Past and Future Vision of Veterinary Research: Study of Factors Affecting Racehorse Performance in Hong Kong

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PREFACE

The objective of this research project was to investigate the reasons associated with the premature retirement of Thoroughbred horses in training at the Hong Kong Jockey Club (HKJC) and to develop intervention strategies in an attempt to reduce training and racing injuries.

The impetus for this project was a survey aimed at identifying the reasons for a decline in the race attendance and betting revenue in 2004. This identified premature retirement and an increase in turnover of horses, which reduced the opportunity to "get to know" individual horses, as one of the reasons for the decline.

Content analysis of reasons for retirement identified superficial digital flexor (SDF) tendon injury as the major reason for the premature retirement in this population.

A follow up descriptive analysis of retirement of Thoroughbred racehorses due to tendon injuries at the Hong Kong Jockey Club (1992–2004) provided population-based data on the frequency, career and economic losses associated with tendon injury induced retirement.

Further evaluation of detailed training data (1997-2004) to identify risk factors for retirement because of tendon injuries in Thoroughbred racehorses was undertaken. Conditional logistic regression analyses were performed to identify risk factors for retirement from racing attributable to tendon injury. Results suggest that resources focused on obtaining accurate training data may be misdirected in the absence of internationally agreed criteria for incident tendon injury among racehorses. Nevertheless, changes in training intensity and findings of previous clinical examinations could be used to identify horses at risk of tendon injury–associated retirement.

One of the by-products of this process was the identification of a population of horses which were absent from the race track for protracted periods of time but were not evident on the clinical database as suffering from injury or disease. At the time, injured horses, once identified were

required to have an Official Veterinary Examination (OVE) before they were allowed to race again. This information was published and considered by some trainers to have a negative impact on public perceptions of the horse and owner's opinion of the trainer. Consequently it was possible that this population of horses, which were absent from racing, had injuries which may have been minor but which were not presented for veterinary examination. In consultation with trainers, a new unpublished category was introduced. The "To watch" category included horses that were absent from racing and training.

The impact of the intervention strategy by introduction of the track work and race monitoring system and the "To watch" category was reviewed by assessment of the number of pre-race inspection failures; the number of official veterinary examination (OVE) notices issued and the number of horses in the "To-watch" category.

This book concludes with a philosophical view point on the veterinary management of Thoroughbred racing injuries in which a "Think-out-of-the box" concept in assessing the risk of racehorse injuries is discussed. One outcome of this is an integrated technology approach for tracking horse performance. By allowing standardised recording and review of detailed training and biometric data of individual horses this will assist future development of Intervention Strategies (for example, alteration of training pattern for Trainers with high injury rates in an attempt to reduce risk of injury). In addition, development of predictive mathematical models to provide risk indicator system in the form of 'traffic lighting' for different risk zones (Green for low risk; Yellow for moderate risk; and Red for high risk) can be explored to raise awareness of trainers to subject racehorses to veterinary monitoring in continual full training programme to optimise racing performance and health welfare.

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CHAPTER ONE

INTRODUCTION

This publication describes a collaborative project between the Department of Veterinary Regulation and International Liaison, the Department of the Veterinary Clinical Services at The Hong Kong Jockey Club (HKJC), Hong Kong, and the Faculty of Veterinary Science at the University of Liverpool, UK. This study was part of a programme to optimise the longevity and the health and welfare of the Thoroughbred racehorses in Hong Kong. The Hong Kong Jockey Club has been keeping daily data on horse racing records since 1979 and training data since 1997. The project concept was initiated by a review of evidence based references on equine wastage and injuries in training and racing of sports horses.

Longevity is of economic importance in the Thoroughbred racing industry because of expenses and time invested in breeding and training. In spite of the high costs invested in racehorses, there have been few earlier studies of risk factors that can affect length of racing careers of Thoroughbreds. Tendon injury is one of the most common causes of wastage in the performance horse; the majority of tendon injuries occur to the superficial digital flexor. The age-related risk in tendon injuries provides further support that overstrain injuries are associated with accumulated degeneration. These data provide a valuable resource for further research into the aetiology of tendon injury in the racehorse. The research group has conducted a review to outline the epidemiology and aetiology of equine tendon injury, the different functions of the tendons in the equine forelimb, and suggested possible reasons for the high rate of failure of the superficial digital flexor tendon. An understanding of the mechanisms leading to matrix degeneration and subsequent tendon gross failure is the key to developing appropriate treatment and preventative measures. However there is currently limited information regarding the number of races and the period for evaluation of outcome which is critical for assessment of tendonitis treatments.

Knowledge of factors that influence longevity is crucial for optimization of the training methods aiming at reducing wastage, which refers to losses that occur in the racing industry. An understanding of the role of some factors may help owners, trainers and other equine professionals to optimize the performance of the horses under their care.

A number of studies have been published aimed at reducing the risk of injury to Thoroughbred racehorses and eventing horses in the UK. In addition to the horse's medication history and the state of any pre-existing injuries and degenerative conditions, the cumulative musculoskeletal stresses of training and racing have been considered as a significant risk factor. Many other risk factors for racetrack and training injuries in Thoroughbred racehorses worldwide have also been documented by different research groups to address the equine welfare concern for horse wastage in the racing industry. A review of risk factors for training and racetracks injuries with a list of evidence based references is outlined in Table 1.These projects have involved the analysis of retrospective data and the design and analysis of prospective cohort and case control studies to provide references for development of rational risk reduction strategies.

Table 1 - Review of risk factors for Racetrack injuries in Racehorses

Reported Risk Factors for Catastrophic Fractures

1. The gender of the horse

   Horses to be prevented from racing (It is not realistic to expect male or female horses to be prevented from racing because of risk of injury. However these variables should be included in multivariable models to account for the confounding effect they may have on other risk factors within the model.)

2. Total distance accumulated during a 2-month period was positively associated with the risk of catastrophic musculoskeletal injury.

3. The risk of catastrophic musculoskeletal injury was greatest within 30 days of a period of above average high-intensity exercise.

   • A period of high-intensity exercise was defined as a 60-day period where the average daily high-speed distance accumulated was greater than the seventy-fifth percentile cut-off for the population.

- The authors calculated that this level of high-speed exercise equated to approximately 25 furlongs (5km) per 30-day period (approximately 5.8 furlongs (1.2km) per week.

4. A longer interval since the last 60-day-plus period without a race (i.e. lay-up) and the distance exercised in the last month (suspensory apparatus failure) or 2 months (condylar fracture of the third metacarpus) were associated with an increased risk of these outcomes.

   - For every extra day since the last 60-day plus lay-up the odds of condylar fracture of the third metacarpus increased by 0.3%. The odds of suspensory apparatus failure remained level for up to 120 days since the last 60-day-plus lay-up, but increased thereafter: 3.4 times for periods between 121 and 214 days since the last 60-day-plus lay-up; and 5.9 times for periods greater than 320 days since the last 60-day-plus lay-up.

   - For every extra furlong exercised at fast pace the odds of suspensory apparatus failure or condylar fracture of the third metacarpus increased by 4%.

5. Multiple measures of exercise intensity were all positively associated with the outcome for proximal sesamoid bone fracture.

   - For example, case horses were more likely to spend more time in active training and racing, complete more exercise events, have higher exercise intensities in the 12 months before the case date, and have exercised further during their career.

6. Associations between the risk of fracture in training or racing and exercise distance over relatively short time periods identified in UK.

   - Horses that exceeded 220 furlongs (44 km) at canter (<= 14 m/s) and 30 furlongs (6 km) at gallop (> 14 m/s) in a 30-day period were at the highest risk of fracture. This level of gallop and distance exercise equates to approximately 7 furlongs (1.4km) per week.

   - The risk of pelvic or tibial stress fracture increased with increasing distance cantered up to a maximum at around 250 furlongs (50 km) per 30-day period. The association with the distance galloped compares closely with that reported in California (25 furlongs per 30-day period), even though the case definitions were quite different, providing stronger evidence of a potentially casual association.

7. The association between average distances exercised at fast pace and musculoskeletal injury has been demonstrated in a study of 2-year-old Thoroughbred horses in Australia.

   • These authors used a cut-off of speeds greater than or equal to 800m per minute (approximately 13.3m/s) to indicate fast work. Horses that had a greater percentage of fast work days during their first fast work preparation were more likely to sustain a musculoskeletal injury that ended the training preparation.

   • The average distance trained at speeds greater than or equal to 800m/min was also positively associated with musculoskeletal injury.

8. In a further study from Australia that investigated fatalities in flat racing, high-speed distance accumulated during the period 31 to 60 days before a race start was most important in determining the likelihood of fatality.

9. In jump racing, the total number of career starts and having started more than once in the 14 days before the case race were both associated with an increased likelihood of fatality.

   • Although these studies used a broader case definition of "fatality," it was previously reported that most cases were caused by musculoskeletal injury and it is most likely that this result is caused by the effect of exercise on the skeleton, as in the previous studies.

   • The differences in hazard period between these studies may be caused by the broader case definition or local differences in the racing population and racing and training practices.

10. Association between increased amounts of high-speed exercise and the risk of several musculoskeletal injury case definitions have been identified in several studies.

    • These findings are consistent with the hypothesis that horses doing a lot of this type of exercise are also accumulating subclinical or clinical bone damage that can result in a catastrophic outcome.

    • Adaptation in the racehorse is principally influenced by the training schedule to which the horse is exposed. Structural changes to the distal

condyles of the third metacarpus and metatarsus of horses in race training have been observed and more specifically the subchondral bone of this region has been shown to undergo an adaptive response to high-speed exercise.

11. Observed association between low exercise distance and increased risk is a healthy horse effect, whereas the association with longer racing distance is caused by accumulation of microdamage and subclinical injury.

12. Risk of injury after a lay-up period:
    A strong association between risk of humeral fracture and the number of days since the end of the last 60-day-plus lay-up was demonstrated in racehorses in California.

    - Using a case-crossover design, where cases act as their own controls at a prior point in time, a hazard period of 10 days following a 60-day-plus lay-up was identified as being most significant with respect to the risk of fracture.

    - The authors hypothesized that this may be caused by the fact that osteoclastic resorption has taken place but osteoblastic remodelling is not yet complete.

    - Horses returning to exercise before the remodelling process is complete (about 3 months) may have bones that are less able to withstand training load than before the lay-up period.

    - Exercise is believed to suppress the resorption of bone, as the initial part of the reparative process, preventing a reduction in bone strength while the horse continues to train.

13. Horses with greater than 32 days since their last race were 2.5 times more likely to have a catastrophic musculoskeletal injury during racing, compared with horses with less than 14 days since their last race.

    - The problem with this and other similar studies is the lack of information on the exercise activity between races (i.e. in training). It is difficult to be sure that the increase in risk was associated with changes in bone structure during a true lay-off period and not an effect of pre-existing injury that prevented an appearance on the racecourse at any earlier date.

Research Opportunities at the HKJC

The HKJC conducted a public survey of 1500 punters at Off-Course Betting Centres in 2004 and revealed that 22% attributed the decrease in betting turnover to the high turnover of horses. The respondents indicated that they were "Unfamiliar with new horses." Other reasons for causes of reduction in betting turnover are listed below:

- 57% respondents indicated "Poor economy/ less spare money"
- 35% respondents indicated "Inconsistent horse performance (e.g. injuries)"
- 16% respondents indicated "Too many lower class races"

The Hong Kong Jockey Club collects, stores, and maintains a large volume of data for all horses trained in Hong Kong. Data are collected from about 1200 horses stabled and trained at the Sha Tin Racecourse. A wide range of variables are included in this dataset, e.g. track parameters, environment, training and racing performance, veterinary medical records, and veterinary management. This has provided an extensive dataset on racehorse health and performance in a regulated racehorse population environment where all importation and exportation of horses is officially controlled. A wide range of information established in a database in the early 1970s at the HKJC, including records of the health and racing performance of more than 6000 horses, provided an opportunity for a retrospective analysis of the pattern of wastage from retirement and injuries from racing of thoroughbred racehorses at the Hong Kong Jockey Club (Appendix 1).

This study utilised the resources and epidemiology expertise at University of Liverpool and the HKJC to develop strategies which aim to reduce the risk of injury to racehorses during racing and training in Hong Kong.

The following project concept design was considered possible given an environment suitable to extensive and detailed data collection within an integrated framework:

Retrospective analysis of data collected in the past several years was made available. This approach has two broad objectives. The first is to investigate outcomes of interest using data already collected. Outcomes of interest are likely to include (though not be limited to), variables that influence injury, retirement or performance. The second broad objective is

to extend the approach to a more general assessment of the usefulness of different data types and different variables, and finally an assessment of data collection, collation, analysis and reporting methodology, as well as development of intervention strategy.

Review of systems and objectives for on-going routine data collection, collation, analysis and reporting. This process could then be extended to design and future development of a clinical Decision Support System (DSS). This approach involves development of a software framework incorporating database, analytical, reporting and expert systems functions. The system could be designed to accept data from current or future operating database systems developed and maintained by the HKJC. A variety of manual, automated analysis and reporting functions can be integrated into the DSS to allow real time analysis and automated reporting and monitoring of patterns in the data. Performance targets for monitored variables can be used to generate a rule-based diagnostic system (expert-system) that can detect and diagnose possible problems and either indicates corrective measures or diagnostic approaches for further investigation. Major benefits of a DSS include the ability to make real time use of routinely collected data, to detect unanticipated or new problems, and to aid in making effective and efficient decisions in the management of a large and complex operation.

On-going studies of risk factors associated with horse health and performance in horses training and racing in Hong Kong can be performed at several levels including large scale, population based studies and tightly focussed, in-depth studies on subsets of the data (targeted studies).

Population studies involve collecting more routine data on the racehorse population and applying a variety of analytical techniques to screen the data for patterns and associations. This approach can be used as an initial investigative method for generation of hypotheses about underlying relationships amongst variables. It can also be used for semi- or fully-automated, on-going monitoring of horse health and performance indices to enable early detection of possible problems in the future.

Targeted studies are designed with specific objectives in mind and are generally applied to samples of animals drawn from the population. This approach may involve detailed data collection focussing on particular parameters to investigate issues of interest.

A framework of science-based templates can be drawn on when investigating problems in the future. Incorporating designs for different types of investigations, templates for selecting samples of animals and methodologies for analysis of data collected can be developed in such studies.

A key component of all analyses will be the use of a wide range of analytical techniques including descriptive and univariable analyses as well as complex and advanced, multivariable logistic regression techniques. Multivariable analytical techniques are particularly useful when dealing with complex, multifactorial problems by allowing separation of influences due to multiple risk factors while simultaneously controlling for confounding due to other factors.

The clinical information in the free text veterinary records related to the reasons for the retirement of racehorses provides valuable information for Jockey Club clinicians and managers about the different causes of retirement of racehorses at HKJC. Areas of veterinary interest, for example tendon injury, osteoarthritis, exercise-induced pulmonary haemorrhage, and fractures, as well as non-veterinary reasons for retirement, for example poor racing ability, old age, and compulsory retirement, can be identified. The statistical analysis can facilitate the quantitative analysis of the numerical results obtained from the content analysis. A horse's retirement may result from intrinsic factors, for example genetic, or extrinsic factors, for example training or policy changes in the rules for retirement, acting either alone or in combination.

Surveys of the incidence of the reasons for retirement identified in this study are a prerequisite for epidemiological studies. The categorised data also support clinical epidemiological research in two ways; first, as a sampling tool, to select a categorised veterinary problem from the existing database, and secondly, as a data collection tool for retrieving certain specific clinical data from the selected category. The approach can then facilitate follow up descriptive study to describe the frequency and pattern of retirements associated with injuries in Thoroughbred racehorses and to compare the characteristics of these horses with those that retired for other reasons. The findings from the descriptive study will provide a useful resource for further case-control studies to investigate risk factors for retirement from racing due to any specific injury of interest. This is the first step toward the development of management tools to reduce the incidence of training and racing injury related retirement in Hong Kong.

Project Objectives

The objectives of this study are:-

1. To use the data that has already been collected to describe the frequency and nature of wastage retirement pattern and categorisation of career ending injuries among the population of Thoroughbred racehorses at the HKJC.
    a. Tendon injury was identified as the single most important veterinary reason for retirement of Thoroughbreds recorded in clinical records at the Hong Kong Jockey Club between 1992 and 2004.
    b. This study provides population based data on the frequency, career and economic losses associated with tendon injury induced retirement. This descriptive study has provided a useful resource for further case-control studies to investigate risk factors for retirement from racing due to tendon injury. This is the first step toward the development of management tools to reduce the incidence of tendon injury related retirement in Hong Kong.

2. To identify the risk factors for these injuries by analysing these data using multivariable statistical models.
    a. Further evaluation of detailed training data (1997-2004) to identify risk factors for retirement because of tendon injuries in Thoroughbred racehorses was undertaken. Conditional logistic regression analyses were performed to identify risk factors for retirement from racing attributable to tendon injury. Two multivariable conditional logistic regression models were created. In addition to identification of risk factors for tendon injury among racing Thoroughbreds, results have suggested that resources focused on obtaining accurate training data may be misdirected in the absence of internationally agreed criteria for incident tendon injury among racehorses. Nevertheless, changes in training intensity and findings of previous clinical examinations could be used to identify horses at risk of tendon injury-associated retirement.

3. To reduce the number of horses lost from racing each year by introducing rational intervention strategies to reduce the risk of career ending injuries.

a. One of the by-products of the investigation on the risk factors for tendon injury associated retirements was the identification of a population of horses which were absent from the race track for protracted periods of time but were not evident on the clinical database as suffering from injury or disease. The impact of the intervention strategy by introduction of the track work and race monitoring system and the "To watch" category was reviewed by assessment of the number of pre-race inspection failures; the number of official veterinary examination (OVE) notices issued, and the number of horses in the "To-watch" category.

4. To foster links with other internationally recognised centres of excellence in the field of Thoroughbred racing, including the network of International Group of Specialist Racing Association of the International Federation of Horseracing Authorities.

5. To develop prospective studies which allow the effect of training on the risk of injuries to be estimated.

a. Key research issues for the Hong Kong racing industry revolve around animal and jockey welfare. This focus is dictated by community concerns over wastage rates for racehorses, jockey injuries, and injuries and fatalities sustained in training and racing. Although there will inevitably be injury in athletic competition, these losses, associated with voluntary retirement, euthanasia and death could be reduced if risk factors were identified and modified.

b. This book concludes with a philosophical view point on the veterinary management of Thoroughbred racing injuries in which a "Think-out-of-the box" concept in assessing the risk of racehorse injuries is discussed. One outcome of this is an integrated technology approach for tracking horse performance recently developed by Cambridge Design UK in consultation with HKJC. By allowing standardised recording and review of detailed training and biometric data of individual horses this will assist in optimising horse welfare, safety and racing performance.

CHAPTER TWO

CONTENT ANALYSIS OF FREE-TEXT CLINICAL RECORDS HELD AT THE HONG KONG JOCKEY CLUB

Review of the pattern of wastage of racing Thoroughbreds in the racing population in Hong Kong and identification of the most common causes of retirement from racing is the prerequisite starting point for epidemiological studies into the factors affecting racehorse performance and wastage in Hong Kong.

A wide range of information was established in a database in the early 1970s at the Hong Kong Jockey Club, including records of the health and racing performance of more than 6000 horses, which provided an opportunity for a retrospective analysis of the pattern of injuries and retirement from racing of thoroughbred racehorses at the Hong Kong Jockey Club.

The Racing Information System (RIS) is critical of the Club's business systems. It records and stores details of owners, horses, trainers, jockeys and race data in over 404 Microsoft Access Tables and 3710 data fields including racing records, ownership, trainers and earnings. The oldest records date back to 1972. Data and information are disseminated via system interfaces to both internal and external systems, including a trackwork database.

Analysis of free text data in clinical records provides useful reference to epidemiologists in the planning of analytical studies and for the identification of new research initiatives. This paper describes the methodology used to develop a systematic, replicable technique for compressing many words of text into fewer content categories based on explicit rules of a user-defined coding dictionary to examine the free text clinical records kept in the databases of the Hong Kong Jockey Club.

This was made possible with the use of content analysis software packages WordStat and SimStat, Provalis Research, Quebec, Canada. This technique enables a large volume of free text records to be sorted in a systematic manner with high accuracy and reliability.

The text-mining approach using WordStat described in this study has proved to be a useful sampling and data categorisation tool in the content analysis of clinical narrative in the veterinary records (Lam K., Parkin T, C. Riggs C., Morgan K. (2007). Use of free text clinical records in identifying syndromes and analysing health data. Veterinary Record 161, 547-551). The reasons for retirement from racing in Hong Kong for 3727 Thoroughbred racehorses, between the 1992/93 and 2003/04 racing seasons, were categorized into a user-defined dictionary. The most critical and difficult task in this process was the initial definition of the categories. Knowledge of the database in data collection, target population and clinical domain were important in screening the database to define these categories.

In addition, the technique of categorization using WordStat facilitated future standardization of data entry in the veterinary records at the Hong Kong Jockey Club. The user-defined dictionary which allows expansion and modification of categorisation is also applicable for analysis of other free text veterinary records including reasons for issuance of official veterinary examinations due to training or racing injuries or other health reasons (for example, EIPH). Inter-category relationship can be easily assessed by the dendrogram function of similarity index to identify the clustering effect of cross-matched case occurrence among different categories. This technique enables effective filtering of records that have two or more related categories of interests for further evaluation and a new precise combination category can then be created.

Since documentation styles vary among individual clinicians, the outcome of the study has effected a change of management to include precise key word category incorporated in the prospective entry of veterinary records for reasons of retirements as well as in official veterinary examination records. This has added value to structure a standardized input format for ease of recording and specific defined categorization of common veterinary diagnoses in racing Thoroughbreds in Hong Kong.

The software also has a wide application for use in inter-disciplinary investigation, such as the assessment of clinical syndromes including lameness and disease surveillance, for example fever cases, where veterinary clinical records can be interrogated by user-defined categories. Sophisticated thesauri can also be developed using content analysis on any text records. A structured clinical data input by categorization alongside free-text descriptions in all the veterinary clinical records allows effective monitoring of the ever-changing patterns of veterinary issues of interest over time. Timely data analysis can then provide management decision support in implementing intervention strategies and follow-up assessment in the surveillance of racing injuries and equine disease.

The clinical information related to the reasons for retirement of racehorses in the free-text veterinary records has provided valuable information for both Jockey Club clinicians and managers to understand the pattern of different causes of retirement over the past 12 years. Areas of veterinary interest (tendon injury; osteoarthritis; exercised induced pulmonary haemorrhage; and fractures of which more than 50% affected the proximal sesamoid bones) and non-veterinary reasons for retirement (poor racing ability; old age; and compulsory retirement) have been identified in this study. The findings enable prioritization of focus of research on tendon injury related retirement for further descriptive analysis and investigation of risk factors for affecting the career ending injury.

CHAPTER THREE

DESCRIPTIVE ANALYSIS OF RETIREMENT OF THOROUGHBRED RACEHORSES DUE TO TENDON INJURIES IN HONG KONG (1992 TO 2004)

Tendon injury has been identified as the single most important veterinary reason for retirement of Thoroughbreds recorded in clinical records at the Hong Kong Jockey Club.

This paper details a descriptive analysis of retirement of Thoroughbred racehorses associated with superficial digital flexor tendon injuries, and comparison of their characteristics with the remaining population of horses retired for other reasons can provide population based data on the frequency, career and economic losses associated with tendon injury retirement (Lam K., Parkin T, C. Riggs C., Morgan K (2007). Descriptive analysis of retirement of Thoroughbred racehorses due to tendon injuries at the Hong Kong Jockey Club (1992–2004). Equine Veterinary Journal Mar;39(2):143-8). The useful resources of findings from the descriptive analysis can enable further case-control studies to investigate risk factors for retirement from racing due to tendon injury as a first step toward the development of management tools to monitor the incidence of injury related retirement in Hong Kong.

The mean annual cumulative incidence of retirements due to tendon injury was 3.2% accounting for 14% of all retirements. The risk of tendon injury increased over the 12-year period from 2.3-4.2%. The racing career, number of starts and earnings of horses retired with tendon injuries were reduced by 25.6%, 41.2% and 53.3% respectively. Thirteen percent of these horses never raced in Hong Kong. A greater proportion of 3-4 year old and entire male animals were retired because of tendon injuries. Ninety seven percent of injuries affect the forelimb, the left more frequently than

the right. Only 19.7% of retired horses that had received ultrasound examination for tendon injury retired for this reason.

However methodology of statistical analysis of census data has to be considered in a study of the whole population. Epidemiology is the study of the frequency, distribution and determinants of disease and health (in veterinary terms of productivity and welfare) in populations. In any epidemiological study one has to define the population for which one wants to find out frequency distribution or determinants. This is commonly known as the target population. One can define this population for each specific study. Often it defines itself, as in this study, the racehorse population in Hong Kong. The definition of the population is often defined by the question being asked. By using statistical methods one can arrive at estimates of the frequency, distribution and determinants within certain confidence limits with a known degree of accuracy. This is achieved by randomly selecting a study or sample population. By using statistical sampling one can generalise from the study population to the target population. One cannot generalise from the study population to all the populations in the world. It would be inappropriate to suggest that the frequency of injury in racehorses in Hong Kong can be made reference to that in trotting horses in United States. Similarly it is already known that the distribution of training and racing injuries in Hong Kong is different to those in the United Kingdom. It appears not to be applicable to generalise between these populations. One might use analogy but this is not statistical generalisation.

In an example of the sample of a target population with a frequency estimate of 36% with 95% confidence intervals of (25- 45%), it states that the frequency in the study or sample population is 36%. In reference to generalisation to the whole population one would be 95% confident that the true value in the target population is somewhere between 25 and 45%. However this cannot be generalised to a completely different population.

In this descriptive analysis of tendon injury related retirement, a census of the target or whole population but not a sample was studied. The retirement rate applies to the true retirement rate of the whole population. No generalisation to the whole population is required as it already refers to all the data from that whole population. It appears not to be appropriate to apply this data statistically to other populations. The target population is defined as Hong Kong racehorses. In this case no statistical tests were conducted in the study.

A number of studies have highlighted the importance of tendon injuries to Thoroughbred horses but few have provided population based data on the quantitative contribution of this injury to racehorse longevity, performance and associated economic losses in the racing career. The structure of racehorse management in Hong Kong offers the opportunity to do this and to identify important risk factors for tendon injury. Although the primary purpose of this study is to improve the health of the racehorse population in Hong Kong this study is also of relevance to the Thoroughbred population worldwide.

However it remains an interesting and often repeated problem deciding whether a set of census data is a sample and requires statistical tests.

Statistics as a science provides ways in which one can generalise results from a sample to the population. As this paper is based on complete census data from the whole population the issue of inference from the sample to the population appears to be redundant. One may argue that these data could be interpreted as a sample in time, but it is hardly random and it referred to cumulative data for 12 years - arguably “since records began at the Hong Kong Jockey Club”. This study appeared to be justified in not using statistical tests in that the actual true differences were described in the whole population and not estimating these differences from a sample of this population.

It was acknowledged that not all measures are proportions and therefore: “As this is complete census data, no statistical inference to the population is necessary”.

Arguably this is an interesting perspective. Readers must be made to understand that results apply exclusively to this population during this time period. The results appear not to have any relevance to any other group of horses even another cohort from Hong Kong. However the intention of the study is to conduct studies to yield data to implement a programme to maximise the health and welfare of Thoroughbred racehorses in Hong Kong. This implies that the research intends to use data from the studies to make inferences about other horses in Hong Kong. It has been observed that male racehorses are more likely than female racehorses to have an injury of interest in the population studied. The argument is that there is no need to perform statistical analysis of this sex distribution because the total population has been studied. But if one wishes to infer that one needs to monitor male horses more closely for this

injury in Hong Kong to improve health and welfare, one must recognize that there might be some variation between the study population and the next cohort group of horses to be studied; statistical inference on the observed data will allow variation to be accounted for that might occur by chance. In this case inferential methods are preferred.

The overall aim of epidemiological research being conducted at the HKJC is to reduce the number of horses that are replaced each season. This will have major economic benefits for the racing industry in Hong Kong. Further case control studies will identify risk factors for the major reasons for retirement, thus also enabling intervention strategy as a management tool to monitor the horse welfare effectively.

CHAPTER FOUR

EVALUATION OF DETAILED TRAINING DATA IN HONG KONG TO IDENTIFY RISK FACTORS FOR RETIREMENT BECAUSE OF TENDON INJURIES IN THOROUGHBRED RACEHORSES

Following the identification of injuries of the SDF tendon as the single most important veterinary medical reason for retirement of racing Thoroughbreds, descriptive epidemiological techniques were used to study the characteristics of premature retirement associated with tendon injury and highlighted the reduction in duration of racing career, number of race starts, and earnings compared with other reasons for retirements.

Analytical techniques were then used to identify the risk factors for the career-ending tendon injuries. Data on variables currently collected by the HKJC were analysed using univariable and multivariable conditional logistic regression techniques in this study (Lam K., Parkin T, C. Riggs C., Morgan K (2007). Evaluation of detailed training data to identify risk factors for retirement because of tendon injuries in Thoroughbred racehorses. American Journal Veterinary Research Nov;68(11):1188-97).

Compared with control horses, case horses were older at the time of import, accumulated more race distance soon after import, were more likely to have had previous official veterinary or ultrasonographic examinations, raced fewer times during their career, and were in training for a longer period and had exercised at a reduced intensity during the 180-day period preceding the last fast-paced work date.

This process can also identify the strengths and weaknesses of current data collection and areas where additional or more accurate data needs to be collected. These analyses provide useful references to develop intervention

strategies to reduce the risk of injury, to prioritise areas for future research and to develop novel causal hypotheses for these injuries.

Epidemiology uses the power of scientific analysis to provide evidence that an exposure may be associated with developing or preventing an outcome of event. Sometimes, however, the most basic methods of epidemiology are not enough to determine "the causes of happenings," or whether an exposure is truly associated with an outcome of an event. Other exposures or characteristics among the population may be confounding the exposure-outcome relationship. Logistic regression and matching data are known methods to deal with confounding factors in large datasets. Logistic regression is an efficient way to control for many potential confounders at one time. Matching, if done correctly when planning the study design for the investigation, reduces confounding before the analysis even begins. In this study, it was the lack of the need to account for seasonal differences between case and control as the result of the matching.

The results of this study highlighted the difficulty in identifying incident cases of tendon injury. Changes in training intensity and clinical examination to diagnosis of tendon injuries may be used as management tools to identify "horses at risk" from the clinical database.

There are a number of study design issues from the findings of the study which warrant further discussion.

In general, the process of building a logistic model is very similar to that of building a linear regression model. It involves the following steps:

- Laying out a tentative causal web diagram to guide the thinking process;
- Performing unconditional analyses of relationships between predictors and the outcome of interest using a liberal P-value;
- Evaluation of relationships (correlations) among predictor variables;
- Building the model using automated procedures (with caution), forward selection, backward elimination, stepwise selection, best subset regression, or manual model-building guided by a causal web diagram (which is the preferred method in this study to take into account of variables that are biologically meaningful);
- Evaluating confounding;
- Evaluating interaction during the model building process.