13
	6 – 10 mm length	18 (66.7)	9 (33.3)	1.29	0.6 - 2.9	0.54	5 (18.5)	22 (81.5)	1.91	0.7 - 5.30	0.22	3 (11.1)	24 (88.9)	0.76	0.2 - 2.58	0.66
	> 10 mm length	6 (33.3)	12 (66.7)	0.29	0.1 - 0.8	0.01	1 (5.6)	17 (94.4)	0.42	0.1 - 3.2	0.41	2 (11.1)	16 (88.9)	0.90	0.2 - 4.0	0.89
	Absent	1382 (62.4)	832 (37.6)				258 (11.7)	1956 (88.3)				277 (12.5)	1937 (87.5)			
Fragment Proximal Dorsal P1	Present	31 (58.5)	22 (41.5)	0.89	0.5 - 1.6	0.69	5 (9.4)	48 (90.6)	0.91	0.4 - 2.3	0.84	5 (9.4)	48 (90.6)	0.66	0.3 - 1.7	0.39
	Absent	1446 (62.3)	874 (37.7)				272 (11.7)	2048 (88.3)				296 (12.8)	2024 (87.2)			
Fragment Plantar P1	Present	92 (61.7)	57 (38.3)	1.01	0.7 - 1.4	0.94	19 (12.8)	130 (87.2)	1.22	0.7 - 2.0	0.44	23 (15.4)	126 (84.6)	1.21	0.8 - 1.9	0.42
	Absent	1385 (62.3)	839 (37.7)				258 (11.6)	1966 (88.4)				278 (12.5)	1946 (87.5)			

Table 72. Radiographic findings in the hind proximal sesamoids and associations with starting a race at 2 or 3 years of age and starting a race at 2 and 3 years of age for all horses, and number of days from sale to first race start for starters only. All models include log market price.

		Start a Race at 2 or 3 Years Old					**Start a Race at 2 and 3 Years Old**					**Days from Sale to First Start**				
		Yes n (%)	No n (%)	OR	95% CI	P	Yes n (%)	No n (%)	OR	95% CI	P	n (%)	Mean (Median; Range)	Difference	95% CI	P
Vascular Channels	1 - 2 regular	852 (78.8)	229 (21.2)	1.11	0.8 - 1.5	0.51	403 (37.8)	678 (62.7)	1.05	0.8 - 1.4	0.71	852 (45.5)	530.9 (526; 166 - 931)	-4.8	-29.3 - 19.8	0.70
	> 2 regular	305 (80.1)	76 (19.9)	1.17	0.8 - 1.7	0.39	147 (38.6)	234 (61.4)	1.10	0.8 - 1.5	0.56	305 (16.3)	526.6 (515; 171 - 922)	-8.2	-37.1 - 20.7	0.58
	1 - 2 irregular	428 (80.3)	105 (19.7)	1.24	0.9 - 1.7	0.22	192 (36.0)	341 (64.0)	1.01	0.8 - 1.4	0.94	428 (22.8)	530.6 (540; 163 - 923)	-7.2	-34.1 - 19.7	0.60
	> 2 irregular	55 (78.6)	15 (21.4)	1.12	0.6 - 2.1	0.73	28 (40.0)	42 (60.0)	1.20	0.7 - 2.1	0.50	55 (2.9)	542.7 (530; 206 - 869)	2.5	-47.1 - 52.0	0.92
	Absent	234 (76.0)	74 (24.0)				108 (35.1)	200 (64.9)				234 (12.5)	540.7 (528; 176 - 908)			
Modelling	Present	76 (80.0)	19 (20.0)	1.06	0.6 - 1.8	0.82	39 (41.1)	56 (58.9)	1.19	0.8 - 1.8	0.41	76 (4.1)	522.6 (508; 206 - 861)	-10.1	-48.8 - 28.6	0.61
	Absent	1798 (78.9)	480 (21.1)				839 (36.8)	1439 (63.2)				1798 (95.9)	532.1 (528; 163 - 931)			
Lucency	Present	186 (78.8)	50 (21.2)	1.03	0.7 - 1.4	0.85	74 (31.4)	162 (68.6)	0.78	0.6 - 1.0	0.09	186 (9.9)	538.1 (547; 176 - 922)	3.2	-22.4 - 28.8	0.81
	Absent	1688 (79.0)	449 (21.0)				804 (37.6)	1333 (62.4)				1688 (90.1)	531.0 (525; 163 - 931)			
Fracture	Present	32 (78.0)	9 (22.0)	1.04	0.5 - 2.2	0.92	16 (39.0)	25 (61.0)	1.17	0.6 - 2.2	0.63	32 (1.7)	502.9 (514; 209 - 816)	-36.7	-95.8 - 22.3	0.22
	Absent	1842 (79.0)	490 (21.0)				862 (37.0)	1470 (63.0)				1842 (98.3)	532.2 (527; 163 - 931)			

Table 73. Radiographic findings in the hind proximal sesamoids and associations with number of race starts and number of places for all horses, and percentage of starts placed for starters only. All models include log market price.

		Number of Starts					Number of Places				Percent of Starts Placed				
		n (%)	Mean (Median; Range)	IRR	95% CI	P	Mean (Median; Range)	IRR	95% CI	P	n (%)	Mean (Median; Range)	Difference	95% CI	P
Vascular Channels	1 - 2 regular	1081 (45.5)	6.0 (5; 0 - 30)	1.14	1.0 - 1.3	0.07	2.1 (1; 0 - 13)	1.22	1.0 - 1.5	0.03	852 (45.5)	31.5 (32; 0 - 100)	1.0	-2.8 - 4.8	0.61
	> 2 regular	381 (16.1)	6.1 (6; 0 - 27)	1.17	1.0 - 1.4	0.07	2.2 (1; 0 - 15)	1.28	1.0 - 1.6	0.02	305 (16.3)	34.4 (33; 0 - 100)	3.7	-0.8 - 8.2	0.11
	1 - 2 irregular	533 (22.5)	6.0 (5; 0 - 23)	1.15	1.0 - 1.3	0.07	2.1 (1; 0 - 15)	1.24	1.0 - 1.5	0.03	428 (22.8)	29.3 (27; 0 - 100)	-0.6	-4.8 - 3.6	0.77
	> 2 irregular	70 (2.9)	5.6 (5; 0 - 18)	1.07	0.8 - 1.4	0.62	2.0 (1; 0 - 8)	1.20	0.8 - 1.7	0.33	55 (2.9)	30.7 (33; 0 - 100)	1.3	-6.4 - 9.0	0.74
	Absent	308 (13.0)	5.2 (4; 0 - 23)				1.7 (1; 0 - 11)				234 (12.5)	29.3 (25; 0 - 100)			
Modelling	Present	95 (4.0)	5.9 (6; 0 - 19)	1.00	0.8 - 1.3	0.97	2.2 (1; 0 - 9)	1.08	0.8 - 1.4	0.61	76 (4.1)	32.5 (33; 0 - 100)	1.5	-4.5 - 7.6	0.62
	Absent	2278 (96.0)	5.9 (5; 0 - 30)				2.1 (1; 0 - 15)				1798 (95.9)	31.1 (30; 0 - 100)			
Lucency	Present	236 (909)	5.7 (5; 0 - 24)	0.97	0.8 - 1.1	0.70	2.1 (1; 0 - 12)	1.03	0.9 - 1.2	0.77	186 (9.9)	31.4 (32; 0 - 100)	1.3	-2.7 - 5.3	0.53
	Absent	2137 (90.1)	5.9 (5; 0 - 30)				2.1 (1; 0 - 15)				1688 (90.1)	31.1 (30; 0 - 100)			
Fracture	Present	41 (1.7)	6.0 (6; 0 - 24)	1.03	0.7 - 1.4	0.86	2.2 (1; 0 - 10)	1.15	0.8 - 1.8	0.52	32 (1.7)	35.6 (33; 0 - 100)	6.4	-2.8 - 15.6	0.18
	Absent	2332 (98.3)	5.9 (5; 0 - 30)				2.1 (1; 0 - 15)				1842 (98.3)	31.1 (30; 0 - 100)			

Table 74. Radiographic findings in the hind proximal sesamoids and associations with number of starts being seven or more and number of places being two or more amongst all horses. All models include log market price.

		Starts ≥ 7					Places ≥ 2				
		Yes n (%)	No n (%)	OR	95% CI	P	Yes n (%)	No n (%)	OR	95% CI	P
Vascular Channels	1 - 2 regular	374 (34.6)	707 (65.4)	1.33	1.0 - 1.8	0.04	388 (35.9)	693 (64.1)	1.41	1.1 - 1.9	0.02
	> 2 regular	138 (36.2)	243 (63.8)	1.43	1.0 – 2.0	0.03	132 (34.6)	249 (65.4)	1.32	1.0 - 1.8	0.10
	1 - 2 irregular	186 (34.9)	347 (65.1)	1.36	1.0 - 1.8	0.05	186 (34.9)	347 (65.1)	1.38	1.0 - 1.9	0.04
	> 2 irregular	21 (30.0)	49 (70.0)	1.08	0.6 - 1.9	0.78	25 (35.7)	45 (64.3)	1.44	0.8 - 2.5	0.20
	Absent	87 (28.2)	221 (71.8)				84 (27.3)	224 (72.7)			
Modelling	Present	36 (37.9)	59 (62.1)	1.19	0.8 - 1.8	0.41	35 (36.8)	60 (63.2)	1.12	0.7 - 1.7	0.61
	Absent	770 (33.8)	1508 (66.2)				780 (34.2)	1498 (65.8)			
Lucency	Present	81 (34.3)	155 (65.7)	1.03	0.8 - 1.4	0.86	80 (33.9)	156 (66.1)	1.02	0.8 - 1.4	0.89
	Absent	725 (33.9)	1412 (66.1)				735 (34.4)	1402 (65.6)			
Fracture	Present	12 (29.3)	29 (70.7)	0.81	0.4 - 1.6	0.55	14 (34.1)	27 (65.9)	1.08	0.6 - 2.1	0.81
	Absent	794 (34.0)	1538 (66.0)				801 (34.3)	1531 (65.7)			

Table 75. Radiographic findings in the hind proximal sesamoids and associations with prize money earned for all horses and prize money per race start for starters only. All models include log market price.

		Prize Money Earned ($)					Prize Money per Start ($)				
		n (%)	GMean (Median; Range)	GM Ratio*	95% CI	P	n (%)	GMean (Median; Range)	GM Ratio*	95% CI	P
Vascular Channels	1 - 2 regular	1081 (45.5)	339 (2600; 0 - 2,760,460)	1.28	0.7 - 2.3	0.40	852 (45.5)	95 (994; 0 - 197,176)	1.09	0.7 - 1.7	0.72
	> 2 regular	381 (16.1)	490 (4400; 0 - 3,399,700)	1.73	0.9 - 3.5	0.12	305 (16.3)	132 (1186; 0 - 242,836)	1.43	0.8 - 2.5	0.19
	1 - 2 irregular	533 (22.5)	257 (2400; 0 - 3,470,325)	1.06	0.6 - 2.0	0.85	428 (22.8)	76 (837; 0 - 216,895)	0.79	0.5 - 1.3	0.36
	> 2 irregular	70 (2.9)	347 (2800; 0 - 287,350)	1.47	0.5 - 4.9	0.52	55 (2.9)	105 (1233; 0 - 39,000)	1.49	0.6 - 3.8	0.40
	Absent	308 (13.0)	204 (1375; 0 - 169,050)				234 (12.5)	66 (696; 0 - 49,417)			
Modelling	Present	95 (4.0)	447 (4900; 0 - 321,742)	1.39	0.5 - 3.6	0.49	76 (4.1)	126 (1425; 0 - 45,963)	1.43	0.7 – 3.0	0.34
	Absent	2278 (96.0)	309 (2550; 0 - 3,470,325)				1798 (95.9)	91 (951; 0 - 242,836)			
Lucency	Present	236 (909)	331 (2238; 0 - 392,000)	1.24	0.7 - 2.3	0.50	186 (9.9)	95 (965; 0 - 39,200)	1.26	0.8 - 2.0	0.35
	Absent	2137 (90.1)	316 (2600; 0 - 3,470,325)				1688 (90.1)	91 (967; 0 - 242,836)			
Fracture	Present	41 (1.7)	776 (3110; 0 - 125,930)	3.61	0.9 - 15.1	0.08	32 (1.7)	195 (1324; 0 - 19,056)	3.89	1.3 - 11.8	0.02
	Absent	2332 (98.3)	309 (2600; 0 - 3,470,325)				1842 (98.3)	91 (966; 0 - 242,836)			

*GM ratio is the ratio of the geometric means

Table 76. Radiographic findings in the hind proximal sesamoids and associations with earning any prize money, earning prize money greater than the estimated cost of training ($40,000) and earning prize money greater than the market price for all horses. All models include log market price.

		Prize Money > $0					Prize Money > $40,000					Prize Money > Market Price				
		Yes n (%)	No n (%)	OR	95% CI	P	Yes n (%)	No n (%)	OR	95% CI	P	Yes n (%)	No n (%)	OR	95% CI	P
Vascular Channels	1 - 2 regular	678 (62.7)	403 (37.3)	1.00	0.8 - 1.3	0.97	135 (12.5)	946 (87.5)	1.83	1.1 - 3.0	0.02	137 (12.7)	944 (87.3)	1.77	1.1 - 2.7	0.01
	> 2 regular	250 (65.6)	131 (34.4)	1.12	0.8 - 1.5	0.50	56 (14.7)	325 (85.3)	2.11	1.2 - 3.7	0.01	52 (13.6)	329 (86.4)	2.01	1.2 - 3.3	0.01
	1 - 2 irregular	318 (59.7)	215 (40.3)	0.91	0.7 - 1.2	0.50	57 (10.7)	476 (89.3)	1.63	0.9 - 2.8	0.08	72 (13.5)	461 (86.5)	1.81	1.1 - 2.9	0.01
	> 2 irregular	44 (62.9)	26 (37.1)	1.05	0.6 - 1.8	0.87	10 (14.3)	60 (85.7)	2.32	1.0 - 5.3	0.05	13 (18.6)	57 (81.4)	2.64	1.3 - 5.5	0.01
	Absent	187 (60.7)	121 (39.3)				19 (6.2)	289 (93.8)				27 (8.8)	281 (91.2)			
Modelling	Present	60 (63.2)	35 (36.8)	1.04	0.7 - 1.6	0.87	18 (18.9)	77 (81.1)	1.87	1.1 - 3.2	0.02	15 (15.8)	80 (84.2)	1.34	0.8 - 2.4	0.32
	Absent	1417 (62.2)	861 (37.8)				259 (11.4)	2019 (88.6)				286 (12.6)	1992 (87.4)			
Lucency	Present	151 (64.0)	85 (36.0)	1.15	0.9 - 1.5	0.33	28 (11.9)	208 (88.1)	1.18	0.8 - 1.8	0.45	31 (13.1)	205 (86.9)	0.96	06 - 1.4	0.84
	Absent	1326 (62.0)	811 (38.0)				249 (11.7)	1888 (88.3)				270 (12.6)	1867 (87.4)			
Fracture	Present	30 (73.2)	11 (26.8)	1.90	0.9 - 3.8	0.07	6 (14.6)	35 (85.4)	1.78	0.7 - 4.3	0.21	8 (19.5)	33 (80.5)	1.40	0.6 - 3.1	0.41
	Absent	1447 (62.0)	885 (38.0)				271 (11.6)	2061 (88.4)				293 (12.6)	2039 (87.4)			

Table 77. Radiographic findings in the tarsi and associations with starting a race at 2 or 3 years of age and starting a race at 2 and 3 years of age for all horses, and number of days from sale to first race start for starters only. All models include log market price.

		Start a Race at 2 or 3 Years Old					Start a Race at 2 and 3 Years Old					Days from Sale to First Start				
		Yes n (%)	No n (%)	OR	95% CI	P	Yes n (%)	No n (%)	OR	95% CI	P	n (%)	Mean (Median; Range)	Difference	95% CI	P
OCD DIRT / Medial / Lateral Malleolus	Present	83 (74.8)	28 (25.2)	0.73	0.4 - 1.3	0.29	36 (32.4)	75 (67.6)	0.82	0.5 - 1.2	0.33	83 (4.4)	545.1 (555; 226 - 900)	12.3	-24.9 - 49.4	0.52
	Absent	1791 (79.2)	471 (20.8)				842 (37.2)	1420 (62.8)				1791 (95.6)	531.1 (526; 163 - 931)			
OCD Medial / Lateral Ridge Talus	Present	43 (72.9)	16 (27.1)	0.79	0.5 - 1.2	0.29	22 (37.3)	37 (62.7)	1.04	0.6 - 1.8	0.89	43 (2.3)	505.8 (517; 198 - 844)	-29.0	-80.0 – 22.0	0.26
	Absent	1831 (79.1)	483 (20.9)				856 (37.0)	1458 (63.0)				1831 (97.7)	532.3 (527; 163 - 931)			
Osteophyte Talocalcaneal-centroquatral / Centrodistal Joint	Present	208 (77.9)	59 (22.1)	0.97	0.7 - 1.3	0.85	84 (31.5)	183 (68.5)	0.78	0.6 - 1.0	0.07	208 (11.1)	546.3 (546; 163 - 922)	14.4	-9.9 - 38.7	0.25
	Absent	1666 (79.1)	440 (20.9)				794 (37.7)	1312 (62.3)				1666 (88.9)	529.9 (524; 166 - 931)			
Osteophyte Tarsometatarsal Joint	Present	681 (80.8)	162 (19.2)	1.20	1.0 - 1.5	0.09	325 (38.6)	518 (61.4)	1.11	0.9 - 1.3	0.22	681 (36.3)	522.5 (518; 163 - 923)	-15.2	-31.1 - 0.7	0.06
	Absent	1193 (78.0)	337 (22.0)				553 (36.1)	977 (63.9)				1193 (63.7)	537.0 (532; 166 - 931)			

Table 78. Radiographic findings in the tarsi and associations with number of race starts and number of places for all horses, and percentage of starts placed for starters only. All models include log market price.

		Number of Starts					Number of Places				Percent of Starts Placed				
		n (%)	Mean (Median; Range)	IRR	95% CI	P	Mean (Median; Range)	IRR	95% CI	P	n (%)	Mean (Median; Range)	Difference	95% CI	P
OCD DIRT / Medial / Lateral Malleolus	Present	111 (4.7)	4.9 (4; 0 - 18)	0.83	0.7 - 1.0	0.08	1.9 (1; 0 - 12)	0.90	0.7 - 1.2	0.44	83 (4.4)	32.5 (33; 0 - 100)	1.8	-4.0 - 7.6	0.54
	Absent	2262 (95.3)	5.9 (5; 0 - 30)				2.1 (1; 0 - 15)				1791 (95.6)	31.1 (30; 0 - 100)			
OCD Medial / Lateral Ridge Talus	Present	59 (2.5)	6.1 (5; 0 - 22)	1.04	0.8 - 1.4	0.76	2.2 (1; 0 - 8)	1.08	0.8 - 1.6	0.66	43 (2.3)	31.5 (29; 0 - 100)	0.9	-7.0 - 8.9	0.82
	Absent	2314 (97.5)	5.9 (5; 0 - 30)				2.1 (1; 0 - 15)				1831 (97.7)	31.2 (30; 0 - 100)			
Osteophyte Talocalcaneal-centroquatral / Centrodistal Joint	Present	267 (11.2)	5.9 (5; 0 - 22)	1.00	0.9 - 1.2	0.98	2.0 (1; 0 - 12)	1.01	0.8 - 1.2	0.93	208 (11.1)	30.8 (29; 0 - 100)	0.0	-3.8 - 3.8	0.99
	Absent	2106 (88.8)	5.9 (5; 0 - 30)				2.1 (1; 0 - 15)				1666 (88.9)	31.2 (30; 0 - 100)			
Osteophyte Tarsometatarsal Joint	Present	843 (35.5)	6.0 (5; 0 - 30)	1.04	1.0 - 1.1	0.46	2.2 (1; 0 - 15)	1.09	1.0 - 1.2	0.18	681 (36.3)	30.5 (33; 0 - 100)	-0.8	-3.3 - 1.7	0.52
	Absent	1530 (64.5)	5.8 (5; 0 - 27)				2.0 (1; 0 - 15)				1193 (63.7)	31.5 (30; 0 - 100)			

Table 79. Radiographic findings in the tarsi and associations with number of starts being seven or more and number of places being two or more amongst all horses. All models include log market price.

		Starts ≥ 7					**Places ≥ 2**				
		Yes n (%)	No n (%)	OR	95% CI	P	Yes n (%)	No n (%)	OR	95% CI	P
OCD DIRT / Medial / Lateral Malleolus	Present	32 (28.8)	79 (71.2)	0.78	0.5 - 1.2	0.25	37 (33.3)	74 (66.7)	0.97	0.7 - 1.5	0.87
	Absent	774 (34.2)	1488 (65.8)				778 (34.4)	1484 (65.6)			
OCD Medial / Lateral Ridge Talus	Present	19 (32.2)	40 (67.8)	0.93	0.5 - 1.6	0.79	23 (39.0)	36 (61.0)	1.27	0.8 - 2.2	0.38
	Absent	787 (34.0)	1527 (66.0)				792 (34.2)	1522 (65.8)			
Osteophyte Talocalcaneal-centroquatral / Centrodistal Joint	Present	94 (35.2)	173 (64.8)	1.07	0.8 - 1.4	0.61	84 (31.5)	183 (68.5)	0.89	0.7 – 1.2	0.42
	Absent	712 (33.8)	1394 (66.2)				731 (34.7)	1375 (65.3)			
Osteophyte Tarsometatarsal Joint	Present	291 (34.5)	552 (65.5)	1.04	0.8 - 1.2	0.66	292 (34.6)	551 (65.4)	1.03	0.9 - 1.2	0.76
	Absent	515 (33.7)	1015 (66.3)				523 (34.2)	1007 (65.8)			

Table 80. Radiographic findings in the tarsi and associations with prize money earned for all horses and prize money per race start for starters only. All models include log market price.

		Prize Money Earned ($)					Prize Money per Start ($)				
		n (%)	GMean (Median; Range)	GM Ratio*	95% CI	P	n (%)	GMean (Median; Range)	GM Ratio*	95% CI	P
OCD DIRT / Medial / Lateral Malleolus	Present	111 (4.7)	158 (1000; 0 - 1,232,985)	0.52	0.2 - 1.3	0.14	83 (4.4)	56 (1000; 0 - 112,090)	0.75	0.4 - 1.5	0.42
	Absent	2262 (95.3)	331 (2624; 0 - 3,470,325)				1791 (95.6)	93 (967; 0 - 242,836)			
OCD Medial / Lateral Ridge Talus	Present	59 (2.5)	191 (2850; 0 - 368,200)	0.67	0.2 - 2.2	0.52	43 (2.3)	56 (1029; 0 - 73,640)	0.91	0.4 - 2.4	0.85
	Absent	2314 (97.5)	324 (2600; 0 - 3,470,325)				1831 (97.7)	93 (967; 0 - 242,836)			
Osteophyte Talocalcaneal-centroquatral / Centrodistal Joint	Present	267 (11.2)	324 (2850; 0 - 730,305)	1.18	0.7 - 2.1	0.59	208 (11.1)	93 (1076; 0 - 46,505)	1.22	0.8 – 2.0	0.39
	Absent	2106 (88.8)	316 (2600; 0 - 3,470,325)				1666 (88.9)	91 (954; 0 - 242,836)			
Osteophyte Tarsometatarsal Joint	Present	843 (35.5)	347 (2780;0 - 1,724,100)	1.21	0.8 - 1.8	0.33	681 (36.3)	98 (977; 0 - 90,742)	0.97	0.7 - 1.3	0.86
	Absent	1530 (64.5)	302 (2512; 0 - 3,470,325)				1193 (63.7)	87 (967; 0 - 242,836)			

*GM ratio is the ratio of the geometric means

Table 81. Radiographic findings in the tarsi and associations with earning any prize money, earning prize money greater than the estimated cost of training ($40,000) and earning prize money greater than the market price for all horses. All models include log market price.

		Prize Money > $0					Prize Money > $40,000					Prize Money > Market Price				
		Yes n (%)	No n (%)	OR	95% CI	P	Yes n (%)	No n (%)	OR	95% CI	P	Yes n (%)	No n (%)	OR	95% CI	P
OCD DIRT / Medial / Lateral Malleolus	Present	61 (55.0)	50 (45.0)	0.74	0.5 - 1.1	0.13	9 (8.1)	102 (91.9)	0.69	0.3 - 1.4	0.30	14 (12.6)	97 (87.4)	0.97	0.5 - 1.7	0.92
	Absent	1416 (62.6)	846 (37.4)				268 (11.8)	1994 (88.2)				287 (12.7)	1975 (87.3)			
OCD Medial / Lateral Ridge Talus	Present	32 (54.2)	27 (45.8)	0.74	0.4 - 1.3	0.26	7 (11.9)	52 (88.1)	1.15	0.5 - 2.6	0.74	8 (13.6)	51 (86.4)	1.01	0.5 - 2.2	0.97
	Absent	1445 (62.4)	869 (37.6)				270 (11.7)	2044 (88.3)				293 (12.7)	2021 (87.3)			
Osteophyte Talocalcaneal-centroquatral / Centrodistal Joint	Present	166 (62.2)	101 (37.8)	1.05	0.8 - 1.4	0.72	32 (12.0)	235 (88.0)	1.14	0.8 - 1.7	0.52	41 (15.4)	226 (84.6)	1.17	0.8 - 1.7	0.40
	Absent	1311 (62.3)	795 (37.7)				245 (11.6)	1861 (88.4)				260 (12.3)	1846 (87.7)			
Osteophyte Tarsometatarsal Joint	Present	530 (62.9)	313 (37.1)	1.06	0.9 - 1.3	0.54	111 (13.2)	732 (86.8)	1.26	1.0 - 1.6	0.08	124 (14.7)	719 (85.3)	1.28	1.0 - 1.7	0.05
	Absent	947 (61.9)	583 (38.1)				166 (10.8)	1364 (89.2)				177 (11.6)	1353 (88.4)			

Table 82. Radiographic findings in the stifles and associations with starting a race at 2 or 3 years of age and starting a race at 2 and 3 years of age for all horses, and number of days from sale to first race start for starters only. All models include log market price.

		Start a Race at 2 or 3 Years Old					**Start a Race at 2 and 3 Years Old**					**Days from Sale to First Start**				
		Yes n (%)	No n (%)	OR	95% CI	P	Yes n (%)	No n (%)	OR	95% CI	P	n (%)	Mean (Median; Range)	Difference	95% CI	P
OCD	Present	75 (74.3)	26 (25.7)	0.80	0.5 - 1.3	0.34	31 (30.7)	70 (69.3)	0.78	0.5 - 1.2	0.25	75 (4.0)	571.8 (568; 228 - 922)	37.6	-1.4 - 79.6	0.06
	Absent	1799 (79.2)	473 (20.8)				847 (37.3)	1425 (62.7)				1799 (96.0)	530.0 (525; 163 - 931)			
OCD	≤ 20 mm length	39 (78.0)	11 (22.0)	0.97	0.5 - 1.9	0.93	16 (32.0)	34 (68.0)	0.82	0.5 - 1.5	0.51	39 (2.1)	600.7 (600; 228 - 858)	66.0	12.5 - 119.5	0.02
	21 to 40 mm length	25 (73.5)	9 (26.5)	0.77	0.4 - 1.7	0.50	10 (29.4)	24 (70.6)	0.73	0.3 - 1.5	0.40	25 (1.3)	549.4 (543; 279 - 922)	16.1	-50.4 - 82.6	0.64
	> 40 mm length	9 (69.2)	4 (30.8)	0.68	0.2 - 2.2	0.52	5 (38.5)	8 (61.5)	1.17	0.4 - 3.6	0.79	9 (0.5)	509.0 (500; 267 - 765)	-28.7	-139.1 - 81.7	0.61
	Absent	1799 (79.2)	473 (20.8)				847 (37.3)	1425 (62.7)				1799 (96.1)	530.0 (525; 163 - 922)			
OCLL Medial Condyle	Present	107 (80.5)	26 (19.5)	1.08	0.7 - 1.7	0.72	44 (33.1)	89 (66.9)	0.83	0.6 - 1.2	0.31	107 (5.7)	554.5 (579; 171 - 922)	24.9	-8.0 - 57.8	0.14
	Absent	1767 (78.9)	473 (21.1)				834 (37.2)	1406 (62.8)				1767 (94.3)	530.3 (523; 163 - 931)			
OCLL Medial Condyle	≤ 6 mm deep	73 (83.9)	14 (16.1)	1.36	0.8 - 2.4	0.31	33 (37.9)	54 (62.1)	1.01	0.7 - 1.6	0.96	73 (3.9)	550.5 (568; 171 - 922)	21.1	-18.4 - 60.6	0.30
	> 6 mm deep	14 (70.0)	6 (30.0)	0.68	0.3 - 1.8	0.43	2 (10.0)	18 (90.0)	0.20	0.0 - 0.9	0.03	14 (0.8)	593.8 (634; 269 - 847)	59.7	-29.0 – 148.4	0.19
	Absent	1767 (78.9)	473 (21.1)				834 (37.2)	1406 (62.8)				1767 (95.3)	530.3 (523; 163 - 931)			

Table 83. Radiographic findings in the stifles and associations with number of race starts and number of places for all horses, and percentage of starts placed for starters only. All models include log market price.

		Number of Starts					Number of Places				Percent of Starts Placed				
		n (%)	Mean (Median; Range)	IRR	95% CI	P	Mean (Median; Range)	IRR	95% CI	P	n (%)	Mean (Median; Range)	Difference	95% CI	P
OCD	Present	101 (4.3)	5.1 (4; 0 - 21)	0.88	0.7 - 1.1	0.23	1.6 (0; 0 - 9)	0.78	0.6 - 1.0	0.09	75 (4.0)	24.1 (25; 0 - 75)	-6.4	-12.4 - -0.3	0.04
	Absent	2272 (95.7)	5.9 (5; 0 - 30)				2.1 (1; 0 - 15)				1799 (96.0)	31.5 (30; 0 - 100)			
OCD	≤ 20 mm length	50 (2.1)	5.0 (4; 0 - 21)	0.85	0.6 - 1.2	0.30	1.6 (0; 0 - 9)	0.77	0.5 - 1.2	0.21	39 (2.1)	23.0 (25; 0 - 73)	-7.3	-15.7 - 1.0	0.09
	21 to 40 mm length	34 (1.4)	5.0 (4; 0 - 19)	0.85	0.6 - 1.2	0.40	1.5 (0; 0 - 6)	0.72	0.4 - 1.2	0.20	25 (1.3)	24.3 (17; 0 - 75)	-6.4	-16.8 – 4.0	0.23
	> 40 mm length	13 (0.5)	6.1 (8; 0 - 15)	1.04	0.6 - 1.9	0.90	1.8 (0; 0 - 9)	0.87	0.4 - 1.9	0.73	9 (0.5)	22.0 (12; 0 - 64)	-7.6	-24.8 - 9.6	0.39
	Absent	2272 (95.7)	5.9 (5; 0 - 30)				2.1 (1; 0 - 15)				1799 (96.1)	31.5 (30; 0 - 100)			
OCLL Medial Condyle	Present	133 (5.6)	6.0 (5; 0 - 22)	1.01	0.8 - 1.2	0.91	2.1 (1; 0 - 12)	0.98	0.1 - 0.9	0.88	107 (5.7)	29.6 (30; 0 - 100)	-1.9	-7.0 - 3.3	0.48
	Absent	2240 (94.4)	5.9 (5; 0 - 30)				2.1 (1; 0 - 15)				1767 (94.3)	31.3 (30; 0 - 100)			
OCLL Medial Condyle	≤ 6 mm deep	87 (3.7)	6.1 (5; 0 - 22)	1.03	0.8 - 1.3	0.82	2.0 (1; 0 - 15)	0.97	0.7 - 1.3	0.84	73 (3.9)	28.9 (27; 0 - 100)	-2.6	-8.7 - 3.6	0.41
	> 6 mm deep	20 (0.9)	4.5 (4; 0 - 18)	0.77	0.5 - 1.2	0.28	1.2 (0; 0 - 8)	0.61	0.3 - 1.2	0.15	14 (0.8)	22.1 (25; 0 - 100)	-8.1	-22.0 - 5.7	0.25
	Absent	2240 (95.4)	5.9 (5; 0 - 30)				2.1 (1; 0 - 15)				1767 (95.3)	31.3 (30; 0 - 100)			

Table 84. Radiographic findings in the stifles and associations with number of starts being seven or more and number of places being two or more amongst all horses. All models include log market price.

		Starts ≥ 7					Places ≥ 2				
		Yes n (%)	No n (%)	OR	95% CI	P	Yes n (%)	No n (%)	OR	95% CI	P
OCD	Present	30 (29.7)	71 (70.3)	0.82	0.5 - 1.3	0.38	25 (24.8)	76 (75.2)	0.65	0.4 - 1.0	0.07
	Absent	776 (34.2)	1496 (65.8)				790 (34.8)	1482 (65.2)			
OCD	≤ 20 mm length	12 (24.0)	38 (76.0)	0.61	0.3 - 1.2	0.14	10 (20.0)	40 (80.0)	0.49	0.2 – 1.0	0.04
	21 to 40 mm length	10 (29.4)	24 (70.6)	0.81	0.4 - 1.7	0.58	9 (26.5)	25 (73.5)	0.70	0.3 - 1.5	0.37
	> 40 mm length	7 (53.8)	6 (46.2)	2.31	0.8 - 6.9	0.13	4 (30.8)	9 (69.2)	0.95	0.3 - 3.1	0.93
	Absent	776 (34.2)	1496 (65.8)				790 (34.8)	1482 (65.2)			
OCLL Medial Condyle	Present	39 (29.3)	94 (70.7)	0.80	0.5 - 1.2	0.24	42 (31.6)	91 (68.4)	0.87	0.6 - 1.3	0.45
	Absent	767 (34.2)	1473 (65.8)				773 (34.5)	1467 (65.5)			
OCLL Medial Condyle	≤ 6 mm deep	26 (29.9)	61 (70.1)	0.82	0.5 - 1.3	0.39	27 (31.0)	60 (69.0)	0.84	0.5 - 1.3	0.45
	> 6 mm deep	4 (20.0)	16 (80.0)	0.49	0.2 - 1.5	0.20	4 (20.0)	16 (80.0)	0.51	0.2 - 1.5	0.24
	Absent	767 (34.2)	1473 (65.8)				773 (34.5)	1467 (65.5)			

Table 85. Radiographic findings in the stifles and associations with prize money earned for all horses and prize money per race start for starters only. All models include log market price.

		Prize Money Earned ($)					Prize Money per Start ($)				
		n (%)	GMean (Median; Range)	GM Ratio*	95% CI	P	n (%)	GMean (Median; Range)	GM Ratio*	95% CI	P
OCD	Present	101 (4.3)	120 (500; 0 - 511,550)	0.45	0.2 - 1.2	0.09	75 (4.0)	43 (406; 0 - 46,505)	0.59	0.3 - 1.2	0.16
	Absent	2272 (95.7)	331 (2740; 0 - 3,470,325)				1799 (96.0)	95 (979; 0 - 242,836)			
OCD	≤ 20 mm length	50 (2.1)	112 (525; 0 - 511,550)	0.40	0.1 - 1.5	0.16	39 (2.1)	42 (440; 0 - 46,505)	0.46	0.2 - 1.3	0.13
	21 to 40 mm length	34 (1.4)	123 (762; 0 - 331,000)	0.45	0.1 - 2.1	0.32	25 (1.3)	44 (383; 0 - 41,375)	0.62	0.2 - 2.2	0.46
	> 40 mm length	13 (0.5)	117 (330; 0 - 59,050)	0.62	0.1 - 7.6	0.71	9 (0.5)	34 (319; 0 - 5570)	0.70	0.1 - 5.6	0.74
	Absent	2272 (95.7)	331 (2740; 0 - 3,470,325)				1799 (96.1)	95 (979; 0 - 242,836)			
OCLL Medial Condyle	Present	133 (5.6)	331 (2600; 0 - 137,150)	1.00	0.5 - 2.2	0.99	107 (5.7)	95 (1100; 0 - 20,186)	0.91	0.5 - 1.7	0.76
	Absent	2240 (94.4)	316 (2600; 0 - 3,470,325)				1767 (94.3)	91 (967; 0 - 242,836)			
OCLL Medial Condyle	≤ 6 mm deep	87 (3.7)	372 (2600; 0 - 137,150)	1.06	0.4 - 2.8	0.90	73 (3.9)	105 (1138; 0 - 10,500)	0.91	0.8 - 6.6	0.92
	> 6 mm deep	20 (0.9)	123 (375; 0 - 101,200)	0.54	0.1 - 4.1	0.55	14 (0.8)	44 (772; 0 - 10,120)	0.36	0.0 - 14.5	0.59
	Absent	2240 (95.4)	316 (2600; 0 - 3,470,325)				1767 (95.3)	91 (967; 0 - 242,836)			

*GM ratio is the ratio of the geometric means

Table 86. Radiographic findings in the stifles and associations with earning any prize money, earning prize money greater than the estimated cost of training ($40,000) and earning prize money greater than the market price for all horses. All models include log market price.

		Prize Money > $0					Prize Money > $40,000					Prize Money > Market Price				
		Yes n (%)	No n (%)	OR	95% CI	P	Yes n (%)	No n (%)	OR	95% CI	P	Yes n (%)	No n (%)	OR	95% CI	P
OCD	Present	54 (53.5)	47 (46.5)	0.73	0.5 - 1.1	0.13	12 (11.9)	89 (88.1)	1.21	0.7 - 2.3	0.55	13 (12.9)	88 (87.1)	0.90	0.5 - 1.6	0.72
	Absent	1423 (62.6)	849 (37.4)				265 (11.7)	2007 (88.3)				288 (12.7)	1984 (87.3)			
OCD	≤ 20 mm length	26 (52.0)	24 (48.0)	0.68	0.4 - 1.2	0.18	6 (12.0)	44 (88.0)	1.18	0.5 - 2.8	0.71	7 (14.0)	43 (86.0)	1.03	0.5 - 2.3	0.95
	21 to 40 mm length	19 (55.9)	15 (44.1)	0.80	0.4 - 1.6	0.53	2 (5.9)	32 (94.1)	0.54	0.1 - 2.3	0.40	3 (8.8)	31 (91.2)	0.59	0.2 – 2.0	0.39
	> 40 mm length	7 (53.8)	6 (46.2)	0.83	0.3 - 2.5	0.75	3 (23.1)	10 (76.9)	3.64	1.0 - 13.9	0.06	2 (15.4)	11 (84.6)	0.91	0.2 - 4.2	0.91
	Absent	1423 (62.6)	849 (37.4)				265 (11.7)	2007 (88.3)				288 (12.7)	1984 (87.3)			
OCLL Medial Condyle	Present	84 (63.2)	49 (36.8)	1.02	0.7 - 1.5	0.91	17 (12.8)	116 (87.2)	1.11	0.7 - 1.9	0.69	14 (10.5)	119 (89.5)	0.84	0.5 - 1.5	0.55
	Absent	1393 (62.2)	847 (37.8)				260 (11.6)	1980 (88.4)				287 (12.8)	1953 (87.2)			
OCLL Medial Condyle	≤ 6 mm deep	56 (64.4)	31 (35.6)	1.06	0.7 - 1.7	0.80	9 (10.3)	78 (89.7)	0.85	0.4 - 1.7	0.65	10 (11.5)	77 (88.5)	0.96	0.5 - 1.9	0.90
	> 6 mm deep	11 (55.0)	9 (45.0)	0.83	0.3 - 2.0	0.68	3 (15.0)	17 (85.0)	1.79	0.5 - 6.3	0.37	1 (5.0)	19 (95.0)	0.29	0.0 - 2.2	0.24
	Absent	1393 (62.6)	847 (37.8)				260 (11.6)	1980 (88.4)				287 (12.8)	1953 (87.2)			

Table 87. Summary of statistical analysis of radiographic findings in the forelimbs and all outcome variables.

	Start 2or3YO	Start 2&3YO	Days to 1st Start	No. of Starts	No. of Places	% Starts Placed	Starts ≥7	Places ≥2	Prize Money	Prize Money /Start	Prize Money >0	Prize Money >40000	Prize Money >MarketPrice
ForeFoot													
Club	Yes	Yes	**Sig -ve**	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	**No**	**No**
Modelling Dorsal P3	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	**Sig +ve**	Yes	Yes	**Sig +ve**
Modelling Toe P3	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	**No**	Yes	Yes	Yes	Yes
Fore Fetlock													
Defect Sagittal Ridge Present	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Defect Sagittal Ridge ≤5mm	**No**	**No**	Yes	Yes	Yes	Yes	Yes	Yes	**No**	**No**	**No**	**No**	**No**
Defect Sagittal Ridge 6 to10mm	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	**No**	Yes	Yes	Yes
Defect Sagittal Ridge >10mm	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	**No**	Yes	Yes	Yes
Fragment Proximal Dorsal P1	**No**	**No**	**No**	Yes	Yes	Yes	**No**	Yes	**No**	**No**	**No**	**No**	**No**
Fragment Palmar P1	**No**	**No**	**No**	**No**	**No**	Yes	**No**	**No**	**No**	Yes	**No**	**No**	**No**
Fore Sesamoids													
Vascular Channels 1 - 2 regular	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	**No**	**No**	Yes	Yes	Yes
Vascular Channels >2 regular	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Vascular Channels 1 - 2 irregular	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	**No**	**No**	Yes	Yes	Yes
Vascular Channels >2 irregular	Yes	Yes	Yes	Yes	Yes	Yes	Yes	**Sig +ve**	Yes	Yes	Yes	Yes	Yes
Modelling	**Sig -ve**	Yes	Yes	Yes	Yes	Yes	Yes	Yes	**No**	**No**	**No**	**No**	**No**
Lucency	Yes	Yes	**Sig -ve**	Yes	Yes	Yes	Yes	Yes	**No**	Yes	Yes	Yes	Yes
Fracture	**No**	**Sig -ve**	**No**	Yes	**No**	**Yes**	**No**	**No**	**No**	Yes	Yes	**No**	**No**
Carpus													
Osteophyte / Enthesiophyte	Yes	Yes	Yes	Yes	**Sig +ve**	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Change Radial / Third Carpal	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	**No**	**No**	Yes	**No**	Yes
OCLL Ulnar	Yes	**Sig +ve**	Yes	Yes	Yes	Yes	**Sig +ve**	Yes	**Sig +ve**	Yes	**Sig +ve**	**Sig +ve**	Yes
First / FifthCarpal	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes

Sig -ve=negative significant difference (P<0.05), Sig +ve=positive significant difference (P<0.05), Yes=enough observations for meaningful statistical analysis, No=not enough observations for meaningful statistical analysis

Table 88. Summary of statistical analysis of radiographic findings in the hindlimbs and all outcome variables.

	Start 2or3YO	Start 2&3YO	Days to 1st Start	No. of Starts	No. of Places	% Starts Placed	Starts ≥7	Places ≥2	Prize Money	Prize Money /Start	Prize Money >0	Prize Money >40000	Prize Money >MarketPrice
Hind Fetlock													
Defect Sagittal Ridge Present	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Defect Sagittal Ridge ≤5mm	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	**No**	**No**	Yes	**No**	Yes
Defect Sagittal Ridge 6 to10mm	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	**No**	Yes	Yes	Yes	**No**
Defect Sagittal Ridge >10mm	**No**	**Sig -ve**	**Sig -ve**	**Sig -ve**	**No**	**No**	**No**	**No**	**Sig -ve**	**No**	**Sig -ve**	**No**	**No**
Fragment Proximal Dorsal P1	Yes	Yes	Yes	Yes	Yes	**No**	Yes	**No**	**No**	**No**	Yes	**No**	**No**
Fragment Plantar P1	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Hind Sesamoids													
Vascular Channels 1 - 2 regular	Yes	Yes	Yes	Yes	**Sig +ve**	Yes	**Sig +ve**	**Sig +ve**	Yes	Yes	Yes	**Sig +ve**	**Sig +ve**
Vascular Channels >2 regular	Yes	Yes	Yes	Yes	**Sig +ve**	Yes	**Sig +ve**	Yes	Yes	Yes	Yes	**Sig +ve**	**Sig +ve**
Vascular Channels 1 - 2 irregular	Yes	Yes	Yes	Yes	**Sig +ve**	Yes	**Sig +ve**	**Sig +ve**	Yes	Yes	Yes	Yes	**Sig +ve**
Vascular Channels >2 irregular	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	**Sig +ve**
Modelling	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	**Sig +ve**	Yes
Lucency	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Fracture	Yes	Yes	Yes	Yes	Yes	Yes	**No**	Yes	Yes	**Sig +ve**	Yes	Yes	Yes
Tarsus													
OCD DIRT / Malleoli	**No**	Yes	Yes	Yes	Yes	Yes	Yes	Yes	**No**	**No**	Yes	**No**	Yes
OCD Trochlear Ridge Talus	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	**No**	**No**	**No**	Yes	Yes
Osteo Talocalcaneal / Centrodistal Joint	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
OsteoTarsometatarsal Joint	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Stifle													
OCD	Yes	Yes	Yes	Yes	Yes	**Sig -ve**	Yes	**No**	**No**	**No**	Yes	Yes	Yes
OCD ≤20mm	Yes	Yes	**Sig -ve**	Yes	Yes	**No**	**No**	**Sig -ve**	**No**	**No**	**No**	Yes	Yes
OCD 21to40mm	**No**	**No**	Yes	Yes	**No**	**No**	**No**	**No**	**No**	**No**	**No**	**No**	No
OCD >40mm	**No**	**No**	Yes	Yes	**No**	**No**	Yes	**No**	Yes	**No**	**No**	Yes	**No**
OCLL Medial Condyle	Yes	Yes	Yes	Yes	**No**	Yes	Yes	Yes	**No**	Yes	Yes	Yes	Yes
OCLL ≤6mm	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	**No**	Yes	Yes	**No**	Yes
OCLL>6mm	**No**	**Sig -ve**	**No**	Yes	**No**	**No**	**No**	**No**	**No**	**No**	**No**	Yes	**No**

Sig -ve=negative significant difference (P<0.05), Sig +ve=positive significant difference (P<0.05), Yes=enough observations for meaningful statistical analysis, No=not enough observations for meaningful statistical analysis

Discussion

To our knowledge this is the largest published study to examine associations between radiographic findings observed on yearling radiographs and subsequent racing performance. A total of 2373 horses with radiographs of front feet, all four fetlocks, carpi, tarsi and stifles were analysed. Kane *et al.* (2003a) examined 1162 Thoroughbred yearlings and Cohen *et al*. (2006) reported radiographic findings and performance in 348 yearlings. Associations between radiographic lesions and subsequent performance have also been examined in Standardbred racehorses (Courouce-Malblanc *et al.* 2006; Grondahl and Engeland 1995; Jorgensen *et al.* 1997). Other studies have focused on radiographic proximal sesamoid bone changes in Standardbreds (Grondahl *et al.* 1994) and Thoroughbreds (Spike-Pierce and Bramlage 2003).

None of these studies have found consistent, strong relationships between radiographic findings and performance. Grondahl and Engeland (1995) reported fewer starts and slightly lower earnings for horses with radiographic lesions when compared to those without in 753 Standardbreds. In contrast both Jorgensen *et al.* (1997) and Courouce-Malblanc *et al.* (2006) found no relationship between radiographic lesions and performance in 243 and 865 Standardbreds respectively, but horses with lesions had reduced longevity. Studies of Thoroughbred yearlings have been confined to performance at 2 and 3 years of age. Cohen *et al.* (2006) found no significant associations between radiographic lesions and performances but numbers of cases in each lesion category were low resulting in low statistical power. Kane *et al.* (2003a) found a number of radiographic lesions that were associated with starting a race, but only one radiographic finding (enthesiophytes of hind sesamoid bones) was associated with various measures of performance such as per cent of starts placed, prize money per start, and total prize money. The findings of the current study are consistent with this, as few strong associations between radiographic findings and performance were identified.

It is likely that there are a number of reasons for this. Even with the large numbers available for the current study there were still categories of lesions in which there were too few numbers for analyses with adequate statistical power. Also, there is likely to be a selection bias in that horses with more severe radiographic lesions, and those with clinical signs, will not be presented for sale. For many conditions, the horses available for radiographic examination are the less severe cases. Thirdly, many lesions will be treated appropriately and subsequently perform well. For example, arthroscopic surgery is often performed prior to sale. Fourthly, it is well established that radiography will not identify all lesions, and we have identified limitations due to poor film quality and the agreement of interpretation. Finally, as identified in Standardbred racehorses, lesions may not affect performance but may affect longevity, and these effects may not be identified if only 2 and 3-year-old racing is examined. Despite these limitations some associations between radiographic findings and reduced measures of performance were identified.

Lesions associated with reduced performance

Lesions that were associated with reduced performance indicators were of the fore fetlocks, hind fetlocks or stifle, whereas no abnormalities of the carpus or tarsus were associated with poor performance. Only two lesions had associations with more than one performance indicator, suggesting that most associations with performance were weak.

A defect greater than 10 mm in length in the sagittal ridge of the metatarsus was the lesion associated with the most performance indicators (Table 88). This has not been reported in Thoroughbreds by others. Kane *et al*. (2003a) did not grade the size of lucent lesions within the sagittal ridge of the metatarsus and only recorded the finding in 13 horses. Cohen *et al.* (2006) also found no association with performance, but only observed the finding in 12 horses. Poorer performance has been described in Standardbred racehorses with sagittal ridge lesions (Grondahl and Engeland 1995). Interestingly lesions of the sagittal ridge of the third metacarpal bone were not associated with any reduced performance in the current study. Storgaard Jorgensen *et al.* (1997) reported sagittal ridge osteochondrosis in 39 Standardbreds and found no association with performance, but combined

observations for forelimbs and hindlimbs. In the current study the grading system used was based on the length of lesion, not severity, and a review of the comments made by the radiologists revealed that hindlimb lesions tended to be deeper. Also a flexed lateromedial view was only performed for forelimbs and not for hindlimbs. Therefore hindlimb sagittal ridge lesions were more severe than those identified in forelimbs.

Sesamoid modelling (osteophytes and enthesiophytes) in forelimbs was associated with a reduced chance of starting a race as a 2 or 3-year-old, and there were trends for less prize money earned, decreased numbers of starts, reduced chance of winning any prize money and prize money greater than market price. Kane *et al*. (2003a) distinguished between osteophytes and enthesiophytes and found forelimb enthesiophytes were associated with less chance of starting a race, and hindlimb sesamoid enthesiophytes were associated with winning less prize money and lower prize money per start. In contrast, sesamoid modelling in the hind fetlocks in the current study was associated with an increased chance of winning prize money greater than the estimated cost of training. Spike-Pierce and Bramlage (2003) found no association between sesamoid modelling and performance.

Sesamoid fractures in forelimbs were associated with reduced performance in only one category (start a race at 2 and 3 years old) but in nearly all other categories confidence intervals were too wide to be certain that there was no effect (n=33).

Based on previous studies, subchondral cystic lesions of the medial condyle of the femur were expected to be associated with reductions in performance indices (Howard *et al.* 1995). Subchondral cystic lesions of the stifle were not evaluated by Kane *et al.* (2003a) as caudocranial views were not performed. Cohen *et al.* (2006) observed subchondral cystic lesions of the stifle in 18 cases but did not define their size. In the current study stifle cysts 6 mm deep or less (n=87) were not associated with performance, whereas cysts greater than 6 mm deep were less likely to start a race at 2 and 3 years of age than horses with no radiographic evidence of a cyst. Horses with cysts greater than 6 mm deep had lower values in all other performance indices, but these were not significant probably due to low numbers (n=20). The results are very similar to those of Howard *et al.* (1995) who found that 56% of horses with subchondral bone cysts raced following arthroscopic debridement of the cyst.

Only mild osteochondrosis lesions of the stifle were associated with poorer performance outcomes. No associations were demonstrated with more severe lesions but low numbers were observed. Interestingly there was a trend for horses with greater than 40 mm length lesions to be more likely to win over $40,000. Based on an arthroscopic grading system of stifle osteochondrosis Foland *et al.* (1992) demonstrated a significantly worse prognosis for more severe lesions. Evaluation of lesions in the present study was by radiography, and a poor correlation between radiographic findings and arthroscopic findings has been demonstrated (Steinheimer *et al.* 1995). The impact of surgical treatment on the results is also unknown, but treatment of stifle osteochondrosis was the most commonly reported surgical intervention in this study.

Lesions with no effect on performance

As found by others (Grondahl *et al.* 1994; Kane *et al.* 2003a) vascular channels in the proximal sesamoid bones of forelimbs did not have a negative association with any performance indicators in the current study. In fact horses with greater than two irregular vascular channels in sesamoid bones of forelimbs had an increased chance of placing greater than two times and there was a trend for them to be more likely to win more prize money than their market price when compared to horses with no vascular channels. In hindlimbs, vascular channel abnormalities were associated with increased number of places, increased likelihood of starting seven or more times, two or more places and a greater chance of earning more than their market price. In contrast Spike-Pearce and Bramlage (2003) found that vascular channel abnormalities in sesamoid bones were associated with poorer performance; horses with more than two irregular (non-parallel sides and greater than 2 mm wide) vascular channels had a significant decrease in number of starts, mean total earnings and mean earnings per start. Unlike the current study, and that of Kane *et al.* (2003a), Spike-Pierce and Bramlage (2003) did not adjust for

the effect of yearling sale price. This is important as sale price was shown to have a significant positive effect on performance. There is therefore limited evidence that increased numbers and size of vascular channels are detrimental to performance, and under Australian racing conditions they appear to be associated with improved performance.

It was possible to conclude with confidence that hindlimb sesamoid fractures had no detrimental effect on performance (n=41) as confidence intervals were narrower in most categories, and there was a significant increase in prize money per start in horses with fractures. Hindlimb sesamoid fractures tended to be smaller and a greater proportion were apical compared with forelimb sesamoid fractures. Kane *et al.* (2003a) found no association between sesamoid fractures and performance in fore and hindlimbs, but only observed 11 fractures in forelimbs and 31 fractures in hindlimbs. When treated surgically, hindlimb apical sesamoid fractures in young horses have a better prognosis than forelimb apical fractures and have similar performance records to controls, which is consistent with the current study (Schnabel *et al.* 2006).

Modelling of the dorsal aspect of the distal phalanx was associated with an increase in prize money earned per race start and an increased chance of earning more than the market price of the yearling. In all other performance categories it was possible to conclude with confidence that there was no association with performance.

Cystic lesions within the ulnar carpal bone (n=529) and modelling of the dorsal aspect of the carpal bones (n=125) were common observations that were definitely not associated with poorer performance, or were associated with slightly improved performance in one or more categories. Kane *et al.* (2003a) also found no effect of ulnar carpal bone cystic lesions on performance and concluded they were an incidental finding. In contrast they found ‘dorsomedial carpal disease’ was associated with a decreased chance of starting a race. The definition of dorsomedial carpal disease included modelling but also a thickened dorsal cortex and/or fragmentation. The equivalent category in the current study (change in radial and third carpal bones) showed no significant association with starts.

No associations between performance and the tarsal lesions examined were identified, and the confidence intervals for osteophytes of the distal tarsal joints were narrow in all performance categories, indicating that these are of little concern in a young racing Thoroughbred. Baird and Pilsworth (2001) reported an association between wedge-shaped third tarsal bones and fractures in thoroughbred racehorses, indicating that examination of presale tarsal radiographs is of value however this abnormality was rarely observed in the current study. For osteochondrosis lesions confidence intervals were narrow in all but three performance categories, and this is consistent with studies of osteochondrosis in young horses which have demonstrated a good prognosis following surgery (Laws *et al.* 1993).

Improved performance associated with radiographic lesions has not been previously reported. It is unlikely that a radiographic lesion will result in better performance, however some lesions could be a result of greater athleticism in young growing animals. The magnitude of the positive associations observed was relatively low, indicating that the presence of particular lesions is not a strong reason for purchasing a yearling.

Lesions with not enough cases for analysis

If the 95% confidence interval of the odds, risk or geometric mean ratios contains the value of interest, in this case a ratio below 0.5, but it is not statistically significant it is possible that there were not enough cases with an abnormal finding for a meaningful statistical analysis. Therefore no conclusions regarding the association between the abnormal radiographic finding and race performance outcome can be drawn. This is because the 95% confidence interval shows that the ratio in the population may have been as low as the value in which we were interested, but it may also be higher than one. If the number of observations increases, the outcome of the analysis could go in either direction, i.e., be statistically significant or remain non-significant.

Similarly, for the 95% confidence interval for the difference in means for the outcome 'Days from Sale to First Race Start', an increase of 90 days was considered to be important, therefore if the 95% confidence interval contained 90 days but the analysis was not significant at $P<0.05$, there were not considered to be enough observations for a meaningful interpretation of this analysis. For the performance outcome 'Percentage of Starts Placed' the value of interest was considered to be -15% or lower.

Kane *et al*. (2003a) found supracondylar lysis was associated with a reduced chance of starting a race at 2 or 3 years of age. We could make no conclusion on this factor, as this finding was rarely observed in yearlings in the current study. Supracondylar lysis is also not a common observation in race horses in Australia, but the reasons for this are not clear. Other lesions that were not seen in large enough numbers to be able to confidently determine their significance were both dorsal and palmar proximal first phalanx fragments in fore fetlock joints, plantar fragments in the hind fetlocks, sagittal ridge defect 5 mm length or less in the fore fetlocks, and stifle osteochondrosis lesions greater than 20 mm in length. Fracture of the fore proximal sesamoid bones, sagittal ridge defects greater than 10 mm in the hind fetlocks, and subchondral cysts greater than 6 mm in the medial condyle of the femur were positive for some outcomes, but each had insufficient numbers for seven or more of the 13 race performance measures.

Conclusions

This study has identified a number of associations between lesions observed on yearling radiographs and performance at 2 and 3 years of age in Thoroughbred racehorses, and will therefore assist veterinarians to interpret these radiographs. We were able to conclude with some confidence that large osteochondrosis lesions of the sagittal ridge of hind fetlocks was associated with poorer performance. It is also possible that stifle osteochondrosis lesions and subchondral cystic lesions, as well as forelimb sesamoid abnormalities (fracture, lucency and modelling), are associated with poorer performance.

We can also confidently conclude that modelling of the dorsal aspect of the third phalanx, sagittal ridge defects in fore fetlocks, sesamoid vascular channel abnormalities in fore and hindlimbs, carpal osteophytes and enthesiophytes, lucencies in the ulnar carpal bone, presence of first or fifth carpal bones, lucency and fractures of hind sesamoid bones, and distal tarsal joint modelling were not associated with poorer performance. Osteochondral fragments of the first phalanx in the dorsal and plantar aspect of the hind fetlock and osteochondrosis lesions of the tarsus are also unlikely to affect future performance. Further investigation of orthopaedic findings that occur in only a small proportion of the population to establish the effect on race career is warranted.

This study only investigates the associations between orthopaedic findings and performance in the first 2 years of racing. The effect of these lesions on career longevity in Thoroughbred horses is unknown.

We conclude that radiographic examination is only one aspect of the process of evaluation of a yearling and that many horses are able to perform well despite radiographic lesions.

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A Prospective Study of Presale Radiographs of Thoroughbred Yearlings

RIRDC Publication No. 09/082

By Melissa Jackson, Andrew Vizard, Garry Anderson, Andrew Clarke, John Mattoon, Roger Lavelle, Nola Lester, Todd Smithenson and Chris Whitton

Studies have shown that purchasing a yearling as a potential future racehorse is a high risk investment. Orthopaedic disease and musculoskeletal injuries are common causes of economic loss within the racing industry.

The effectiveness of a pre-purchase radiographic examination is limited by the quality of that examination and the experience of the person interpreting the radiographs.

This report describes a detailed examination of the quality of radiographs submitted to the first year of radiographic repositories at yearling sales in Australia, the repeatability of their interpretation, the prevalence of orthopaedic lesions identified by radiography, and the relationship between the lesions identified and future performance. The economic return for an investment in a yearling after its first 2 years of racing is also examined.

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Cover photo: Positioning the lower limb for a flexed lateromedial radiograph of the fetlock joint
Insert: The resulting radiographic image

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