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The use of anthropometric measurements to model the performance of Warm-blood horses

by

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Declaration

I, Ashlyn Southern hereby declare that this thesis, submitted for the MSc (Agric) Animal Science: Animal Production Physiology and Product Quality degree at the University of Pretoria, is my own work and has not previously been submitted by me for a degree at any other University.

Ashlyn Southern

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Abstract

Warmblood horses are crossbreds of cold- and hot-blooded horses, and they are bred specifically for their participation as sport horses, which currently dominate the equine sporting industry. This study evaluated horses at four years of age to determine if anthropometric measurements can be used to predict their jumping performance. The objective was to determine which stationary measurements have the best predictive value of jumping performance. This study also evaluated whether there was a difference in performance over the different heights of jumps as well as whether free-jumping versus under-saddle give more accurate results.

Stationary and jumping measurements of twenty horses of four years of age were taken by means of pictures and videos with a camera and using the Kinovea Software Program to calibrate and determine measurements. These horses had only been given the basics of training in the show jumping discipline. The stationary measurements included linear traits such as head length, neck length, wither height and chest girth among others as well as angular traits such as the shoulder angle and angles taken from X-rays of the horses' legs. The jumping section was divided into two parts – under-saddle and free-jumping. The measurements for the jumping included linear traits such as stride length prior to jump, take-off distance and height of limbs above the jump among others as well as angular measurements such as the jump angle and the femorotibial angle among others. These jumping measurements were taken in an indoor sand arena over three different jump heights.

Statistical analysis of stationary and jumping measurements was done by means of Linearized Mixed model analysis in SAS, and differences between means were tested at $P < 0.05$. A significant difference ($P < 0.05$) was found between the stride length of horses being ridden under-saddle compared to free-jumping, which means that the rider has a big influence on the stride length of the horse. For several other measurements there was no significant difference obtained from free-jumping compared to under-saddle, which indicates that the horses studied did not adjust those measurements despite having a rider on its back. The take-off distance can be used to predict successful jumps however not many stationary measurements could be used to predict this jumping measurement. The forelimb angle of geldings jumping at 80cm was influenced ($P < 0.05$) by all of the X-ray stationary measurements that were recorded however this same angle of mares jumping at 80cm was not influenced by the X-ray angles at all. At 120cm free-jumping, there were only two equations ($P \leq 0.05$) that could be used to predict the star rating of a horse. For geldings, the take-off distance of the hindlimb jumping measurement and for mares the time that the mare was airborne could be used as predictors. This time airborne equation for mares had a high significance with $P < 0.0001$.

The results confirm that equine stud farms can determine the jumping performance of horses based on certain stationary measurements. This study also identified the most important jumping traits that are influenced more by a rider, which may improve our understanding of predicting equestrian sport performance.

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List of Abbreviations

BLBL	Back left to back left
BRBR	Back right to back right
DME	Detailed movement evaluation
FIBI	Front inside to back inside
FIBO	Front inside to back outside
FJ	Free-jumping
FLFL	Front left to front left
FOBI	Front outside to back inside
FOBO	Front outside to back outside
FRFR	Front right to front right
FSI	First stallion inspection
HRMCP	Distance between the humeroradial and the metacarpophalangeal joints
KWPN	Royal Dutch Warmblood Riding Horse Studbook
MANOVA	Multifactorial analysis of variance
NS	Not significant
SPT	Stationary performance test
US	Under-saddle

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Chapter 1: Introduction

1.1 Introduction

Historically, horses were bred for warfare, transportation and agriculture. Since the industrial era; however, horses have been selected and bred more for sport and recreation (Rovere *et al.*, 2017). In the equine sport, several disciplines have emerged, and each relies on different aspects of the horse with regards to physique and characteristics with the main disciplines being dominated by warmblood breeds (Rovere *et al.*, 2017). The breeding of horses is now focused on making the best performance sport horse as more emphasis is put on traits that will increase the possibility of a successful competitor (Koenen *et al.*, 2004).

The discipline of show jumping demands a combination of agility, speed and strength from both the horse and the rider. As competitors navigate a course of obstacles, the horses' physical traits are put to the test resulting in the conformation of the horse being extremely important to the sport. Conformation is not only important for the success in the sport arena, but also to the longevity of the horse with regards to injuries and lifespan within the sport. The significance of conformation in the different equine disciplines has been recognized by many authors, however, its precise role in show jumping continues to be a topic of conversation and research. Variations in the conformation of a horse can highly influence the way that the horse jumps with regards to technique, power, balance and height that the horse can clear. Understanding the way that the conformation of a horse influences its jump will therefore help breeders when it comes to breeding for a successful competitor.

In order to understand the way that the conformation influences the jump of the horse, the specific measurements and traits that influence jumping technique first need to be identified. Once the traits have been identified, further conclusions can be made when looking at the overall picture.

1.2 Aim and objectives

The problem statement of this project is based on the fact that breeders auction off their horses at around 4 years of age, with only the basics of training complete. At this young age, it is very difficult to predict their future in showjumping without a scientific backing to stand on. The horses at this young age do show promise in certain disciplines but there is little research done on how talented the horse is based on its conformation and anthropometric measurements.

The aim of this study is to provide stud farms and breeders with a model that they can use on young horses based on their anthropometric measures to predict future jumping performance of Warmblood horses. The objective of this study is to determine which measurements have the highest correlation or best predictive value for jumping performance.

1.3 Hypothesis

Stationary measurements can be used to predict the jumping performance of Warmblood horses.

Chapter 2: Literature Review

2.1 Domestication of the horse

The horse (*Equus caballus*) was domesticated over 5 500 years ago when humans used them to their benefit for warfare, transportation, agriculture, and as companion animals (Raudsepp *et al.*, 2019). Since the industrial era; however, the breeding and selection of horses has strayed from the historical point of breeding them for warfare and agriculture as horses are now bred specifically for sport and recreation (Rovere *et al.*, 2017). Breeders now breed horses by focusing on specific traits such as performance, temperament and appearance (Petersen *et al.*, 2013). Different breeders tend to focus on different aspects or characteristics of the horse which means that the goals of horse breeding will differ from farm to farm, regardless if they are the same breed of horse or not.

2.2 General classification of horse breeds

Horses are broadly categorized into one of three categories: hot-, warm- or cold-blooded. This however has nothing to do with the temperature of the horses' blood but is actually related to the origin of the breed. Hot-blooded breeds for example are breeds that were originally situated in environments like the desert and consist of breeds such as Arabian horses and Thoroughbreds. Hot-blooded breeds generally have a more exuberant temperament (sometimes described as more energetic or nervous) compared to other breeds in the warm- and cold-blooded types (Sly, 2010, p. 9). Cold-blooded horses consist of the heavy draught breeds as they originated in cold climates and so were much stockier in order to suit their environment (Sly, 2010, p. 9). These are breeds such as the Clydesdale, Percheron and Shire horse breeds, which are generally calmer than the hot-blooded horse breeds. The breeds that are being analysed in this study are the Warmblood breeds such as the Hanoverian, Selle-Français and the Trakehner horse breeds. These breeds of horses are crossbreeds of cold- and hot-blooded horses. They have the athletic quality of the hot-blooded breeds as well as the calmer nature of the cold-blooded breeds (Sly, 2010, p. 9).

2.3 Disciplines of the equine sport

Within sport and recreation, a number of disciplines have emerged such as dressage, showjumping and eventing among others. Over the past few years, trainers have started to focus on certain disciplines and training horses specifically to excel in a certain discipline or a combined set of disciplines (Rovere *et al.*, 2017). In order to increase the chance of winning at the highest level, it is not only the trainers that are focusing on specific disciplines, but the breeders as well (Rovere *et al.*, 2017).

The three main equine sports; dressage, show jumping and eventing, are dominated by warmblood breeds and in showjumping, Roman-Popovici *et al.* (2015) found that 34% of the best showjumpers came from the Warmblood breed in Germany, 26.2% came from Belgium, 18.4% came from the Netherlands, 9.7% came from Great Britain, 8.7% were Selle Français horses and 2.9% were Swedish Warmbloods (Sobotková *et al.*, 2022).

Show jumping originated from foxhunting where centuries ago it was considered a popular sport on horseback where the riders were able to hunt on flat ground in the countryside. However, during the 1800s with the introduction of the Enclosures Act in England, the horses and riders were now faced with obstacles that were not there previously (Hallett, 2015). Due to this, horses that were able to jump over fences and property borders were selected for in hunting which kept this popular sport alive. What is now considered an Olympic sport, show jumping occurs in an arena where the horse and rider have to jump a series of obstacles in a time frame. Penalties are given if the combination do not make it within the time, if the horse knocks down a fence or if the horse refuses the jump completely. It is therefore important that the horses have clean, precise jumps that will result in the fewest number of penalties (FEI, 2021). This sport combines athleticism, precision, and the partnership between the horse and rider, and has garnered widespread attention and admiration in the realm of competitive sports. Within this dynamic sport, the performance of the horse is the main focus, as their characteristics and sporting abilities influence the success or failure in the arena. Understanding the factors that contribute to the making of an equine athlete (such as breeding, training and management) is of most importance for the riders, trainers, breeders and researchers.

2.4 Breeding of the equine athlete

When it comes to breeding horses, no matter the breed nor whether it is for showjumping or for any other kind of discipline, a horse breeders main aim is to breed a foal that shows optimal growth and development (Coudkova *et al.*, 2022). The problem comes in when the breeder tries to decide how to achieve this optimal growth rate (Pimentel *et al.*, 2017). When breeders breed for too high growth rates, it has been shown that a high number of developmental orthopaedic diseases occur in the horses (Gallio *et al.*, 2014). For a breeding farm to succeed and breed for foals that show optimal growth and development, it is important for the breeders to have stallions with good quality semen. It was reported by Gottschalk *et al.*, (2017) that the most highly correlated sperm quality trait with stallion fertility was the total number of progressively motile sperm, but this trait had the lowest heritability with a h^2 value of 0.13.

In order for horse breeders to make genetic progress and to end up with their desired horse, they need to have breeding objectives set out (Viklund *et al.*, 2011). A good breeding objective is essential so that breeders can decide on certain selection strategies (Dekkers and Gibson, 1998). This good breeding objective should consist of a full definition of all the traits of the horse that are important to the breeder that could have economical value (Koenen *et al.*, 2004). By contrast to other livestock species, the traits in equine breeding are very difficult to measure as they are not defined in a specific manner (Koenen *et al.*, 2004). With regards to livestock species such as cattle and sheep, the traits that are selected for in a breeding objective relate to economic importance and profit, while in horses, it is very difficult to measure the economic importance and what traits relate to profit as some people measure success differently to others. In the sporting world of equine recreation, one owner may measure a horse's success based on the amount of money they win while another owner might measure it as the number of competitions the horse has participated in (Seierø *et al.*, 2016). As it is difficult to evaluate the success of performance, many studies use different ways to define this success. Some

use financial profit to determine if the horse is successful (Langlois and Blouin, 2004), while others determine success based on the number of penalties in competition or time it takes to get around a track (Janssens *et al.*, 1997). This results in disagreement and antagonizing conclusions from different studies.

Different equine breeds excel and dominate in different disciplines of horse riding based on their conformation and characteristics. Horses are bred both for performance in order to excel in competitions as well as for leisure. When bred for performance, more emphasis is put on traits that will increase the possibility of a successful competitor whereas if bred for leisure, the temperament and character of the horse is more important (Koenen *et al.*, 2004).

Koenen *et al.* (2004) researched the breeding objectives of different breeding organisations of Warmblood horses across Europe in order to distinguish the traits that these organisations of different breeds prioritise when selecting. Organisations were asked to state their breeding objectives as well as weight the specific traits according to the importance for that organisation on a scale of 0 (least important) to 10 (most important). The relative weightings that the organisations gave is shown in Table 2.1.

Table 2.1 Individual relative weights (0=not relevant, 10=extremely relevant) for breeding objective traits of breeding organisations in Europe (Koenen *et al.*, 2004)

Organisation	Show Jumping	Dressage	Eventing	Driving	Conformation	Gaits	Behaviour
Bavarian WB ^a	8	9	6	5	8	9	9
Belgian WB ^a	10	10	8	2	10	2	8
Danish WB ^a	10	10	5	1	8	9	7
Finnish WB ^a	9	9	5	1	10	10	9
Dutch WB ^a	10	10	1	1	8	8	9
Hanoverian	10	10	6	6	8	10	10
Holsteiner	10	5	7	5	7	7	7
Irish Sport Horse	8	5	5	1	8	9	7
Norwegian WB ^a	9	9	9	2	8	9	7
Selle Français	10	7	8	1	9	9	8
Swedish WB ^a	10	10	6	6	7	8	8
Trakehner	5	10	10	1	9	10	8

^a Warmblood

As can be seen in this table, different breeding organisations focus on different disciplines of recreational riding. These disciplines require different horses with regards to their physique and characteristics. Organisations indicated which discipline they breed for as it is implied that each one has opposing characteristics. Alongside the disciplines, these organisations also focus on traits such as conformation, gaits and behaviour which can be seen in the table as well as two other traits not present being health and fertility. From Table 2.1, one can see that the Warmblood organisations that focus more on show jumping than the other disciplines include the Holsteiner, Irish Sport Horse and Selle Français breeding organisations as they all weighted the show jumping breeding objective higher than any other discipline breeding objective. The Trakehner organisation can be seen to put more emphasis on the dressage and eventing disciplines as this organisation has weighted both of these as extremely important whereas they weighted the show jumping discipline half as important.

Horse breeders also consider longevity as a significant trait as this represents the amount of time that the horse can be used for their specific purpose and therefore the amount of time that the animal is productive (Seierø *et al.*, 2016). Unfortunately, this trait is very difficult to measure in the equine industry as when trying to measure longevity, one can accidentally measure other traits such as talent. Not many breeding societies emphasize longevity in their breeding objectives, instead they focus more on the conformation and soundness of the horse (Seierø *et al.*, 2016) which could be considered as an alternative measure of longevity. In a study conducted by Seierø *et al.* (2016), it was shown that there is a genetic correlation between jumping traits of younger horses and longevity traits and these correlations were between 0.56-0.74. Longevity is a very difficult trait to measure as the information needed to measure this trait only occurs later in the animal's life. However, this trait is important in order to increase the probability of a successful animal. Since longevity is difficult to measure, indirect measures of longevity may be the closest way to genetically improve the breed. Indirect measures of longevity include traits such as conformation and hindquarter strength.

Besides the disciplines, different breeding organisations focus on different types of conformation. Some breeders focus more on the aesthetic conformation of a horse as it often comes across more visually appealing and therefore will result in higher financial profit when the horse is sold (Koenen *et al.*, 2004). Other breeders focus more on the conformation that will increase the possibility of success in competitions, for example, in dressage, horses need to have fluid movements in their gaits and so more emphasis is put on the heritability of gaits.

Becker *et al.* (2013) performed a study where they looked at the correlations between movement characteristics (such as irregular tail tone or posture, irregular hind leg movement or any general irregularities of movement) that they assessed in detailed movement evaluations (DME) and traits that are assessed during studbook inspections such as conformation and performance traits. These studbook inspections are essential if a breeder wants to use the mare for breeding (Becker *et al.*, 2013). This study was conducted on mares and foals and the reason that they were able to get reliable results on the foals was due to the fact that the movement characteristics that were tested remain constant over time and the intralimb coordination pattern is already defined at a young age (Back *et al.*, 1994). This study showed that there is an unfavourable genetic correlation between the DME traits and conformation as well as an unfavourable genetic correlation between the DME traits and dressage performance (Becker *et al.*, 2013).

When comparing showjumping and dressage, horses that are bred for showjumping move more economically so that they can get to the jump faster and clear the jump, whereas horses that are bred for dressage move more expressively so that they can gain points with their flamboyant movements. In a dressage horse, a rectangle frame (which helps the movement of the back) with a short neck is advantageous as these horses are able to move with more expression however, this conformation type and the expressive movements may cause the horse to overstrain the mechanisms of coordination (Becker *et al.*, 2013). Therefore, it is more common for horses that are bred for dressage to show irregularities in movement compared to horses bred for showjumping (Becker *et al.*, 2013).

Above it is mentioned that a rectangle frame helps the movement of the back. The horse's back plays a very important role for locomotion and any changes in the structure or the functionality of the back can affect the coordination of the horse and the way the horse moves (van Weeren *et al.*, 2010).

2.5 Horse performance tests

Since breeders like to breed horses that will excel in a certain discipline such as showjumping or dressage, there are a few ways to test sport horses in Europe when they are young to see if they have potential (Hellsten *et al.*, 2006). It is very important for a breeder to have a way to test young stallions in order for early selection as it takes a number of years to attain performance results for these horses (Olsson *et al.*, 2008). It is also important for these tests to be conducted on young horses so that they can be selected at an early stage in their lives in order for the breeding farm to have short generation intervals and therefore provide more income (Olsson *et al.*, 2008). These tests are done to provide data for genetic evaluation of young horses, and also to identify horses that have the potential to be very talented in the disciplines (Hellsten *et al.*, 2006). Examples of these tests are first stallion inspection (FSI), stationary performance tests (SPT) and young horse competition tests (Thorén Hellsten *et al.*, 2006).

In a study done by Huizinga *et al.* (1991) where they assessed the SPT of Warmblood stallions in the Netherlands, it was proven that by selecting on the SPT of stallions, it is possible to breed for the improvement of performance in different disciplines. After conducting a test, Strom and Philipsson (1978) concluded that when stallions are selected for breeding based on their performance test, it results in higher genetic progress compared to when the stallions are selected based on their performance as well as a progeny test. This was true for when the genetic correlation between the performance test and the ability to perform well in competitions was greater than 0.8.

When a stallion is selected for breeding in the Royal Dutch Warmblood Riding Horse Studbook (KWPN), a number of stages have to be passed before the stallion can be used to breed. The breeder first preselects the stallions based on certain aspects such as conformation, gaits and pedigree (Ducro *et al.*, 2007). Once the breeder has selected, the stallions go to the FSI which occurs annually. These stallions are then judged on seven different traits. These traits include the gaits walk, trot and canter and all three of these gaits are judged while the horse is free moving and the gaits walk and trot are also judged when the horse is in hand (Ducro *et al.*, 2007). There are then three jumping traits that are judged when the horse is free-jumping and these include take-off, technique and power and these jumping traits are judged while the horse jumps over a series of three jumps (Ducro *et al.*, 2007). The last trait that is judged is balance and this trait is based on the general movement of the horse. These traits in the inspections of Warmblood horses are judged on a scale of 1 to 10 and this remains as the most common method to evaluate the performance and conformation of the Warmblood horses (Becker *et al.*, 2013).

During this study done by Ducro *et al.* (2007) and as can be seen from Table 2.2 it was found that the walk gait has a negative genetic correlation of -0.45 with showjumping and the trot gait also had a negative genetic correlation of -0.36 with showjumping (Ducro *et al.*, 2007). The FSI jumping traits: take-off, technique

and power, showed positive genetic correlations with competition showjumping of higher than 0.8 however these FSI jumping traits had negative correlations of -0.48 with dressage (Ducro *et al.*, 2007).

Table 2.2 Heritabilities and estimated genetic correlations of FSI (First Stallion Inspection)-traits with show jumping (Ducro *et al.*, 2007)

FSI traits	Heritability	Genetic correlation with Show Jumping
Walk	0.35	-0.45
Trot	0.50	-0.36
Canter	0.25	0.06
Balance	0.37	-0.14
Take-off	0.45	0.92
Technique	0.56	0.81
Power	0.61	0.85

At this FSI, the heritabilities of the traits that were analysed had a moderate to high heritability which means that these results can be used to select stallions that can be used in the breeding category (Ducro *et al.*, 2007).

Following this FSI, the stallions that passed this stage and are therefore considered the best enter the SPT. The stallions that then excel in this test are allowed to breed. During this SPT, multiple traits are evaluated and scored on a scale. The traits that are included in the SPT are walk, trot, canter, riding ability, show jumping, free-jumping, cross country, character, behaviour and training report (Huizinga *et al.*, 1991). Table 2.3 shows the genetic correlations that were found in this study between the traits of the stallions SPT and their progeny's performances in dressage and show jumping.

Table 2.3 Estimated genetic correlations between traits of stationary performance testing of stallions and performances in dressage and jumping competition from offspring of breeding stallions (Huizinga *et al.*, 1991).

Stationary Performance Test	Dressage	Show Jumping
Walk	0.81	0.07
Trot	0.81	-0.04
Canter	0.93	-0.01
Riding Ability	0.83	-0.07
Jumping Ability	0.05	0.84
Free-jumping	0.49	0.95
Cross Country	0.28	0.47
Character	0.46	-0.01

Performances of potential breeding stallions are good predictors for performances of their offspring in competition. This indicates that performance testing of stallions at station under uniform circumstances is an effective tool to select for riding horse characteristics (Huizinga *et al.*, 1991). The final approval of a stallion as a good sire to be used in the breeding group is based on his own performance as well as his progeny's performance (Ducro *et al.*, 2007).

In Europe, field performance tests are used to test mares and geldings. In this test, the gaits, jumping and rideability and sometimes conformation is tested (Hellsten *et al.*, 2006).

In some of these tests (especially when testing for the KWPN) the percentage of thoroughbred blood is also analysed as this has been shown to affect the performance of the Warmblood horse. As mentioned, a Warmblood breed is a crossbreed of a hot-blood and a cold-blood which creates a good sport horse and the Thoroughbred breed has made a big impact and improvement to these sport horses. The proportion of Thoroughbred in the sport horse pedigree has a big impact on their performance (Sobotková *et al.*, 2022). A loss in genetic proportion of these thoroughbreds can cause a loss in endurance, courage and energy in these Warmblood sport horses (Misař and Sobotková, 2019 cited by Sobotková *et al.*, 2022). An important note that came out of a study done by Huizinga *et al.* (1991) was that when stallions had a Thoroughbred percentage class of 51-75%, their male progeny performed poorly in the traits of gaits and riding ability. These male progenies scored 0.62 points lower than the male progeny from stallions with no Thoroughbred blood (Huizinga *et al.*, 1991).

The results of a study done by Monika *et al.* (2018) shows that the performance of a Warmblood horse with a percentage of 75 or higher of thoroughbred blood, is negatively affected with regards to traits such as character, rideability and trot gait.

With a thoroughbred proportion of 30.1-70%, the horses of this group performed better than the horses with no thoroughbred proportion at all (Sobotková *et al.*, 2022). In the study done by Rovere *et al.* (2017), the horses that had a thoroughbred proportion of 12.5-50% performed the best in dressage as well as showjumping. In the study done by Sobotková *et al.* (2022), horses that had a thoroughbred proportion of 40.1-50% performed the absolute best out of all the horses.

2.6 Conformation and movement

In Warmblood horse breeding, conformation and movement are two important factors that are looked at (Holmstrom *et al.*, 1990). From Table 2.1 we could see that all of the organisations weighted conformation as a very high relevant breeding objective. This could be due to the fact that the conformation of a horse has always been regarded as an important indicator of performance (Matsuura *et al.*, 2021). The conformation also influences the soundness of the horse and therefore the overall health. Proper conformation in the different equine disciplines establishes proper movement and balance of the horse. In order to understand conformation, one must look at the body measurements of the horse. A study of a horses' body measurements was done by Matsuura *et al.* (2021) to determine the accuracy of a 3D scanning device. This study used eight riding horses, six being Thoroughbred horses and two being crossbred horses. The results of this study showed that the 3D

scanning device is extremely accurate when measuring the body measurements of the horses. The mean 3D measurement of the horses' height at withers was 157.5 (± 2.5) cm and the height at the croup was 158.7 (± 2.6) cm. In the study by Sadek *et al.* (2006), it was found that Arabian horses have a wither height of 149 (± 0.29) cm in mares and 150 (± 0.5) cm in stallions. The croup height was found to be 148 (± 0.28) cm in mares and 151 (± 0.48) cm in stallions (Sadek *et al.*, 2006). The wither and body length determine whether the horse has a rectangular or square frame. Holmstrom *et al.* (1990), found that Swedish Warmblood horses have a rectangular body shape, meaning that their wither height is smaller than their body length.

With regards to the forelimbs, Holmstrom *et al.* (1990) found that a sloping shoulder, a long radius with a short cannon bone and a flat croup is good for movement. It was found by a number of people that the conformation of the hindquarters is very important in the overall conformation and is often the most important part of the horse (Holmstrom *et al.*, 1990). The hindquarters of the horse are used to drive the horse forward as well as accept the full weight of the horse when jumping, and in dressage the hindquarters balance out the weight to keep the body in balance (Holmstrom and Philipsson, 1993). For dressage, horses that stand with their hindlimbs more underneath their body perform better whereas horses that have their hindlimbs more behind their body tend to be fast (Holmstrom *et al.*, 1990). The angle of the hock is also an important factor to look at as horses with small hock angles have lower resistance in this area and are therefore unable to support themselves (Schmidt, 1928 cited by Holmstrom *et al.*, 1990), whereas horses with large hock angles end up putting strain on the joints in the hindlimb (Wrangel 1911-1913; Forsell 1927; Anon 1940; Bengtsson 1983 cited by Holmstrom *et al.*, 1990). Therefore, a normal hock angle is desirable. Holmstrom *et al.* (1990) found that range in the hock angles was less in showjumping horses (with the range being 9 degrees) as opposed to in the dressage horses which had a range of 15 degrees in the hock angle. Relating to performance in dressage, Müller and Schwark (1979) found that the optimum angle of the hock joint was 154° (Holmstrom and Philipsson, 1993).

Kronacher and Ogrizek (1931) (cited by Holmstrom *et al.*, 1990) did a study where they looked at the conformation of the horse and compared it to the different gaits (walk, trot and canter) and it showed that there was a positive correlation between the humerus, femur and pelvis lengths and the length of the stride in the walking gait of the Brandenburg horses. Holmstrom *et al.* (1990) also found that there was another positive correlation between the angle of the slope of the shoulder and the length of the stride in the walking gait. Surprisingly, it was found and agreed upon by many people that the height of the withers is not at all related to the length of the stride in horses in any of their gaits (von Wagener 1934; Krüger 1957; Dušek, Ehrlein, Engelhardt and Hornicke 1970; Dušek 1974 cited by Holmstrom *et al.*, 1990).

The correlation between horse conformation and jumping ability was also studied by Langlois *et al.* (1978) (cited by Holmstrom *et al.*, 1990) and they found that horses that excel in showjumping generally have a wider breast and pelvis, a greater chest girth, a longer pelvis and a smaller angle of the femur with respect to the horizontal plane compared to horses that were not good in showjumping. Unfortunately, in this study even though the difference was significant, it was small and it was recommended that the conformation alone should not determine whether the horse would be a good jumper or not.

In the study done by Holmstrom *et al.* (1990), the age and the sex of the horse was also investigated as an influence on the conformation. Female horses (mares) tend to be shorter at the withers with longer bodies and shorter limbs compared to the male horses. The mares also had narrower forecannons and metacarpal bones as well as having smaller hock angles but larger fetlock angles in the hindlimb. This study also investigates the difference between the conformation of horses that excelled in showjumping compared to the conformation of horses that excelled in dressage and it was found that the horses that excelled in showjumping had smaller fetlock angles in the forelimbs compared to the other horses. The horses that excelled in dressage tended to have shorter necks and tibias with narrower forecannons and metacarpal bones compared to the showjumpers. The dressage horses also had larger angles of the fore and hind fetlock joints, larger angles of the hip joint and larger angles between the femur and the horizontal plane.

2.7 Heritabilities and repeatabilities

Lewczuk (2017) looked at the heritabilities and repeatabilities of certain jumping parameters when a horse jumps an obstacle. After measuring multiple parameters using video image analysis, it was found that the round arc that the horse's body forms when jumping known as the bascule of the horse had the highest values of repeatability and this is a very important part of the jumping technique (Lewczuk, 2017). Table 2.4 shows the linear parameters that were measured by Lewczuk (2017) and the repeatabilities of the additional parameters of the jump and as can be seen in this table, the repeatability of the parameters relating to the head (9 and 11) were higher when the horses were being ridden by a rider compared to when the horse was free-jumping.

The head and neck of the horse play an important role in all aspects of the jump. During the approach to the jump, the horse is able to concentrate on the jump based on the movement of the splenius muscle in the neck. As the horse takes off, it raises its head and neck and is therefore able to lower its weight in the initial stage of the jump. In the middle of the jump, the horse lowers its head and extends its neck. During this middle part of the jump, by using its head and neck, the horse can change its centre of gravity in order to give a good bascule over the jump. Upon landing, the horse raises its head to reduce weight (Galloux and Barrey, 1997).

Table 2.4 The measured (1-6) and additionally calculated (7-11) linear parameters of jump with the repeatabilities of additional parameters of the jump (Lewczuk, 2017)

Parameter	Description	Repeatability (with rider)	Repeatability (without rider)
1 Taking off	Distance between the hind hoof standing closer to obstacle (before airborne phase) and the front obstacle		
2 Landing	Distance between the front hoof standing closer to obstacle (after airborne phase) and the second stand of obstacle		
3 Lifting of individual limbs FR, FL, HR, HL	Distance between the lowest point of hoof above the pole and the highest pole of obstacle		
4 Elevation of the head	Distance between the highest point of head and the highest pole of obstacle on the bascule frame		
5 Elevation of the withers	Distance between the highest point of withers and the highest pole of obstacle on the bascule frame		
6 Elevation of the croup	Distance between the highest point of croup (sacrum) and the highest pole of obstacle on the bascule frame		
7 “work of the fore part”	Distance between the mean lifting of front limbs – FL and FR (3) and the elevation of withers (5)	0.37	0.42
8 “work of the hind part”	Distance between the mean lifting of hind limbs – HL and HR (3) and the elevation of withers (5)	0.26	0.37
9 “work of the head”	Distance between the elevation of head (4) and withers (5)	0.56	0.45
10 “work of the croup”	Distance between the elevation of croup (6) and withers (5)	0.17	0.17
11 “bend of the upper line”	Distance between the elevation of head (4) and croup (6)	0.55	0.48

2.8 Kinematic jumping traits

De Godoi *et al.* (2016) performed a study to analyse the relationship between the conformation and kinematic traits of young Brazilian Sport horses on successful free jumps and it was found that the jumping kinematic patterns of a six-month-old Brazilian Sport Horse was the same pattern as that horse at five years old. Since this is the case, the kinematic traits of a horse can be used when selecting for future show jumpers.

The traits that were measured included stance horse morphology traits and kinematics related traits. The stance horse morphology traits consisted of linear traits: wither height, croup height, body length, neck length, distance from shoulder to fetlock, length of forearm, length of forelimb shank, length of forelimb pastern, leg length, length of hindlimb shank, length of hindlimb pastern; and angular traits: head angle, neck angle, scapulohumeral angle, humeroradial angle, radial-metacarpal angle, scapula-floor angle, coxal-floor angle, coxofemoral angle, femorotibial angle, tibiometatarsal angle. The kinematics related traits consisted of jump performance: last stride length prior to jumping, last stride velocity prior to jumping, jumping length, jumping velocity, take-off distance, landing distance, forelimb height at jumping, hindlimb height at jumping, height of withers during jumping, horizontal displacement of withers during jumping; and horse conformation traits that were measured on the horses' body during jumping: head angle, neck angle, scapulohumeral angle, humeroradial angle, radial-metacarpal angle, coxofemoral angle, femorotibial angle, tibiometatarsal angle, withers-metatarsophalangeal angle, vertical distance between the scapulohumeral and metacarpophalangeal joints, vertical distance between the humeroradial and metacarpophalangeal joints, linear distance between the humeroradial and metacarpophalangeal joints, vertical distance between the femorotibial and metacarpophalangeal joints.

In this study, the forelimbs contributed 59% of the knockdowns whereas the hindlimbs were responsible for 41% of the knockdowns. In the highest age class (36-39 months), the forelimbs were responsible for 70% of the knockdowns.

From the results of this study, it was found that none of the stance horse morphology traits – linear traits that were measured were important. Regarding the stance horse morphology traits – angular traits, it was found that the neck angle was important in the youngest age class – aged 22-25 months. This angle helps the bascule of the horse and plays a very important role in fence clearance. An increase of this neck angle by one degree can cause a reduction in the clearance of a jump by up to 4.7% and so a small angle of the neck is desirable (de Godoi *et al.*, 2016). Table 2.5 shows the stance horse morphology traits – angular traits that were measured with their results in this study.

The kinematic traits – jump performance that had a significant effect on the probability of the horse having a successful jump was (1) the length of the horses' stride before the jump, (2) the distance from the fence that the horse took off from and (3) the height of the forelimbs at jumping. The best show jumping horses are able to adjust these factors when approaching the jump depending on the height in order to clear the fence and if they are unable to adjust these factors, the probability of fence

knockdown increases (de Godoi *et al.*, 2016). The first kinematic trait observed showed that an increase of one centimetre in the length of the stride decreased the probability of the horse clearing the jump by 1.6% (de Godoi *et al.*, 2016). The second kinematic trait observed showed that an increase in one centimetre in the distance from the fence would lead to a 3.1% increase in the probability of fence clearance (de Godoi *et al.*, 2016). The final kinematic trait observed caused the greatest change in the probability of clearance of the jump and an increase in only one centimetre was shown to improve the probability of a jump clearance by 17.1% (de Godoi *et al.*, 2016). Table 2.6 shows the kinematic traits when jumping that were measured with their results in this study.

With regards to the kinematic related traits based on the conformation of the horse, there were some angles that were significant. The stress that is placed on the hindlimb at take-off and the forelimb at landing is enormous (Dyson, 2000) and two angles that relate to the limbs of the horse play a role in successful jumps are now discussed. In the forelimb, the distance between the humeral-radial joint and the fetlock shows the flexion grade of the front legs of the horse and a higher flexion of these forelimbs resulted in better jumpers (Santamaría *et al.*, 2006). This value needs to be small as this means the horse is picking up its feet and a higher flexion. An increase in one centimetre of this distance decreases the chance of a successful jump by 9.4% (de Godoi *et al.*, 2016). In the hindlimb of the horse, an increase in the femoral-tibial angle by one degree can cause a higher probability of the clearance of a jump by up to 5.1% (de Godoi *et al.*, 2016). Table 2.7 shows the results of the kinematic traits of the conformation of the horse that was measured in de Godoi *et al.* (2016).

Table 2.5 Mean, minimum and maximum values of the stance horse morphology traits – angular traits (de Godoi *et al.*, 2016)

Angular traits	Age class I			Age class II			Age class III		
	Mean	Min	Max	Mean	Min	Max	Mean	Min	Max
Head angle	71.9	54.1	89.4	72.5	57.9	93.3	70.00	57.00	84.40
Neck angle	86.86	65.20	103.60	88.93	72.90	104.80	88.34	73.80	102.70
Scapulohumeral angle	108.5	96.50	129.00	108.5	99.90	124.5	107.2	97.90	120.90
Humeroradial angle	145.92	128.20	162.50	146.42	135.40	160.20	144.15	133.00	155.30
Radial-metacarpal angle	182.40	173.70	189.00	182.77	177.30	192.90	182.71	175.50	188.90
Coxofemoral angle	79.30	65.40	99.90	85.10	66.50	99.20	83.20	64.70	104.80
Femorotibial angle	116.67	95.80	137.50	122.25	95.40	138.60	121.51	104.30	147.30
Tibiometatarsal angle	152.15	132.20	159.10	154.04	144.50	163.90	155.09	148.00	163.00
Scapula-floor angle	58.90	51.30	70.20	58.96	50.70	68.80	59.52	50.40	70.20
Coxal-floor angle	23.11	11.50	36.00	25.69	13.40	38.90	24.38	12.90	35.90

Table 2.6 Mean, minimum and maximum values of the kinematics related traits – jump-performance traits (de Godoi *et al.*, 2016)

Jump-performance traits	Age class I			Age class II			Age class III		
	Mean	Min	Max	Mean	Min	Max	Mean	Min	Max
Last stride length prior to jumping*	2.60	1.45	3.59	2.77	1.91	3.61	2.81	1.94	3.43
Last stride velocity prior to jumping	5.32	3.05	7.39	5.41	3.72	6.76	5.64	3.95	7.12
Jumping length	3.47	1.51	4.93	3.83	1.73	5.03	4.08	2.34	5.30
Jumping velocity	5.02	1.86	9.02	4.67	1.82	6.25	4.71	2.39	7.04
Take-off distance*	1.17	0.36	2.41	1.51	0.76	2.27	1.52	0.97	2.74
Landing distance	1.63	0.52	2.39	1.59	0.66	2.67	1.79	0.59	3.11
Forelimb height at jumping*	0.22	0.01	0.48	0.22	0.00	0.54	0.17	0.00	0.49
Hindlimb height at jumping	0.24	0.00	0.69	0.24	0.00	0.59	0.22	0.00	0.80
Height of withers during jumping	1.64	1.38	1.95	1.92	1.69	2.20	2.10	1.72	5.52
Horizontal displacement of withers during jumping	0.16	-0.70	0.85	0.09	-0.53	0.71	0.12	-0.64	0.90

*The three traits that were important in this study

Table 2.7 Mean, minimum and maximum values of the kinematics related traits – horse-conformation traits (de Godoi *et al.*, 2016)

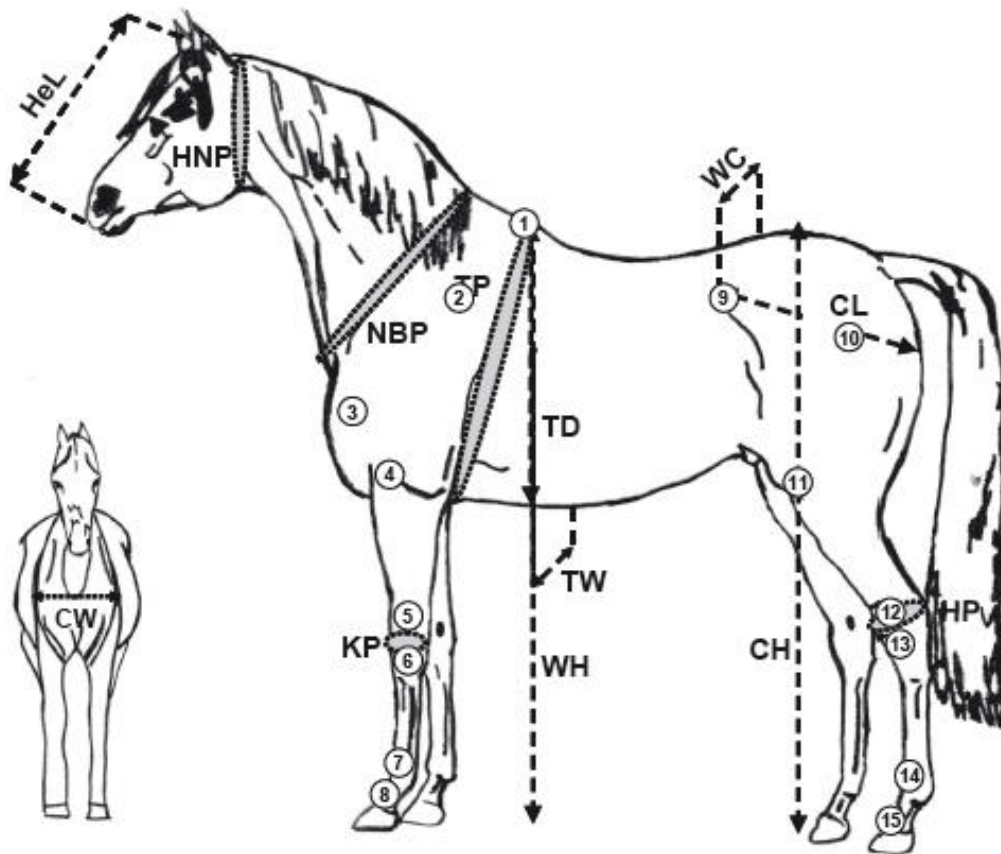
Horse conformation traits	Age class I			Age class II			Age class III		
	Mean	Min	Max	Mean	Min	Max	Mean	Min	Max
Linear distance between the humeroradial and metacarpophalangeal joints	0.40	0.20	0.57	0.38	0.21	0.60	0.37	0.21	0.57
Vertical distance between the humeroradial and metacarpophalangeal joints	0.33	0.09	0.53	0.29	0.10	0.54	0.30	0.08	0.55
Vertical distance between the scapulohumeral and metacarpophalangeal joints	0.52	0.25	0.71	0.51	0.19	0.77	0.51	0.35	0.75
Vertical distance between the femorotibial and metatarsophalangeal joints	0.31	0.02	0.49	0.27	0.02	0.50	0.21	-0.20	0.42
Scapulohumeral angle	98.95	92.00	150.30	99.70	96.10	157.80	98.30	94.90	135.30
Humeroradial angle	74.90	46.60	127.20	75.50	46.0	119.60	77.90	53.2	129.40
Radial-metacarpal angle	78.10	42.70	128.80	71.75	41.50	124.00	71.5	36.60	114.70
Neck angle	48.60	27.60	92.60	4.85	23.40	65.50	40.3	23.50	62.20
Head angle	82.40	55.40	114.20	84.40	54.50	135.10	89.95	55.50	132.60
Femorotibial angle	76.60	37.70	147.20	74.55	48.10	106.30	71.75	53.70	101.00
Coxofermoral angle	77.00	57.10	132.50	79.20	53.50	105.70	80.90	59.60	102.40
Tibiometatarsal angle	111.40	97.00	155.30	100.40	43.40	14190	92.70	40.40	128.1
Withers-metatarsophalangeal angle	131.85	37.70	147.20	131.65	96.80	159.60	135.50	102.60	155.3

A study that analysed the correlation between the conformation of horses and their performance traits was conducted by Holmstrom and Philipsson (1993). This study was done on Swedish Warmblood horses aged 4 years. Over many years, it has always been observed that the conformation of the horse is partly responsible for its performance (Holmstrom and Philipsson, 1993). This was also noted by Sánchez-Guerrero *et al.* (2016) where it was stated that conformation is an indicator of performance. There were five conformation traits that were analysed in this study and these included type, head neck and body, correctness of extremities, locomotion walk, and locomotion trot. The performance traits that were analysed included the gaits under the saddle (walk, trot and canter), jumping ability, and health. Both the conformation traits as well as the performance traits were scored on a scale of 1 to 10. It was found that some conformational measures of the horse did significantly influence the performance of that horse. The angle of the hip joint and the angle between the femur and the horizontal plane had a significant effect on the performance with regards to the gaits of the horse. When both of these angles were smaller, it resulted in higher scores when looking at the gait performance. The scores for gaits were also significantly influenced by the height at withers as well as the length of the humerus and femur – here there was a positive correlation. Looking at the performance trait of jumping ability, high scores were characteristic of horses that had a small width in the middle of the front cannon, a short hind phalanx, and large angles relating to the stifle joint and hock joint (Holmstrom and Philipsson, 1993). In Holmstrom and Philipsson (1993) as well as a study done by Thafvelin (1978), it was found that the trot gait had a stronger correlation to the canter gait compared to the correlation between the walk and canter gait. The canter gait also has a very strong correlation with jumping (Holmstrom and Philipsson, 1993).

Conformation is a very important characteristic of a sport horse and is highly correlated to the performance of the horse (Sánchez *et al.*, 2013). The Pura Raza Español horses were used in a study by Sánchez *et al.* (2013) to identify the indirect measurements that are related to the quality of movement in the different gaits. The need to find indirect measurements is because biokinematic analyses is very expensive and so biokinematic variables were identified. 13 different conformation measurements were used and the genetic correlations between these measurements and 16 biokinematic variables at trot (4 linear, 6 temporal and 6 angular) were estimated.

The conformation measurements that were taken were head length (HeL), head-neck perimeter (HNP), neck-body perimeter (NBP), chest width (CW), thorax width (TW), thorax depth (TD), thorax perimeter (TP), croup length (CL), croup width (WC), knee perimeter (KP), hock perimeter (HP), withers height (WH) and croup height (CH) and can be seen in Figure 1.

Figure 2.1 Representation of the conformation measurements taken in the Pura Raza Español horses in the study done by Sánchez *et al.* (2013)



The biokinematic variables were obtained using a camcorder while the Pura Raza Español horses trotted on a treadmill. The variables included: linear – length of the forelimb and hindlimb, and the maximum height of the hoof of the forelimb and hindlimb; temporal – forelimb and hindlimb duration, forelimb and hindlimb stance phase duration, and forelimb and hindlimb swing phase duration; angular – minimal angle of carpus, stifle and tarsus minimal retraction-protraction angle of the hindlimb, maximal retraction-protraction angle of forelimb, and maximal angle of pelvis (Sánchez *et al.*, 2013).

The results of this study showed that there were 155 genetic correlations that were significant between the conformation measurements and the biokinematic variables at the trot gait. The highest genetic correlation was that between the maximal angle of the pelvis with the neck-body perimeter which had a genetic correlation of 0.7 and the maximal angle of the pelvis with the thorax perimeter which also had a genetic correlation of 0.7 while the lowest genetic correlation was that between the hindlimb stand phase duration and the knee perimeter and that had a genetic correlation of 0.02 (Sánchez *et al.*, 2013).

The conformation trait that had the most correlation to the biokinematic variables at trot was croup length which had 16 significant genetic correlations while croup width had the least correlation with only seven significant genetic correlations. The variables that were the most significantly correlated to the different body measurements was forelimb length and forelimb duration which was significant in 12 out of the 13 body measurements measured whereas the variable that was least correlated to body measurements was the minimal

angle of carpus. Unlike many other studies Sánchez *et al.* (2013) found that withers height had correlations with most of the biokinematic variables at trot whereas the other studies found very little significant correlations with wither height.

The angle of the stifle was also found to be important when looking at the quality of gaits (Sánchez *et al.*, 2013). When the angle of the stifle is large it results in the quadriceps constricting and when the horse is performing collected trot or canter, this quadriceps muscle is the most overworked muscle (Sánchez *et al.*, 2013). If this muscle is unable to support the weight of the horse and rider, the weight is then shifted to the forelimb which changes the balance of the horse (Sánchez *et al.*, 2013).

2.9 Measuring of horses

In livestock animals, measuring the body size of the animals is an important factor of looking after them as it has an impact on the longevity, health, production and reproduction life of the animal and in the case of performance horses, the performance of the horses. With regards to horses, the biometric parameters and locomotion characteristics have a correlation to sport performance and this is sometimes the only way for genetic improvement (Pallottino *et al.*, 2015)

Pérez-Ruiz *et al.* (2020) investigated a new way to take body measurements of animals using digital 3D modeling by capturing the data with a LiDAR sensor. This sensor had 16 laser beams that scanned the horse and was able to provide a 3D reconstruction of the horse with measurements. There were 17 different measurements taken using the LiDAR-based system as well as manually taking the measurements by using standard measuring sticks, measuring tapes and compasses.

When working with horses and trying to measure them, there is always a risk of danger for the handler as horses can be unpredictable at times and although manual measurements are sometimes preferred, it also costs time and money to do these measurements as well as the risk factor mentioned (Pérez-Ruiz *et al.*, 2020). Another factor that causes an issue with manual measurements of horses is the age of the horse. Some young foals are unable to stand still or simply don't want to stand still for a person to manually measure them and so taking into consideration all these risks with manual measurements, the study done by Pérez-Ruiz *et al.* (2020) is a big step in the right direction as it can change the way that we measure horses as well as possibly other livestock animals while reducing these risks. Measuring horses and other livestock species is important in order for the breeder, farmer, or any other individual in charge of the animals to monitor the growth and development of the animal and so it is important to find easier and safer ways to do these measurements (Pérez-Ruiz *et al.*, 2020).

Matsuura *et al.* (2021) also investigated a different way of taking body measurements of horses but they used a highly versatile tablet-type 3D scanning device. The advantage to this technique compared to the manual way of taking measurements is that it is done without touching the animal and so it eliminates the risks mentioned previously (Matsuura *et al.*, 2021). This study compared these 3D measurements taken by the 3D scanner (which also contained a LiDAR scanner) with the manual measurements that were also taken. With this technique, it was difficult to obtain measurements of the head as there was constant slight movement of

the head which made it difficult to scan for measurements (Matsuura *et al.*, 2021). The results of this study showed that there was a correlation coefficient of 0.856-0.998 between the measurements taken manually and the measurements taken from the 3D scanner (Matsuura *et al.*, 2021).

In all of these studies mentioned in this literature review where a score system was implemented, the scoring worked on a scale of 1 (very bad) to 10 (excellent). These systems of scoring are very traditional and are used in performance and conformation tests as well as breed shows (Kuhnke *et al.*, 2019). These scoring systems are used to gain genetic potential in the breed; however, some breeders tend to use the scale incorrectly or inflate the scores of the horses in order to seem better than another breeder which can cause a loss in genetic gain (Kuhnke *et al.*, 2019). The movement from this type of scoring to a linear scoring method, which is being used by the dairy cattle, sheep and pig industries to score conformation, can greatly improve the potential of the equine industry (Kuhnke *et al.*, 2019). This linear system gives more descriptive information and allows the comparability between individuals as well as allowing the buyer to make their own assumptions in the case of purchasing (Kuhnke *et al.*, 2019).

Chapter 3: Materials and Methods

3.1 Ethics

The research protocol for this study was reviewed, presented and approved by the Animal Research Committee of the Department of Animal Science, followed by the submission and approval of the Research Ethics application by the Ethics Committee of the Faculty of Natural and Agricultural Sciences at the University of Pretoria. Thereafter the research ethics application was approved by the Animal Ethics Committee of the University of Pretoria (Ethics approval no. NAS360/2022). The ethical approvals included permission from the owner of the stud farm where the study was conducted.

3.2 Location

The data was recorded on an equine stud farm in South Africa. The stationary measurements were recorded from 20 Warmblood sport horses on a flat surface while the jumping measurements were taken in an indoor sand arena (details of procedures are described under the relevant headings in this chapter).

3.3 Animal selection

A cohort of twenty young Warmblood sport horses, of both sexes, that had only been given the basics of training were selected from a stud farm's auction lineup for 2023. Nineteen of these horses were four years of age being born between 12 October 2018 and 03 April 2019 which meant the age in months ranged from 48 to 54 months when the measurements were taken. The last horse was five years of age being born on 10 October 2017 which meant this horse was 66 months of age when the measurements were taken. The reason that this five-year-old was included was because he was a full brother to one of the four-year-old horses. Of these twenty auction horses that were chosen, twelve of them were geldings and eight of them were mares.

General information of each horse was gathered which included the age of each horse in months when the measurements were recorded, the sex (gelding or mare), the sire and the dam, the hot-blood percentage (where available) and the weight of the horse.

3.4 Stationary measurements data collection

Stationary measurements were chosen based on research that was done in the literature review including the studies by de Godoi *et al.* (2016) and Sánchez *et al.* (2013) and by considering other measurements that could be of interest and could relate to jumping performance. The final stationary linear and angular measurements that were chosen are described in Table 3.1 and 3.2 respectively.

Each horse stood on a flat surface with a trained handler standing next to them with a measuring stick of known measurement. This stick was used to calibrate the measurements in the software program from pixels to centimeters. A picture of the horses left side of their body was taken by the EOS 5D Mark III Camera. This picture was then analysed by the Kinovea® software program and measurements were obtained for the horse's

stationary body measurements. Figure 3.1 shows the stationary measurements (linear and angular) taken from a particular horse using the Kinovea® software program.

Measurements that had to be taken in person (head-neck perimeter, neck-body perimeter and chest girth) were taken using a three-metre measuring tape while the horse was standing on the flat surface.

X-ray images that were taken by a veterinarian were obtained from the stud farm. Using the Kinovea® software program, angles were obtained from these X-ray images. Figure 3.2 (a), (b) and (c) shows the X-ray images of a horse and the angles taken from it.

Table 3.1 Description of the stationary linear measurements (measured in centimeters) recorded from the Warmblood sport horses

Stationary Measurement	Description
Head length	Distance between the tip of the muzzle and the point just behind the ears
Neck length	Distance between the point between the ears and the top of the withers
Croup length	Linear distance between the tuber sacrale (highest point of the rump) and the tuber ischii (furthest point away from body)
Wither height	Vertical distance between the highest point of the interscapular region and the ground
Croup height	Vertical distance between the highest point of the tuber sacrale and the ground
Head-neck perimeter	The circumference measurement taken from just behind the ears and underneath the top part of the neck (between the head and neck measurement)
Neck-body perimeter	The circumference measurement taken from the withers to the bottom part of the neck (between the neck and body measurement)
Chest girth	The vertical circumference measurement taken from the withers
Femur length	The linear distance between the tuber ischii (furthest point away from the body) and the patella
Body length	Horizontal distance between the left-most point (excluding neck and head) and the right-most point (tuber ischii)

Table 3.2 Description of the stationary angular measurements (measured in degrees) recorded from the Warmblood sport horses

Stationary Measurement	Description
Shoulder angle	Caudal angle formed by the intersection of the line between the withers and the scapula-humerus joint with the horizontal line
Hoof angle	Cranial angle where the point is put at the area where hair meets hoof and each line of angle is adjusted to be in line with the horses' features
Hip joint angle	Cranial angle formed by the intersection of the croup length line and the femur length line
Hock joint angle	Cranial angle formed by the intersection of the line between the patella and the tarsals with the line between the tarsals and the metatarsals
X-Ray forelimb fetlock angle	Cranial angle situated in the fetlock joint cavity formed by the intersection of the line of the metacarpus bone and the long pastern bone of the forelimb
X-Ray forelimb hoof angle	Cranial angle situated in the pastern joint cavity formed by the intersection of the line of the long pastern bone of the forelimb and the most cranial-ventral part of the distal phalanx
X-Ray hindlimb fetlock angle	Cranial angle situated in the fetlock joint cavity formed by the intersection of the line of the metatarsus bone and the long pastern bone of the hindlimb
X-Ray hindlimb hoof angle	Cranial angle situated in the pastern joint cavity formed by the intersection of the line of the long pastern bone of the hindlimb and the most cranial-ventral part of the distal phalanx
X-Ray hock angle	Cranial angle formed by the intersection of the line between the patella and the tarsals with the line between the tarsals and the metatarsals
X-Ray stifle angle	Caudal angle formed by the intersection of the femur line and the tibia line

Figure 3.1 Stationary measurements obtained using the Kinovea® Software Program with a measuring stick as known measurement

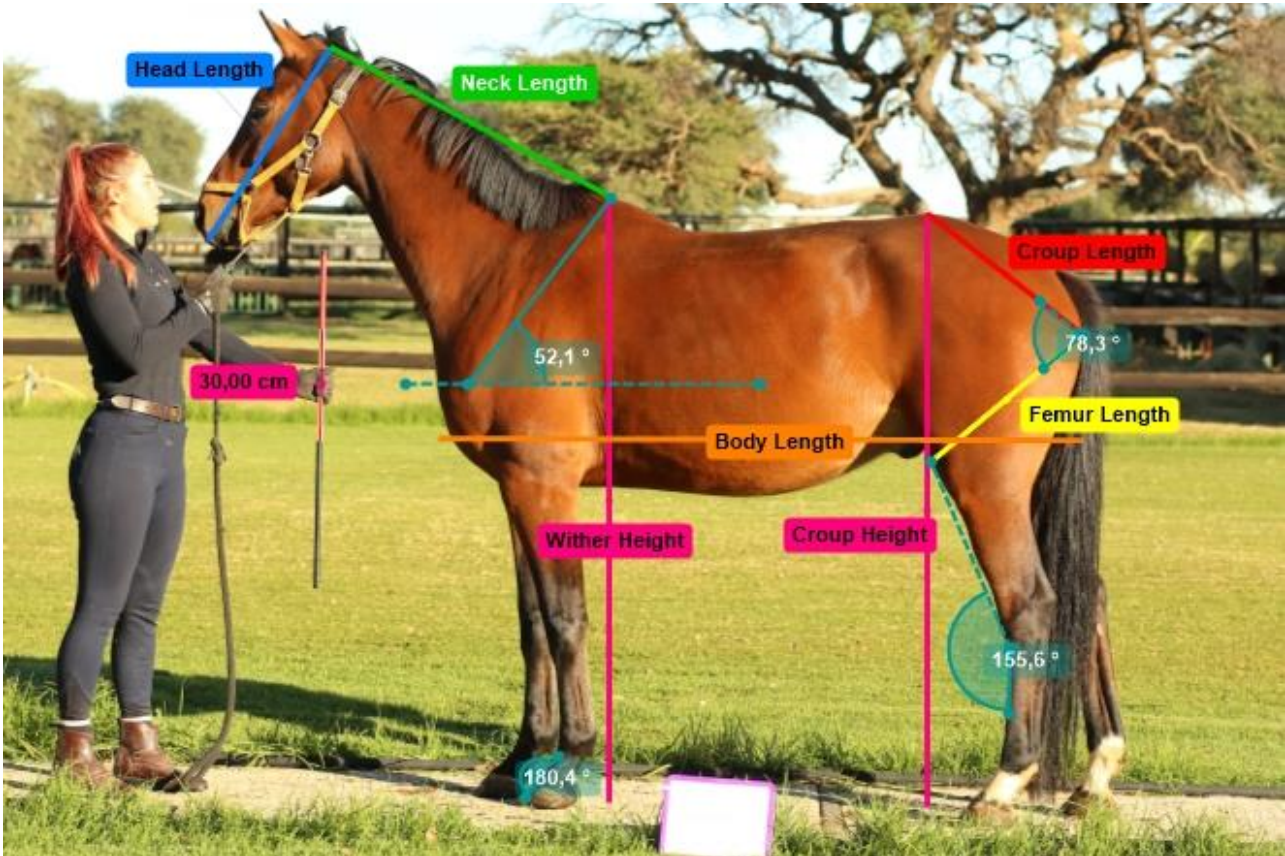


Figure 3.2 X-Ray image of the (a) forelimb fetlock and hoof, (b) hock and (c) stifle stationary angular measurements taken using the Kinovea® Software Program



(a)

(b)

(c)

3.5 Jumping measurements data collection

Jumping measurements were chosen based on research described in the literature review including the study by de Godoi *et al.* (2016) and looking at other measurements that could be of interest. The final jumping linear and angular measurements that were chosen are described in Table 3.3 and 3.4 respectively. Figures 3.3 to 3.6 show the jumping linear and angular measurements taken while the horse was free-jumping (which were the same measurements that was taken when the horses was under-saddle).

3.5.1 Under-saddle measurements

Each horse went through the same process for under-saddle measurements. The horse was warmed up by a trained rider using the stud farms normal pre-jumping warm-up program. A line of jumps was set up in the middle of the arena for data collection purposes. This line consisted of two cross-bar jumps before the main jump was measured. These cross bars were set at a height that corresponded with the main jump and stayed the same for each horse over the different main jump heights. The main jump was set up as an oxer and ranged in height according to the project. The horse was taken over a few jumps as a warm-up which was part of the normal jumping warm-up program of the stud farm.

The EOS 5D Mark III Camera was set up on a tripod at the edge of the arena in line with the main jump and perpendicular to the line of jumps. Once the horse was warmed up, the data collection started. The camera was switched on and the same measuring stick that was used in the stationary measurements was used in the jumping measurement videos to get a calibration method for the Kinovea® Software program to convert pixels to centimetres. The horse was taken over the line of jumps three times with the main jump at a height of 80cm. The camera recorded each jump that the horse did. The main jump height was then adjusted to 100cm and the cross bars also raised to correspond with the main jump. The horse again went over this line three times. If the horse knocked the jump or did not perform well (based on the expertise of the trainer present), the horse was taken over the jump again in order to get a better average of measurements.

3.5.2 Free-jumping measurements

Each horse went through the same process for free-jumping measurements. The free-jumping measurements occurred in the same arena as the under-saddle measurements but the arena was set up for a free-jumping round. Every horse at the stud had been trained to do free-jumping, so the horses were experienced with the procedure which improved the accuracy of the measurements. Each horse was warmed up by the trained handlers by trotting and cantering and then taken over a few warm-up jumps. This pre-data-collection warm-up was the standard free-jumping warm-up used at the stud farm. A line of enclosed jumps was set up on the edge of the arena. This line consisted of two cross-bar jumps and one upright jump before the main jump that was measured. These cross-bars and upright bar were set at a height that corresponded with the main jump and stayed the same for each horse over the different main jump heights. The main jump was set up as an oxer and ranged in height according to the project.

The EOS 5D Mark III Camera was set up on a tripod at the other end of the arena in line with the main jump and perpendicular to the line of jumps. The camera was switched on and the same measuring stick that was used in the stationary and under-saddle measurements was used in the free-jumping measurement videos to get a calibration method for the Kinovea® Software program to convert pixels to centimeters. Each horse was taken over the line of jumps two times with the main jump at a height of 80cm. Each time that the horse went over the jump the camera was recording. The main jump height was then adjusted to 100cm and the cross-bars and upright bar were also raised to correspond with the main jump. The horse again went over this line two times. The main jump height was then adjusted to 120cm and the cross-bars and upright also raised to correspond with the main jump. The horse then went over this line three times. If the horse knocked the jump over any height or did not perform well (based on the expertise of the trainer present), the horse was taken over the jump again in order to get a better average of measurements. Horses are able to jump higher without a rider present which is the reason for adding the 120cm round of jumps in the free-jumping section of this project.

Table 3.3 (a) Description of the jumping linear measurements (measured in centimeters) recorded from the Warmblood sport horses (before the jump)

Jumping Measurement	Description
Front outside to back outside	Horizontal distance measured in the last stride before the jump from the front forelimb to the back hindlimb measured at the tip of the hoof.
Front outside to back inside	Horizontal distance measured in the last stride before the jump from the front forelimb to the front hindlimb measured at the tip of the hoof.
Front inside to back inside	Horizontal distance measured in the last stride before the jump from the back forelimb to the front hindlimb measured at the tip of the hoof.
Front inside to back outside	Horizontal distance measured in the last stride before the jump from the back forelimb to the back hindlimb measured at the tip of the hoof.
Back left to back left	Horizontal distance measured in the last stride before the jump from the second last time the horses back left hoof touches the ground until the last time the horses back left hoof touches the ground before take-off
Back right to back right	Horizontal distance measured in the last stride before the jump from the second last time the horses back right hoof touches the ground until the last time the horses back right hoof touches the ground before take-off
Front left to front left	Horizontal distance measured in the last stride before the jump from the second last time the horses front left hoof touches the ground until the last time the horses front left hoof touches the ground before take-off
Front right to front right	Horizontal distance measured in the last stride before the jump from the second last time the horses front right hoof touches the ground until the last time the horses front right hoof touches the ground before take-off

Table 3.3 (b) Description of the jumping linear measurements (measured in centimeters) recorded from the Warmblood sport horses (during and after the jump)

Jumping Measurement	Description
Take-off distance of forelimb	Horizontal distance between the front pole of the jump and the tip of the hoof of the forelimb closest to the jump before the flight phase
Take-off distance of hindlimb	Horizontal distance between the front pole of the jump and the tip of the hoof of the hindlimb closest to the jump before the flight phase
Landing distance of forelimb	Horizontal distance between the back pole of the jump and the tip of the forelimb hoof closest to the jump just after the flight phase
Landing distance of hindlimb	Horizontal distance between the back pole of the jump and the tip of the hindlimb hoof closest to the jump just after the flight phase
Jump distance	Horizontal distance between the take-off distance of the hindlimb and the landing distance of the forelimb
Height of right forelimb	Vertical distance from the top of the jump to the lowest point of the front right hoof
Height of left forelimb	Vertical distance from the top of the jump to the lowest point of the front left hoof
Height of right hindlimb	Vertical distance from the top of the jump to the lowest point of the back right hoof
Height of left hindlimb	Vertical distance from the top of the jump to the lowest point of the back left hoof
Elevation of head	Vertical distance from the top of the jump to the point between the ears when the head is above the jump
Elevation of withers	Vertical distance from the top of the jump to the withers when the wither is above the jump
Elevation of croup	Vertical distance from the top of the jump to the croup when the croup is above the jump
Linear HRMCP ¹	Linear distance between the humeroradial joint and the metacarpophalangeal joint measured when the forelimb is directly above the jump
Vertical HRMCP	Vertical distance between the humeroradial joint and the metacarpophalangeal joint measured when the forelimb is directly above the jump

¹ Distance between the humeroradial and the metacarpophalangeal joints

Table 3.4 Description of the jumping angular measurements (measured in degrees) recorded from the Warmblood sport horses

Jumping Measurement	Description
Middle head angle	Ventral angle formed by the intersection of the head length line with the neck length line when the horse is parallel with the ground (horse is mid jump)
Above head angle	Ventral angle formed by the intersection of the head length line with the neck length line when the horse's head is above the middle of the jump
Middle femorotibial angle	Caudal angle formed by the intersection of the femur length line and the line between the patella with the tarsus when the horse is parallel with the ground (horse is mid jump)
Above femorotibial angle	Caudal angle formed by the intersection of the femur length line and the line between the patella with the tarsus when the horse's hindlimbs are above the middle of the jump
Forelimb angle one	Cranial dorsal angle formed by the intersection of the radius line with the vertical line when the forelimbs are above the first pole of the jump
Forelimb angle two	Cranial dorsal angle formed by the intersection of the radius line with the vertical line when the forelimbs are above the middle of the jump
Forelimb angle three	Cranial dorsal angle formed by the intersection of the radius line with the vertical line when the forelimbs are above the second pole of the jump
Jump angle at take-off	Cranial angle formed by the intersection of the line from the tip of the hoof to the point between the ears with the horizontal line
Time airborne	Time between the last hoof leaving the ground and the first hoof landing on the ground

Figure 3.3 Jumping measurements: last stride before the jump measurements including front outside to back outside, front outside to back inside, front inside to back inside and front inside to back outside measured using Kinovea® Software Program



Figure 3.4 Jumping measurements: take-off distance of hindlimb and the jump angle at take-off measured using Kinovea® Software Program

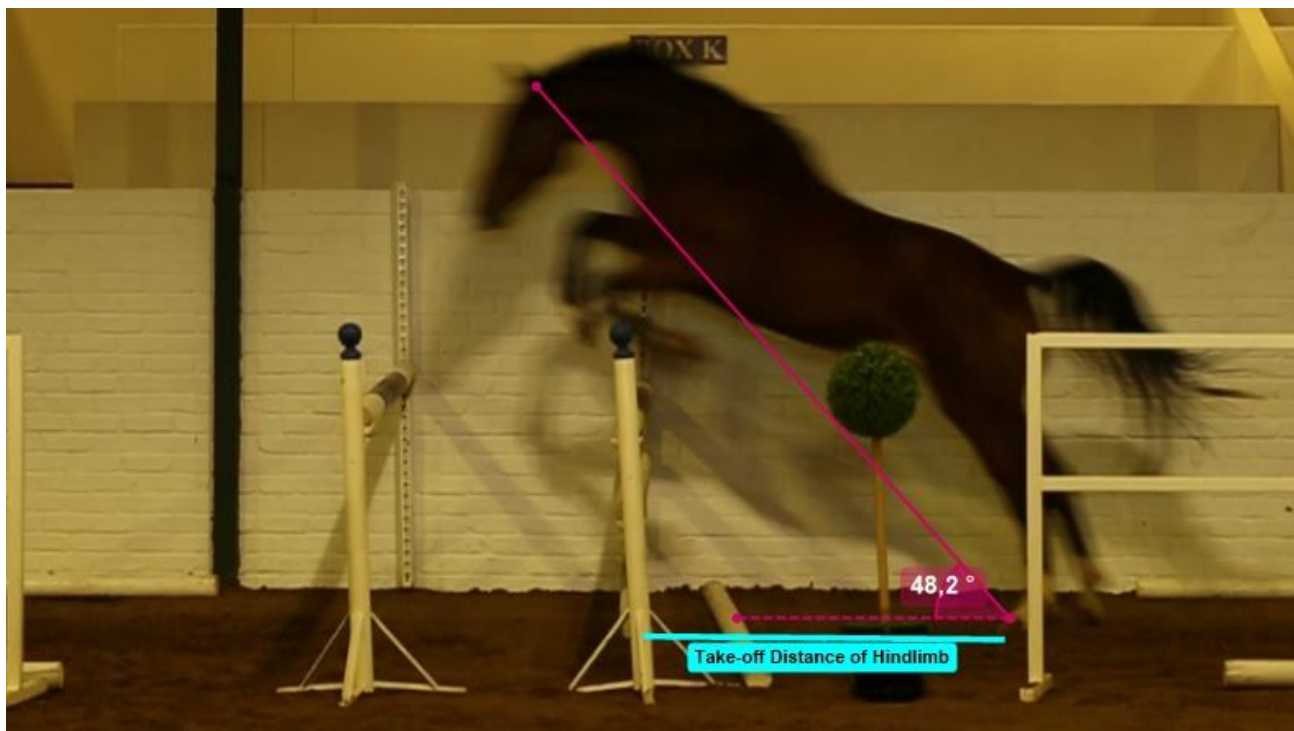


Figure 3.5 Jumping measurements: linear and vertical distances between the humeroradial and the metacarpophalangeal joints and the height of the left forelimb measured when the forelimbs are above the second pole of the oxer jump using Kinovea® Software Program

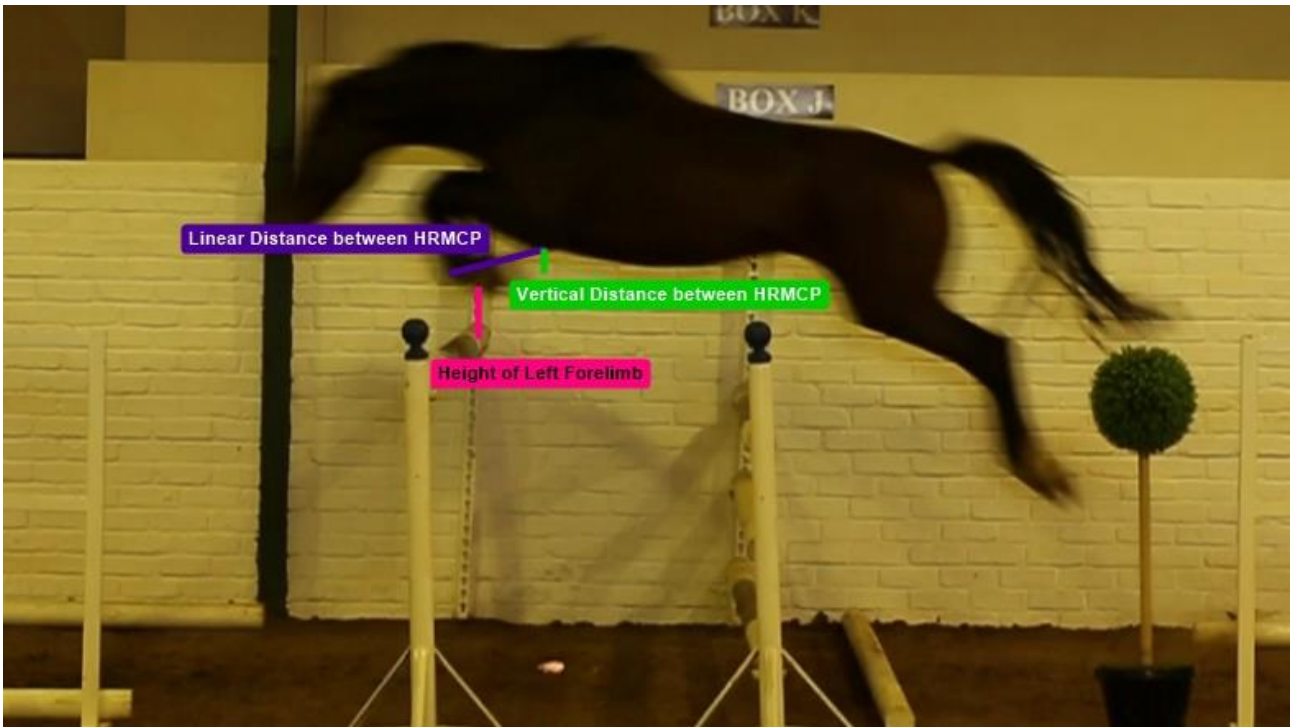


Figure 3.6 Jumping measurements: elevation of withers, middle head angle and middle femorotibial angle measured mid jump using Kinovea® Software Program



3.6 Statistical analyses

Once the data from all jumps had been recorded, unsuccessful jumps were removed from the dataset based on pre-recording decisions. The jumps that fell under the category of “unsuccessful” were instances where the horse did not jump correctly, i.e., an extra stride was put in, the horse got frightened by outside distractions, or the horse knocked the jump causing the jump to fall. This enabled the remaining data to be data based on natural talent of the horse by disregarding the rare, odd jumps. Once the unsuccessful jumps had been disregarded, averages were obtained for each section: every horse had one line of averages for 80cm under-saddle, 100cm under-saddle, 80cm free-jumping, 100cm free-jumping and 120cm free-jumping. This data was then captured in Excel and exported to SAS Version 9.4 for statistical analyses.

In this study the statistical analyses compared the effects of the fixed factors including the height of the jump, the under-saddle vs free-jumping and the sex of the horse on stationary measurements and jumping measurements. This was done by means of Generalised Linear Multifactorial analysis of variance (MANOVA) procedures and Mixed Model Analyses, to compare least square means and standard errors. Categorical data was analysed by means of Chi-square analyses and Log-linear Regression analyses. Correlation analyses to analyse associations between different measures and performance based on Pearson Product Moment Correlations coefficients. A significant level of 95% ($P \leq 0.05$) was used for all critical values.

Chapter 4: Results

4.1 Introduction

This section presents the findings of this study on the influence of a horse's conformation on their show jumping performance, aiming to pinpoint which conformation traits have the highest correlation or best predictive value for jumping performance.

The first part of this chapter analyses the stationary measurements by themselves to determine the differences between mares and geldings. The correlations between these stationary measurements are also discussed to analyse which body measurements were closely related to one another.

The jumping measurements are then presented to compare the effects of a horse being ridden (under-saddle) versus when a horse was free-jumping. These results will determine how much of an influence the rider had on the horse for the different jumping traits that were measured. The jumping section also explores the changes that a horse makes over different heights of a jump, showing how the horse thinks about the upcoming obstacle and adjusts its technique.

Subsequent to analysing the stationary and jumping measurements independently, the following section combines these variables, where prediction equations were statistically derived from the combined data. In this section, the stationary measurements act as independent variables to determine the jumping measurements which act as the dependent variables. Equations were determined to predict the jumping measurements from known stationary measurements. These equations will give horse owners an idea of how the horse will jump based on their stationary measurements.

Proceeding this, the next section analyses the jumping measurements which act as the independent variables which were used to determine prediction equations for star ratings of the horse. At certain stud farms, each horse is given a star rating for each discipline to give potential buyers an idea of how well they predict the horse is suited for each discipline. By using jumping measurements to find prediction equations, the star ratings can be scientifically based on how the horse jumps.

4.2 Stationary measurements

The means (\pm SE) of the body measurements and stationary linear measurements and the differences between the geldings and the mares are presented in Table 4.1. This table shows that geldings had larger ($P \leq 0.05$) linear measurements than the mares for a number of the stationary measurements. The age in months did not differ significantly indicating that the differences in the stationary measurements and jumping measurements between the geldings and the mares were not based on age. Examining the three main size measurements (weight, wither height and body length), Table 4.1 provides evidence that the geldings were heavier, taller and longer than the mares ($P \leq 0.05$). The croup height difference that is presented in this table also supports this argument as the geldings had a mean croup height of 164.27cm which was taller ($P \leq 0.05$) than the mares which had a mean croup height of 160.67cm. The mares and geldings had a similar mean head length however the geldings had a longer mean neck length ($P \leq 0.05$) compared to the mares. Two of the

circumference measurements (head-neck perimeter and neck-body perimeter) did not differ between the geldings and the mares however the third circumference measurement, the chest girth, did differ with mares having a smaller ($P \leq 0.05$) chest girth compared to the geldings.

The means (\pm SE) of the stationary angular measurements and the differences between the geldings and the mares are presented in Table 4.2. Fewer of these measurements differed ($P \leq 0.05$) between the geldings and the mares compared to the body and linear measurements in Table 4.1. Excluding the X-ray angles, the only angle that differed was the hoof angle with geldings having a larger ($P \leq 0.05$) hoof angle with a mean of 184.84° compared to the mares with a mean hoof angle of 179.42° . The X-ray forelimb hoof angle followed this trend with geldings having a larger ($P \leq 0.05$) hoof angle compared to the mares. The X-ray fetlock angles, however, of both the forelimb and the hindlimb, were greater ($P \leq 0.05$) in the mares than in the geldings. These two fetlock angles were the only stationary measurements where the mares were significantly bigger than the geldings.

The correlation analysis presented in Table 4.3 revealed several significant relationships among the stationary measurements of the horses. Notably, the weight of the horse showed strong positive correlations with wither height ($r = 0.854$, $p < 0.001$), croup height ($r = 0.912$, $p < 0.001$), and chest girth ($r = 0.830$, $p < 0.001$). This indicated that the heavier the horse, the taller and rounder around the chest the horse was. The wither height and croup height had a very strong positive correlation ($r = 0.946$, $p < 0.001$) demonstrating that the height of the horse at the withers and on the croup were positively associated with one another. The length of the femur had a very high moderate negative correlation with both the hip joint angle ($r = -0.645$, $p < 0.001$) and hock joint angle ($r = -0.656$, $p < 0.001$). This indicated that as the length of the femur increased, the smaller the hip joint and hock joint angles became. Observing the results of the X-ray angles of the forelimb and the hindlimb, the fetlock angle had a strong negative correlation with the hoof angle when looking at the forelimb measurements ($r = -0.810$, $p < 0.001$) and a moderate negative correlation when looking at the hindlimb measurements ($r = -0.616$, $p < 0.001$).

Table 4.1 Means (\pm SE) of body measurements and stationary linear measurements of geldings and mares

Effect	Sex	Mean (\pm SE)					
		Age (months)	Weight (kg)	Head length (cm)	Neck length (cm)	Croup length (cm)	Wither height (cm)
Sex	Gelding	52.92 (\pm 0.4264)	547.83 (\pm 4.9993) ^a	63.94 (\pm 0.2879)	88.54 (\pm 1.1001) ^a	53.64 (\pm 0.2914) ^a	166.51 (\pm 0.6380) ^a
	Mare	51.88 (\pm 0.5222)	531.38 (\pm 6.1228) ^b	63.57 (\pm 0.3526)	83.12 (\pm 1.3474) ^b	52.59 (\pm 0.3568) ^b	161.65 (\pm 0.7814) ^b

Effect	Sex	Mean (\pm SE)					
		Croup height (cm)	Head-Neck Perimeter (cm)	Neck-Body perimeter (cm)	Chest girth (cm)	Femur length (cm)	Body length (cm)
Sex	Gelding	164.27 (\pm 0.6762) ^a	81.07 (\pm 0.3311)	124.31 (\pm 0.5532)	194.03 (\pm 0.6339) ^a	53.87 (\pm 0.4897) ^a	172.55 (\pm 0.8105) ^a
	Mare	160.67 (\pm 0.8282) ^b	81.39 (\pm 0.4055)	123.13 (\pm 0.6776)	189.57 (\pm 0.7764) ^b	50.60 (\pm 0.5997) ^b	168.02 (\pm 0.9926) ^b

Means with different superscript letters within a column and within an effect differ significantly ($P \leq 0.05$).

Table 4.2 Means (\pm SE) of stationary angular measurements of geldings and mares

Effect	Sex	Mean (\pm SE)				
		Shoulder angle	Hoof angle	Hip joint angle	Hock joint angle	X-ray forelimb fetlock angle
Sex	Gelding	55.54 (\pm 0.4095)	184.84 (\pm 0.5784) ^a	82.14 (\pm 0.6662)	155.38 (\pm 0.4624)	149.28 (\pm 0.5478) ^a
	Mare	55.39 (\pm 0.5016)	179.42 (\pm 0.7084) ^b	83.28 (\pm 0.8159)	155.29 (\pm 0.5664)	153.93 (\pm 0.6709) ^b

Effect	Sex	Mean (\pm SE)				
		X-ray forelimb hoof angle	X-ray hindlimb fetlock angle	X-ray hindlimb hoof angle	X-ray hock angle	X-ray stifle angle
Sex	Gelding	157.87 (\pm 0.4663) ^a	151.48 (\pm 0.5812) ^a	153.94 (\pm 0.5415)	164.39 (\pm 0.3358)	137.78 (\pm 0.3567)
	Mare	155.97 (\pm 0.5710) ^b	153.58 (\pm 0.7118) ^b	154.02 (\pm 0.7658)	163.45 (\pm 0.4112)	136.76 (\pm 0.4369)

Means with different superscript letters within a column and within an effect differ significantly ($P \leq 0.05$).

All angles measured in degrees.

Table 4.3 (a) Correlations between body measurements and stationary linear measurements

	Age	Weight	Head length	Neck length	Croup length	Wither height	Croup height	Head-neck perim. ^a	Neck-body perim. ^a	Chest girth	Femur length	Body length
Age												
Weight	0,253*											
Head length	-0,049	0,759**										
Neck length	0,178	0,733**	0,778**									
Croup length	0,102	0,401**	0,397**	0,305*								
Wither height	0,223*	0,854**	0,719**	0,781**	0,488**							
Croup height	0,250*	0,912**	0,747**	0,772**	0,363*	0,946**						
Head-neck perim. ^a	0,148	0,470**	0,371*	0,337*	0,129	0,331*	0,450**					
Neck-body perim. ^a	0,290*	0,567**	0,442**	0,492**	0,349*	0,435**	0,442**	0,419**				
Chest girth	0,175	0,830**	0,725**	0,752**	0,478**	0,780**	0,829**	0,566**	0,643**			
Femur length	0,351*	0,697**	0,298*	0,524**	-0,020	0,628**	0,716**	0,377*	0,413**	0,606**		
Body length	0,176	0,739**	0,707**	0,707**	0,545**	0,788**	0,744**	0,594**	0,741**	0,833**	0,576**	
Shoulder angle	0,150	-0,115	-0,152	-0,185	-0,347*	-0,022	0,016	-0,220*	-0,566**	-0,152	0,004	-0,386**
Hoof angle	0,221*	0,156	0,000	0,084	0,067	0,435**	0,333*	0,028	0,007	0,287*	0,147	0,180
Hip joint angle	-0,243*	-0,402**	0,031	-0,075	-0,039	-0,236*	-0,335*	-0,374*	-0,375*	-0,308*	-0,645**	-0,347*
Hock joint angle	-0,658**	-0,323*	0,022	-0,249*	-0,022	-0,227*	-0,340*	-0,271*	-0,282*	-0,299*	-0,656**	-0,284*
X ForeFet ^b	-0,293*	0,065	0,140	-0,168	-0,049	-0,020	0,042	0,247*	-0,158	-0,254*	-0,073	-0,026
X ForeHoof ^c	0,273*	-0,232*	-0,285*	-0,044	-0,222*	-0,178	-0,237*	-0,120	-0,071	0,028	0,028	-0,113
X HindFet ^d	-0,209*	0,361*	0,202*	0,278*	0,129	0,371*	0,404**	0,193	0,060	0,282*	0,166	0,110
X HindHoof ^e	-0,036	-0,291*	0,078	-0,142	0,011	-0,290*	-0,330*	0,049	-0,162	-0,150	-0,255*	0,004
X-Ray hock angle	-0,144	-0,483**	-0,355*	-0,331*	0,014	-0,355*	-0,493**	-0,635**	-0,183	-0,423**	-0,450**	-0,398**
X-Ray stifle angle	0,204*	0,280*	0,122	0,345*	0,086	0,308*	0,306*	-0,104	0,057	0,283*	0,462**	0,171

* P < 0.05

** P < 0.0001

^a Perimeter; ^b X-Ray forelimb fetlock angle; ^c X-Ray forelimb hoof angle; ^d X-Ray hindlimb fetlock angle; ^e X-Ray hindlimb hoof angle

Table 4.3 (b) Correlations between stationary angular measurements

	Shoulder angle	Hoof angle	Hip joint angle	Hock joint angle	X ForeFet ^a	X ForeHoof ^b	X HindFet ^c	X HingHoof ^d	X hock angle	X stifle angle
Hoof angle	0,337*									
Hip joint angle	0,188	-0,036								
Hock joint angle	0,003	0,032	0,404**							
X ForeFet ^a	-0,210*	-0,339*	-0,089	0,199*						
X ForeHoof ^b	0,351*	0,315*	0,092	-0,235*	-0,810**					
X HindFet ^c	0,097	0,109	-0,005	-0,030	0,243*	-0,351*				
X HindHoof ^d	0,096	-0,363*	0,329*	0,108	0,032	0,230*	-0,616**			
X-Ray hock angle	-0,175	0,059	0,238*	0,340*	-0,318*	0,313*	-0,359*	-0,085		
X-Ray stifle angle	0,190	0,178	-0,338*	-0,444**	-0,269*	0,225*	0,292*	-0,311*	0,015	

* P ≤ 0.05

** P < 0.001

^a X-Ray forelimb fetlock angle; ^b X-Ray Forelimb hoof angle; ^c X-Ray Hindlimb fetlock angle; ^d X-Ray Hindlimb hoof angle

4.3 Jumping measurements

Each table in this section is divided into a part (a) and a part (b). The first part (a) of the table are the means (\pm SE) of the jumping measurements in sections at the same height showing the differences between under-saddle and free-jumping. This first part of the table additionally highlights the differences between the geldings and the mares. The second part (b) of the table are the means (\pm SE) of the jumping measurements with the differences between the different jumping heights (80cm, 100cm and 120cm) of free-jumping. The differences between the geldings and the mares over the different jumping heights of free-jumping is displayed in the second part of the table as well.

The means (\pm SE) of the four jumping linear measurements that were taken to represent the final stride before the jump are presented in Table 4.4 (a) and (b). These four jumping measurements include the front outside to back outside (FOBO), front outside to back inside (FOBI), front inside to back inside (FIBI), and front inside to back outside (FIBO). These four measurements were related to the distance between the hooves described in the materials and methods chapter in Table 3.3 (a).

As observed in Table 4.4 (a), the length of the final stride before the jump was influenced by the sex of the horse as for three out of the four stride measurements, there was a difference ($P \leq 0.05$) between geldings and mares where geldings had a larger overall stride (FOBO) with a mean of 306.20cm compared to mares with a mean of 274.59cm. The reason that the geldings had a statistically longer stride length for these measurements could be related to what is shown in Table 4.1 where the geldings were bigger ($P \leq 0.05$) than the mares. This suggests that the geldings reached further than the mares because they were taller. The FIBI stride was the only stride length in this table that did not differ significantly between geldings and mares. Taking this into account, it can then be concluded that the inside legs of a stride did not differ between the mares and geldings but it is in fact the outside legs that extend and shorten when leading up to a jump when comparing the geldings and the mares. Even though this measurement did not differ between the geldings and the mares, it was the only measurement in this table that differed ($P \leq 0.05$) between under-saddle and free-jumping for both 80cm and 100cm where the means were 130.85cm and 129.66cm respectively for under-saddle and 143.41cm and 140.93cm respectively for free-jumping. This indicates that this stride measurement of FIBI was influenced by the rider as it changed significantly when the horse was being ridden under-saddle.

As illustrated in the free-jumping heights section shown in Table 4.4 (b), there were no significant differences between the different heights when the geldings and mares were not taken into account. It is understandable though that there would be differences ($P \leq 0.05$) seen under the “Height*Sex (USFJ)” interaction of Table 4.4 (b) due to the fact that these measurements were influenced by the different sexes namely geldings and mares seen in Table 4.4 (a).

The means (\pm SE) of the four jumping linear measurements that were taken to represent the distance travelled by each hoof before the jump are presented in Table 4.5 (a) and (b). These four jumping measurements include the back left to back left (BLBL), back right to back right (BRBR), front left to front left (FLFL), and front right to front right (FRFR). These four measurements were related to the distance each hoof travelled before the jump which is described in the materials and methods chapter in Table 3.3 (a). There was unfortunately not enough data of the distance that the front left hoof travelled in this study to determine any significance or mean values. This was the same for the front right leg at 120cm of free-jumping.

The front right leg travel distance had no significant differences between the means of geldings and mares, under-saddle and free-jumping and over the different heights of free-jumping. This measurement was therefore a constant measurement in all different scenarios of this study. The back left leg did not differ significantly in the distance travelled between under-saddle and free-jumping and between geldings and mares which can be seen in Table 4.5 (a). This back left leg did however, differ significantly in the different heights of free-jumping as this leg travelled further ($P \leq 0.05$) over the 80cm free-jumping height with a mean of 286.13cm compared to the 100cm with a mean of 254.53cm and 120cm with a mean of 236.65cm free-jumping heights. From Table 4.5 (a), the back right leg had a longer ($P \leq 0.05$) distance travelled for geldings under-saddle at 80cm (with a mean of 285.31cm) compared to geldings free-jumping at 80cm (with a mean of 246.34cm). Looking at the 100cm jump means, a mares' back right leg travelled a longer distance ($P \leq 0.05$) when the mare was jumping under-saddle (with a mean of 297.97cm) compared to free-jumping (with a mean of 237.91cm). Therefore, at the different heights of 80cm and 100cm, geldings had a significant difference at 80cm between under-saddle and free-jumping while the mare had a significant difference at 100cm between under-saddle and free-jumping. However, both mares and geldings had longer distances travelled under-saddle than when they were free-jumping.

Table 4.4 (a) Means (\pm SE) of jumping linear measurements representing the stride before the jump: FOBO¹, FOBI², FIBI³, and FIBO⁴ within the same height between under-saddle and free-jumping and between geldings and mares

Effect	Sex:USFJ:Height	Mean (\pm SE)			
		FOBO ¹	FOBI ²	FIBI ³	FIBO ⁴
Height (USFJ) ⁵	US:80	300.20 (\pm 7.9693)	221.74 (\pm 4.2742) ^a	130.85 (\pm 3.5655) ^a	214.29 (\pm 6.7780)
	FJ:80	299.12 (\pm 12.2004)	206.03 (\pm 5.4485) ^b	143.41 (\pm 4.5451) ^b	221.38 (\pm 10.3766)
Height (USFJ)	US:100	296.47 (\pm 7.0439) ^a	219.79 (\pm 4.2742)	129.66 (\pm 3.5655) ^a	210.48 (\pm 5.9909)
	FJ:100	270.90 (\pm 9.4504) ^b	209.92 (\pm 3.8459)	140.93 (\pm 3.2082) ^b	202.41 (\pm 8.0377)
Sex	Gelding	306.20 (\pm 5.5315) ^a	222.68 (\pm 2.3748) ^a	138.61 (\pm 1.9810)	223.34 (\pm 4.7046) ^a
	Mare	274.59 (\pm 6.6328) ^b	207.86 (\pm 3.2070) ^b	133.59 (\pm 2.6753)	200.17 (\pm 5.6412) ^b
Height*Sex (USFJ)	Gelding:US:80	303.70 (\pm 12.6006)	223.21 (\pm 5.2348) ^a	133.14 (\pm 4.3668)	218.13 (\pm 10.7169)
	Mare:US:80	296.70 (\pm 9.7604)	220.26 (\pm 6.7580) ^a	128.56 (\pm 5.6375)	210.44 (\pm 8.3013)
	Gelding:FJ:80	310.04 (\pm 10.9124)	220.88 (\pm 5.2348) ^a	142.24 (\pm 4.3668)	228.16 (\pm 9.2811)
	Mare:FJ:80	288.20 (\pm 21.8248)	191.18 (\pm 9.5573) ^b	144.59 (\pm 7.9726)	214.59 (\pm 18.5622)
Height*Sex (USFJ)	Gelding:US:100	299.90 (\pm 10.9124) ^a	225.78 (\pm 5.2348) ^a	129.73 (\pm 4.3668) ^a	210.73 (\pm 9.2811) ^{ab}
	Mare:US:100	293.04 (\pm 8.9099) ^a	213.80 (\pm 6.7580) ^{ab}	129.58 (\pm 5.6375) ^a	210.22 (\pm 7.5780) ^a
	Gelding:FJ:100	301.10 (\pm 10.9124) ^a	216.91 (\pm 4.9911) ^{ab}	146.07 (\pm 4.1636) ^b	226.64 (\pm 9.2811) ^a
	Mare:FJ:100	240.70 (\pm 15.4325) ^b	202.93 (\pm 5.8526) ^b	135.78 (\pm 4.8822) ^{ab}	178.18 (\pm 13.1255) ^b

Means with different superscript letters within a column and within an effect differ significantly ($P \leq 0.05$).

¹ Front outside to back outside; ² Front outside to back inside; ³ Front inside to back inside; ⁴ Front inside to back outside; ⁵ Under-saddle, Free-jumping.

Table 4.4 (b) Means (\pm SE) of jumping linear measurements representing the stride before the jump: FOBO¹, FOBI², FIBI³, and FIBO⁴ between different heights of free-jumping and between geldings and mares

Effect	Sex:USFJ:Height	Mean (\pm SE)			
		FOBO ¹	FOBI ²	FIBI ³	FIBO ⁴
Height (USFJ) ⁵	FJ:80	299.12 (\pm 12.2004)	206.03 (\pm 5.4485)	143.41 (\pm 4.5451)	221.38 (\pm 10.3766)
	FJ:100	270.90 (\pm 9.4504)	209.92 (\pm 3.8459)	140.93 (\pm 3.2082)	202.41 (\pm 8.0377)
	FJ:120	277.34 (\pm 13.3649)	213.36 (\pm 4.0789)	141.50 (\pm 3.4026)	209.60 (\pm 11.3670)
Height*Sex (USFJ)	Gelding:FJ:80	310.04 (\pm 10.9124) ^a	220.88 (\pm 5.2348) ^a	142.24 (\pm 4.3668) ^{ab}	228.16 (\pm 9.2811) ^a
	Mare:FJ:80	288.20 (\pm 21.8248) ^{abc}	191.18 (\pm 9.5573) ^b	144.59 (\pm 7.9726) ^{ab}	214.59 (\pm 18.5622) ^{abc}
	Gelding:FJ:100	301.10 (\pm 10.9124) ^a	216.91 (\pm 4.9911) ^a	146.07 (\pm 4.1636) ^{ab}	226.64 (\pm 9.2811) ^a
	Mare:FJ:100	240.70 (\pm 15.4325) ^b	202.93 (\pm 5.8526) ^b	135.78 (\pm 4.8822) ^a	178.18 (\pm 13.1255) ^b
	Gelding:FJ:120	320.67 (\pm 15.4325) ^{ac}	224.77 (\pm 5.2348) ^a	149.06 (\pm 4.3668) ^b	241.93 (\pm 13.1255) ^{ac}
	Mare:FJ:120	234.00 (\pm 21.8248) ^b	201.95 (\pm 6.2567) ^b	133.93 (\pm 5.2193) ^a	177.28 (\pm 18.5622) ^b

Means with different superscript letters within a column and within an effect differ significantly ($P \leq 0.05$).

¹ Front outside to back outside; ² Front outside to back inside; ³ Front inside to back inside; ⁴ Front inside to back outside; ⁵ Under-saddle, Free-jumping.

Table 4.5 (a) Means (\pm SE) of jumping linear measurements representing the distance travelled before the jump by each hoof: BLBL¹, BRBR², and FRFR³ within the same height between under-saddle and free-jumping and between geldings and mares

Effect	Sex:USFJ:Height	Mean (\pm SE)		
		BLBL ¹	BRBR ²	FRFR ³
Height (USFJ) ⁴	US:80	270.96 (\pm 8.4559)	277.38 (\pm 10.2594)	284.12 (\pm 11.5576)
	FJ:80	286.13 (\pm 12.6839)	246.01 (\pm 14.0482)	296.01 (\pm 14.9208)
Height (USFJ)	US:100	269.20 (\pm 8.6647)	280.35 (\pm 9.5968)	297.60 (\pm 12.1828)
	FJ:100	254.53 (\pm 9.1465)	264.74 (\pm 10.1303)	315.28 (\pm 18.8735)
Sex	Gelding	260.20 (\pm 5.0204)	273.81 (\pm 6.3692)	290.64 (\pm 9.6313)
	Mare	268.98 (\pm 6.8696)	261.92 (\pm 7.7230)	305.86 (\pm 11.0656)
Height*Sex (USFJ)	Gelding:US:80	255.76 (\pm 10.6960)	285.31 (\pm 14.5089) ^a	258.88 (\pm 18.8735)
	Mare:US:80	286.17 (\pm 13.0998)	269.46 (\pm 14.5089) ^{ab}	309.36 (\pm 13.3456)
	Gelding:FJ:80	281.91 (\pm 11.3448)	246.34 (\pm 12.5651) ^b	289.95 (\pm 13.3456)
	Mare:FJ:80	290.35 (\pm 22.6896)	245.69 (\pm 25.1302) ^{ab}	302.07 (\pm 26.6912)
Height*Sex (USFJ)	Gelding:US:100	268.98 (\pm 11.3448)	262.74 (\pm 12.5651) ^{ab}	282.58 (\pm 15.4102)
	Mare:US:100	269.43 (\pm 13.0998)	297.97 (\pm 14.5089) ^a	302.62 (\pm 18.8735)
	Gelding:FJ:100	256.29 (\pm 11.3448)	291.57 (\pm 12.5651) ^a	321.17 (\pm 26.6912)
	Mare:FJ:100	252.76 (\pm 14.3501)	237.91 (\pm 15.8938) ^b	309.39 (\pm 26.6912)

Means with different superscript letters within a column and within an effect differ significantly ($P \leq 0.05$).

¹ Back left to back left; ² Back right to back right; ³ Front right to front right; ⁴ Under-saddle, Free-jumping.

Table 4.5 (b) Means (\pm SE) of jumping linear measurements representing the distance travelled before the jump by each hoof: BLBL¹, BRBR², and FRFR³ between different heights of free-jumping and between geldings and mares

Effect	Sex:USFJ:Height	Mean (\pm SE)		
		BLBL ¹	BRBR ²	FRFR ³
Height (USFJ) ⁴	FJ:80	286.13 (\pm 12.6839) ^b	246.01 (\pm 14.0482)	296.01 (\pm 14.9208)
	FJ:100	254.53 (\pm 9.1465) ^a	264.74 (\pm 10.1303)	315.28 (\pm 18.8735)
	FJ:120	236.65 (\pm 8.7876) ^a	259.83 (\pm 12.5651)	-
Height*Sex (USFJ)	Gelding:FJ:80	281.91 (\pm 11.3448) ^a	246.34 (\pm 12.5651) ^a	289.95 (\pm 13.3456)
	Mare:FJ:80	290.35 (\pm 22.6896) ^{ac}	245.69 (\pm 25.1302) ^{ab}	302.07 (\pm 26.6912)
	Gelding:FJ:100	256.29 (\pm 11.3448)	291.57 (\pm 12.5651) ^b	321.17 (\pm 26.6912)
	Mare:FJ:100	252.76 (\pm 14.3501)	237.91 (\pm 15.8938) ^a	309.39 (\pm 26.6912)
	Gelding:FJ:120	235.91 (\pm 10.1471) ^b	282.90 (\pm 17.7698) ^{ab}	-
	Mare:FJ:120	237.38 (\pm 14.3501) ^{bc}	236.75 (\pm 17.7698) ^a	-

Means with different superscript letters within a column and within an effect differ significantly ($P \leq 0.05$).

¹ Back left to back left; ² Back right to back right; ³ Front right to front right; ⁴ Under-saddle, Free-jumping.

The means (\pm SE) of the four jumping linear measurements that were taken for the take-off and landing distances of the jump are presented in Table 4.6 (a) and (b). These measurements include take-off distance of the forelimb, take-off distance of the hindlimb, landing distance of the forelimb and landing distance of the hindlimb. These four measurements were related to the distance from the jump to the closest hoof in each section described in the materials and methods chapter in Table 3.3 (b).

An interesting result from Table 4.6 relates to the take-off distance of the hindlimb. This measurement is an important factor in the equine discipline of show jumping as it highly affects how the horse jumps. Shown in Table 4.6 (a) and (b), this measurement had no significant differences between the different heights of free-jumping, between geldings and mares or between under-saddle and free-jumping which was an interesting result to achieve. Since this measurement is so crucial to the success of the jump of a horse it is interesting to note the no significance in means. This suggests that the horse did not change its take-off distance of the hindlimb no matter the circumstances that were explored in this study. Indeed, the rider can adjust the horse's take-off distance when approaching a jump but when looking at these results, when the rider is not specifically in training to extend or shorten the take-off distance, the horse will use its natural instinct to judge the distance. Since there were no significant differences over the different heights of free-jumping, which are presented in Table 4.6 (b), it implies that horses did not adjust their take-off distance based on the height of the jump but instead take off in similar positions.

The take-off distance of the forelimb was the only distance out of the four in this table that differed ($P \leq 0.05$) between geldings and mares with geldings taking-off closer to the jump with a mean of 170.59cm away from the jump compared to mares with a mean of 179.62cm away from the jump. This could be linked back to the overall length of the stride between geldings and mares with the geldings having a longer stride and therefore getting closer to the jump with the extended length in stride. Noting the results over the different heights of free-jumping in Table 4.6 (b), it shows that at 80cm the horses took-off with their forelimb further away ($P \leq 0.05$) than when the horses were jumping 100cm and 120cm. Even though there were no significant differences between the hindlimb take-off distances in free-jumping, there was one for the forelimb take-off distance.

The landing distance of the hindlimb had very few significant differences with the only ones being related to the 100cm height of the jump. Under-saddle, horses landed closer ($P \leq 0.05$) to the jump with their hindlimbs compared to when horses was free-jumping. This statement is true for the geldings which can be seen in the "Height*Sex (USFJ)" interaction at a height of 100cm in Table 4.6 (a). The mares, however, did not differ significantly for this measurement.

Where the hindlimb landing distances differed ($P \leq 0.05$) at the 100cm height, the forelimb landing distances differed ($P \leq 0.05$) at the 80cm height with a free-jumping horse landing further away from the jump compared to when the horse was ridden under-saddle (which is the same trend that was seen in the hindlimb for 100cm). Similar to the landing distance of the hindlimb, the landing distance

of the forelimb also differed ($P \leq 0.05$) for the geldings jumping 100cm free-jumping versus under-saddle. In Table 4.6 (b), it can be seen that the landing distance of the forelimb differed in the mares free-jumping between 80cm and 120cm with the means being 178.17cm and 204.08cm respectively away from the jump.

The means (\pm SE) of the jump distance which was related to the take-off and landing distances mentioned above is presented in Table 4.7 (a) and (b). Within the 80cm height jumps, the jump distance differed ($P \leq 0.05$) when comparing under-saddle versus free-jumping as can be seen from Table 4.7 (a). Horses had a longer jump distance when free-jumping 80cm with a mean of 404.60cm compared to under-saddle with a mean of 349.97cm. In Table 4.7 (b), the jump distance while free jumping was shown to be longer ($P \leq 0.05$) at 120cm compared to 80cm and 100cm.

The means (\pm SE) of the linear and vertical distances between the humeroradial and the metacarpophalangeal joints (HRMCP) are also presented in Table 4.7 (a) and (b). Both the linear and the vertical HRMCP differed ($P \leq 0.05$) when comparing geldings and mares with geldings having a larger value for both the linear and the vertical measurements. The linear HRMCP had a larger ($P \leq 0.05$) value for geldings jumping 80cm under saddle compared to mares free jumping at 80cm. This was the same for the vertical HRMCP at 100cm. It was observed in Table 4.7 (b) that the vertical HRMCP did not differ significantly over the different heights of free-jumping. The linear distance however was larger ($P \leq 0.05$) when a horse was free-jumping 80cm compared to when the horse was free-jumping 120cm. For this linear distance, Table 4.7 (b) showed that mares free-jumping at 120cm had a lower ($P \leq 0.05$) value compared to all other means in that category.

Besides mares free-jumping at 120cm, the linear and vertical HRMCP did not differ significantly over the different heights of free-jumping, indicating that horses did not adjust these measurements over different height of free-jumping but was rather a fixed measurement. In addition, these two measurements were not adjusted between under-saddle and free-jumping explaining even more so that it was a fixed measurement. The main factor that showed to be important with these two variables was the sex of the horse.

Table 4.6 (a) Means (\pm SE) of the take-off and landing distances of the forelimb and hindlimb within the same height between under-saddle and free-jumping and between geldings and mares

Effect	Sex:USFJ:Height	Mean (\pm SE)			
		TO-F ¹	TO-H ²	LD-F ³	LD-H ⁴
Height (USFJ) ⁵	US:80	176.44 (\pm 3.667)	136.33 (\pm 4.4498)	139.65 (\pm 8.4536) ^a	233.91 (\pm 13.7037)
	FJ:80	185.09 (\pm 3.667)	142.91 (\pm 4.4498)	181.88 (\pm 5.6923) ^b	258.82 (\pm 7.0923)
Height (USFJ)	US:100	171.15 (\pm 3.667)	135.37 (\pm 4.4498)	161.54 (\pm 11.1831)	221.33 (\pm 13.7037) ^a
	FJ:100	172.25 (\pm 3.667)	137.35 (\pm 4.4498)	184.46 (\pm 5.5915)	252.83 (\pm 6.9060) ^b
Sex	Gelding	170.59 (\pm 2.117) ^a	137.41 (\pm 2.5691)	169.67 (\pm 4.7075)	235.23 (\pm 7.3616)
	Mare	179.62 (\pm 2.593) ^b	139.33 (\pm 3.1465)	169.15 (\pm 6.1252)	246.81 (\pm 7.4760)
Height*Sex (USFJ)	Gelding:US:80	169.03 (\pm 4.638) ^b	131.99 (\pm 5.6286)	146.14 (\pm 9.2605) ^a	225.61 (\pm 19.3800)
	Mare:US:80	183.86 (\pm 5.680) ^a	140.66 (\pm 6.8936)	133.16 (\pm 14.1456) ^a	242.21 (\pm 19.3800)
	Gelding:FJ:80	177.83 (\pm 4.638) ^{ab}	139.76 (\pm 5.6286)	185.58 (\pm 7.3873) ^b	265.49 (\pm 9.6900)
	Mare:FJ:80	192.35 (\pm 5.680) ^a	146.05 (\pm 6.8936)	178.17 (\pm 8.6624) ^b	252.16 (\pm 10.3590)
Height*Sex (USFJ)	Gelding:US:100	168.61 (\pm 4.638)	138.10 (\pm 5.6286)	154.93 (\pm 14.1456) ^a	205.88 (\pm 19.3800) ^a
	Mare:US:100	173.69 (\pm 5.680)	132.64 (\pm 6.8936)	168.14 (\pm 17.3247) ^{ab}	236.78 (\pm 19.3800) ^{ab}
	Gelding:FJ:100	165.61 (\pm 4.638)	132.19 (\pm 5.6286)	188.19 (\pm 7.0728) ^b	259.86 (\pm 9.1358) ^b
	Mare:FJ:100	178.90 (\pm 5.680)	142.51 (\pm 6.8936)	180.74 (\pm 8.6624) ^{ab}	245.81 (\pm 10.3590) ^{ab}

Means with different superscript letters within a column and within an effect differ significantly ($P \leq 0.05$).

¹ Take-off distance of forelimb; ² Take-off distance of hindlimb; ³ Landing distance of forelimb; ⁴ Landing distance of hindlimb; ⁵ Under-saddle, Free-jumping.

Table 4.6 (b) Means (\pm SE) of the take-off and landing distances of the forelimb and hindlimb between different heights of free-jumping and between geldings and mares

Effect	Sex:USFJ:Height	Mean (\pm SE)			
		TO-F ¹	TO-H ²	LD-F ³	LD-H ⁴
Height (USFJ) ⁵	FJ:80	185.09 (\pm 3.667) ^b	142.91 (\pm 4.4498)	181.88 (\pm 5.6923) ^a	258.82 (\pm 7.0923)
	FJ:100	172.25 (\pm 3.667) ^a	137.35 (\pm 4.4498)	184.46 (\pm 5.5915) ^{ab}	252.83 (\pm 6.9060)
	FJ:120	171.91 (\pm 3.667) ^a	142.41 (\pm 4.4498)	198.36 (\pm 5.5915) ^b	251.59 (\pm 6.9060)
Height*Sex (USFJ)	Gelding:FJ:80	177.83 (\pm 4.638) ^{ab}	139.76 (\pm 5.6286)	185.58 (\pm 7.3873) ^{ab}	265.49 (\pm 9.6900)
	Mare:FJ:80	192.35 (\pm 5.680) ^b	146.05 (\pm 6.8936)	178.17 (\pm 8.6624) ^a	252.16 (\pm 10.3590)
	Gelding:FJ:100	165.61 (\pm 4.638) ^a	132.19 (\pm 5.6286)	188.19 (\pm 7.0728) ^{ab}	259.86 (\pm 9.1358)
	Mare:FJ:100	178.90 (\pm 5.680) ^{ab}	142.51 (\pm 6.8936)	180.74 (\pm 8.6624) ^{ab}	245.81 (\pm 10.3590)
	Gelding:FJ:120	173.65 (\pm 4.638) ^a	147.36 (\pm 5.6286)	192.64 (\pm 7.0728) ^{ab}	238.78 (\pm 9.1358)
	Mare:FJ:120	170.18 (\pm 5.680) ^a	137.45 (\pm 6.8936)	204.08 (\pm 8.6624) ^b	264.40 (\pm 10.3590)

Means with different superscript letters within a column and within an effect differ significantly ($P \leq 0.05$).

¹ Take-off distance of forelimb; ² Take-off distance of hindlimb; ³ Landing distance of forelimb; ⁴ Landing distance of hindlimb; ⁵ Under-saddle, Free-jumping.

Table 4.7 (a) Means (\pm SE) of the jump distance and the linear and vertical distance between the humeroradial and the metacarpophalangeal joints within the same height between under-saddle and free-jumping and between geldings and mares

Effect	Sex:USFJ:Height	Mean (\pm SE)		
		Jump distance	Linear HRMCP ¹	Vertical HRMCP
Height (USFJ) ²	US:80	349.97 (\pm 14.3189) ^a	48.68 (\pm 1.4588)	13.65 (\pm 1.1598)
	FJ:80	404.60 (\pm 9.6417) ^b	44.65 (\pm 1.4588)	12.10 (\pm 1.1598)
Height (USFJ)	US:100	382.60 (\pm 18.9421)	44.62 (\pm 1.4588)	13.69 (\pm 1.1598)
	FJ:100	413.36 (\pm 9.4710)	44.30 (\pm 1.4588)	12.13 (\pm 1.1598)
Sex	Gelding	399.05 (\pm 7.9737)	46.91 (\pm 0.8423) ^a	14.23 (\pm 0.6696) ^a
	Mare	390.70 (\pm 10.3750)	42.84 (\pm 1.0316) ^b	11.41 (\pm 0.8201) ^b
Height*Sex (USFJ)	Gelding:US:80	355.39 (\pm 15.6855) ^a	50.68 (\pm 1.8453) ^a	14.49 (\pm 1.4670)
	Mare:US:80	344.56 (\pm 23.9600) ^a	46.68 (\pm 2.2600) ^{ab}	12.81 (\pm 1.7967)
	Gelding:FJ:80	405.90 (\pm 12.5127) ^b	45.94 (\pm 1.8453) ^{ab}	12.86 (\pm 1.4670)
	Mare:FJ:80	403.30 (\pm 14.6725) ^b	43.37 (\pm 2.2600) ^b	11.35 (\pm 1.7967)
Height*Sex (USFJ)	Gelding:US:100	391.73 (\pm 23.9600)	46.66 (\pm 1.8453)	15.59 (\pm 1.4670) ^a
	Mare:US:100	373.48 (\pm 29.3449)	42.59 (\pm 2.2600)	11.79 (\pm 1.7967) ^{ab}
	Gelding:FJ:100	414.32 (\pm 11.9800)	44.86 (\pm 1.8453)	13.83 (\pm 1.4670) ^{ab}
	Mare:FJ:100	412.40 (\pm 14.6725)	43.73 (\pm 2.2600)	10.43 (\pm 1.7967) ^b

Means with different superscript letters within a column and within an effect differ significantly ($P \leq 0.05$).

¹ Distance between the humeroradial and the metacarpophalangeal joints; ² Under-saddle, Free-jumping.

Table 4.7 (b) Means (\pm SE) of the jump distance and the linear and vertical distance between the humeroradial and the metacarpophalangeal joints between different heights of free-jumping and between geldings and mares

Effect	Sex:USFJ:Height	Mean (\pm SE)		
		Jump distance	Linear HRMCP ¹	Vertical HRMCP
Height (USFJ) ²	FJ:80	404.60 (\pm 9.6417) ^a	44.65 (\pm 1.4588) ^a	12.10 (\pm 1.1598)
	FJ:100	413.36 (\pm 9.4710) ^a	44.30 (\pm 1.4588) ^{ab}	12.13 (\pm 1.1598)
	FJ:120	452.43 (\pm 9.4710) ^b	40.36 (\pm 1.4588) ^b	11.69 (\pm 1.1598)
Height*Sex (USFJ)	Gelding:FJ:80	405.90 (\pm 12.5127) ^a	45.94 (\pm 1.8453) ^a	12.86 (\pm 1.4670)
	Mare:FJ:80	403.30 (\pm 14.6725) ^a	43.37 (\pm 2.2600) ^a	11.35 (\pm 1.7967)
	Gelding:FJ:100	414.32 (\pm 11.9800) ^{ac}	44.86 (\pm 1.8453) ^a	13.83 (\pm 1.4670)
	Mare:FJ:100	412.40 (\pm 14.6725) ^{ac}	43.73 (\pm 2.2600) ^a	10.43 (\pm 1.7967)
	Gelding:FJ:120	453.40 (\pm 11.9800) ^b	44.68 (\pm 1.8453) ^a	13.57 (\pm 1.4670)
	Mare:FJ:120	451.45 (\pm 14.6725) ^{bc}	36.05 (\pm 2.2600) ^b	9.81 (\pm 1.7967)

Means with different superscript letters within a column and within an effect differ significantly ($P \leq 0.05$).

¹ Distance between the humeroradial and the metacarpophalangeal joints; ² Under-saddle, Free-jumping.

The means (\pm SE) of the height above the jump that each limb reached are presented in Table 4.8 (a) and (b). These measurements include the right forelimb height, left forelimb height, right hindlimb height and left hindlimb height above the jump. In both sections of this table (a and b), a number of significant differences were observed within the different sections.

The means between the sexes (geldings and mares) only differed ($P \leq 0.05$) for the height that the back legs were lifted above the jump. Shown in Table 4.8 (a), mares lifted their back legs up higher ($P \leq 0.05$) than geldings. For the height that the right hindlimb was lifted above the jump, the mares and geldings means were 30.87cm and 25.22cm respectively and for the height that the left hindlimb was lifted above the jump, the mares and geldings means were 31.02cm and 24.95cm respectively.

For all four of the horses' limbs, there was a difference ($P \leq 0.05$) between the mean height that the limb was lifted above the jump when the horse was under-saddle and when the horse was free-jumping at 80cm and at 100cm with all of these means being larger ($P \leq 0.05$) when the horse was free-jumping compared to when the horse was under-saddle. These results indicate that horses lifted their legs higher when they were free-jumping when they did not have the influence of a rider.

Since free-jumping had a large influence on the height that the limbs were lifted above the jump (mentioned above), the results within free-jumping also made for an interesting comparison as shown in Table 4.8 (b). When horses were free-jumping 80cm, they lifted their limbs higher ($P \leq 0.05$) than when they were free-jumping 100 or 120cm for all variables in this category. The reason for this could be that the 80cm was too low for the natural jump of the horses and that they did not lower completely to the level of the jump. These measurements are important in show jumping as it determines whether the horse will clear the jump or not.

The means (\pm SE) of the elevation of the head, the elevation of the withers and the elevation of the croup are presented in Table 4.9 (a) and (b). For both the elevation of the head and the elevation of the withers, there was a difference ($P \leq 0.05$) between the sexes where geldings elevated their head and withers higher than mares as shown in Table 4.9 (a). The means of the geldings and mares elevation of the head was 118.66cm and 112.51cm respectively while the means of the geldings and mares elevation of the withers was 119.37cm and 113.72cm respectively. The elevation of the croup did not differ significantly between the two sexes. Analysing the results of the 80cm height in Table 4.9 (a), the means of the elevation of the withers and the croup differed between under-saddle and free-jumping. For both of these variables, the horse elevated their withers and croup higher while free-jumping (124.75cm and 123.61cm respectively) compared to when they were being ridden under-saddle (118.63cm and 116.10cm respectively).

Over the different heights of free-jumping observed in Table 4.9 (b), horses jumping 80cm elevated their head, withers and croup higher ($P \leq 0.05$) than when horses were jumping 100cm or 120cm. Similar to what was observed in Table 4.8 (b), this could be due to the 80cm jump being too low for the natural jump of the horses and that they did not lower completely to the level of the jump.

Table 4.8 (a) Means (\pm SE) of the height above the jump each limb (right forelimb, left forelimb, right hindlimb, and left hindlimb) is lifted within the same height between under-saddle and free-jumping and between geldings and mares

Effect	Sex:USFJ:Height	Mean (\pm SE)			
		RF ¹ height	LF ² height	RH ³ height	LH ⁴ height
Height (USFJ) ⁵	US:80	22.92 (\pm 1.7066) ^a	23.22 (\pm 1.6276) ^a	20.13 (\pm 2.1797) ^a	20.20 (\pm 2.1160) ^a
	FJ:80	36.91 (\pm 1.7066) ^b	35.41 (\pm 1.6276) ^b	44.37 (\pm 2.1797) ^b	44.07 (\pm 2.1160) ^b
Height (USFJ)	US:100	18.51 (\pm 1.7066) ^a	19.34 (\pm 1.6276) ^a	21.22 (\pm 2.1797) ^a	21.04 (\pm 2.1160) ^a
	FJ:100	25.89 (\pm 1.7066) ^b	27.40 (\pm 1.6276) ^b	31.32 (\pm 2.1797) ^b	31.33 (\pm 2.1160) ^b
Sex	Gelding	25.92 (\pm 0.9853)	26.49 (\pm 0.9397)	25.22 (\pm 1.2584) ^a	24.95 (\pm 1.2217) ^a
	Mare	23.53 (\pm 1.2068)	23.66 (\pm 1.1509)	30.87 (\pm 1.5413) ^b	31.02 (\pm 1.4962) ^b
Height*Sex (USFJ)	Gelding:US:80	25.72 (\pm 2.1587) ^a	25.21 (\pm 2.0587) ^a	16.26 (\pm 2.7571) ^a	16.40 (\pm 2.6765) ^a
	Mare:US:80	20.13 (\pm 2.6439) ^a	21.23 (\pm 2.5214) ^a	24.00 (\pm 3.3768) ^a	24.00 (\pm 3.2781) ^a
	Gelding:FJ:80	36.04 (\pm 2.1587) ^b	35.86 (\pm 2.0587) ^b	41.01 (\pm 2.7571) ^b	40.41 (\pm 2.6765) ^b
	Mare:FJ:80	37.78 (\pm 2.6439) ^b	34.97 (\pm 2.5214) ^b	47.74 (\pm 3.3768) ^b	47.74 (\pm 3.2781) ^b
Height*Sex (USFJ)	Gelding:US:100	20.90 (\pm 2.1587) ^{ab}	21.65 (\pm 2.0587) ^{ac}	20.84 (\pm 2.7571) ^a	20.49 (\pm 2.6765) ^a
	Mare:US:100	16.13 (\pm 2.6439) ^b	17.04 (\pm 2.5214) ^a	21.60 (\pm 3.3768) ^a	21.60 (\pm 3.2781) ^{ac}
	Gelding:FJ:100	24.45 (\pm 2.1587) ^a	26.61 (\pm 2.0587) ^{bc}	28.25 (\pm 2.7571) ^{ab}	27.39 (\pm 2.6765) ^{bc}
	Mare:FJ:100	27.33 (\pm 2.6439) ^a	28.19 (\pm 2.5214) ^b	34.39 (\pm 3.3768) ^b	35.28 (\pm 3.2781) ^b

Means with different superscript letters within a column and within an effect differ significantly ($P \leq 0.05$).

¹ Right forelimb; ² Left forelimb; ³ Right hindlimb; ⁴ Left hindlimb; ⁵ Under-saddle, Free-jumping.

Table 4.8 (b) Means (\pm SE) of the height above the jump each limb (right forelimb, left forelimb, right hindlimb, and left hindlimb) is lifted between different heights of free-jumping and between geldings and mares

Effect	Sex:USFJ:Height	Mean (\pm SE)			
		RF ¹ height	LF ² height	RH ³ height	LH ⁴ height
Height (USFJ) ⁵	FJ:80	36.91 (\pm 1.7066) ^b	35.41 (\pm 1.6276) ^b	44.37 (\pm 2.1797) ^b	44.07 (\pm 2.1160) ^b
	FJ:100	25.89 (\pm 1.7066) ^a	27.40 (\pm 1.6276) ^a	31.32 (\pm 2.1797) ^a	31.33 (\pm 2.1160) ^a
	FJ:120	23.40 (\pm 1.7066) ^a	23.78 (\pm 1.6276) ^a	30.56 (\pm 2.1797) ^a	30.63 (\pm 2.1160) ^a
Height*Sex (USFJ)	Gelding:FJ:80	36.04 (\pm 2.1587) ^a	35.86 (\pm 2.0587) ^a	41.01 (\pm 2.7571) ^{ac}	40.41 (\pm 2.6765) ^{ad}
	Mare:FJ:80	37.78 (\pm 2.6439) ^a	34.97 (\pm 2.5214) ^{ac}	47.74 (\pm 3.3768) ^a	47.74 (\pm 3.2781) ^a
	Gelding:FJ:100	24.45 (\pm 2.1587) ^b	26.61 (\pm 2.0587) ^b	28.25 (\pm 2.7571) ^b	27.39 (\pm 2.6765) ^{bc}
	Mare:FJ:100	27.33 (\pm 2.6439) ^b	28.19 (\pm 2.5214) ^{bc}	34.39 (\pm 3.3768) ^{bc}	35.28 (\pm 3.2781) ^{cd}
	Gelding:FJ:120	25.11 (\pm 2.1587) ^b	26.19 (\pm 2.0587) ^b	26.44 (\pm 2.7571) ^b	26.59 (\pm 2.6765) ^b
	Mare:FJ:120	21.68 (\pm 2.6439) ^b	21.37 (\pm 2.5214) ^b	34.67 (\pm 3.3768) ^{bc}	34.67 (\pm 3.2781) ^{bcd}

Means with different superscript letters within a column and within an effect differ significantly ($P \leq 0.05$).

¹ Right forelimb; ² Left forelimb; ³ Right hindlimb; ⁴ Left hindlimb; ⁵ Under-saddle, Free-jumping.

Table 4.9 (a) Means (\pm SE) of the elevation of the head, withers and croup within the same height between under-saddle and free-jumping and between geldings and mares

Effect	Sex:USFJ:Height	Mean (\pm SE)		
		Elevation of head	Elevation of withers	Elevation of croup
Height (USFJ) ¹	US:80	123.78 (\pm 3.0409)	118.63 (\pm 1.9758) ^a	116.10 (\pm 1.8103) ^a
	FJ:80	119.94 (\pm 3.0409)	124.75 (\pm 1.9758) ^b	123.61 (\pm 1.8103) ^b
Height (USFJ)	US:100	116.25 (\pm 3.0409)	113.90 (\pm 1.9758)	109.99 (\pm 1.8103)
	FJ:100	109.47 (\pm 3.0409)	114.35 (\pm 1.9758)	112.16 (\pm 1.8103)
Sex	Gelding	118.66 (\pm 1.7556) ^a	119.37 (\pm 1.1407) ^a	114.96 (\pm 1.0452)
	Mare	112.51 (\pm 2.1502) ^b	113.72 (\pm 1.3971) ^b	112.80 (\pm 1.2800)
Height*Sex (USFJ)	Gelding:US:80	126.85 (\pm 3.8464)	121.42 (\pm 2.4992) ^{ab}	117.07 (\pm 2.2898) ^{ac}
	Mare:US:80	120.72 (\pm 4.7109)	115.84 (\pm 3.0609) ^a	115.14 (\pm 2.8044) ^a
	Gelding:FJ:80	121.33 (\pm 3.8464)	126.74 (\pm 2.4992) ^b	123.92 (\pm 2.2898) ^b
	Mare:FJ:80	118.55 (\pm 4.7109)	122.75 (\pm 3.0609) ^{ab}	123.30 (\pm 2.8044) ^{bc}
Height*Sex (USFJ)	Gelding:US:100	120.19 (\pm 3.8464)	117.52 (\pm 2.4992)	111.64 (\pm 2.2898)
	Mare:US:100	112.30 (\pm 4.7109)	110.27 (\pm 3.0609)	108.35 (\pm 2.8044)
	Gelding:FJ:100	109.68 (\pm 3.8464)	115.64 (\pm 2.4992)	112.13 (\pm 2.2898)
	Mare:FJ:100	109.27 (\pm 4.7109)	113.07 (\pm 3.0609)	112.18 (\pm 2.8044)

Means with different superscript letters within a column and within an effect differ significantly ($P \leq 0.05$).

¹ Under-saddle, Free-jumping.

Table 4.9 (b) Means (\pm SE) of the elevation of the head, withers and croup between different heights of free-jumping and between geldings and mares

Effect	Sex:USFJ:Height	Mean (\pm SE)		
		Elevation of head	Elevation of withers	Elevation of croup
Height (USFJ) ¹	FJ:80	119.94 (\pm 3.0409) ^b	124.75 (\pm 1.9758) ^b	123.61 (\pm 1.8103) ^b
	FJ:100	109.47 (\pm 3.0409) ^a	114.35 (\pm 1.9758) ^a	112.16 (\pm 1.8103) ^a
	FJ:120	104.06 (\pm 3.0409) ^a	111.39 (\pm 1.9758) ^a	108.38 (\pm 1.8103) ^a
Height*Sex (USFJ)	Gelding:FJ:80	121.33 (\pm 3.8464) ^a	126.74 (\pm 2.4992) ^a	123.92 (\pm 2.2898) ^a
	Mare:FJ:80	118.55 (\pm 4.7109) ^a	122.75 (\pm 3.0609) ^{ad}	123.30 (\pm 2.8044) ^a
	Gelding:FJ:100	109.68 (\pm 3.8464) ^{bc}	115.64 (\pm 2.4992) ^{bd}	112.13 (\pm 2.2898) ^b
	Mare:FJ:100	109.27 (\pm 4.7109) ^{abc}	113.07 (\pm 3.0609) ^{bc}	112.18 (\pm 2.8044) ^b
	Gelding:FJ:120	110.40 (\pm 3.8464) ^b	115.42 (\pm 2.4992) ^{bd}	110.66 (\pm 2.2898) ^b
	Mare:FJ:120	97.73 (\pm 4.7109) ^c	107.36 (\pm 3.0609) ^c	106.09 (\pm 2.8044) ^b

Means with different superscript letters within a column and within an effect differ significantly ($P \leq 0.05$).

¹ Under-saddle, Free-jumping.

The means (\pm SE) of the middle head angle, above head angle, middle femorotibial angle, and the above femorotibial angle are presented in Table 4.10 (a) and (b). For both the heights of 80cm and 100cm, there was a difference ($P \leq 0.05$) between the means of under-saddle and the means of free-jumping for all four of these jumping angular measurements. Shown in Table 4.10 (a), horses free-jumping at 80cm and 100cm had larger ($P \leq 0.05$) head angles than horses jumping under-saddle, while horses free-jumping at 80cm and 100cm had smaller ($P \leq 0.05$) femorotibial angles than horses jumping under saddle. For the two head angles, the reason for the larger angle while free-jumping could be due to the lack of a bridle as when the horse was being ridden under-saddle the rider held the reins which could result in a smaller head angle of the horse while jumping.

The sex of the horse only had an influence on the femorotibial angle when the hindlimbs were above the jump with geldings having a larger ($P \leq 0.05$) angle than mares (33.56° and 30.30° respectively).

In the free-jumping heights seen in Table 4.10 (b), neither of the two head angles, nor the middle femorotibial angle differed significantly over the different heights. The above femorotibial angle differed ($P \leq 0.05$) between the 80cm and 120cm height and between the 100cm and 120cm height. The above femorotibial angle had a smaller ($P \leq 0.05$) angle for the 120cm height compared to the 80cm and 100cm jump height demonstrating that at the higher height, the horse lifted their legs higher above the ground creating a smaller angle.

The means (\pm SE) of the forelimb angle at three different times within the jump are presented in Table 4.11 (a) and (b). As can be seen from both parts of this table, there was hardly any significance for these angles. The only significant values were at 100cm comparing geldings and mares as well as under saddle and free jumping. Geldings jumping 100cm under-saddle had a larger ($P \leq 0.05$) angle (93.50°) than mares jumping 100cm under-saddle (88.74°) and geldings free-jumping 100cm (88.43°). Since there were hardly any significant differences for these angles, it can be concluded that the horses did not change this angle no matter the height of the jump or whether there was a rider present or not. This indicates that this angle is a fixed characteristic unlike so many others where the horse adjusts their traits based on heights and riders. This shows high importance for this characteristic as these angles could be used to predict jumping performance.

The means (\pm SE) of the jump angle at take-off and the time airborne are presented in Table 4.12 (a) and (b). As can be seen from the first part of this table, the jump angle at take-off did not differ significantly within the same heights between under-saddle and free-jumping or between mares and geldings. Analysing the results from the second part of the table (Table 4.12 (b)), the jump angle at take-off was larger ($P \leq 0.05$) when the horse was free-jumping at 120cm compared to when the horse was free-jumping 80cm or 100cm. At this higher jump height, the horse needed to take-off at a larger angle in order to clear the jump.

The time that the horse was airborne differed ($P \leq 0.05$) between mares and geldings with mares being in the air for a shorter amount of time (0.3862 seconds) compared to geldings (0.4290 seconds) as can be seen in Table 4.12 (a). This jumping trait also differed ($P \leq 0.05$) between under-saddle and free-jumping at 80cm. Horses were in the air longer ($P \leq 0.05$) when free-jumping 80cm compared to when they were being ridden under-saddle at 80cm. This could be explained by the results shown in Table 4.7 (a) where the jump distance differed ($P \leq 0.05$) between horses free-jumping at 80cm and when jumping under-saddle at 80cm. Since horses had a longer ($P \leq 0.05$) jump distance when free-jumping (as shown in Table 4.7) it could result in them being in the air for longer which can be seen in Table 4.12 (a).

Table 4.10 (a) Means (\pm SE) of the middle and above head angles and the middle and above femorotibial angles while jumping within the same height between under-saddle and free-jumping and between geldings and mares

Effect	Sex:USFJ:Height	Mean (\pm SE)			
		Middle head angle	Above head angle	Middle femorotibial angle	Above femorotibial angle
Height (USFJ) ¹	US:80	102.22 (\pm 1.9888) ^a	94.27 (\pm 1.7386) ^a	62.45 (\pm 2.0417) ^a	39.19 (\pm 1.5402) ^a
	FJ:80	115.96 (\pm 1.9087) ^b	105.70 (\pm 1.7386) ^b	47.38 (\pm 2.0417) ^b	28.98 (\pm 1.5402) ^b
Height (USFJ)	US:100	103.76 (\pm 2.1223) ^a	96.01 (\pm 1.7386) ^a	57.25 (\pm 2.0417) ^a	33.81 (\pm 1.5402) ^a
	FJ:100	116.55 (\pm 1.9087) ^b	108.37 (\pm 1.7386) ^b	46.35 (\pm 2.0417) ^b	28.92 (\pm 1.5402) ^b
Sex	Gelding	110.17 (\pm 1.1169)	101.88 (\pm 1.0038)	53.18 (\pm 1.1788)	33.56 (\pm 0.8892) ^a
	Mare	109.48 (\pm 1.4428)	101.38 (\pm 1.2294)	50.42 (\pm 1.4437)	30.30 (\pm 1.0891) ^b
Height*Sex (USFJ)	Gelding:US:80	102.49 (\pm 2.4143) ^{ac}	94.85 (\pm 2.1991) ^a	65.99 (\pm 2.5825) ^a	42.88 (\pm 1.9482) ^a
	Mare:US:80	101.94 (\pm 3.1611) ^a	93.68 (\pm 2.6934) ^a	58.90 (\pm 3.1630) ^a	35.49 (\pm 2.3860) ^b
	Gelding:FJ:80	118.08 (\pm 2.4143) ^b	106.18 (\pm 2.1991) ^b	49.84 (\pm 2.5825) ^b	31.66 (\pm 1.9482) ^{bc}
	Mare:FJ:80	113.84 (\pm 2.9569) ^{bc}	105.21 (\pm 2.6934) ^b	44.92 (\pm 3.1630) ^b	26.31 (\pm 2.3860) ^c
Height*Sex (USFJ)	Gelding:US:100	104.07 (\pm 2.5217) ^a	96.04 (\pm 2.1991) ^a	56.20 (\pm 2.5825) ^{ac}	33.81 (\pm 1.9482) ^a
	Mare:US:100	103.46 (\pm 3.4143) ^a	95.98 (\pm 2.6934) ^{ac}	58.31 (\pm 3.1630) ^a	33.80 (\pm 2.3860) ^a
	Gelding:FJ:100	116.63 (\pm 2.4143) ^b	108.85 (\pm 2.1991) ^{bc}	49.46 (\pm 2.5825) ^{bc}	30.58 (\pm 1.9482) ^{ab}
	Mare:FJ:100	116.46 (\pm 2.9569) ^b	107.88 (\pm 2.6934) ^b	43.24 (\pm 3.1630) ^b	27.26 (\pm 2.3860) ^b

Means with different superscript letters within a column and within an effect differ significantly ($P \leq 0.05$).

¹ Under-saddle, Free-jumping.

Table 4.10 (b) Means (\pm SE) of the middle and above head angles and the middle and above femorotibial angles while jumping between different heights of free-jumping and between geldings and mares

Effect	Sex:USFJ:Height	Mean (\pm SE)			
		Middle head angle	Above head angle	Middle femorotibial angle	Above femorotibial angle
Height (USFJ) ¹	FJ:80	115.96 (\pm 1.9087)	105.70 (\pm 1.7386)	47.38 (\pm 2.0417)	28.98 (\pm 1.5402) ^a
	FJ:100	116.55 (\pm 1.9087)	108.37 (\pm 1.7386)	46.35 (\pm 2.0417)	28.92 (\pm 1.5402) ^a
	FJ:120	117.45 (\pm 1.9087)	110.31 (\pm 1.7386)	37.53 (\pm 2.0417)	24.17 (\pm 1.5402) ^b
Height*Sex (USFJ)	Gelding:FJ:80	118.08 (\pm 2.4143)	106.18 (\pm 2.1991)	49.84 (\pm 2.5825) ^a	31.66 (\pm 1.9482) ^a
	Mare:FJ:80	113.84 (\pm 2.9569)	105.21 (\pm 2.6934)	44.92 (\pm 3.1630) ^{ac}	26.31 (\pm 2.3860) ^{ab}
	Gelding:FJ:100	116.63 (\pm 2.4143)	108.85 (\pm 2.1991)	49.46 (\pm 2.5825) ^a	30.58 (\pm 1.9482) ^a
	Mare:FJ:100	116.46 (\pm 2.9569)	107.88 (\pm 2.6934)	43.24 (\pm 3.1630) ^{abc}	27.26 (\pm 2.3860) ^{ab}
	Gelding:FJ:120	116.45 (\pm 2.4143)	109.91 (\pm 2.1991)	36.50 (\pm 2.5825) ^b	24.05 (\pm 1.9482) ^b
	Mare:FJ:120	118.46 (\pm 2.9569)	110.70 (\pm 2.6934)	38.55 (\pm 3.1630) ^{bc}	24.30 (\pm 2.3860) ^b

Means with different superscript letters within a column and within an effect differ significantly ($P \leq 0.05$).

¹ Under-saddle, Free-jumping.

Table 4.11 (a) Means (\pm SE) of the forelimb angle at three different times within the same height between under-saddle and free-jumping and between geldings and mares

Effect	Sex:USFJ:Height	Mean (\pm SE)		
		Forelimb angle one	Forelimb angle two	Forelimb angle three
Height (USFJ) ¹	US:80	79.76 (\pm 1.6464)	83.90 (\pm 1.4047)	90.54 (\pm 0.9867)
	FJ:80	81.58 (\pm 1.6464)	85.15 (\pm 1.4047)	89.54 (\pm 0.9867)
Height (USFJ)	US:100	81.59 (\pm 1.6464)	85.09 (\pm 1.4047)	91.12 (\pm 0.9867)
	FJ:100	81.90 (\pm 1.6464)	85.88 (\pm 1.4047)	89.35 (\pm 0.9867)
Sex	Gelding	81.27 (\pm 0.9506)	85.93 (\pm 0.8110)	90.51 (\pm 0.5697)
	Mare	80.68 (\pm 1.1642)	83.86 (\pm 0.9933)	89.31 (\pm 0.6977)
Height*Sex (USFJ)	Gelding:US:80	80.05 (\pm 2.0826)	84.62 (\pm 1.7769)	91.50 (\pm 1.2481)
	Mare:US:80	79.47 (\pm 2.5506)	83.17 (\pm 2.1762)	89.59 (\pm 1.5286)
	Gelding:FJ:80	82.49 (\pm 2.0826)	86.50 (\pm 1.7769)	89.87 (\pm 1.2481)
	Mare:FJ:80	80.68 (\pm 2.5506)	83.81 (\pm 2.1762)	89.21 (\pm 1.5286)
Height*Sex (USFJ)	Gelding:US:100	82.79 (\pm 2.0826)	87.34 (\pm 1.7769)	93.50 (\pm 1.2481) ^b
	Mare:US:100	80.39 (\pm 2.5506)	82.84 (\pm 2.1762)	88.74 (\pm 1.5286) ^a
	Gelding:FJ:100	81.93 (\pm 2.0826)	87.44 (\pm 1.7769)	88.43 (\pm 1.2481) ^a
	Mare:FJ:100	81.88 (\pm 2.5506)	84.33 (\pm 2.1762)	90.28 (\pm 1.5286) ^{ab}

Means with different superscript letters within a column and within an effect differ significantly ($P \leq 0.05$).

¹ Under-saddle, Free-jumping.

Table 4.11 (b) Means (\pm SE) of the forelimb angle at three different times within the jump between different heights of free-jumping and between geldings and mares

Effect	Sex:USFJ:Height	Mean (\pm SE)		
		Forelimb angle one	Forelimb angle two	Forelimb angle three
Height (USFJ) ¹	FJ:80	81.58 (\pm 1.6464)	85.15 (\pm 1.4047)	89.54 (\pm 0.9867)
	FJ:100	81.90 (\pm 1.6464)	85.88 (\pm 1.4047)	89.35 (\pm 0.9867)
	FJ:120	80.33 (\pm 1.6464)	84.85 (\pm 1.4047)	88.08 (\pm 0.9867)
Height*Sex (USFJ)	Gelding:FJ:80	82.49 (\pm 2.0826)	86.50 (\pm 1.7769)	89.87 (\pm 1.2481)
	Mare:FJ:80	80.68 (\pm 2.5506)	83.81 (\pm 2.1762)	89.21 (\pm 1.5286)
	Gelding:FJ:100	81.93 (\pm 2.0826)	87.44 (\pm 1.7769)	88.43 (\pm 1.2481)
	Mare:FJ:100	81.88 (\pm 2.5506)	84.33 (\pm 2.1762)	90.28 (\pm 1.5286)
	Gelding:FJ:120	78.94 (\pm 2.0826)	83.69 (\pm 1.7769)	87.25 (\pm 1.2481)
	Mare:FJ:120	81.73 (\pm 2.5506)	86.01 (\pm 2.1762)	88.90 (\pm 1.5286)

Means with different superscript letters within a column and within an effect differ significantly ($P \leq 0.05$).

¹ Under-saddle, Free-jumping.

Table 4.12 (a) Means (\pm SE) of the jump angle at take-off and the time airborne within the same height between under-saddle and free-jumping and between geldings and mares

Effect	Sex:USFJ:Height	Mean (\pm SE)	
		Jump angle at take-off	Time airborne
Height (USFJ) ¹	US:80	45.84 (\pm 0.7126)	0.3271 (\pm 0.01973) ^a
	FJ:80	45.62 (\pm 0.7126)	0.3972 (\pm 0.01329) ^b
Height (USFJ)	US:100	47.16 (\pm 0.7126)	0.4105 (\pm 0.02610)
	FJ:100	46.10 (\pm 0.7126)	0.4315 (\pm 0.01305)
Sex	Gelding	46.60 (\pm 0.4114)	0.4290 (\pm 0.01099) ^a
	Mare	46.66 (\pm 0.5039)	0.3862 (\pm 0.01430) ^b
Height*Sex (USFJ)	Gelding:US:80	46.15 (\pm 0.9014)	0.3619 (\pm 0.02161) ^{ab}
	Mare:US:80	45.53 (\pm 1.1040)	0.2923 (\pm 0.03302) ^b
	Gelding:FJ:80	44.75 (\pm 0.9014)	0.3982 (\pm 0.01724) ^a
	Mare:FJ:80	46.49 (\pm 1.1040)	0.3963 (\pm 0.02022) ^a
Height*Sex (USFJ)	Gelding:US:100	47.79 (\pm 0.9014)	0.4510 (\pm 0.03302)
	Mare:US:100	46.54 (\pm 1.1040)	0.3700 (\pm 0.04044)
	Gelding:FJ:100	45.37 (\pm 0.9014)	0.4306 (\pm 0.01651)
	Mare:FJ:100	46.83 (\pm 1.1040)	0.4325 (\pm 0.02022)

Means with different superscript letters within a column and within an effect differ significantly ($P \leq 0.05$).

¹ Under-saddle, Free-jumping.

Table 4.12 (b) Means (\pm SE) of the jump angle at take-off and the time airborne between different heights of free-jumping and between geldings and mares

Effect	Sex:USFJ:Height	Mean (\pm SE)	
		Jump angle at take-off	Time airborne
Height (USFJ) ¹	FJ:80	45.62 (\pm 0.7126) ^a	0.3972 (\pm 0.01329) ^a
	FJ:100	46.10 (\pm 0.7126) ^a	0.4315 (\pm 0.01305) ^a
	FJ:120	48.56 (\pm 0.7126) ^b	0.5103 (\pm 0.01305) ^b
Height*Sex (USFJ)	Gelding:FJ:80	44.75 (\pm 0.9014) ^a	0.3982 (\pm 0.01724) ^a
	Mare:FJ:80	46.49 (\pm 1.1040) ^{ab}	0.3963 (\pm 0.02022) ^a
	Gelding:FJ:100	45.37 (\pm 0.9014) ^a	0.4306 (\pm 0.01651) ^a
	Mare:FJ:100	46.83 (\pm 1.1040) ^{ab}	0.4325 (\pm 0.02022) ^a
	Gelding:FJ:120	48.58 (\pm 0.9014) ^b	0.5257 (\pm 0.01651) ^b
	Mare:FJ:120	48.53 (\pm 1.1040) ^b	0.4949 (\pm 0.02022) ^b

Means with different superscript letters within a column and within an effect differ significantly ($P \leq 0.05$).

¹ Under-saddle, Free-jumping.

4.4 Jumping versus stationary measurements

The GLM stepwise regression procedures were used to determine the models that could best predict the dependent variables of this section using the stationary measurements. By dividing the dependent variables into similar categories that were studied in the previous section of this chapter, the equations for the variables were analysed and are shown in the tables below (Table 4.13 to Table 4.42). The equations between the two variables were either not significant (NS; Not Significant) or the equations between the two variables was significant, the significance is indicated ($P \leq 0.05$) in the table.

The first category in this section are the four jumping linear measurements that were taken to represent the final stride before the jump. Table 4.13 (a) and (b) present the predictive models for the FOBO stride distance at 80cm and 100cm respectively. The stationary measurements did not influence any of the jumping measurements of the geldings and mares free-jumping at 120cm. Table 4.14 (a), (b) and (c) present the predictive models for the FOBI stride distance at 80cm, 100cm and 120cm respectively. Table 4.15 (a), (b) and (c) present the predictive models for the FIBI stride distance at 80cm, 100cm and 120cm respectively. Table 4.16 presents the predictive models for the FIBO stride distance at 100cm. There was no significant prediction for this jumping measurement at 80cm or 120cm.

Analysing the predictive models for the 80cm height for all these jumping measurements in this category, these tables show that the X-ray stifle angle could predict ($P \leq 0.05$) three out of the four stride measurements for geldings being ridden under-saddle (with the FIBO stride not having a significant equation for the X-ray stifle angle at 80cm for geldings under-saddle). Therefore, the best way to predict these stride measurements if geldings jump 80cm while being ridden was to use the X-ray stifle angle.

Analysing the predictive models for the 100cm jump height for these jumping measurements in this category, these stride measurements were influenced by the stationary perimeter measurements as the regression with the head-neck perimeter and chest girth significantly predicted ($P \leq 0.05$) the FOBO measurement, the regression with the chest girth predicted ($P \leq 0.05$) the FIBI measurement, and the regression with the head-neck perimeter and chest girth predicted ($P \leq 0.05$) the FIBO measurement. These same three jumping measurements (FOBO, FIBI and FIBO) yielded significant equations ($P \leq 0.05$) for the X-ray hindlimb hoof angle for geldings free-jumping at 100cm.

The stationary measurement that had the highest significance ($P \leq 0.05$) overall to these final stride measurements was the shoulder angle. Referring back to Table 4.4, we can see that all four of these stride measurements did not have significant differences in means when increasing in height of the jump while free-jumping. Because of this, the equations for each stride measurement could be used within the different heights. In Table 4.4, it was shown that the FIBI stride was highly influenced by the rider as there were differences ($P \leq 0.05$) between the under-saddle and free-jumping measurements. Therefore, in order to get accurate measurements from the equations, one must separate the free-jumping and under-saddle equations completely.

The next category in this section are the four jumping linear measurements that were taken to represent the distance travelled by each hoof before the jump. Table 4.17 (a), (b) and (c) present the predictive models for the BLBL hoof distance at 80cm, 100cm and 120cm respectively. Table 4.18 (a), (b) and (c) present the predictive models for the BRBR hoof distance at 80cm, 100cm and 120cm respectively. Table 4.19 presents the predictive models for the FRFR hoof distance at 80cm. There were no significant predictive equations for the FRFR hoof distance at 100cm or 120cm. The FLFL hoof showed no significant equations with stationary measurements for any of the heights that were measured. This could be due to the few data points that were obtained for this jumping measurement.

The hoof distance for geldings free-jumping at 80cm was influenced by the head-neck perimeter and the X-ray hock angle as both the BRBR hoof distance and the FRFR hoof distance had significant equations ($P \leq 0.05$) for these two stationary measurements. The wither height influenced mares under-saddle at 100cm as both the BLBL and the BRBR hoof distances had significant equations ($P \leq 0.05$) for this stationary measurement. The X-ray hock angle also influenced the 120cm height as the BLBL hoof distance of geldings and the BRBR hoof distance of mares was influenced by this stationary measurement. Within the BLBL distance, the wither height was the most accurate measurement for mares under-saddle at 80cm, mares under-saddle at 100cm and geldings free-jumping at 120cm as all had significant equations ($P \leq 0.05$). For mares under-saddle at 80cm the equation for the BLBL hoof with the independent variable being wither height is as follows:

$$y = -0,6649x^2 + 214,0364x - 16912,6059$$

While mares under-saddle at 100cm for the same measurements, the equation is as follows:

$$y = 0,4598x^2 - 142,2159x + 11226,5497$$

For mares under-saddle, this shows that the wither height was the most important measurement to use.

Within the BRBR distance, the X-ray hock angle was the most accurate measurement because geldings free-jumping at 80cm, geldings free-jumping at 100cm and mares free-jumping at 120cm all had significant equations ($P \leq 0.05$).

Based on the equations presented in these tables, the most important stationary measurement when measuring these hoof distances was the X-ray hock angle as this was the stationary measurement that had the most significant equations ($P \leq 0.05$) across different regression equations.

Table 4.13 (a) Predictive regression models for the dependent variable: front outside to back outside stride distance at 80cm

Stationary Measurement	Gelding		Mare	
	Under-saddle	Free-jumping	Under-saddle	Free-jumping
Age	NS	NS	NS	NS
Weight	NS	NS	NS	NS
Head length	NS	NS	NS	NS
Neck length	NS	NS	NS	NS
Croup length	NS	NS	NS	NS
Wither height	NS	NS	NS	NS
Croup height	NS	NS	NS	NS
Head-neck perimeter	NS	NS	NS	NS
Neck-body perimeter	NS	NS	NS	NS
Chest girth	NS	NS	NS	NS
Femur length	NS	NS	NS	NS
Body length	NS	NS	NS	NS
Shoulder angle	NS	NS	NS	NS
Hoof angle	NS	NS	NS	NS
Hip joint angle	NS	$y = 8,9879x - 393,9361$	NS	NS
Hock Joint angle	NS	NS	$y = 3,7951x^2 - 1187,4421x + 93160,9243$	NS
X-Ray forelimb fetlock angle	NS	NS	NS	NS
X-Ray forelimb hoof angle	NS	NS	NS	NS
X-Ray hindlimb fetlock angle	NS	NS	NS	NS
X-Ray hindlimb hoof angle	NS	NS	NS	NS
X-Ray hock angle	NS	NS	NS	NS
X-Ray stifle angle	$y = 2,6046x - 59,2074$	NS	NS	NS

NS meaning not significant

 Equations present have a significance of $P \leq 0.05$

Table 4.13 (b) Predictive regression models for the dependent variable: front outside to back outside stride distance at 100cm

Stationary Measurement	Gelding		Mare	
	Under-saddle	Free-jumping	Under-saddle	Free-jumping
Age	NS	NS	NS	NS
Weight	NS	$y = -0,0312x^2 + 36,3197x - 10254,2095$	NS	NS
Head length	NS	NS	NS	NS
Neck length	NS	NS	NS	NS
Croup length	NS	NS	NS	NS
Wither height	NS	NS	NS	NS
Croup height	NS	NS	NS	NS
Head-neck perimeter	NS	$y = 15,1671x - 929,3315$	NS	NS
Neck-body perimeter	NS	NS	NS	NS
Chest girth	NS	$y = -0,6622x^2 + 267,2883x - 26638,4449$	NS	NS
Femur length	NS	NS	NS	NS
Body length	NS	NS	NS	NS
Shoulder angle	NS	NS	NS	NS
Hoof angle	NS	NS	NS	NS
Hip joint angle	NS	NS	NS	NS
Hock Joint angle	NS	NS	NS	NS
X-Ray forelimb fetlock angle	NS	NS	NS	NS
X-Ray forelimb hoof angle	NS	NS	NS	NS
X-Ray hindlimb fetlock angle	NS	$y = 7,7938x - 893,4911$	NS	NS
X-Ray hindlimb hoof angle	NS	NS	NS	NS
X-Ray hock angle	NS	NS	NS	NS
X-Ray stifle angle	NS	NS	NS	NS

NS meaning not significant

 Equations present have a significance of $P \leq 0.05$

Table 4.14 (a) Predictive regression models for the dependent variable: front outside to back inside stride distance at 80cm

Stationary Measurement	Gelding		Mare	
	Under-saddle	Free-jumping	Under-saddle	Free-jumping
Age	NS	NS	NS	NS
Weight	NS	NS	NS	NS
Head length	NS	NS	NS	NS
Neck length	NS	NS	NS	NS
Croup length	$y = -1,612x^2 + 177,373x - 4645,0432$	NS	NS	NS
Wither height	NS	NS	NS	NS
Croup height	NS	NS	NS	NS
Head-neck perimeter	NS	NS	NS	NS
Neck-body perimeter	NS	NS	NS	NS
Chest girth	NS	NS	NS	NS
Femur length	NS	NS	$y = 0,2371x^2 - 21,1562x + 680,8939$	NS
Body length	NS	NS	NS	NS
Shoulder angle	NS	$y = 0,1236x^2 - 9,8187x + 384,2445$	$y = 1,5098x^2 - 168,2815x + 4899,7654$	NS
Hoof angle	NS	$y = 2,9361x - 323,8309$	NS	NS
Hip joint angle	NS	NS	NS	NS
Hock Joint angle	NS	NS	$y = 2,3297x^2 - 730,666x + 57498,6147$	NS
X-Ray forelimb fetlock angle	NS	NS	NS	NS
X-Ray forelimb hoof angle	NS	NS	NS	NS
X-Ray hindlimb fetlock angle	NS	NS	NS	NS
X-Ray hindlimb hoof angle	$y = -1,1709x^2 + 357,0872x - 26994,9029$	NS	NS	NS
X-Ray hock angle	$y = -1,1831x^2 + 386,2927x - 31300,7188$	NS	NS	NS
X-Ray stifle angle	$y = -0,0946x^2 + 29,5051x - 2047,0625$	NS	NS	NS

NS meaning not significant

Equations present have a significance of $P \leq 0.05$

Table 4.14 (b) Predictive regression models for the dependent variable: front outside to back inside stride distance at 100cm

Stationary Measurement	Gelding		Mare	
	Under-saddle	Free-jumping	Under-saddle	Free-jumping
Age	NS	NS	NS	NS
Weight	NS	NS	NS	NS
Head length	NS	NS	NS	NS
Neck length	NS	NS	NS	NS
Croup length	NS	NS	NS	NS
Wither height	NS	NS	NS	NS
Croup height	NS	NS	NS	NS
Head-neck perimeter	NS	NS	NS	NS
Neck-body perimeter	NS	NS	NS	NS
Chest girth	NS	NS	NS	NS
Femur length	NS	NS	NS	NS
Body length	NS	NS	NS	NS
Shoulder angle	NS	$y = -0,1236x^2 + 17,9981x - 399,9609$	NS	NS
Hoof angle	NS	NS	NS	NS
Hip joint angle	NS	NS	NS	NS
Hock Joint angle	NS	NS	NS	NS
X-Ray forelimb fetlock angle	NS	NS	NS	NS
X-Ray forelimb hoof angle	NS	NS	NS	$y = -0,0895x^2 + 26,2435x - 1712,1595$
X-Ray hindlimb fetlock angle	NS	NS	NS	NS
X-Ray hindlimb hoof angle	NS	NS	NS	NS
X-Ray hock angle	NS	NS	NS	$y = -2,6221x + 631,5167$
X-Ray stifle angle	$y = 2,8556x - 169,7785$	NS	NS	NS

NS meaning not significant

 Equations present have a significance of $P \leq 0.05$

Table 4.14 (c) Predictive regression models for the dependent variable: front outside to back inside stride distance at 120cm free-jumping

Stationary Measurement	Gelding	Mare
Age	NS	NS
Weight	$y = 0,4047x + 0,5438$	NS
Head length	NS	NS
Neck length	NS	NS
Croup length	NS	NS
Wither height	NS	NS
Croup height	NS	NS
Head-neck perimeter	NS	NS
Neck-body perimeter	NS	NS
Chest girth	NS	$y = 2,4908x - 272,4091$
Femur length	$y = -0,595x^2 + 64,8266x - 1531,7986$	NS
Body length	NS	$y = 0,2499x^2 - 81,1685x + 6771,608$
Shoulder angle	NS	$y = -5,1995x + 489,4835$
Hoof angle	NS	NS
Hip joint angle	NS	NS
Hock Joint angle	NS	NS
X-Ray forelimb fetlock angle	NS	NS
X-Ray forelimb hoof angle	NS	NS
X-Ray hindlimb fetlock angle	NS	NS
X-Ray hindlimb hoof angle	NS	NS
X-Ray hock angle	NS	NS
X-Ray stifle angle	NS	NS

NS meaning not significant

 Equations present have a significance of $P \leq 0.05$

Table 4.15 (a) Predictive regression models for the dependent variable: front inside to back inside stride distance at 80cm

Stationary Measurement	Gelding		Mare	
	Under-saddle	Free-jumping	Under-saddle	Free-jumping
Age	NS	NS	NS	NS
Weight	NS	NS	NS	NS
Head length	NS	NS	NS	NS
Neck length	NS	NS	NS	NS
Croup length	NS	NS	$y = -3,0656x + 292,5909$	NS
Wither height	NS	NS	NS	NS
Croup height	NS	NS	NS	NS
Head-neck perimeter	NS	NS	NS	NS
Neck-body perimeter	NS	NS	NS	NS
Chest girth	NS	NS	NS	NS
Femur length	NS	NS	NS	NS
Body length	NS	NS	NS	NS
Shoulder angle	NS	$y = 0,1826x^2 - 17,5425x + 551,2863$	NS	NS
Hoof angle	NS	$y = 1,9367x - 217,0667$	NS	NS
Hip joint angle	NS	NS	NS	NS
Hock Joint angle	NS	NS	NS	NS
X-Ray forelimb fetlock angle	NS	NS	NS	NS
X-Ray forelimb hoof angle	NS	NS	$y = -0,6969x^2 + 218,3336x - 16963,2459$	NS
X-Ray hindlimb fetlock angle	NS	NS	NS	NS
X-Ray hindlimb hoof angle	NS	NS	NS	NS
X-Ray hock angle	NS	NS	NS	NS
X-Ray stifle angle	$y = 1,0646x^2 - 295,4783x + 20626,3416$	NS	NS	NS

NS meaning not significant

 Equations present have a significance of $P \leq 0.05$

Table 4.15 (b) Predictive regression models for the dependent variable: front inside to back inside stride distance at 100cm

Stationary Measurement	Gelding		Mare	
	Under-saddle	Free-jumping	Under-saddle	Free-jumping
Age	NS	NS	NS	NS
Weight	NS	NS	NS	NS
Head length	NS	NS	NS	NS
Neck length	NS	NS	NS	NS
Croup length	NS	NS	$y = -0,2257x^2 + 21,6665x - 382,6022$	NS
Wither height	NS	NS	NS	NS
Croup height	NS	NS	NS	NS
Head-neck perimeter	NS	NS	NS	NS
Neck-body perimeter	NS	NS	NS	NS
Chest girth	NS	$y = 0,4943x^2 - 189,9856x + 18390,0237$	NS	NS
Femur length	NS	NS	NS	NS
Body length	NS	NS	NS	NS
Shoulder angle	NS	NS	NS	NS
Hoof angle	NS	NS	NS	NS
Hip joint angle	NS	NS	NS	NS
Hock Joint angle	NS	NS	NS	NS
X-Ray forelimb fetlock angle	NS	NS	NS	NS
X-Ray forelimb hoof angle	NS	NS	NS	NS
X-Ray hindlimb fetlock angle	NS	$y = 0,4815x^2 - 142,5911x + 10689,1866$	NS	NS
X-Ray hindlimb hoof angle	NS	NS	NS	NS
X-Ray hock angle	NS	NS	NS	NS
X-Ray stifle angle	NS	NS	NS	$y = -5,5224x + 891,0439$

NS meaning not significant

Equations present have a significance of $P \leq 0.05$

Table 4.15 (c) Predictive regression models for the dependent variable: front inside to back inside stride distance at 120cm in free-jumping

Stationary Measurement	Gelding	Mare
Age	NS	NS
Weight	NS	NS
Head length	NS	NS
Neck length	NS	NS
Croup length	NS	NS
Wither height	NS	NS
Croup height	NS	NS
Head-neck perimeter	NS	NS
Neck-body perimeter	NS	NS
Chest girth	NS	NS
Femur length	NS	NS
Body length	NS	NS
Shoulder angle	$y = 0,4496x^2 - 46,0562x + 1315,6081$	$y = -4,3472x + 374,3332$
Hoof angle	$y = 1,9109x - 203,8484$	$y = 0,7173x^2 - 255,8523x + 22931,41$
Hip joint angle	NS	NS
Hock Joint angle	NS	NS
X-Ray forelimb fetlock angle	NS	NS
X-Ray forelimb hoof angle	NS	NS
X-Ray hindlimb fetlock angle	NS	NS
X-Ray hindlimb hoof angle	NS	NS
X-Ray hock angle	NS	$y = 1,2763x^2 - 421,2364x + 34876,7089$
X-Ray stifle angle	NS	$y = -5,6136x + 901,4674$

NS meaning not significant

 Equations present have a significance of $P \leq 0.05$

Table 4.16 Predictive regression models for the dependent variable: front inside to back outside stride distance at 100cm

Stationary Measurement	Gelding		Mare	
	Under-saddle	Free-jumping	Under-saddle	Free-jumping
Age	NS	NS	$y = -9,8283x^2 + 1016,9548x - 26089,289$	NS
Weight	NS	$y = -0,023x^2 + 26,8541x - 7607,0132$	NS	NS
Head length	NS	NS	NS	NS
Neck length	NS	NS	NS	NS
Croup length	NS	NS	NS	NS
Wither height	NS	NS	NS	NS
Croup height	NS	NS	NS	NS
Head-neck perimeter	NS	$y = 12,3287x - 773,5251$	NS	NS
Neck-body perimeter	NS	NS	NS	NS
Chest girth	NS	$y = 6,8358x - 1112,3169$	NS	NS
Femur length	NS	NS	NS	NS
Body length	NS	NS	NS	NS
Shoulder angle	NS	$y = -3,7429x^2 + 438,7441x - 12609,1836$	NS	NS
Hoof angle	NS	NS	NS	NS
Hip joint angle	NS	$y = -2,5774x^2 + 412,1874x - 16228,9985$	NS	NS
Hock Joint angle	NS	NS	NS	NS
X-Ray forelimb fetlock angle	NS	NS	NS	NS
X-Ray forelimb hoof angle	NS	NS	NS	NS
X-Ray hindlimb fetlock angle	NS	$y = -0,3407x^2 + 110,1082x - 8641,9592$	NS	NS
X-Ray hindlimb hoof angle	NS	NS	NS	NS
X-Ray hock angle	NS	NS	NS	NS
X-Ray stifle angle	NS	NS	NS	NS

NS meaning not significant

Equations present have a significance of $P \leq 0.05$

Table 4.17 (a) Predictive regression models for the dependent variable: back left to back left hoof distance at 80cm

Stationary Measurement	Gelding		Mare	
	Under-saddle	Free-jumping	Under-saddle	Free-jumping
Age	$y = 0,1976x^2 - 26,6831x + 1111,5804$	NS	NS	NS
Weight	NS	NS	$y = 0,7174x - 96,6733$	NS
Head length	NS	NS	NS	NS
Neck length	NS	NS	NS	NS
Croup length	NS	NS	NS	NS
Wither height	NS	NS	$y = -0,6649x^2 + 214,0364x - 16912,6059$	NS
Croup height	NS	NS	NS	NS
Head-neck perimeter	NS	NS	NS	NS
Neck-body perimeter	NS	NS	$y = 4,9428x - 326,3218$	NS
Chest girth	NS	NS	NS	NS
Femur length	NS	NS	NS	NS
Body length	NS	NS	NS	NS
Shoulder angle	NS	NS	NS	NS
Hoof angle	NS	NS	NS	NS
Hip joint angle	NS	NS	$y = 1,8067x^2 - 304,9363x - 13087,6983$	NS
Hock Joint angle	NS	NS	NS	NS
X-Ray forelimb fetlock angle	NS	NS	NS	NS
X-Ray forelimb hoof angle	NS	NS	NS	NS
X-Ray hindlimb fetlock angle	NS	NS	NS	NS
X-Ray hindlimb hoof angle	NS	NS	NS	NS
X-Ray hock angle	NS	NS	NS	NS
X-Ray stifle angle	NS	NS	NS	NS

NS meaning not significant

 Equations present have a significance of $P \leq 0.05$

Table 4.17 (b) Predictive regression models for the dependent variable: back left to back left hoof distance at 100cm

Stationary Measurement	Gelding		Mare	
	Under-saddle	Free-jumping	Under-saddle	Free-jumping
Age	NS	NS	NS	NS
Weight	NS	NS	NS	NS
Head length	NS	NS	$y = 3,6205x^2 - 452,2583x + 14366,8767$	NS
Neck length	NS	NS	$y = 2,4136x + 70,8782$	NS
Croup length	NS	NS	NS	NS
Wither height	NS	NS	$y = 0,4598x^2 - 142,2159x + 11226,5497$	NS
Croup height	NS	NS	NS	NS
Head-neck perimeter	NS	NS	NS	NS
Neck-body perimeter	NS	NS	NS	NS
Chest girth	NS	NS	NS	NS
Femur length	NS	NS	NS	NS
Body length	NS	NS	NS	NS
Shoulder angle	NS	NS	NS	NS
Hoof angle	NS	NS	NS	NS
Hip joint angle	NS	NS	NS	NS
Hock Joint angle	NS	NS	NS	NS
X-Ray forelimb fetlock angle	NS	NS	NS	NS
X-Ray forelimb hoof angle	NS	NS	NS	NS
X-Ray hindlimb fetlock angle	NS	NS	NS	NS
X-Ray hindlimb hoof angle	NS	NS	NS	NS
X-Ray hock angle	NS	NS	NS	NS
X-Ray stifle angle	NS	NS	NS	NS

NS meaning not significant

 Equations present have a significance of $P \leq 0.05$

Table 4.17 (c) Predictive regression models for the dependent variable: back left to back left hoof distance at 120cm in free-jumping

Stationary Measurement	Gelding	Mare
Age	NS	NS
Weight	NS	NS
Head length	NS	NS
Neck length	NS	NS
Croup length	NS	$y = 9,4481x - 271,0962$
Wither height	$y = -1,0622x^2 + 355,3272x - 29467,5075$	NS
Croup height	NS	NS
Head-neck perimeter	NS	NS
Neck-body perimeter	NS	NS
Chest girth	NS	NS
Femur length	NS	NS
Body length	NS	NS
Shoulder angle	$y = 0,7715x^2 - 77,4582x + 2150,8671$	NS
Hoof angle	NS	$y = 0,6963x^2 - 244,5069x + 21674,6067$
Hip joint angle	NS	NS
Hock Joint angle	NS	NS
X-Ray forelimb fetlock angle	NS	NS
X-Ray forelimb hoof angle	NS	NS
X-Ray hindlimb fetlock angle	NS	NS
X-Ray hindlimb hoof angle	NS	NS
X-Ray hock angle	$y = -5,978x + 1218,9865$	NS
X-Ray stifle angle	NS	NS

NS meaning not significant

 Equations present have a significance of $P \leq 0.05$

Table 4.18 (a) Predictive regression models for the dependent variable: back right to back right hoof distance at 80cm

Stationary Measurement	Gelding		Mare	
	Under-saddle	Free-jumping	Under-saddle	Free-jumping
Age	NS	NS	NS	NS
Weight	NS	NS	NS	NS
Head length	NS	NS	NS	NS
Neck length	NS	NS	NS	NS
Croup length	NS	NS	NS	NS
Wither height	NS	NS	NS	NS
Croup height	NS	NS	NS	NS
Head-neck perimeter	NS	$y = 2,8715x^2 - 450,9111x + 17911,0884$	NS	NS
Neck-body perimeter	NS	NS	NS	NS
Chest girth	NS	NS	$y = 0,4175x^2 - 159,2637x + 15446,4567$	NS
Femur length	NS	NS	NS	NS
Body length	NS	NS	NS	NS
Shoulder angle	NS	NS	NS	NS
Hoof angle	NS	NS	NS	NS
Hip joint angle	NS	NS	NS	NS
Hock Joint angle	NS	NS	NS	NS
X-Ray forelimb fetlock angle	NS	NS	NS	NS
X-Ray forelimb hoof angle	NS	NS	NS	NS
X-Ray hindlimb fetlock angle	NS	NS	NS	NS
X-Ray hindlimb hoof angle	NS	NS	NS	NS
X-Ray hock angle	NS	$y = -9,6095x + 1819,7817$	NS	NS
X-Ray stifle angle	NS	NS	NS	NS

NS meaning not significant

 Equations present have a significance of $P \leq 0.05$

Table 4.18 (b) Predictive regression models for the dependent variable: back right to back right hoof distance at 100cm

Stationary Measurement	Gelding		Mare	
	Under-saddle	Free-jumping	Under-saddle	Free-jumping
Age	NS	NS	NS	$y = -5,6025x^2 + 560,8425x - 13772,2601$
Weight	NS	NS	NS	NS
Head length	NS	NS	NS	NS
Neck length	NS	NS	NS	NS
Croup length	NS	NS	NS	NS
Wither height	NS	NS	$y = -0,2156x^2 + 67,3439x - 4945,183$	NS
Croup height	NS	NS	$y = -0,1739x^2 + 54,0867x - 3895,9293$	NS
Head-neck perimeter	NS	NS	NS	NS
Neck-body perimeter	NS	NS	NS	NS
Chest girth	NS	NS	NS	NS
Femur length	NS	NS	NS	NS
Body length	NS	NS	NS	NS
Shoulder angle	NS	NS	NS	NS
Hoof angle	NS	NS	NS	NS
Hip joint angle	$y = 3,7413x - 43,9105$	NS	NS	$y = 3,0931x - 16,41$
Hock Joint angle	NS	NS	NS	NS
X-Ray forelimb fetlock angle	NS	NS	NS	NS
X-Ray forelimb hoof angle	NS	NS	NS	NS
X-Ray hindlimb fetlock angle	NS	NS	NS	NS
X-Ray hindlimb hoof angle	NS	NS	NS	NS
X-Ray hock angle	NS	$y = -16,7758x + 3035,0399$	NS	NS
X-Ray stifle angle	NS	NS	NS	NS

NS meaning not significant

 Equations present have a significance of $P \leq 0.05$

Table 4.18 (c) Predictive regression models for the dependent variable: back right to back right hoof distance at 120cm in free-jumping

Stationary Measurement	Gelding	Mare
Age	NS	NS
Weight	NS	NS
Head length	NS	NS
Neck length	NS	NS
Croup length	NS	NS
Wither height	NS	NS
Croup height	NS	NS
Head-neck perimeter	NS	NS
Neck-body perimeter	NS	NS
Chest girth	NS	$y = -0,9039x + 409,4618$
Femur length	NS	NS
Body length	NS	NS
Shoulder angle	NS	NS
Hoof angle	NS	$y = 0,6304x + 123,8227$
Hip joint angle	NS	NS
Hock Joint angle	NS	NS
X-Ray forelimb fetlock angle	NS	NS
X-Ray forelimb hoof angle	NS	NS
X-Ray hindlimb fetlock angle	NS	NS
X-Ray hindlimb hoof angle	NS	NS
X-Ray hock angle	NS	$y = -0,9446x^2 + 308,5488x - 24956,5804$
X-Ray stifle angle	NS	NS

NS meaning not significant

 Equations present have a significance of $P \leq 0.05$

Table 4.19 (a) Predictive regression models for the dependent variable: front right to front right hoof distance at 80cm

Stationary Measurement	Gelding		Mare	
	Under-saddle	Free-jumping	Under-saddle	Free-jumping
Age	NS	NS	NS	NS
Weight	NS	NS	NS	NS
Head length	NS	NS	NS	NS
Neck length	NS	NS	NS	NS
Croup length	NS	NS	NS	NS
Wither height	NS	NS	NS	NS
Croup height	NS	NS	NS	NS
Head-neck perimeter	NS	NS	$y = 5,522x - 138,3357$	NS
Neck-body perimeter	NS	NS	NS	NS
Chest girth	NS	NS	NS	NS
Femur length	NS	NS	NS	NS
Body length	NS	NS	$y = 1.1222x^2 - 377.9435x + 32111.5223$	NS
Shoulder angle	NS	NS	NS	NS
Hoof angle	NS	NS	NS	NS
Hip joint angle	NS	NS	NS	NS
Hock Joint angle	NS	NS	$y = -6,4748x + 1314,4112$	NS
X-Ray forelimb fetlock angle	NS	NS	NS	NS
X-Ray forelimb hoof angle	NS	NS	NS	NS
X-Ray hindlimb fetlock angle	NS	NS	NS	NS
X-Ray hindlimb hoof angle	NS	NS	NS	NS
X-Ray hock angle	NS	NS	$y = -8,5315x + 1693,5907$	NS
X-Ray stifle angle	NS	NS	NS	NS

NS meaning not significant

 Equations present have a significance of $P \leq 0.05$

The following section of measurements are the four jumping linear measurements that were taken for the take-off and landing distances. Table 4.20 (a), (b) and (c) present the predictive models for the take-off distance of the forelimb at 80cm, 100cm and 120cm respectively. Table 4.21 (a), (b) and (c) present the predictive models for the take-off distance of the hindlimb at 80cm, 100cm and 120cm respectively. Table 4.22 (a) and (b) present the predictive models for the landing distance of forelimb at 80cm and 100cm respectively. There were no significant equations for this measurement at 120cm. Table 4.23 (a), (b) and (c) present the predictive models for the landing distance of the hindlimb at 80cm, 100cm and 120cm respectively.

The take-off distance of the forelimb and the hindlimb for geldings under-saddle jumping 80cm can be determined by the X-ray stifle angle of the horse. The hoof angle was a significant predictor ($P \leq 0.05$) for the mares at 80cm as for the take-off distance of the forelimb free-jumping and the take-off distance of the hindlimb while free-jumping can be interpreted by the hoof angle. The hoof angle also predicted the geldings landing distance of the forelimb at 80cm while free-jumping. At 120cm free-jumping, the body length was able to predict the mare's take-off distance of the forelimb and the hindlimb as well as the geldings landing distance of the hindlimb. Within the take-off distance of the hindlimb the two important stationary measurements to predict the distance were the hoof angle as well as the X-ray hock angle as mares free-jumping 80cm, mares under-saddle at 100cm and mares free-jumping at 120cm can be predicted by these two stationary measurements. The important stationary measurement for the landing distance of the forelimb of mares free-jumping was the wither height for both 80cm and 100cm.

Table 4.24 (a), (b) and (c) present the predictive models for the jump distance for 80cm, 100cm and 120cm respectively and this measurement is related to the above-mentioned take-off and landing measurements. The stationary measurement that stands out with this jumping measurement was the hoof angle. The equations with the stationary measurements were significant ($P \leq 0.05$) for all free-jumping measurements except geldings at 120cm which makes it a very accurate representation to determine the jump distance at any height.

Table 4.25 (a), (b) and (c) present the predictive models for the linear distance between the humeroradial and the metacarpophalangeal joint at 80cm, 100cm and 120cm respectively. Table 4.26 (a), (b) and (c) present the predictive models for the vertical distance between the humeroradial and the metacarpophalangeal joint at 80cm, 100cm and 120cm respectively. Analysing the 80cm height jumps, the shoulder angle was the most common stationary measurement with significant predictive equations ($P \leq 0.05$) however the linear and vertical measurements did not overlap when it comes to under-saddle or free-jumping and geldings or mares. The neck-body perimeter of mares can predict ($P \leq 0.05$) the linear and vertical distances for under-saddle at 100cm. At 120cm free-jumping the croup length can predict the linear and vertical distances of the mare while the X-ray hindlimb fetlock angle can predict the linear and vertical distance of the gelding. Within the linear distance, the X-ray hindlimb fetlock angle was the stationary measurement that stands out for predicting the jumping measurement.

Table 4.20 (a) Predictive regression models for the dependent variable: take-off distance of the forelimb at 80cm

Stationary Measurement	Gelding		Mare	
	Under-saddle	Free-jumping	Under-saddle	Free-jumping
Age	NS	NS	NS	NS
Weight	NS	NS	NS	NS
Head length	NS	NS	NS	NS
Neck length	NS	NS	NS	NS
Croup length	NS	NS	NS	NS
Wither height	NS	NS	NS	NS
Croup height	NS	NS	NS	NS
Head-neck perimeter	NS	NS	NS	NS
Neck-body perimeter	NS	NS	NS	NS
Chest girth	NS	NS	NS	NS
Femur length	NS	NS	NS	NS
Body length	NS	NS	NS	NS
Shoulder angle	NS	NS	NS	NS
Hoof angle	NS	NS	NS	$y = -0,255x^2 + 88,7815x - 7522,6799$
Hip joint angle	NS	NS	NS	NS
Hock Joint angle	NS	NS	$y = -4,1025x + 820,9301$	NS
X-Ray forelimb fetlock angle	NS	NS	NS	NS
X-Ray forelimb hoof angle	NS	NS	NS	NS
X-Ray hindlimb fetlock angle	NS	NS	NS	NS
X-Ray hindlimb hoof angle	NS	NS	NS	NS
X-Ray hock angle	NS	NS	NS	NS
X-Ray stifle angle	$y = -1,185x^2 + 326,8755x - 22360,7095$	NS	NS	NS

NS meaning not significant

 Equations present have a significance of $P \leq 0.05$

Table 4.20 (b) Predictive regression models for the dependent variable: take-off distance of the forelimb at 100cm

Stationary Measurement	Gelding		Mare	
	Under-saddle	Free-jumping	Under-saddle	Free-jumping
Age	NS	NS	NS	NS
Weight	NS	NS	NS	NS
Head length	NS	NS	NS	NS
Neck length	NS	NS	NS	NS
Croup length	$y = 1,187x^2 - 133,9501x + 3933,5554$	NS	NS	NS
Wither height	NS	NS	NS	NS
Croup height	NS	NS	NS	NS
Head-neck perimeter	NS	NS	$y = 1,0573x^2 - 170,4746x + 7036,599$	NS
Neck-body perimeter	NS	NS	NS	NS
Chest girth	NS	NS	$y = 0,272x^2 - 102,4946x + 9822,7918$	NS
Femur length	NS	NS	NS	NS
Body length	NS	NS	NS	NS
Shoulder angle	NS	NS	NS	NS
Hoof angle	NS	NS	NS	NS
Hip joint angle	NS	NS	NS	NS
Hock Joint angle	NS	NS	NS	$y = -3,2721x^2 + 1020,6246x - 79396,9308$
X-Ray forelimb fetlock angle	NS	NS	NS	NS
X-Ray forelimb hoof angle	NS	NS	NS	NS
X-Ray hindlimb fetlock angle	NS	NS	NS	NS
X-Ray hindlimb hoof angle	NS	NS	NS	$y = 1,7554x^2 - 544,7104x + 42417,2175$
X-Ray hock angle	NS	NS	NS	NS
X-Ray stifle angle	NS	NS	NS	NS

NS meaning not significant

 Equations present have a significance of $P \leq 0.05$

Table 4.20 (c) Predictive regression models for the dependent variable: take-off distance of the forelimb at 120cm in free-jumping

Stationary Measurement	Gelding	Mare
Age	$y = 0,307x^2 - 38,0514x + 1322,2647$	NS
Weight	NS	NS
Head length	NS	NS
Neck length	NS	NS
Croup length	NS	NS
Wither height	NS	NS
Croup height	NS	NS
Head-neck perimeter	NS	NS
Neck-body perimeter	NS	NS
Chest girth	NS	NS
Femur length	NS	NS
Body length	NS	$y = 0,3927x^2 - 130,8126x + 11047,1977$
Shoulder angle	NS	NS
Hoof angle	NS	NS
Hip joint angle	NS	NS
Hock Joint angle	NS	NS
X-Ray forelimb fetlock angle	NS	NS
X-Ray forelimb hoof angle	NS	NS
X-Ray hindlimb fetlock angle	NS	$y = 0,4268x^2 - 132,1384x + 10385,0711$
X-Ray hindlimb hoof angle	NS	NS
X-Ray hock angle	NS	NS
X-Ray stifle angle	NS	NS

NS meaning not significant

 Equations present have a significance of $P \leq 0.05$

Table 4.21 (a) Predictive regression models for the dependent variable: take-off distance of the hindlimb at 80cm

Stationary Measurement	Gelding		Mare	
	Under-saddle	Free-jumping	Under-saddle	Free-jumping
Age	NS	NS	NS	NS
Weight	NS	NS	NS	NS
Head length	NS	NS	NS	NS
Neck length	NS	NS	NS	NS
Croup length	NS	NS	NS	NS
Wither height	NS	NS	$y = -1,8628x + 441,7732$	NS
Croup height	NS	NS	NS	NS
Head-neck perimeter	NS	NS	NS	NS
Neck-body perimeter	NS	NS	NS	NS
Chest girth	NS	NS	NS	NS
Femur length	NS	NS	NS	$y = 1,7273x^2 - 173,5862x + 4481,556$
Body length	NS	NS	NS	NS
Shoulder angle	NS	NS	NS	NS
Hoof angle	NS	NS	NS	$y = 0,0541x^2 - 24,4277x + 2785,1879$
Hip joint angle	NS	NS	NS	NS
Hock Joint angle	NS	NS	NS	NS
X-Ray forelimb fetlock angle	NS	NS	NS	NS
X-Ray forelimb hoof angle	NS	NS	NS	NS
X-Ray hindlimb fetlock angle	NS	NS	NS	NS
X-Ray hindlimb hoof angle	NS	NS	$y = 4,8287x - 604,1873$	NS
X-Ray hock angle	NS	NS	NS	$y = 2,8778x^2 - 940,8009x + 77015,8587$
X-Ray stifle angle	$y = -0,9061x^2 + 249,0291x - 16968,1889$	$y = -2,8737x + 535,6845$	NS	NS

NS meaning not significant

 Equations present have a significance of $P \leq 0.05$

Table 4.21 (b) Predictive regression models for the dependent variable: take-off distance of the hindlimb at 100cm

Stationary Measurement	Gelding		Mare	
	Under-saddle	Free-jumping	Under-saddle	Free-jumping
Age	NS	NS	NS	NS
Weight	NS	NS	NS	NS
Head length	NS	NS	NS	NS
Neck length	$y = 0,1701x^2 - 30,2051x + 1471,287$	NS	NS	NS
Croup length	NS	NS	NS	NS
Wither height	NS	NS	NS	NS
Croup height	NS	NS	NS	NS
Head-neck perimeter	NS	NS	NS	NS
Neck-body perimeter	NS	NS	$y = 0,4935x^2 - 121,4851x + 7597,0357$	NS
Chest girth	NS	NS	NS	NS
Femur length	NS	NS	NS	NS
Body length	NS	NS	NS	NS
Shoulder angle	NS	NS	NS	NS
Hoof angle	NS	NS	$y = 0,3737x^2 - 136,3272x + 12552,3147$	NS
Hip joint angle	NS	NS	NS	NS
Hock Joint angle	NS	NS	NS	NS
X-Ray forelimb fetlock angle	NS	NS	NS	NS
X-Ray forelimb hoof angle	NS	NS	NS	NS
X-Ray hindlimb fetlock angle	NS	NS	NS	NS
X-Ray hindlimb hoof angle	NS	NS	NS	NS
X-Ray hock angle	NS	NS	$y = 2,3096x^2 - 759,0347x + 62477,4616$	NS
X-Ray stifle angle	NS	NS	NS	NS

NS meaning not significant

 Equations present have a significance of $P \leq 0.05$

Table 4.21 (c) Predictive regression models for the dependent variable: take-off distance of the hindlimb at 120cm in free-jumping

Stationary Measurement	Gelding	Mare
Age	NS	NS
Weight	NS	NS
Head length	NS	NS
Neck length	NS	NS
Croup length	NS	NS
Wither height	NS	NS
Croup height	NS	NS
Head-neck perimeter	NS	NS
Neck-body perimeter	NS	$y = 0,6909x^2 - 172,9354x + 10939,5244$
Chest girth	NS	NS
Femur length	NS	NS
Body length	NS	$y = 0,497x^2 - 165,8957x + 13958,9308$
Shoulder angle	NS	NS
Hoof angle	NS	$y = 0,7976x^2 - 287,0171x + 25940,1639$
Hip joint angle	NS	NS
Hock Joint angle	NS	NS
X-Ray forelimb fetlock angle	NS	$y = 0,9947x^2 - 311,0505x + 24435,6597$
X-Ray forelimb hoof angle	NS	NS
X-Ray hindlimb fetlock angle	NS	NS
X-Ray hindlimb hoof angle	NS	NS
X-Ray hock angle	NS	$y = 2,9559x^2 - 968,6939x + 79481,8975$
X-Ray stifle angle	NS	NS

NS meaning not significant

 Equations present have a significance of $P \leq 0.05$

Table 4.22 (a) Predictive regression models for the dependent variable: landing distance of the forelimb at 80cm

Stationary Measurement	Gelding		Mare	
	Under-saddle	Free-jumping	Under-saddle	Free-jumping
Age	NS	NS	NS	NS
Weight	NS	NS	NS	NS
Head length	NS	NS	NS	NS
Neck length	NS	NS	NS	NS
Croup length	NS	NS	NS	NS
Wither height	NS	NS	NS	$y = -0,3897x^2 + 121,3648x - 9242,1077$
Croup height	NS	NS	NS	NS
Head-neck perimeter	NS	NS	NS	NS
Neck-body perimeter	NS	NS	NS	NS
Chest girth	NS	NS	NS	NS
Femur length	NS	NS	NS	NS
Body length	$y = 1,813x - 163,1057$	NS	NS	NS
Shoulder angle	$y = -1,6988x^2 + 193,835x - 5370,0588$	NS	NS	NS
Hoof angle	NS	$y = -0,8834x^2 + 331,6783x - 30922,3815$	NS	NS
Hip joint angle	NS	$y = -0,8353x^2 + 140,69x - 5718,444$	NS	NS
Hock Joint angle	NS	NS	NS	$y = 5,4733x^2 - 1710,9708x + 133867,7032$
X-Ray forelimb fetlock angle	NS	NS	NS	NS
X-Ray forelimb hoof angle	NS	NS	NS	NS
X-Ray hindlimb fetlock angle	NS	NS	$y = -2,2777x + 486,6541$	NS
X-Ray hindlimb hoof angle	$y = 1,7487x - 125,0123$	NS	NS	NS
X-Ray hock angle	NS	NS	NS	NS
X-Ray stifle angle	NS	NS	NS	NS

NS meaning not significant

Equations present have a significance of $P \leq 0.05$

Table 4.22 (b) Predictive regression models for the dependent variable: landing distance of the forelimb at 100cm

Stationary Measurement	Gelding		Mare	
	Under-saddle	Free-jumping	Under-saddle	Free-jumping
Age	NS	NS	NS	NS
Weight	NS	NS	NS	NS
Head length	NS	NS	NS	$y = -6,6894x + 605,9843$
Neck length	NS	NS	NS	NS
Croup length	NS	NS	NS	NS
Wither height	NS	NS	NS	$y = -0,378x^2 + 117,9397x - 8992,5249$
Croup height	NS	NS	NS	$y = -0,2539x^2 + 78,0827x - 5801,7477$
Head-neck perimeter	NS	NS	NS	NS
Neck-body perimeter	NS	NS	NS	NS
Chest girth	NS	NS	NS	NS
Femur length	NS	NS	NS	NS
Body length	NS	NS	NS	NS
Shoulder angle	NS	NS	NS	NS
Hoof angle	NS	NS	NS	NS
Hip joint angle	NS	NS	NS	NS
Hock Joint angle	NS	NS	NS	NS
X-Ray forelimb fetlock angle	NS	NS	NS	NS
X-Ray forelimb hoof angle	NS	NS	NS	NS
X-Ray hindlimb fetlock angle	NS	NS	NS	NS
X-Ray hindlimb hoof angle	NS	NS	NS	NS
X-Ray hock angle	NS	NS	NS	NS
X-Ray stifle angle	NS	NS	NS	NS

NS meaning not significant

 Equations present have a significance of $P \leq 0.05$

Table 4.23 (a) Predictive regression models for the dependent variable: landing distance of the hindlimb 80cm

Stationary Measurement	Gelding		Mare	
	Under-saddle	Free-jumping	Under-saddle	Free-jumping
Age	NS	NS	NS	NS
Weight	NS	NS	NS	NS
Head length	NS	NS	NS	NS
Neck length	NS	NS	NS	NS
Croup length	NS	NS	NS	NS
Wither height	NS	NS	NS	NS
Croup height	NS	NS	NS	NS
Head-neck perimeter	NS	NS	NS	NS
Neck-body perimeter	NS	$y = -0,8048x^2 + 193,7869x - 11380,122$	NS	NS
Chest girth	NS	NS	NS	NS
Femur length	NS	NS	NS	NS
Body length	NS	$y = -0,8969x^2 + 309,1788x - 26337,2469$	NS	NS
Shoulder angle	NS	NS	NS	NS
Hoof angle	NS	NS	NS	NS
Hip joint angle	NS	NS	NS	NS
Hock Joint angle	NS	NS	NS	NS
X-Ray forelimb fetlock angle	NS	NS	NS	NS
X-Ray forelimb hoof angle	NS	NS	NS	NS
X-Ray hindlimb fetlock angle	NS	NS	NS	NS
X-Ray hindlimb hoof angle	NS	NS	NS	NS
X-Ray hock angle	NS	NS	NS	NS
X-Ray stifle angle	NS	NS	NS	NS

NS meaning not significant

 Equations present have a significance of $P \leq 0.05$

Table 4.23 (b) Predictive regression models for the dependent variable: landing distance of the hindlimb 100cm

Stationary Measurement	Gelding		Mare	
	Under-saddle	Free-jumping	Under-saddle	Free-jumping
Age	NS	NS	NS	NS
Weight	NS	NS	NS	NS
Head length	NS	NS	NS	NS
Neck length	NS	NS	NS	NS
Croup length	NS	NS	NS	$y = -2,7941x^2 + 293,2936x - 7439,2947$
Wither height	NS	NS	NS	NS
Croup height	NS	NS	NS	NS
Head-neck perimeter	NS	NS	NS	NS
Neck-body perimeter	NS	NS	NS	NS
Chest girth	NS	NS	NS	NS
Femur length	NS	$y = -5,854x + 566,3434$	NS	NS
Body length	NS	NS	NS	NS
Shoulder angle	NS	NS	NS	NS
Hoof angle	NS	NS	NS	NS
Hip joint angle	NS	NS	NS	NS
Hock Joint angle	NS	NS	NS	NS
X-Ray forelimb fetlock angle	NS	NS	NS	NS
X-Ray forelimb hoof angle	NS	NS	NS	NS
X-Ray hindlimb fetlock angle	NS	NS	NS	NS
X-Ray hindlimb hoof angle	NS	NS	NS	NS
X-Ray hock angle	NS	NS	NS	NS
X-Ray stifle angle	NS	NS	NS	$y = -3,4234x^2 + 948,6967x - 65458,9975$

NS meaning not significant

 Equations present have a significance of $P \leq 0.05$

Table 4.23 (c) Predictive regression models for the dependent variable: landing distance of the hindlimb 120cm in free-jumping

Stationary Measurement	Gelding	Mare
Age	NS	NS
Weight	NS	NS
Head length	NS	NS
Neck length	NS	NS
Croup length	NS	NS
Wither height	NS	NS
Croup height	NS	NS
Head-neck perimeter	NS	NS
Neck-body perimeter	NS	NS
Chest girth	NS	NS
Femur length	NS	NS
Body length	NS	NS
Shoulder angle	NS	NS
Hoof angle	NS	NS
Hip joint angle	NS	NS
Hock Joint angle	NS	NS
X-Ray forelimb fetlock angle	NS	NS
X-Ray forelimb hoof angle	NS	$y = 1,282x^2 - 397,9849x + 31130,9762$
X-Ray hindlimb fetlock angle	NS	NS
X-Ray hindlimb hoof angle	NS	NS
X-Ray hock angle	NS	NS
X-Ray stifle angle	NS	NS

NS meaning not significant

 Equations present have a significance of $P \leq 0.05$

Table 4.24 (a) Predictive regression models for the dependent variable: jump distance at 80cm

Stationary Measurement	Gelding		Mare	
	Under-saddle	Free-jumping	Under-saddle	Free-jumping
Age	NS	NS	NS	NS
Weight	NS	NS	$y = -0,3557x + 535,5694$	NS
Head length	NS	NS	NS	NS
Neck length	NS	NS	NS	NS
Croup length	NS	NS	NS	NS
Wither height	NS	NS	NS	$y = -5,9675x + 1367,9174$
Croup height	NS	NS	NS	NS
Head-neck perimeter	NS	NS	NS	NS
Neck-body perimeter	NS	NS	NS	$y = 1,688x^2 - 418,8531x + 26342,7668$
Chest girth	NS	NS	NS	NS
Femur length	NS	NS	NS	$y = 3,0233x^2 - 301,7538x + 7886,958$
Body length	NS	NS	NS	NS
Shoulder angle	NS	NS	NS	NS
Hoof angle	NS	$y = -1,7774x^2 + 663,5739x - 61491,1985$	NS	$y = 0,9762x^2 - 356,6058x + 32936,7556$
Hip joint angle	NS	NS	NS	NS
Hock Joint angle	NS	NS	NS	NS
X-Ray forelimb fetlock angle	NS	NS	NS	NS
X-Ray forelimb hoof angle	NS	NS	NS	NS
X-Ray hindlimb fetlock angle	NS	NS	NS	NS
X-Ray hindlimb hoof angle	$y = 2,5948x - 46,9537$	NS	NS	NS
X-Ray hock angle	NS	NS	NS	NS
X-Ray stifle angle	NS	NS	NS	NS

NS meaning not significant

 Equations present have a significance of $P \leq 0.05$

Table 4.24 (b) Predictive regression models for the dependent variable: jump distance at 100cm

Stationary Measurement	Gelding		Mare	
	Under-saddle	Free-jumping	Under-saddle	Free-jumping
Age	NS	NS	NS	NS
Weight	NS	NS	NS	NS
Head length	NS	NS	NS	NS
Neck length	NS	NS	NS	NS
Croup length	NS	NS	NS	NS
Wither height	NS	NS	NS	NS
Croup height	NS	NS	NS	NS
Head-neck perimeter	NS	NS	NS	NS
Neck-body perimeter	NS	NS	NS	NS
Chest girth	NS	NS	NS	NS
Femur length	NS	NS	NS	NS
Body length	NS	NS	NS	NS
Shoulder angle	NS	NS	NS	NS
Hoof angle	$y = -5.2118x + 1356.959$	$y = -3,1517x^2 + 1173,5826x - 108778,5756$	NS	$y = -8,0076 + 1849,1576$
Hip joint angle	NS	NS	NS	NS
Hock Joint angle	NS	NS	NS	NS
X-Ray forelimb fetlock angle	NS	NS	NS	NS
X-Ray forelimb hoof angle	NS	NS	NS	NS
X-Ray hindlimb fetlock angle	NS	NS	NS	NS
X-Ray hindlimb hoof angle	NS	NS	NS	NS
X-Ray hock angle	NS	NS	NS	NS
X-Ray stifle angle	NS	NS	NS	NS

NS meaning not significant

Equations present have a significance of $P \leq 0.05$

Table 4.24 (c) Predictive regression models for the dependent variable: jump distance at 120cm in free-jumping

Stationary Measurement	Gelding	Mare
Age	$y = -3,5402x + 640,7421$	NS
Weight	NS	NS
Head length	NS	NS
Neck length	NS	NS
Croup length	NS	NS
Wither height	NS	NS
Croup height	NS	NS
Head-neck perimeter	NS	NS
Neck-body perimeter	NS	NS
Chest girth	NS	NS
Femur length	NS	NS
Body length	NS	NS
Shoulder angle	NS	$y = -16,7971x + 1381,8009$
Hoof angle	NS	$y = 2,6482x^2 - 948,1757x + 85259,9117$
Hip joint angle	NS	NS
Hock Joint angle	$y = -0,2224x^2 + 71,4793x - 5279,536$	NS
X-Ray forelimb fetlock angle	NS	NS
X-Ray forelimb hoof angle	NS	NS
X-Ray hindlimb fetlock angle	NS	NS
X-Ray hindlimb hoof angle	NS	NS
X-Ray hock angle	NS	NS
X-Ray stifle angle	NS	NS

NS meaning not significant

 Equations present have a significance of $P \leq 0.05$

Table 4.25 (a) Predictive regression models for the dependent variable: linear distance between the humeroradial and the metacarpophalangeal joints at 80cm

Stationary Measurement	Gelding		Mare	
	Under-saddle	Free-jumping	Under-saddle	Free-jumping
Age	$y = 0,1832x^2 - 22,2792x + 713,5245$	NS	NS	NS
Weight	NS	NS	NS	NS
Head length	NS	NS	NS	NS
Neck length	NS	NS	NS	NS
Croup length	NS	NS	NS	$y = 1,57x - 39,2022$
Wither height	NS	NS	NS	NS
Croup height	NS	NS	NS	NS
Head-neck perimeter	NS	NS	NS	NS
Neck-body perimeter	NS	NS	NS	NS
Chest girth	NS	NS	NS	NS
Femur length	NS	NS	NS	NS
Body length	NS	NS	NS	NS
Shoulder angle	NS	$y = 0,2947x^2 - 31,6728x + 891,9791$	NS	NS
Hoof angle	NS	NS	NS	NS
Hip joint angle	NS	NS	NS	NS
Hock Joint angle	NS	NS	NS	$y = -1,0184x^2 + 318,9829x - 24929,3156$
X-Ray forelimb fetlock angle	NS	NS	NS	NS
X-Ray forelimb hoof angle	NS	NS	NS	NS
X-Ray hindlimb fetlock angle	$y = 1,1667x - 126,0602$	$y = 0,9321x - 95,2634$	NS	NS
X-Ray hindlimb hoof angle	NS	NS	NS	NS
X-Ray hock angle	NS	NS	NS	NS
X-Ray stifle angle	NS	NS	NS	NS

NS meaning not significant

 Equations present have a significance of $P \leq 0.05$

Table 4.25 (b) Predictive regression models for the dependent variable: linear distance between the humeroradial and the metacarpophalangeal joints at 100cm

Stationary Measurement	Gelding		Mare	
	Under-saddle	Free-jumping	Under-saddle	Free-jumping
Age	NS	NS	NS	NS
Weight	NS	NS	NS	NS
Head length	NS	NS	$y = 0,9247x - 16,1944$	NS
Neck length	NS	NS	NS	NS
Croup length	NS	NS	NS	NS
Wither height	NS	$y = -0,1678x^2 + 56,6756x - 4738,0379$	NS	NS
Croup height	NS	$y = 0,78x - 82,84$	NS	NS
Head-neck perimeter	NS	NS	$y = 0,2085x^2 - 33,1863x + 1360,9663$	NS
Neck-body perimeter	NS	NS	$y = 0,5141x - 20,7063$	NS
Chest girth	NS	NS	$y = 0,0186x^2 - 6,539x + 613,1104$	NS
Femur length	NS	NS	NS	NS
Body length	NS	NS	$y = 0,0346x^2 - 11,092x + 927,1121$	NS
Shoulder angle	NS	NS	NS	NS
Hoof angle	NS	NS	NS	NS
Hip joint angle	NS	NS	NS	NS
Hock Joint angle	NS	$y = -0,1518x^2 + 46,1357x - 3456,8164$	NS	NS
X-Ray forelimb fetlock angle	NS	NS	NS	NS
X-Ray forelimb hoof angle	NS	NS	NS	NS
X-Ray hindlimb fetlock angle	$y = 0,8965x - 89,1485$	NS	NS	NS
X-Ray hindlimb hoof angle	NS	NS	NS	NS
X-Ray hock angle	NS	NS	$y = 0,1763x^2 - 58,7696x + 4936,7611$	NS
X-Ray stifle angle	NS	NS	NS	NS

NS meaning not significant

 Equations present have a significance of $P \leq 0.05$

Table 4.25 (c) Predictive regression models for the dependent variable: linear distance between the humeroradial and the metacarpophalangeal joints at 120cm in free-jumping

Stationary Measurement	Gelding	Mare
Age	NS	NS
Weight	$y = 0,1255x - 24,0997$	$y = 0,0897x - 11,5954$
Head length	NS	$y = -0,4597x^2 + 60,0098x - 1918,1286$
Neck length	NS	NS
Croup length	NS	$y = 1,5908x - 47,6174$
Wither height	$y = 1,2174x - 158,0353$	$y = 0,6654x - 71,5162$
Croup height	$y = 0,9423x - 110,1272$	$y = 0,6613x - 70,1945$
Head-neck perimeter	NS	NS
Neck-body perimeter	NS	NS
Chest girth	$y = 1,0198x - 153,1895$	NS
Femur length	$y = -0,1959x^2 + 21,6876x - 552,3723$	NS
Body length	NS	NS
Shoulder angle	NS	NS
Hoof angle	NS	NS
Hip joint angle	NS	NS
Hock Joint angle	$y = -0,1661x^2 + 50,4314x - 3777,6407$	NS
X-Ray forelimb fetlock angle	NS	NS
X-Ray forelimb hoof angle	NS	NS
X-Ray hindlimb fetlock angle	$y = 0,2671x^2 - 79,5x + 5954,6894$	NS
X-Ray hindlimb hoof angle	NS	NS
X-Ray hock angle	NS	NS
X-Ray stifle angle	NS	NS

NS meaning not significant

Equations present have a significance of $P \leq 0.05$

Table 4.26 (a) Predictive regression models for the dependent variable: vertical distance between the humeroradial and the metacarpophalangeal joints at 80cm

Stationary Measurement	Gelding		Mare	
	Under-saddle	Free-jumping	Under-saddle	Free-jumping
Age	NS	NS	NS	NS
Weight	$y = 0,0031x^2 - 3,3121x + 909,3767$	NS	NS	NS
Head length	NS	NS	NS	NS
Neck length	NS	NS	NS	NS
Croup length	$y = 1,4339x - 62,4239$	NS	NS	NS
Wither height	$y = 0,3044x^2 - 100,9428x + 8377,1432$	NS	NS	NS
Croup height	NS	NS	NS	NS
Head-neck perimeter	NS	NS	NS	NS
Neck-body perimeter	NS	NS	$y = 0,0821x^2 - 19,9376x + 1221,2369$	NS
Chest girth	NS	NS	NS	NS
Femur length	NS	NS	NS	$y = 0,2066x^2 - 19,6142x + 471,8482$
Body length	NS	NS	NS	NS
Shoulder angle	$y = 0,1683x^2 - 18,7242x + 533,1967$	NS	NS	$y = 0,7705x^2 - 86,1204x + 2414,0128$
Hoof angle	NS	NS	NS	NS
Hip joint angle	NS	$y = 0,0221x^2 - 3,1655x + 122,9439$	NS	NS
Hock Joint angle	NS	NS	NS	NS
X-Ray forelimb fetlock angle	NS	NS	NS	NS
X-Ray forelimb hoof angle	NS	NS	NS	NS
X-Ray hindlimb fetlock angle	NS	NS	NS	NS
X-Ray hindlimb hoof angle	NS	NS	NS	NS
X-Ray hock angle	NS	NS	NS	NS
X-Ray stifle angle	NS	NS	NS	NS

NS meaning not significant

 Equations present have a significance of $P \leq 0.05$

Table 4.26 (b) Predictive regression models for the dependent variable: vertical distance between the humeroradial and the metacarpophalangeal joints at 100cm

Stationary Measurement	Gelding		Mare	
	Under-saddle	Free-jumping	Under-saddle	Free-jumping
Age	NS	NS	NS	NS
Weight	NS	NS	NS	NS
Head length	NS	NS	NS	NS
Neck length	NS	NS	NS	NS
Croup length	NS	NS	NS	NS
Wither height	$y = 0,3432x^2 - 114,0991x + 9492,6895$	NS	NS	NS
Croup height	NS	NS	NS	NS
Head-neck perimeter	NS	NS	NS	NS
Neck-body perimeter	NS	NS	$y = 0,1134x^2 - 27,2634x + 1646,5656$	NS
Chest girth	NS	NS	NS	NS
Femur length	NS	NS	NS	$y = 0,1428x^2 - 13,4242x + 321,9897$
Body length	NS	NS	NS	NS
Shoulder angle	NS	NS	$y = 0,6095x^2 - 69,0091x + 1961,2898$	$y = 0,6605x^2 - 72,6893x + 2007,0432$
Hoof angle	NS	NS	NS	NS
Hip joint angle	NS	NS	NS	NS
Hock Joint angle	$y = 0,128x^2 - 38,8267x + 2955,0632$	NS	NS	NS
X-Ray forelimb fetlock angle	NS	NS	NS	NS
X-Ray forelimb hoof angle	$y = -0,3826x^2 + 122,4884x - 9783,0993$	NS	NS	NS
X-Ray hindlimb fetlock angle	NS	NS	NS	NS
X-Ray hindlimb hoof angle	NS	NS	NS	NS
X-Ray hock angle	NS	NS	NS	NS
X-Ray stifle angle	NS	NS	NS	NS

NS meaning not significant

 Equations present have a significance of $P \leq 0.05$

Table 4.26 (c) Predictive regression models for the dependent variable: vertical distance between the humeroradial and the metacarpophalangeal joints at 120cm in free-jumping

Stationary Measurement	Gelding	Mare
Age	NS	NS
Weight	NS	NS
Head length	NS	NS
Neck length	NS	NS
Croup length	NS	$y = -0,0708x^2 + 6,4902x - 135,2563$
Wither height	NS	NS
Croup height	NS	NS
Head-neck perimeter	NS	NS
Neck-body perimeter	NS	NS
Chest girth	NS	NS
Femur length	NS	NS
Body length	NS	NS
Shoulder angle	NS	NS
Hoof angle	NS	NS
Hip joint angle	NS	NS
Hock Joint angle	NS	NS
X-Ray forelimb fetlock angle	NS	NS
X-Ray forelimb hoof angle	$y = -0,4936x^2 + 157,7696x - 12585,5843$	NS
X-Ray hindlimb fetlock angle	$y = 0,2367x^2 - 71,3701x + 5389,9124$	NS
X-Ray hindlimb hoof angle	NS	NS
X-Ray hock angle	NS	NS
X-Ray stifle angle	NS	NS

NS meaning not significant

Equations present have a significance of $P \leq 0.05$

This next section of measurements are the four jumping linear measurements that were taken for the height that each limb was lifted above the jump. Table 4.27 (a), (b) and (c) present the prediction models for the height of the right forelimb at 80cm, 100cm and 120cm respectively. Table 4.28 (a), (b) and (c) present the predictive models for the height of the left forelimb at 80cm, 100cm and 120cm respectively. Table 4.29 (a), (b) and (c) present the predictive models for the height of the right hindlimb at 80cm, 100cm and 120cm respectively. Table 4.30 (a), (b) and (c) present the predictive models for the height of the left hindlimb at 80cm, 100cm and 120cm respectively.

Within 80cm the stationary measurement that stood out for mares under-saddle and free-jumping was the equation with croup length as this stationary measurement significantly predicted ($P \leq 0.05$) most of the mare jumps at 80cm. At 120cm the stationary measurements that had significant equations ($P \leq 0.05$) for all gelding limbs were the X-ray forelimb fetlock angle and the X-ray forelimb hoof angle. Within the height of the right forelimb, the head length significantly predicted ($P \leq 0.05$) for both 80cm and 100cm for mares free-jumping. Within the height of the left forelimb, the equation with head-neck perimeter significantly predicted ($P \leq 0.05$) for both 80cm and 100cm for geldings free-jumping while the croup length had significant equations ($P \leq 0.05$) for both 80cm and 100cm for mares free-jumping. Within the height of the right hindlimb, the equation with femur length significantly predicted ($P \leq 0.05$) for both 80cm and 100cm for geldings free-jumping. Within the height of the left hindlimb, the equations with X-ray hock angle significantly predicted ($P \leq 0.05$) both 80cm and 100cm for geldings free-jumping.

Table 4.27 (a) Predictive regression models for the dependent variable: height of right forelimb at 80cm

Stationary Measurement	Gelding		Mare	
	Under-saddle	Free-jumping	Under-saddle	Free-jumping
Age	NS	NS	NS	NS
Weight	NS	NS	NS	NS
Head length	NS	NS	NS	$y = -1,3571x^2 + 173,7676x - 5515,7848$
Neck length	NS	NS	NS	NS
Croup length	NS	NS	$y = 0,4255x^2 - 41,6187x + 1029,3588$	NS
Wither height	NS	NS	NS	NS
Croup height	NS	NS	NS	NS
Head-neck perimeter	NS	$y = -0,4261x^2 + 70,8155x - 2902,0275$	NS	NS
Neck-body perimeter	NS	NS	NS	$y = 1,1702x - 106,2984$
Chest girth	NS	NS	NS	NS
Femur length	$y = 0,208x^2 - 20,5199x + 524,7886$	NS	NS	NS
Body length	NS	$y = -0,1616x^2 + 56,5451x - 4902,9804$	NS	NS
Shoulder angle	NS	NS	NS	NS
Hoof angle	NS	NS	NS	NS
Hip joint angle	NS	$y = -1,045x + 121,8772$	NS	NS
Hock Joint angle	$y = -1,4185x + 246,1274$	NS	NS	NS
X-Ray forelimb fetlock angle	NS	NS	NS	NS
X-Ray forelimb hoof angle	NS	NS	$y = 0,3223x^2 - 102,9718x + 8234,732$	NS
X-Ray hindlimb fetlock angle	NS	NS	NS	NS
X-Ray hindlimb hoof angle	NS	NS	NS	NS
X-Ray hock angle	NS	NS	NS	NS
X-Ray stifle angle	NS	NS	NS	NS

NS meaning not significant

Equations present have a significance of $P \leq 0.05$

Table 4.27 (b) Predictive regression models for the dependent variable: height of right forelimb at 100cm

Stationary Measurement	Gelding		Mare	
	Under-saddle	Free-jumping	Under-saddle	Free-jumping
Age	NS	NS	NS	NS
Weight	NS	NS	$y = -0,0024x^2 + 2,4983x - 617,3922$	NS
Head length	NS	NS	NS	$y = -1,4866x^2 + 189,9699x - 6031,917$
Neck length	NS	NS	NS	NS
Croup length	NS	NS	NS	NS
Wither height	NS	NS	NS	NS
Croup height	NS	NS	NS	NS
Head-neck perimeter	NS	NS	NS	NS
Neck-body perimeter	NS	NS	NS	NS
Chest girth	NS	NS	NS	$y = -0,2715x^2 + 104,0478x - 9931,7687$
Femur length	$y = 1,3234x - 50,3905$	NS	NS	NS
Body length	NS	NS	NS	NS
Shoulder angle	NS	NS	NS	NS
Hoof angle	NS	NS	NS	NS
Hip joint angle	NS	NS	NS	NS
Hock Joint angle	$y = -0,1202x^2 + 35,936x - 2657,9798$	NS	NS	NS
X-Ray forelimb fetlock angle	NS	NS	$y = 0,1361x^2 - 41,1404x + 3123,3261$	NS
X-Ray forelimb hoof angle	NS	NS	NS	NS
X-Ray hindlimb fetlock angle	NS	NS	NS	NS
X-Ray hindlimb hoof angle	NS	NS	NS	NS
X-Ray hock angle	NS	NS	NS	NS
X-Ray stifle angle	NS	NS	NS	NS

NS meaning not significant

 Equations present have a significance of $P \leq 0.05$

Table 4.27 (c) Predictive regression models for the dependent variable: height of right forelimb at 120cm in free-jumping

Stationary Measurement	Gelding	Mare
Age	NS	NS
Weight	$y = -0,0024x^2 + 2,6915x - 716,322$	NS
Head length	$y = 1,0796x - 43,9118$	NS
Neck length	NS	NS
Croup length	NS	NS
Wither height	NS	NS
Croup height	NS	NS
Head-neck perimeter	NS	NS
Neck-body perimeter	NS	NS
Chest girth	NS	NS
Femur length	NS	NS
Body length	NS	NS
Shoulder angle	NS	NS
Hoof angle	NS	$y = 0,2327x^2 - 82,6314x + 7351,3413$
Hip joint angle	NS	NS
Hock Joint angle	NS	NS
X-Ray forelimb fetlock angle	$y = -0,01x^2 + 4,35x - 339,53$	NS
X-Ray forelimb hoof angle	$y = -0,7457x + 142,8424$	NS
X-Ray hindlimb fetlock angle	NS	NS
X-Ray hindlimb hoof angle	NS	NS
X-Ray hock angle	NS	NS
X-Ray stifle angle	NS	NS

NS meaning not significant

 Equations present have a significance of $P \leq 0.05$

Table 4.28 (a) Predictive regression models for the dependent variable: height of left forelimb at 80cm

Stationary Measurement	Gelding		Mare	
	Under-saddle	Free-jumping	Under-saddle	Free-jumping
Age	NS	NS	NS	NS
Weight	NS	NS	NS	NS
Head length	NS	NS	NS	NS
Neck length	NS	NS	NS	NS
Croup length	NS	NS	$y = 0,3411x^2 - 32,7297x + 796,8208$	$y = -0,2158x^2 + 24,2545x - 642,3558$
Wither height	NS	NS	NS	NS
Croup height	NS	NS	NS	NS
Head-neck perimeter	NS	$y = 0,262x^2 - 40,4946x + 1595,6101$	NS	NS
Neck-body perimeter	NS	NS	NS	NS
Chest girth	NS	NS	NS	NS
Femur length	$y = 0,1964x^2 - 19,435x + 499,4312$	NS	NS	NS
Body length	NS	NS	NS	NS
Shoulder angle	NS	NS	NS	NS
Hoof angle	NS	NS	NS	NS
Hip joint angle	NS	NS	NS	NS
Hock Joint angle	$y = -1,351x + 235,1319$	NS	NS	NS
X-Ray forelimb fetlock angle	NS	NS	NS	NS
X-Ray forelimb hoof angle	NS	NS	NS	$y = -0,083x^2 + 25,0252x - 1848,8866$
X-Ray hindlimb fetlock angle	NS	NS	NS	NS
X-Ray hindlimb hoof angle	NS	NS	NS	NS
X-Ray hock angle	NS	NS	NS	NS
X-Ray stifle angle	NS	NS	NS	NS

NS meaning not significant

Equations present have a significance of $P \leq 0.05$

Table 4.28 (b) Predictive regression models for the dependent variable: height of left forelimb at 100cm

Stationary Measurement	Gelding		Mare	
	Under-saddle	Free-jumping	Under-saddle	Free-jumping
Age	NS	NS	NS	NS
Weight	NS	NS	NS	NS
Head length	NS	NS	NS	NS
Neck length	NS	NS	NS	NS
Croup length	NS	NS	NS	$y = -0,071x^2 + 9,8026x - 290,4325$
Wither height	NS	NS	NS	NS
Croup height	NS	NS	NS	NS
Head-neck perimeter	NS	$y = 1,7683x - 116,7403$	NS	NS
Neck-body perimeter	NS	NS	NS	NS
Chest girth	NS	NS	NS	NS
Femur length	NS	NS	NS	NS
Body length	NS	NS	NS	NS
Shoulder angle	NS	NS	NS	NS
Hoof angle	NS	NS	NS	NS
Hip joint angle	NS	NS	NS	NS
Hock Joint angle	NS	NS	NS	NS
X-Ray forelimb fetlock angle	NS	$y = 0,9238x - 111,3063$	$y = 0,206x^2 - 62,3572x + 4730,9072$	NS
X-Ray forelimb hoof angle	NS	NS	NS	NS
X-Ray hindlimb fetlock angle	NS	NS	NS	NS
X-Ray hindlimb hoof angle	NS	NS	NS	NS
X-Ray hock angle	NS	NS	NS	NS
X-Ray stifle angle	NS	NS	NS	NS

NS meaning not significant

 Equations present have a significance of $P \leq 0.05$

Table 4.28 (c) Predictive regression models for the dependent variable: height of left forelimb at 120cm in free-jumping

Stationary Measurement	Gelding	Mare
Age	NS	NS
Weight	$y = -0,0049x^2 + 5,3247x - 1424,0645$	NS
Head length	NS	NS
Neck length	NS	NS
Croup length	NS	NS
Wither height	NS	NS
Croup height	NS	NS
Head-neck perimeter	NS	NS
Neck-body perimeter	NS	NS
Chest girth	NS	NS
Femur length	NS	NS
Body length	NS	NS
Shoulder angle	NS	NS
Hoof angle	NS	$y = 0,2574x^2 - 91,4289x + 8134,2605$
Hip joint angle	NS	NS
Hock Joint angle	NS	NS
X-Ray forelimb fetlock angle	$y = -0,0169x^2 + 6,0442x - 499,461$	NS
X-Ray forelimb hoof angle	$y = -0,0794x^2 + 23,8133x - 1753,2422$	NS
X-Ray hindlimb fetlock angle	NS	NS
X-Ray hindlimb hoof angle	NS	NS
X-Ray hock angle	NS	NS
X-Ray stifle angle	NS	NS

NS meaning not significant

 Equations present have a significance of $P \leq 0.05$

Table 4.29 (a) Predictive regression models for the dependent variable: height of right hindlimb at 80cm

Stationary Measurement	Gelding		Mare	
	Under-saddle	Free-jumping	Under-saddle	Free-jumping
Age	$y = 0,9684x - 34,984$	NS	NS	NS
Weight	NS	NS	NS	NS
Head length	NS	NS	NS	NS
Neck length	NS	NS	NS	NS
Croup length	NS	NS	$y = 0,2743x^2 - 25,6223x + 610,9247$	$y = 2,9317x - 106,4511$
Wither height	NS	NS		
Croup height	NS	NS	NS	NS
Head-neck perimeter	NS	NS	NS	NS
Neck-body perimeter	NS	NS	NS	NS
Chest girth	NS	NS	NS	NS
Femur length	NS	$y = -2,1231x + 155,3755$	NS	NS
Body length	NS	NS	NS	NS
Shoulder angle	NS	NS	NS	NS
Hoof angle	NS	NS	NS	NS
Hip joint angle	NS	NS	NS	NS
Hock Joint angle	NS	NS	NS	NS
X-Ray forelimb fetlock angle	NS	NS	NS	NS
X-Ray forelimb hoof angle	NS	NS	NS	NS
X-Ray hindlimb fetlock angle	NS	NS	NS	NS
X-Ray hindlimb hoof angle	NS	NS	NS	NS
X-Ray hock angle	NS	NS	NS	NS
X-Ray stifle angle	NS	NS	NS	NS

NS meaning not significant

 Equations present have a significance of $P \leq 0.05$

Table 4.29 (b) Predictive regression models for the dependent variable: height of right hindlimb at 100cm

Stationary Measurement	Gelding		Mare	
	Under-saddle	Free-jumping	Under-saddle	Free-jumping
Age	NS	NS	NS	NS
Weight	NS	NS	NS	NS
Head length	NS	NS	NS	NS
Neck length	NS	$y = -1,0346x + 119,8547$	NS	NS
Croup length	NS	NS	NS	NS
Wither height	NS	NS	NS	NS
Croup height	NS	NS	NS	NS
Head-neck perimeter	NS	NS	NS	NS
Neck-body perimeter	NS	NS	NS	NS
Chest girth	$y = 0,3816x^2 - 148,7358x + 14505,7824$	NS	NS	NS
Femur length	$y = -1,2077x + 85,8976$	$y = -1,6908x + 119,3265$	NS	NS
Body length	NS	NS	NS	NS
Shoulder angle	NS	NS	NS	NS
Hoof angle	NS	NS	NS	NS
Hip joint angle	NS	NS	NS	NS
Hock Joint angle	NS	NS	NS	NS
X-Ray forelimb fetlock angle	NS	NS	NS	NS
X-Ray forelimb hoof angle	NS	NS	NS	NS
X-Ray hindlimb fetlock angle	NS	NS	NS	NS
X-Ray hindlimb hoof angle	NS	NS	NS	NS
X-Ray hock angle	$y = 0,3247x^2 - 104,7745x + 8469,1768$	$y = 0,785x^2 - 255,7879x + 20858,0107$	NS	NS
X-Ray stifle angle	NS	NS	$y = 2,285x^2 - 623,6702x + 42572,0176$	NS

NS meaning not significant

 Equations present have a significance of $P \leq 0.05$

Table 4.29 (c) Predictive regression models for the dependent variable: height of right hindlimb at 120cm in free-jumping

Stationary Measurement	Gelding	Mare
Age	NS	NS
Weight	NS	NS
Head length	NS	NS
Neck length	NS	NS
Croup length	NS	NS
Wither height	NS	NS
Croup height	NS	NS
Head-neck perimeter	NS	NS
Neck-body perimeter	NS	NS
Chest girth	NS	NS
Femur length	NS	NS
Body length	NS	NS
Shoulder angle	NS	NS
Hoof angle	NS	NS
Hip joint angle	NS	NS
Hock Joint angle	NS	NS
X-Ray forelimb fetlock angle	$y = -0,209x^2 + 61,4911x - 4491,1795$	NS
X-Ray forelimb hoof angle	$y = -0,4646x^2 + 147,4372x - 11666,5246$	NS
X-Ray hindlimb fetlock angle	NS	NS
X-Ray hindlimb hoof angle	NS	NS
X-Ray hock angle	NS	NS
X-Ray stifle angle	NS	NS

NS meaning not significant

 Equations present have a significance of $P \leq 0.05$

Table 4.30 (a) Predictive regression models for the dependent variable: height of left hindlimb at 80cm

Stationary Measurement	Gelding		Mare	
	Under-saddle	Free-jumping	Under-saddle	Free-jumping
Age	$y = 0,961x - 34,453$	NS	NS	NS
Weight	NS	NS	NS	NS
Head length	NS	NS	NS	NS
Neck length	NS	NS	NS	NS
Croup length	NS	NS	$y = 0,2743x^2 - 25,6223x + 610,9247$	$y = 2,9317x - 106,4511$
Wither height	NS	NS	NS	NS
Croup height	NS	NS	NS	NS
Head-neck perimeter	NS	NS	NS	NS
Neck-body perimeter	NS	NS	NS	NS
Chest girth	NS	NS	NS	NS
Femur length	NS	NS	NS	NS
Body length	NS	NS	NS	NS
Shoulder angle	NS	NS	NS	NS
Hoof angle	NS	NS	NS	NS
Hip joint angle	NS	NS	NS	NS
Hock Joint angle	NS	NS	NS	NS
X-Ray forelimb fetlock angle	NS	NS	NS	NS
X-Ray forelimb hoof angle	NS	NS	NS	NS
X-Ray hindlimb fetlock angle	NS	NS	NS	NS
X-Ray hindlimb hoof angle	NS	NS	NS	NS
X-Ray hock angle	NS	$y = 1,178x^2 - 385,8082x + 31622,634$	NS	NS
X-Ray stifle angle	NS	NS	NS	NS

NS meaning not significant

 Equations present have a significance of $P \leq 0.05$

Table 4.30 (b) Predictive regression models for the dependent variable: height of left hindlimb at 100cm

Stationary Measurement	Gelding		Mare	
	Under-saddle	Free-jumping	Under-saddle	Free-jumping
Age	NS	NS	NS	NS
Weight	NS	NS	NS	NS
Head length	NS	NS	NS	NS
Neck length	$y = -0,6279x + 76,08$	$y = -0,9111x + 108,0557$	NS	NS
Croup length	NS	NS	NS	NS
Wither height	NS	NS	NS	NS
Croup height	NS	NS	NS	NS
Head-neck perimeter	NS	NS	NS	NS
Neck-body perimeter	NS	NS	NS	NS
Chest girth	$y = 0,3655x^2 - 142,4531x + 13892,2341$	NS	NS	NS
Femur length	NS	NS	NS	NS
Body length	NS	NS	NS	NS
Shoulder angle	NS	NS	NS	NS
Hoof angle	NS	NS	NS	NS
Hip joint angle	NS	NS	NS	NS
Hock Joint angle	NS	NS	NS	NS
X-Ray forelimb fetlock angle	NS	NS	NS	$y = 0,3438x^2 - 104,3312x + 7943,7969$
X-Ray forelimb hoof angle	NS	NS	NS	NS
X-Ray hindlimb fetlock angle	NS	NS	NS	NS
X-Ray hindlimb hoof angle	NS	NS	NS	NS
X-Ray hock angle	$y = 0,3418x^2 - 110,5263x + 8949,7509$	$y = 0,8096x^2 - 264,2101x + 21576,0822$	NS	NS
X-Ray stifle angle	NS	NS	$y = 2,285x^2 - 623,6702x + 42572,0176$	NS

NS meaning not significant

Equations present have a significance of $P \leq 0.05$

Table 4.30 (c) Predictive regression models for the dependent variable: height of left hindlimb at 120cm in free-jumping

Stationary Measurement	Gelding	Mare
Age	NS	NS
Weight	NS	NS
Head length	NS	NS
Neck length	NS	NS
Croup length	NS	NS
Wither height	NS	NS
Croup height	NS	NS
Head-neck perimeter	NS	NS
Neck-body perimeter	NS	NS
Chest girth	NS	NS
Femur length	NS	NS
Body length	NS	NS
Shoulder angle	NS	NS
Hoof angle	NS	NS
Hip joint angle	$y = 0,6167x - 24,0663$	NS
Hock Joint angle	NS	NS
X-Ray forelimb fetlock angle	$y = -0,145x^2 + 42,7636x - 3122,4683$	NS
X-Ray forelimb hoof angle	$y = -0,341x^2 + 108,1x - 8536,0599$	NS
X-Ray hindlimb fetlock angle	NS	NS
X-Ray hindlimb hoof angle	NS	NS
X-Ray hock angle	NS	NS
X-Ray stifle angle	NS	NS

NS meaning not significant

 Equations present have a significance of $P \leq 0.05$

The next section presents the predictive models for the jumping linear measurements that were taken to show the elevation of the horse above the jump which include the elevation of the head at 80cm, 100cm and 120cm in Table 4.31 (a), (b) and (c) respectively; the elevation of the withers at 80cm, 100cm and 120cm in Table 4.32 (a), (b) and (c) respectively; and the elevation of the croup at 80cm, 100cm and 120cm in Table 4.33 (a), (b) and (c) respectively.

Analysing the 80cm height, geldings measurements of head, withers and croup under-saddle could be predicted by the croup height or femur length stationary measurement. The head-neck perimeter could predict the head, wither and croup free-jumping measurements. At 100cm, the elevation of the withers and the croup was very similar when it came to the prediction by stationary measurements with the age, head length, croup length, neck-body perimeter, chest girth, body length hoof angle, hip joint angle and x-ray forelimb hoof angle all having significant equations ($P \leq 0.05$) with different sexes and under-saddle versus free-jumping. Within 120cm, the weight, head length, wither height and chest girth can all be used to predict the geldings free-jumping measurements for head, withers and croup. Within the elevation of the head, one of the key stationary measurements taken note of was the croup height as for all sections under 80cm, this stationary measurement had a significant equation. Head-neck perimeter for geldings was also a noteworthy stationary measurement for the elevation of the head. When looking at the elevation of the withers, the chest girth stood out as a stationary measurement to predict the jumping measurement.

The next section are the jumping angular measurements that were taken of the head and the femorotibial angles. Table 4.34 (a), (b) and (c) present the predictive models for the mid head angle at 80cm, 100cm and 120cm respectively. Table 4.35 (a), (b) and (c) present the predictive models for the above head angle at 80cm, 100cm and 120cm respectively. Table 4.36 (a), (b) and (c) present the predictive models for the middle femorotibial angle at 80cm, 100cm, and 120cm respectively. Table 4.37 (a), (b) and (c) present the predictive models for the above femorotibial angle at 80cm, 100cm, and 120cm respectively.

When considering the head angles, the femur length for geldings under-saddle shows importance for both 80cm and 100cm. At 120cm, the head-neck perimeter and the neck-body perimeter were important stationary measurements to look at.

Table 4.31 (a) Predictive regression models for the dependent variable: elevation of head at 80cm

Stationary Measurement	Gelding		Mare	
	Under-saddle	Free-jumping	Under-saddle	Free-jumping
Age	NS	NS	NS	NS
Weight	NS	$y = 0,2364x - 8,1972$	NS	NS
Head length	NS	NS	NS	NS
Neck length	NS	NS	$y = -0,0976x^2 + 16,0863x - 530,8103$	NS
Croup length	NS	NS	NS	NS
Wither height	NS	NS	$y = -0,2564x^2 + 81,7013x - 6376,0817$	$y = -0,2848x^2 + 90,7536x - 7099,4346$
Croup height	$y = 1,8901x - 183,6431$	$y = 1,8429x - 181,4153$	$y = -0,2347x^2 + 74,5012x - 5783,0815$	$y = -0,2575x^2 + 81,8768x - 6378,9815$
Head-neck perimeter	$y = -0,6972x^2 + 116,9353x - 4766,6256$	$y = -0,477x^2 + 81,0839x - 3314,0998$	NS	NS
Neck-body perimeter	NS	NS	NS	NS
Chest girth	NS	$y = 1,8695x - 241,3971$	NS	NS
Femur length	$y = 2,5447x - 10,2259$	$y = 2,1697x + 4,4481$	NS	NS
Body length	NS	NS	NS	NS
Shoulder angle	NS	NS	NS	NS
Hoof angle	NS	NS	NS	NS
Hip joint angle	$y = 0,1799x^2 - 32,3134x + 1563,4908$	$y = 0,0305x^2 - 7,3406x + 517,9574$	NS	NS
Hock Joint angle	NS	NS	NS	NS
X-Ray forelimb fetlock angle	NS	NS	NS	NS
X-Ray forelimb hoof angle	NS	NS	NS	NS
X-Ray hindlimb fetlock angle	NS	NS	NS	NS
X-Ray hindlimb hoof angle	NS	NS	NS	NS
X-Ray hock angle	NS	$y = 1,1984x^2 - 396,7821x + 32956,2592$	NS	NS
X-Ray stifle angle	NS	NS	NS	NS

NS meaning not significant

Equations present have a significance of $P \leq 0.05$

Table 4.31 (b) Predictive regression models for the dependent variable: elevation of head at 100cm

Stationary Measurement	Gelding		Mare	
	Under-saddle	Free-jumping	Under-saddle	Free-jumping
Age	NS	NS	NS	NS
Weight	NS	NS	NS	NS
Head length	NS	NS	NS	NS
Neck length	NS	NS	NS	NS
Croup length	NS	NS	NS	NS
Wither height	NS	NS	$y = -0,2036x^2 + 64,5255x - 4989,5893$	NS
Croup height	NS	NS	NS	NS
Head-neck perimeter	$y = -1,1757x^2 + 192,9883x - 7791,2527$	$y = -0,6079x^2 + 102,66x - 4214,2998$	NS	NS
Neck-body perimeter	NS	NS	NS	NS
Chest girth	NS	NS	NS	NS
Femur length	NS	NS	NS	NS
Body length	NS	NS	NS	NS
Shoulder angle	NS	NS	NS	NS
Hoof angle	NS	NS	NS	NS
Hip joint angle	$y = 0,0794x^2 - 15,2796x + 837,6762$	$y = -2,0265x + 276,1397$	NS	NS
Hock Joint angle	NS	NS	NS	NS
X-Ray forelimb fetlock angle	NS	NS	NS	NS
X-Ray forelimb hoof angle	NS	NS	NS	NS
X-Ray hindlimb fetlock angle	NS	NS	NS	NS
X-Ray hindlimb hoof angle	NS	NS	$y = -0,8419x^2 + 262,5317x - 20348,8603$	NS
X-Ray hock angle	NS	$y = 1,1425x^2 - 378,8979x + 31513,1796$	NS	NS
X-Ray stifle angle	NS	NS	NS	NS

NS meaning not significant

Equations present have a significance of $P \leq 0.05$

Table 4.31 (c) Predictive regression models for the dependent variable: elevation of head at 120cm in free-jumping

Stationary Measurement	Gelding	Mare
Age	NS	NS
Weight	$y = -0,0011x^2 + 1,4952x - 377,1924$	NS
Head length	$y = 4,228x - 159,9227$	NS
Neck length	NS	NS
Croup length	NS	NS
Wither height	$y = 2,3915x - 287,8042$	$y = -0,1778x^2 + 56,2819x - 4346,2448$
Croup height	$y = 2,141x - 241,3105$	NS
Head-neck perimeter	$y = -0,5545x^2 + 93,3153x - 3806,9958$	NS
Neck-body perimeter	NS	NS
Chest girth	$y = 2,1075x - 298,5056$	NS
Femur length	NS	NS
Body length	NS	NS
Shoulder angle	NS	NS
Hoof angle	NS	NS
Hip joint angle	NS	NS
Hock Joint angle	NS	NS
X-Ray forelimb fetlock angle	NS	NS
X-Ray forelimb hoof angle	NS	NS
X-Ray hindlimb fetlock angle	NS	NS
X-Ray hindlimb hoof angle	NS	NS
X-Ray hock angle	$y = 1,3196x^2 - 436,6094x + 36214,6954$	NS
X-Ray stifle angle	NS	NS

NS meaning not significant

 Equations present have a significance of $P \leq 0.05$

Table 4.32 (a) Predictive regression models for the dependent variable: elevation of withers at 80cm

Stationary Measurement	Gelding		Mare	
	Under-saddle	Free-jumping	Under-saddle	Free-jumping
Age	$y = 0,2579x^2 - 28,9903x + 928,8902$	NS	NS	NS
Weight	NS	NS	NS	NS
Head length	NS	NS	NS	NS
Neck length	$y = 0,0316x^2 - 4,6356x + 282,675$	NS	NS	NS
Croup length	$y = 2,4133x - 8,0225$	NS	NS	NS
Wither height	$y = 0,233x^2 - 75,9894x + 6311,3977$	NS	NS	NS
Croup height	$y = 0,1907x^2 - 61,1343x + 5015,3921$	NS	NS	NS
Head-neck perimeter	NS	$y = -0,2335x^2 + 39,8148x - 1564,8341$	NS	NS
Neck-body perimeter	$y = 1,4637x - 60,5383$	NS	NS	NS
Chest girth	$y = 0,0516x^2 - 18,7845x + 1823,7876$	$y = 1,1028x - 87,2206$	NS	NS
Femur length	$y = 0,2042x^2 - 20,2205x + 615,2292$	NS	NS	$y = 0,3495x^2 - 33,972x + 941,6211$
Body length	$y = -0,0333x^2 + 12,5374x - 1048,4719$	NS	NS	NS
Shoulder angle	NS	NS	NS	$y = 0,973x^2 - 108,7649x + 3157,3957$
Hoof angle	$y = -0,6308x^2 + 233,7245x - 21519,2487$	NS	NS	$y = -1,16x + 330,8845$
Hip joint angle	NS	NS	NS	NS
Hock Joint angle	$y = 0,0569x^2 - 18,8665x + 1677,1752$	NS	NS	NS
X-Ray forelimb fetlock angle	NS	NS	NS	NS
X-Ray forelimb hoof angle	NS	NS	$y = 0,0445x^2 - 15,6511x + 1473,7186$	NS
X-Ray hindlimb fetlock angle	NS	NS	NS	NS
X-Ray hindlimb hoof angle	NS	NS	NS	NS
X-Ray hock angle	NS	NS	NS	NS
X-Ray stifle angle	NS	NS	NS	NS

NS meaning not significant

Equations present have a significance of $P \leq 0.05$

Table 4.32 (b) Predictive regression models for the dependent variable: elevation of withers at 100cm

Stationary Measurement	Gelding		Mare	
	Under-saddle	Free-jumping	Under-saddle	Free-jumping
Age	NS	NS	NS	$y = 9,5376x - 381,6955$
Weight	NS	NS	NS	NS
Head length	NS	$y = 3,0669x - 80,4468$	NS	$y = -1,7083x^2 + 217,1363x - 6775,8266$
Neck length	NS	NS	NS	NS
Croup length	$y = 0,4153x^2 - 41,9058x + 1168,8205$	NS	NS	NS
Wither height	NS	NS	NS	NS
Croup height	NS	NS	NS	NS
Head-neck perimeter	NS	NS	NS	NS
Neck-body perimeter	$y = -0,0322x^2 + 9,773x - 599,065$	NS	NS	NS
Chest girth	$y = 0,2372x^2 - 90,8948x + 8820,5984$	$y = 1,2588x - 128,6073$	NS	NS
Femur length	NS	NS	NS	NS
Body length	$y = 0,0047x^2 - 0,6059x + 81,4053$	NS	NS	NS
Shoulder angle	NS	NS	$y = 0,68x^2 - 74,87x + 2177,81$	NS
Hoof angle	$y = -0,6861x^2 + 254,3749x - 23449,2515$	NS	NS	NS
Hip joint angle	NS	NS	NS	$y = -1,2406x + 216,3767$
Hock Joint angle	NS	NS	NS	NS
X-Ray forelimb fetlock angle	NS	NS	NS	NS
X-Ray forelimb hoof angle	NS	NS	NS	$y = -1,7175x + 380,9496$
X-Ray hindlimb fetlock angle	NS	$y = 0,3396x^2 - 101,7451x + 7731,1114$	NS	NS
X-Ray hindlimb hoof angle	NS	NS	NS	NS
X-Ray hock angle	NS	NS	NS	NS
X-Ray stifle angle	NS	NS	NS	NS

NS meaning not significant

Equations present have a significance of $P \leq 0.05$

Table 4.32 (c) Predictive regression models for the dependent variable: elevation of withers at 120cm in free-jumping

Stationary Measurement	Gelding	Mare
Age	NS	NS
Weight	$y = -0,001x^2 + 1,24x - 269,8537$	NS
Head length	$y = 0,1252x^2 - 12,6033x + 408,8348$	NS
Neck length	NS	NS
Croup length	NS	NS
Wither height	$y = 1,5608x - 144,4674$	NS
Croup height	$y = 1,1973x - 81,2656$	NS
Head-neck perimeter	NS	NS
Neck-body perimeter	NS	NS
Chest girth	$y = 0,2137x^2 - 81,7068x + 7920,0651$	NS
Femur length	NS	NS
Body length	$y = 0,863x - 33,4849$	NS
Shoulder angle	NS	NS
Hoof angle	NS	$y = 0,4459x^2 - 158,8706x + 14245,7204$
Hip joint angle	NS	NS
Hock Joint angle	NS	NS
X-Ray forelimb fetlock angle	NS	NS
X-Ray forelimb hoof angle	NS	NS
X-Ray hindlimb fetlock angle	$y = 0,4104x^2 - 123,0371x + 9329,6126$	NS
X-Ray hindlimb hoof angle	NS	NS
X-Ray hock angle	NS	NS
X-Ray stifle angle	NS	NS

NS meaning not significant

 Equations present have a significance of $P \leq 0.05$

Table 4.33 (a) Predictive regression models for the dependent variable: elevation of croup at 80cm

Stationary Measurement	Gelding		Mare	
	Under-saddle	Free-jumping	Under-saddle	Free-jumping
Age	$y = 0,1948x^2 - 22,0105x + 732,9211$	NS	NS	NS
Weight	NS	NS	NS	NS
Head length	NS	NS	$y = -1,2403x^2 + 159,1139x - 4979,7163$	$y = -1,6464x^2 + 210,1627x - 6572,8933$
Neck length	$y = 0,0085x^2 - 0,8233x + 123,1414$	NS	NS	NS
Croup length	$y = 1,8885x + 15,7753$	NS	NS	NS
Wither height	$y = 0,2437x^2 - 79,9807x + 6673,7945$	NS	NS	NS
Croup height	$y = 0,2003x^2 - 64,6936x + 5334,2341$	NS	NS	NS
Head-neck perimeter	NS	$y = -0,2185x^2 + 36,9073x - 1431,0931$	NS	NS
Neck-body perimeter	NS	NS	$y = 1,1513x - 26,6238$	NS
Chest girth	$y = 0,9367x - 64,6792$	NS	NS	NS
Femur length	$y = 0,1848x^2 - 18,9239x + 597,6916$	NS	NS	NS
Body length	NS	NS	NS	NS
Shoulder angle	NS	NS	NS	NS
Hoof angle	$y = -0,5206x^2 + 193,0016x - 17761,7528$	NS	NS	NS
Hip joint angle	NS	NS	$y = 0,4261x^2 - 71,7496x + 3121,505$	$y = 0,2521x^2 - 43,3821x + 1979,8846$
Hock Joint angle	NS	NS	NS	NS
X-Ray forelimb fetlock angle	NS	NS	NS	NS
X-Ray forelimb hoof angle	NS	NS	$y = 0,0173x^2 - 7,3168x + 835,4276$	NS
X-Ray hindlimb fetlock angle	NS	NS	NS	NS
X-Ray hindlimb hoof angle	NS	NS	NS	NS
X-Ray hock angle	NS	NS	NS	NS
X-Ray stifle angle	NS	NS	NS	NS

NS meaning not significant

Equations present have a significance of $P \leq 0.05$

Table 4.33 (b) Predictive regression models for the dependent variable: elevation of croup at 100cm

Stationary Measurement	Gelding		Mare	
	Under-saddle	Free-jumping	Under-saddle	Free-jumping
Age	NS	NS	NS	$y = 11,0295x - 459,9759$
Weight	NS	NS	$y = 0,1092x + 50,3208$	NS
Head length	NS	$y = 2,3154x - 35,9026$	NS	$y = -2,1424x^2 + 273,3109x - 8590,8656$
Neck length	NS	NS	NS	NS
Croup length	$y = 0,1825x^2 - 17,1208x + 504,2343$	NS	NS	NS
Wither height	$y = 0,3349x^2 - 110,4926x + 9218,2774$	NS	NS	NS
Croup height	NS	NS	NS	NS
Head-neck perimeter	NS	NS	NS	NS
Neck-body perimeter	$y = 1,1484x - 31,1187$	NS	NS	NS
Chest girth	$y = 0,1905x^2 - 73,1012x + 7118,4033$	NS	NS	NS
Femur length	NS	NS	NS	NS
Body length	$y = 0,7713x - 21,4479$	NS	NS	NS
Shoulder angle	NS	NS	NS	NS
Hoof angle	$y = -0,6086x^2 + 225,5613x - 20776,5224$	NS	NS	NS
Hip joint angle	NS	NS	NS	$y = -1,5387x + 240,3122$
Hock Joint angle	NS	NS	NS	NS
X-Ray forelimb fetlock angle	NS	NS	NS	NS
X-Ray forelimb hoof angle	NS	$y = -0,5402x^2 + 171,995x - 13571,006$	$y = -0,21x^2 + 65,22x - 4923,51$	$y = -2,3028x + 471,3616$
X-Ray hindlimb fetlock angle	NS	NS	NS	NS
X-Ray hindlimb hoof angle	NS	NS	NS	NS
X-Ray hock angle	NS	NS	NS	NS
X-Ray stifle angle	NS	NS	NS	NS

NS meaning not significant

Equations present have a significance of $P \leq 0.05$

Table 4.33 (c) Predictive regression models for the dependent variable: elevation of croup at 120cm in free-jumping

Stationary Measurement	Gelding	Mare
Age	NS	NS
Weight	$y = 0,1454x + 31,0144$	NS
Head length	$y = 0,1249x^2 - 12,9327x + 426,3271$	NS
Neck length	NS	NS
Croup length	NS	NS
Wither height	$y = 1,2509x - 97,631$	NS
Croup height	NS	NS
Head-neck perimeter	NS	$y = 1,7985x - 40,2865$
Neck-body perimeter	NS	NS
Chest girth	$y = 0,1813x^2 - 69,4244x + 6753,1671$	NS
Femur length	NS	NS
Body length	NS	NS
Shoulder angle	NS	NS
Hoof angle	NS	NS
Hip joint angle	NS	NS
Hock Joint angle	NS	NS
X-Ray forelimb fetlock angle	NS	NS
X-Ray forelimb hoof angle	$y = -0,5647x^2 + 179,6707x - 14174,2186$	NS
X-Ray hindlimb fetlock angle	$y = 0,3621x^2 - 108,7118x + 8264,0257$	NS
X-Ray hindlimb hoof angle	NS	NS
X-Ray hock angle	NS	$y = -1,7402x + 390,5318$
X-Ray stifle angle	NS	NS

NS meaning not significant

 Equations present have a significance of $P \leq 0.05$

Table 4.34 (a) Predictive regression models for the dependent variable: middle head angle at 80cm

Stationary Measurement	Gelding		Mare	
	Under-saddle	Free-jumping	Under-saddle	Free-jumping
Age	NS	NS	NS	NS
Weight	$y = 0,0054x^2 - 5,9912x + 1754,0309$	NS	NS	NS
Head length	NS	NS	$y = -2,6518x + 270,9218$	NS
Neck length	NS	NS	$y = -0,6452x + 156,5158$	NS
Croup length	NS	NS	NS	NS
Wither height	NS	NS	NS	NS
Croup height	NS	NS	NS	$y = 0,088x^2 - 27,6491x + 2280,4035$
Head-neck perimeter	NS	NS	NS	$y = 0,1658x^2 - 25,5427x + 1093,3729$
Neck-body perimeter	NS	NS	NS	NS
Chest girth	NS	NS	NS	NS
Femur length	$y = -1,6042x + 188,9087$	NS	NS	NS
Body length	NS	NS	NS	NS
Shoulder angle	NS	NS	NS	NS
Hoof angle	NS	NS	NS	NS
Hip joint angle	NS	NS	NS	NS
Hock Joint angle	NS	NS	NS	NS
X-Ray forelimb fetlock angle	NS	NS	NS	NS
X-Ray forelimb hoof angle	NS	NS	NS	NS
X-Ray hindlimb fetlock angle	NS	$y = 0,4686x^2 - 142,8214x + 10993,4571$	NS	NS
X-Ray hindlimb hoof angle	NS	$y = 0,2478x^2 - 75,7604x + 5902,6505$	NS	NS
X-Ray hock angle	NS	NS	NS	NS
X-Ray stifle angle	NS	$y = 0,4058x^2 - 114,7909x + 8226,0638$	NS	NS

NS meaning not significant

Equations present have a significance of $P \leq 0,05$

Table 4.34 (b) Predictive regression models for the dependent variable: middle head angle at 100cm

Stationary Measurement	Gelding		Mare	
	Under-saddle	Free-jumping	Under-saddle	Free-jumping
Age	NS	NS	NS	NS
Weight	NS	NS	NS	NS
Head length	NS	NS	NS	NS
Neck length	NS	NS	NS	NS
Croup length	NS	NS	NS	NS
Wither height	NS	NS	NS	NS
Croup height	$y = -1,2743x + 313,8947$	NS	NS	NS
Head-neck perimeter	NS	NS	NS	NS
Neck-body perimeter	NS	$y = 0,219x^2 - 55,4108x + 3617,9537$	NS	NS
Chest girth	NS	NS	NS	NS
Femur length	$y = -0,0687x^2 + 5,4475x + 11,1487$	NS	NS	NS
Body length	NS	NS	NS	NS
Shoulder angle	NS	NS	$y = 1,7902x + 3,6869$	NS
Hoof angle	NS	NS	NS	NS
Hip joint angle	$y = -0,1072x^2 + 19,1615x - 744,5814$	NS	NS	NS
Hock Joint angle	$y = 0,036x^2 - 9,5866x + 724,5733$	NS	NS	NS
X-Ray forelimb fetlock angle	NS	NS	NS	NS
X-Ray forelimb hoof angle	NS	NS	NS	NS
X-Ray hindlimb fetlock angle	NS	NS	NS	NS
X-Ray hindlimb hoof angle	NS	NS	NS	NS
X-Ray hock angle	NS	NS	NS	NS
X-Ray stifle angle	NS	NS	NS	$y = 1,0025x^2 - 277,712x + 19342,9697$

NS meaning not significant

Equations present have a significance of $P \leq 0.05$

Table 4.34 (c) Predictive regression models for the dependent variable: middle head angle at 120cm in free-jumping

Stationary Measurement	Gelding	Mare
Age	NS	NS
Weight	NS	NS
Head length	NS	NS
Neck length	NS	NS
Croup length	NS	NS
Wither height	NS	NS
Croup height	NS	NS
Head-neck perimeter	$y = 0,3419x^2 - 56,9947x + 2487,8131$	$y = 1,5699x - 9,3157$
Neck-body perimeter	$y = 0,211x^2 - 53,9356x + 3557,0111$	NS
Chest girth	NS	NS
Femur length	NS	NS
Body length	NS	NS
Shoulder angle	NS	NS
Hoof angle	$y = 0,5338x^2 - 198,3538x + 18534,7519$	NS
Hip joint angle	$y = 0,9994x + 34,3566$	NS
Hock Joint angle	NS	$y = -0,5897x^2 + 181,3986x - 13827,371$
X-Ray forelimb fetlock angle	NS	NS
X-Ray forelimb hoof angle	NS	NS
X-Ray hindlimb fetlock angle	NS	NS
X-Ray hindlimb hoof angle	NS	NS
X-Ray hock angle	NS	NS
X-Ray stifle angle	NS	NS

NS meaning not significant

 Equations present have a significance of $P \leq 0.05$

Table 4.35 (a) Predictive regression models for the dependent variable: above head angle at 80cm

Stationary Measurement	Gelding		Mare	
	Under-saddle	Free-jumping	Under-saddle	Free-jumping
Age	NS	NS	NS	NS
Weight	NS	NS	NS	NS
Head length	NS	NS	NS	NS
Neck length	NS	NS	NS	NS
Croup length	NS	NS	NS	NS
Wither height	NS	NS	NS	NS
Croup height	NS	NS	NS	NS
Head-neck perimeter	$y = -2,8038x + 322,1499$	$y = -1,7663x + 249,37$	NS	NS
Neck-body perimeter	$y = -1,8234x + 321,5114$	NS	NS	NS
Chest girth	NS	NS	NS	NS
Femur length	$y = -0,0679x^2 + 5,1522x + 15,2382$	$y = -1,1215x + 166,593$	NS	NS
Body length	NS	NS	NS	$y = 0,1653x^2 - 54,8976x + 4654,5227$
Shoulder angle	NS	NS	NS	NS
Hoof angle	NS	NS	NS	NS
Hip joint angle	$y = -0,165x^2 + 29,4287x + 1205,6526$	$y = -0,0236x^2 + 5,1071x - 153,8327$	NS	NS
Hock Joint angle	$y = 1,7209x - 172,541$	NS	$y = -2,66x + 506,85$	NS
X-Ray forelimb fetlock angle	NS	NS	NS	NS
X-Ray forelimb hoof angle	NS	NS	NS	NS
X-Ray hindlimb fetlock angle	NS	NS	NS	NS
X-Ray hindlimb hoof angle	NS	NS	NS	NS
X-Ray hock angle	NS	NS	NS	$y = 0,9296x^2 - 304,8311x + 25089,785$
X-Ray stifle angle	NS	NS	NS	NS

NS meaning not significant

Equations present have a significance of $P \leq 0.05$

Table 4.35 (b) Predictive regression models for the dependent variable: above head angle at 100cm

Stationary Measurement	Gelding		Mare	
	Under-saddle	Free-jumping	Under-saddle	Free-jumping
Age	NS	NS	NS	NS
Weight	NS	NS	NS	NS
Head length	NS	NS	NS	NS
Neck length	NS	NS	NS	NS
Croup length	NS	NS	$y = -0,1272x^2 + 11,8919x - 176,683$	NS
Wither height	NS	NS	NS	NS
Croup height	NS	NS	NS	NS
Head-neck perimeter	NS	$y = -1,7608x + 251,5885$	NS	NS
Neck-body perimeter	NS	NS	NS	NS
Chest girth	NS	NS	NS	NS
Femur length	$y = -0,0729x^2 + 6,1749x - 24,1128$	NS	NS	NS
Body length	NS	NS	NS	$y = 0,1294x^2 - 42,4949x + 3589,4668$
Shoulder angle	NS	NS	NS	NS
Hoof angle	NS	NS	NS	NS
Hip joint angle	$y = -0,142x^2 + 25,1359x - 1007,5988$	$y = 0,8981x + 35,0766$	NS	NS
Hock Joint angle	$y = 1,11x - 76,59$	NS	NS	NS
X-Ray forelimb fetlock angle	NS	NS	NS	NS
X-Ray forelimb hoof angle	NS	NS	NS	NS
X-Ray hindlimb fetlock angle	NS	NS	NS	NS
X-Ray hindlimb hoof angle	NS	NS	NS	NS
X-Ray hock angle	NS	NS	NS	$y = 0,6981x^2 - 230,3659x + 19107,2559$
X-Ray stifle angle	NS	NS	$y = -0,8222x^2 + 227,4285x - 15627,8725$	$y = -2,9307x + 508,6913$

NS meaning not significant

Equations present have a significance of $P \leq 0.05$

Table 4.35 (c) Predictive regression models for the dependent variable: above head angle at 120cm in free-jumping

Stationary Measurement	Gelding	Mare
Age	NS	NS
Weight	NS	NS
Head length	NS	NS
Neck length	NS	NS
Croup length	NS	NS
Wither height	NS	NS
Croup height	$y = -0,7228x + 228,6476$	NS
Head-neck perimeter	$y = 0,249x^2 - 41,6659x + 1849,4946$	$y = -0,044x^2 + 9,1801x - 344,9288$
Neck-body perimeter	$y = 0,1072x^2 - 27,8064x + 1908,4263$	NS
Chest girth	$y = -0,8123x + 267,5117$	NS
Femur length	$y = -0,9074x + 158,792$	NS
Body length	$y = -0,5916x + 211,9859$	NS
Shoulder angle	NS	NS
Hoof angle	NS	NS
Hip joint angle	$y = 0,0085x^2 - 0,5565x + 97,9792$	NS
Hock Joint angle	NS	$y = -0,6126x^2 + 188,052x - 14315,9571$
X-Ray forelimb fetlock angle	NS	NS
X-Ray forelimb hoof angle	NS	NS
X-Ray hindlimb fetlock angle	NS	NS
X-Ray hindlimb hoof angle	NS	NS
X-Ray hock angle	NS	NS
X-Ray stifle angle	NS	NS

NS meaning not significant

 Equations present have a significance of $P \leq 0.05$

Table 4.36 (a) Predictive regression models for the dependent variable: middle femorotibial angle at 80cm

Stationary Measurement	Gelding		Mare	
	Under-saddle	Free-jumping	Under-saddle	Free-jumping
Age	NS	NS	NS	NS
Weight	NS	NS	NS	NS
Head length	NS	NS	NS	NS
Neck length	NS	NS	NS	NS
Croup length	NS	NS	NS	NS
Wither height	NS	NS	NS	NS
Croup height	NS	NS	NS	NS
Head-neck perimeter	NS	NS	NS	NS
Neck-body perimeter	NS	$y = -0,0065x^2 + 0,1061x + 136,9823$	NS	NS
Chest girth	NS	NS	NS	NS
Femur length	NS	NS	NS	$y = -0,5548x^2 + 55,5995x - 1339,7578$
Body length	NS	NS	NS	NS
Shoulder angle	NS	$y = 0,0346x^2 - 2,2825x + 69,335$	NS	NS
Hoof angle	NS	NS	NS	$y = -0,0997x^2 + 37,2401x - 3424,2318$
Hip joint angle	NS	NS	NS	NS
Hock Joint angle	NS	NS	NS	NS
X-Ray forelimb fetlock angle	NS	NS	NS	NS
X-Ray forelimb hoof angle	NS	NS	NS	NS
X-Ray hindlimb fetlock angle	$y = 0,4023x^2 - 122,496x + 9383,51$	NS	NS	NS
X-Ray hindlimb hoof angle	$y = 0,1302x^2 - 39,0264x + 2984,7633$	NS	NS	NS
X-Ray hock angle	NS	NS	NS	$y = -1,1363x^2 + 372,7942x - 30523,1809$
X-Ray stifle angle	NS	NS	NS	NS

NS meaning not significant

Equations present have a significance of $P \leq 0.05$

Table 4.36 (b) Predictive regression models for the dependent variable: middle femorotibial angle at 100cm

Stationary Measurement	Gelding		Mare	
	Under-saddle	Free-jumping	Under-saddle	Free-jumping
Age	NS	NS	NS	NS
Weight	NS	NS	NS	NS
Head length	NS	NS	NS	NS
Neck length	NS	NS	NS	NS
Croup length	NS	NS	NS	NS
Wither height	NS	NS	NS	NS
Croup height	NS	NS	NS	NS
Head-neck perimeter	NS	NS	NS	NS
Neck-body perimeter	$y = 0,3858x^2 - 97,5608x + 6216,3121$	$y = 0,1184x^2 - 30,6958x + 2033,2639$	$y = -0,2122x^2 + 52,6124x - 3197,4888$	NS
Chest girth	NS	NS	NS	NS
Femur length	NS	NS	NS	NS
Body length	NS	NS	NS	NS
Shoulder angle	NS	$y = 0,0584x^2 - 5,2038x + 157,4155$	NS	NS
Hoof angle	NS	NS	$y = -0,1998x^2 + 72,2142x - 6461,5435$	NS
Hip joint angle	NS	NS	NS	NS
Hock Joint angle	NS	NS	NS	NS
X-Ray forelimb fetlock angle	NS	NS	NS	NS
X-Ray forelimb hoof angle	NS	NS	NS	NS
X-Ray hindlimb fetlock angle	NS	NS	NS	NS
X-Ray hindlimb hoof angle	NS	NS	NS	NS
X-Ray hock angle	NS	NS	$y = -0,8221x^2 + 269,4285x - 22011,0237$	NS
X-Ray stifle angle	NS	NS	NS	NS

NS meaning not significant

 Equations present have a significance of $P \leq 0.05$

Table 4.36 (c) Predictive regression models for the dependent variable: middle femorotibial angle at 120cm in free-jumping

Stationary Measurement	Gelding	Mare
Age	NS	NS
Weight	$y = 0,004x^2 - 4,3153x + 1204,7152$	NS
Head length	NS	NS
Neck length	NS	NS
Croup length	NS	NS
Wither height	NS	NS
Croup height	NS	NS
Head-neck perimeter	NS	NS
Neck-body perimeter	NS	NS
Chest girth	NS	NS
Femur length	NS	NS
Body length	NS	NS
Shoulder angle	NS	NS
Hoof angle	NS	NS
Hip joint angle	NS	NS
Hock Joint angle	NS	$y = 3,4134x - 491,5124$
X-Ray forelimb fetlock angle	NS	NS
X-Ray forelimb hoof angle	NS	NS
X-Ray hindlimb fetlock angle	NS	NS
X-Ray hindlimb hoof angle	NS	NS
X-Ray hock angle	NS	NS
X-Ray stifle angle	NS	$y = 0,6545x^2 - 175,6317x + 11815,4373$

NS meaning not significant

 Equations present have a significance of $P \leq 0.05$

Table 4.37 (a) Predictive regression models for the dependent variable: above femorotibial angle at 80cm

Stationary Measurement	Gelding		Mare	
	Under-saddle	Free-jumping	Under-saddle	Free-jumping
Age	NS	NS	NS	NS
Weight	NS	NS	NS	NS
Head length	NS	NS	NS	NS
Neck length	NS	$y = -0,1101x^2 + 19,3133x - 810,2328$	NS	NS
Croup length	NS	NS	NS	NS
Wither height	NS	NS	NS	NS
Croup height	NS	NS	NS	NS
Head-neck perimeter	NS	NS	NS	NS
Neck-body perimeter	NS	$y = -0,0685x^2 + 15,7863x - 871,5609$	NS	NS
Chest girth	NS	NS	NS	NS
Femur length	NS	NS	NS	NS
Body length	NS	NS	NS	NS
Shoulder angle	NS	NS	NS	NS
Hoof angle	NS	NS	NS	NS
Hip joint angle	NS	NS	NS	NS
Hock Joint angle	NS	NS	NS	NS
X-Ray forelimb fetlock angle	NS	NS	NS	NS
X-Ray forelimb hoof angle	NS	NS	NS	NS
X-Ray hindlimb fetlock angle	NS	NS	NS	NS
X-Ray hindlimb hoof angle	NS	$y = -0,1368x^2 + 43,5002x - 3419,9393$	NS	NS
X-Ray hock angle	NS	NS	NS	$y = -0,7832x^2 + 257,8788x - 21194,986$
X-Ray stifle angle	NS	NS	$y = 3,2736x - 412,217$	NS

NS meaning not significant

Equations present have a significance of $P \leq 0.05$

Table 4.37 (b) Predictive regression models for the dependent variable: above femorotibial angle at 100cm

Stationary Measurement	Gelding		Mare	
	Under-saddle	Free-jumping	Under-saddle	Free-jumping
Age	NS	NS	NS	NS
Weight	NS	NS	NS	NS
Head length	NS	NS	NS	NS
Neck length	NS	NS	NS	NS
Croup length	NS	NS	NS	NS
Wither height	NS	NS	NS	NS
Croup height	NS	NS	NS	NS
Head-neck perimeter	NS	NS	NS	NS
Neck-body perimeter	NS	NS	NS	NS
Chest girth	NS	NS	NS	NS
Femur length	NS	NS	NS	NS
Body length	NS	NS	$y = -0,108x^2 + 35,9187x - 2948,6838$	NS
Shoulder angle	NS	NS	NS	NS
Hoof angle	NS	NS	NS	NS
Hip joint angle	NS	NS	NS	NS
Hock Joint angle	NS	NS	NS	NS
X-Ray forelimb fetlock angle	NS	NS	NS	NS
X-Ray forelimb hoof angle	NS	NS	NS	NS
X-Ray hindlimb fetlock angle	NS	NS	$y = -0,1259x^2 + 38,8148x - 2953,664$	NS
X-Ray hindlimb hoof angle	$y = -0,1092x^2 + 34,7135x - 2719,4905$	NS	NS	NS
X-Ray hock angle	NS	NS	$y = -0,5807x^2 + 190,3538x - 15561,437$	NS
X-Ray stifle angle	NS	NS	NS	$y = -0,4855x^2 + 136,7383x - 9591,0591$

NS meaning not significant

Equations present have a significance of $P \leq 0.05$

Table 4.37 (c) Predictive regression models for the dependent variable: above femorotibial angle at 120cm in free-jumping

Stationary Measurement	Gelding	Mare
Age	NS	NS
Weight	NS	NS
Head length	NS	NS
Neck length	NS	NS
Croup length	NS	NS
Wither height	NS	NS
Croup height	$y = 0,1795x^2 - 58,7753x + 4830,4207$	NS
Head-neck perimeter	NS	NS
Neck-body perimeter	NS	NS
Chest girth	NS	NS
Femur length	$y = 0,156x^2 - 16,8594x + 477,3861$	NS
Body length	NS	NS
Shoulder angle	NS	NS
Hoof angle	NS	NS
Hip joint angle	NS	NS
Hock Joint angle	NS	NS
X-Ray forelimb fetlock angle	NS	NS
X-Ray forelimb hoof angle	NS	NS
X-Ray hindlimb fetlock angle	NS	NS
X-Ray hindlimb hoof angle	NS	NS
X-Ray hock angle	NS	NS
X-Ray stifle angle	NS	$y = 2,7615x - 353,3612$

^a NS meaning Not Significant

^b Equations present have a significance of $P \leq 0.05$

The next section presents the predictive models for the jumping angular measurements that were taken of the forelimb while at three different points of the jump. They are forelimb angle one at 80cm, 100cm and 120cm in Table 4.38 (a), (b) and (c) respectively; forelimb angle two at 80cm, 100cm and 120cm in Table 4.39 (a), (b) and (c) respectively; and forelimb angle three at 80cm, 100cm and 120cm in Table 4.40 (a), (b) and (c) respectively

The forelimb angle of geldings jumping at 80cm (under-saddle and free-jumping) was influenced ($P \leq 0.05$) by all of the X-ray stationary measurements that were recorded while the forelimb angle one of mares jumping at 80cm was not influenced by the X-ray angles at all. Only at 100cm were there overlapping significant equations ($P \leq 0.05$) for the geldings and the mares while for both 80cm and 120cm, there were no overlapping equations and no overlapping significant stationary measurements for the geldings and the mares. At 120cm, the mares had no significant equations with any stationary measurement.

Similar to the forelimb angle one, geldings forelimb angle two was highly influenced by the X-ray stationary measurements but this time only while geldings were free-jumping. The forelimb angle two of geldings free-jumping at 120cm was also influenced by the X-ray stationary measurements that were taken. The croup length measurement was also a measurement that stood out in all of these forelimb angles (one, two and three). An important fact to remember that was presented in Table 4.11, is that there were no significant differences with the forelimb measurements at all when comparing heights, sex and under-saddle versus free-jumping. That makes these equations quite interesting to look at given the fact that the horses did not adjust this forelimb angle at all based on outside factors (such as rider and height of jump). That makes this angle quite a significant measurement to analyse.

Table 4.41 (a), (b) and (c) present the predictive models for the jump angle at 80cm, 100cm and 120cm respectively. From these tables it follows that the best predictor for geldings was the head-neck perimeter as for both under-saddle and for free-jumping at all heights of jumps, there were significant equations for this stationary measurement. Another stationary measurement had the same significance for geldings and that was the hip joint angle. Both of these stationary measurements can therefore be used to predict the jump angle at take-off of geldings at any height and whether the horse was under-saddle or if it was free-jumping. Unlike the geldings, the neck length of the mares was the important stationary measurement to look at. For all heights for both under-saddle and free-jumping, the neck length had significant equations for the mares. Considering the results from Table 4.12, where there were no significant differences between the sexes for the jump angle, the difference of mares and geldings and their predictive models is interesting to note.

Table 4.42 (a), (b) and (c) present the predictive models for the time that the horse was airborne while jumping at 80cm, 100cm and 120cm respectively. The one stationary measurement that stands out for this jumping measurement was the hoof angle as there were a number of significant equations for this stationary measurement including geldings and mares free-jumping at 80cm, geldings free-jumping 100cm and mares free-jumping 120cm.

Table 4.38 (a) Predictive regression models for the dependent variable: forelimb angle one at 80cm

Stationary Measurement	Gelding		Mare	
	Under-saddle	Free-jumping	Under-saddle	Free-jumping
Age	NS	NS	NS	NS
Weight	NS	NS	NS	NS
Head length	NS	NS	NS	NS
Neck length	NS	NS	NS	NS
Croup length	NS	NS	NS	NS
Wither height	NS	NS	NS	NS
Croup height	NS	NS	NS	NS
Head-neck perimeter	NS	NS	NS	NS
Neck-body perimeter	NS	NS	$y = 0,1933x^2 - 47,5529x + 2999,7594$	$y = 0,2182x^2 - 53,3823x + 3339,6772$
Chest girth	NS	NS	NS	NS
Femur length	NS	NS	NS	NS
Body length	NS	NS	NS	NS
Shoulder angle	NS	NS	NS	$y = 0,6123x^2 - 70,3153x + 2093,8382$
Hoof angle	NS	NS	$y = 0,1402x^2 - 51,0364x + 4720,5647$	$y = 0,2204x^2 - 79,7577x + 7291,2089$
Hip joint angle	NS	NS	NS	NS
Hock Joint angle	NS	NS	NS	NS
X-Ray forelimb fetlock angle	$y = -0,1051x^2 + 29,9864x - 2051,7538$	NS	NS	NS
X-Ray forelimb hoof angle	$y = 1,0097x - 79,3619$	NS	NS	NS
X-Ray hindlimb fetlock angle	NS	$y = 0,1353x^2 - 41,2652x + 3225,8342$	NS	NS
X-Ray hindlimb hoof angle	NS	$y = 0,0702x^2 - 21,4884x + 1725,5007$	NS	NS
X-Ray hock angle	NS	NS	NS	NS
X-Ray stifle angle	$y = 0,1766x^2 - 47,8594x + 3320,4753$	$y = 0,2135x^2 - 59,4221x + 4214,6712$	NS	NS

NS meaning not significant

Equations present have a significance of $P \leq 0.05$

Table 4.38 (b) Predictive regression models for the dependent variable: forelimb angle one at 100cm

Stationary Measurement	Gelding		Mare	
	Under-saddle	Free-jumping	Under-saddle	Free-jumping
Age	NS	NS	NS	NS
Weight	NS	$y = 0,0638x + 46,9962$	$y = 0,0043x^2 - 4,3799x + 1196,2078$	NS
Head length	NS	$y = 1,2158x + 4,1979$	NS	NS
Neck length	NS	NS	NS	NS
Croup length	NS	NS	NS	NS
Wither height	NS	$y = 0,6115x - 19,886$	NS	NS
Croup height	NS	NS	NS	NS
Head-neck perimeter	NS	NS	NS	NS
Neck-body perimeter	NS	NS	$y = 0,2026x^2 - 49,7376x + 3127,821$	NS
Chest girth	NS	$y = -0,0023x^2 + 1,5327x - 129,5186$	NS	NS
Femur length	NS	NS	NS	NS
Body length	NS	$y = 0,3805x + 16,2835$	NS	NS
Shoulder angle	NS	NS	NS	$y = 0,7678x^2 - 86,8768x + 2534,6588$
Hoof angle	NS	$y = -0,2334x^2 + 86,9803x - 8017,6392$	$y = 0,1876x^2 - 68,0376x + 6242,4998$	NS
Hip joint angle	NS	NS	NS	NS
Hock Joint angle	NS	NS	NS	NS
X-Ray forelimb fetlock angle	NS	NS	NS	NS
X-Ray forelimb hoof angle	NS	NS	NS	NS
X-Ray hindlimb fetlock angle	NS	NS	NS	NS
X-Ray hindlimb hoof angle	NS	NS	NS	NS
X-Ray hock angle	NS	NS	NS	NS
X-Ray stifle angle	$y = 0,358x^2 - 97,4645x + 6712,2911$	NS	NS	NS

NS meaning not significant

Equations present have a significance of $P \leq 0.05$

Table 4.38 (c) Predictive regression models for the dependent variable: forelimb angle one at 120cm in free-jumping

Stationary Measurement	Gelding	Mare
Age	NS	NS
Weight	NS	NS
Head length	$y = 0,179x^2 - 20,621x + 664,8261$	NS
Neck length	NS	NS
Croup length	NS	NS
Wither height	NS	NS
Croup height	NS	NS
Head-neck perimeter	NS	NS
Neck-body perimeter	NS	NS
Chest girth	$y = 0,9091x - 97,4492$	NS
Femur length	NS	NS
Body length	NS	NS
Shoulder angle	NS	NS
Hoof angle	$y = -0,4801x^2 + 178,5299x - 16510,5805$	NS
Hip joint angle	NS	NS
Hock Joint angle	NS	NS
X-Ray forelimb fetlock angle	NS	NS
X-Ray forelimb hoof angle	NS	NS
X-Ray hindlimb fetlock angle	NS	NS
X-Ray hindlimb hoof angle	NS	NS
X-Ray hock angle	NS	NS
X-Ray stifle angle	NS	NS

NS meaning not significant

 Equations present have a significance of $P \leq 0.05$

Table 4.39 (a) Predictive regression models for the dependent variable: forelimb angle two at 80cm

Stationary Measurement	Gelding		Mare	
	Under-saddle	Free-jumping	Under-saddle	Free-jumping
Age	NS	NS	NS	NS
Weight	NS	NS	NS	NS
Head length	NS	NS	NS	NS
Neck length	NS	NS	NS	NS
Croup length	$y = 0,0525x^2 - 4,5462x + 177,1533$	NS	$y = -1,4308x + 158,4186$	NS
Wither height	NS	NS	NS	NS
Croup height	NS	NS	NS	NS
Head-neck perimeter	NS	NS	NS	NS
Neck-body perimeter	NS	NS	NS	$y = 0,0646x^2 - 15,863x + 1056,1662$
Chest girth	$y = 0,1753x^2 - 68.0002x + 6674,8356$	NS	NS	NS
Femur length	NS	NS	NS	NS
Body length	NS	NS	NS	NS
Shoulder angle	NS	NS	NS	$y = 0,0771x^2 - 9,3378x + 363,9667$
Hoof angle	NS	NS	NS	$y = 0,0676x^2 - 24,4105x + 2286,333$
Hip joint angle	NS	NS	NS	NS
Hock Joint angle	NS	NS	NS	NS
X-Ray forelimb fetlock angle	NS	NS	$y = -1,0079x + 238,3155$	NS
X-Ray forelimb hoof angle	NS	$y = -0,3194x^2 + 102,1349x - 8072,5681$	NS	NS
X-Ray hindlimb fetlock angle	NS	$y = 0,149x^2 - 45,4778x + 3555,2342$	NS	NS
X-Ray hindlimb hoof angle	NS	$y = 0,076x^2 - 23,1341x + 1845,8238$	NS	NS
X-Ray hock angle	NS	NS	NS	NS
X-Ray stifle angle	NS	$y = 0,2138x^2 - 59,7084x + 4251,6038$	NS	NS

NS meaning not significant

Equations present have a significance of $P \leq 0.05$

Table 4.39 (b) Predictive regression models for the dependent variable: forelimb angle two at 100cm

Stationary Measurement	Gelding		Mare	
	Under-saddle	Free-jumping	Under-saddle	Free-jumping
Age	NS	NS	NS	NS
Weight	NS	NS	NS	$y = 0,0035x^2 - 3,5622x + 986,7467$
Head length	NS	$y = 1,3209x + 2,9842$	NS	NS
Neck length	NS	NS	NS	NS
Croup length	$y = 2,5163x - 47,628$	NS	NS	NS
Wither height	NS	NS	NS	NS
Croup height	NS	NS	NS	NS
Head-neck perimeter	NS	NS	NS	NS
Neck-body perimeter	NS	NS	$y = 0,1494x^2 - 36,5049x + 2309,1221$	NS
Chest girth	NS	NS	NS	NS
Femur length	NS	NS	NS	NS
Body length	NS	NS	NS	NS
Shoulder angle	NS	NS	NS	$y = 0,4022x^2 - 44,2139x + 1297,3336$
Hoof angle	NS	NS	NS	NS
Hip joint angle	NS	NS	NS	NS
Hock Joint angle	NS	NS	NS	NS
X-Ray forelimb fetlock angle	NS	NS	NS	NS
X-Ray forelimb hoof angle	NS	NS	NS	NS
X-Ray hindlimb fetlock angle	NS	NS	NS	NS
X-Ray hindlimb hoof angle	NS	NS	NS	NS
X-Ray hock angle	NS	NS	NS	NS
X-Ray stifle angle	NS	NS	NS	NS

NS meaning not significant

Equations present have a significance of $P \leq 0.05$

Table 4.39 (c) Predictive regression models for the dependent variable: forelimb angle two at 120cm in free-jumping

Stationary Measurement	Gelding	Mare
Age	NS	NS
Weight	NS	NS
Head length	$y = 1,9776x - 42,7528$	NS
Neck length	NS	NS
Croup length	NS	$y = 0,6568x^2 - 71,5788x + 2029,624$
Wither height	NS	NS
Croup height	NS	NS
Head-neck perimeter	NS	NS
Neck-body perimeter	NS	NS
Chest girth	NS	NS
Femur length	NS	NS
Body length	NS	NS
Shoulder angle	NS	NS
Hoof angle	NS	NS
Hip joint angle	NS	NS
Hock Joint angle	NS	NS
X-Ray forelimb fetlock angle	NS	NS
X-Ray forelimb hoof angle	$y = -0,5239x^2 + 167,7017x - 13328,8682$	$y = 0,4049x^2 - 125,6147x + 9821,6873$
X-Ray hindlimb fetlock angle	$y = 0,2867x^2 - 86,6318x + 6622,4223$	NS
X-Ray hindlimb hoof angle	NS	NS
X-Ray hock angle	NS	NS
X-Ray stifle angle	$y = 0,3542x^2 - 98,1278x + 6876,1594$	NS

NS meaning not significant

 Equations present have a significance of $P \leq 0.05$

Table 4.40 (a) Predictive regression models for the dependent variable: forelimb angle three at 80cm

Stationary Measurement	Gelding		Mare	
	Under-saddle	Free-jumping	Under-saddle	Free-jumping
Age	NS	NS	NS	NS
Weight	NS	NS	NS	NS
Head length	NS	NS	NS	NS
Neck length	NS	NS	NS	NS
Croup length	$y = 0,902x + 43,1158$	NS	$y = -0,0935x^2 + 8,2983x - 87,6863$	NS
Wither height	NS	NS	NS	NS
Croup height	NS	NS	NS	NS
Head-neck perimeter	NS	NS	NS	NS
Neck-body perimeter	NS	NS	NS	NS
Chest girth	$y = 0,1963x^2 - 79,3481x + 7510,1056$	$y = 0,224x^2 - 87,0298x + 8538,8564$	NS	NS
Femur length	NS	NS	NS	NS
Body length	NS	$y = 0,0862x^2 - 29,7237x + 2649,0341$	NS	NS
Shoulder angle	NS	NS	NS	NS
Hoof angle	NS	NS	NS	NS
Hip joint angle	NS	NS	NS	NS
Hock Joint angle	NS	NS	NS	NS
X-Ray forelimb fetlock angle	NS	NS	NS	$y = -0,4563x + 159,4451$
X-Ray forelimb hoof angle	NS	NS	$y = 0,8038x - 35,7802$	NS
X-Ray hindlimb fetlock angle	NS	NS	NS	NS
X-Ray hindlimb hoof angle	NS	NS	NS	NS
X-Ray hock angle	$y = -0,0861x^2 + 29,1963x - 2380,6601$	NS	NS	NS
X-Ray stifle angle	NS	NS	NS	NS

NS meaning not significant

Equations present have a significance of $P \leq 0.05$

Table 4.40 (b) Predictive regression models for the dependent variable: forelimb angle three at 100cm

Stationary Measurement	Gelding		Mare	
	Under-saddle	Free-jumping	Under-saddle	Free-jumping
Age	NS	NS	NS	NS
Weight	NS	NS	$y = 0,0032x^2 - 3,257x + 911,5862$	NS
Head length	NS	NS	NS	NS
Neck length	NS	NS	NS	NS
Croup length	$y = 1,6625x + 4,3311$	$y = 0,7647x + 47,4093$	NS	NS
Wither height	NS	NS	NS	NS
Croup height	NS	NS	NS	NS
Head-neck perimeter	NS	NS	NS	NS
Neck-body perimeter	NS	NS	NS	NS
Chest girth	NS	$y = 0,1528x^2 - 59,3296x + 5845,8862$	NS	NS
Femur length	NS	NS	NS	NS
Body length	NS	NS	NS	NS
Shoulder angle	NS	NS	NS	NS
Hoof angle	NS	NS	NS	NS
Hip joint angle	NS	NS	NS	NS
Hock Joint angle	NS	NS	NS	NS
X-Ray forelimb fetlock angle	NS	$y = -0,0949x^2 + 27,6591x - 1922,6797$	NS	NS
X-Ray forelimb hoof angle	$y = -0,3765x^2 + 120,5558x - 9551,9455$	NS	NS	NS
X-Ray hindlimb fetlock angle	NS	NS	NS	$y = -0,0197x^2 + 6,443x - 433,7814$
X-Ray hindlimb hoof angle	NS	NS	NS	NS
X-Ray hock angle	NS	NS	NS	$y = -0,1236x^2 + 39,7578x - 3106,0345$
X-Ray stifle angle	NS	NS	NS	NS

NS meaning not significant

Equations present have a significance of $P \leq 0.05$

Table 4.40 (c) Predictive regression models for the dependent variable: forelimb angle three at 120cm in free-jumping

Stationary Measurement	Gelding	Mare
Age	NS	NS
Weight	NS	NS
Head length	NS	NS
Neck length	NS	NS
Croup length	NS	$y = -0,9716x + 140,0017$
Wither height	NS	NS
Croup height	NS	NS
Head-neck perimeter	NS	NS
Neck-body perimeter	NS	NS
Chest girth	NS	NS
Femur length	NS	NS
Body length	NS	NS
Shoulder angle	NS	NS
Hoof angle	NS	NS
Hip joint angle	NS	NS
Hock Joint angle	NS	NS
X-Ray forelimb fetlock angle	NS	NS
X-Ray forelimb hoof angle	$y = -0,3948x^2 + 126,52x - 10043,4717$	NS
X-Ray hindlimb fetlock angle	NS	NS
X-Ray hindlimb hoof angle	NS	NS
X-Ray hock angle	NS	NS
X-Ray stifle angle	NS	NS

NS meaning not significant

 Equations present have a significance of $P \leq 0.05$

Table 4.41 (a) Predictive regression models for the dependent variable: jump angle at take-off at 80cm

Stationary Measurement	Gelding		Mare	
	Under-saddle	Free-jumping	Under-saddle	Free-jumping
Age	NS	NS	NS	NS
Weight	NS	NS	NS	NS
Head length	NS	NS	NS	$y = -0,6036x + 84,8677$
Neck length	NS	NS	$y = -0,1924x + 61,5228$	$y = -0,1579x + 59,6163$
Croup length	NS	NS	NS	NS
Wither height	NS	NS	NS	NS
Croup height	NS	NS	NS	NS
Head-neck perimeter	$y = -0,0522x^2 + 9,5002x - 380,962$	$y = -0,1581x^2 + 26,446x - 1059,094$	NS	NS
Neck-body perimeter	NS	NS	NS	NS
Chest girth	NS	$y = 0,4282x - 38,3293$	NS	NS
Femur length	NS	NS	NS	NS
Body length	NS	NS	NS	NS
Shoulder angle	NS	NS	NS	NS
Hoof angle	NS	NS	NS	NS
Hip joint angle	$y = 0,0115x^2 - 2,5723x + 179,3389$	$y = 0,0212x^2 - 4,0772x + 236,1838$	NS	NS
Hock Joint angle	NS	NS	NS	NS
X-Ray forelimb fetlock angle	NS	NS	NS	NS
X-Ray forelimb hoof angle	NS	NS	NS	NS
X-Ray hindlimb fetlock angle	NS	NS	NS	NS
X-Ray hindlimb hoof angle	NS	NS	$y = 0,8186x - 81,0059$	NS
X-Ray hock angle	NS	NS	NS	NS
X-Ray stifle angle	NS	NS	NS	NS

NS meaning not significant

Equations present have a significance of $P \leq 0.05$

Table 4.41 (b) Predictive regression models for the dependent variable: jump angle at take-off at 100cm

Stationary Measurement	Gelding		Mare	
	Under-saddle	Free-jumping	Under-saddle	Free-jumping
Age	NS	NS	NS	NS
Weight	NS	NS	$y = -0,0007x^2 + 0,7x - 121,7662$	NS
Head length	NS	NS	$y = -0,6975x + 90,8784$	$y = -0,22x^2 + 26,94x - 775,328$
Neck length	NS	NS	$y = -0,1835x + 61,7928$	$y = -0,0058x^2 + 0,7297x + 27,0371$
Croup length	NS	NS	NS	NS
Wither height	NS	NS	NS	NS
Croup height	NS	NS	NS	NS
Head-neck perimeter	$y = -0,225x^2 + 37,0853x - 1478,4777$	$y = -0,1373x^2 + 23,2516x - 936,7778$	NS	NS
Neck-body perimeter	NS	NS	NS	NS
Chest girth	NS	NS	NS	$y = -0,4298x + 128,3045$
Femur length	NS	NS	NS	NS
Body length	NS	NS	NS	$y = -0,3337x + 102,8981$
Shoulder angle	NS	NS	NS	NS
Hoof angle	NS	NS	NS	NS
Hip joint angle	$y = -0,0007x^2 - 0,324x + 79,1253$	$y = 0,0189x^2 - 3,6529x + 217,5779$	NS	NS
Hock Joint angle	NS	NS	NS	NS
X-Ray forelimb fetlock angle	NS	NS	NS	NS
X-Ray forelimb hoof angle	NS	NS	NS	NS
X-Ray hindlimb fetlock angle	NS	NS	NS	NS
X-Ray hindlimb hoof angle	NS	NS	$y = 0,6896x - 60,3343$	$y = 0,8108x - 78,9885$
X-Ray hock angle	NS	NS	NS	NS
X-Ray stifle angle	NS	NS	NS	NS

NS meaning not significant

Equations present have a significance of $P \leq 0.05$

Table 4.41 (c) Predictive regression models for the dependent variable: jump angle at take-off at 120cm in free-jumping

Stationary Measurement	Gelding	Mare
Age	NS	NS
Weight	NS	NS
Head length	NS	$y = -0,8295x + 101,2675$
Neck length	NS	$y = -0,1855x + 63,9569$
Croup length	NS	NS
Wither height	NS	$y = -0,0421x^2 + 13,2051x - 983,3315$
Croup height	NS	NS
Head-neck perimeter	$y = -0,1448x^2 + 24,0364x - 947,4365$	NS
Neck-body perimeter	NS	NS
Chest girth	NS	NS
Femur length	NS	NS
Body length	NS	NS
Shoulder angle	NS	NS
Hoof angle	NS	NS
Hip joint angle	$y = 0,0201x^2 - 3,7766x + 222,7073$	NS
Hock Joint angle	NS	NS
X-Ray forelimb fetlock angle	NS	NS
X-Ray forelimb hoof angle	NS	NS
X-Ray hindlimb fetlock angle	NS	NS
X-Ray hindlimb hoof angle	NS	$y = -0,2309x^2 + 72,2157x - 5595,321$
X-Ray hock angle	NS	NS
X-Ray stifle angle	NS	NS

NS meaning not significant

 Equations present have a significance of $P \leq 0.05$

Table 4.42 (a) Predictive regression models for the dependent variable: time airborne at 80cm

Stationary Measurement	Gelding		Mare	
	Under-saddle	Free-jumping	Under-saddle	Free-jumping
Age	NS	NS	NS	NS
Weight	NS	NS	$y = -0,0006x + 0,6112$	NS
Head length	NS	NS	NS	NS
Neck length	NS	NS	NS	NS
Croup length	NS	NS	NS	NS
Wither height	NS	NS	NS	$y = -0,0078x + 1,6643$
Croup height	NS	NS	NS	NS
Head-neck perimeter	NS	$y = -0,0028x^2 + 0,4687x - 18,9308$	NS	NS
Neck-body perimeter	NS	NS	NS	$y = 0,0021x^2 - 0,5258x + 33,0492$
Chest girth	NS	NS	NS	NS
Femur length	NS	NS	NS	NS
Body length	NS	NS	NS	NS
Shoulder angle	NS	NS	NS	NS
Hoof angle	NS	$y = -0,0037x^2 + 1,3967x - 129,5939$	NS	$y = 0,0009x^2 - 0,339x + 31,6192$
Hip joint angle	NS	NS	NS	NS
Hock Joint angle	NS	NS	NS	NS
X-Ray forelimb fetlock angle	NS	NS	NS	NS
X-Ray forelimb hoof angle	NS	NS	NS	NS
X-Ray hindlimb fetlock angle	NS	NS	NS	NS
X-Ray hindlimb hoof angle	NS	NS	NS	NS
X-Ray hock angle	NS	NS	NS	NS
X-Ray stifle angle	NS	NS	NS	NS

NS meaning not significant

Equations present have a significance of $P \leq 0.05$

Table 4.42 (b) Predictive regression models for the dependent variable: time airborne at 100cm

Stationary Measurement	Gelding		Mare	
	Under-saddle	Free-jumping	Under-saddle	Free-jumping
Age	NS	NS	NS	NS
Weight	NS	NS	NS	NS
Head length	NS	NS	NS	$y = -0,0129x^2 + 1,6239x - 50,7748$
Neck length	NS	NS	NS	NS
Croup length	NS	NS	NS	NS
Wither height	NS	NS	NS	NS
Croup height	NS	NS	NS	NS
Head-neck perimeter	NS	NS	NS	NS
Neck-body perimeter	NS	NS	NS	NS
Chest girth	NS	NS	NS	NS
Femur length	NS	NS	NS	NS
Body length	NS	NS	NS	NS
Shoulder angle	NS	NS	NS	NS
Hoof angle	NS	$y = -0,0036x^2 + 1,3429x - 124,1488$	NS	NS
Hip joint angle	$y = 0,0238x - 1,5805$	NS	NS	NS
Hock Joint angle	NS	NS	NS	NS
X-Ray forelimb fetlock angle	NS	NS	NS	NS
X-Ray forelimb hoof angle	NS	NS	NS	NS
X-Ray hindlimb fetlock angle	NS	NS	NS	NS
X-Ray hindlimb hoof angle	NS	NS	NS	NS
X-Ray hock angle	NS	NS	NS	NS
X-Ray stifle angle	NS	NS	NS	NS

NS meaning not significant

Equations present have a significance of $P \leq 0.05$

Table 4.42 (c) Predictive regression models for the dependent variable: time airborne at 120cm in free-jumping

Stationary Measurement	Gelding	Mare
Age	NS	NS
Weight	NS	NS
Head length	NS	NS
Neck length	NS	NS
Croup length	NS	NS
Wither height	NS	NS
Croup height	NS	NS
Head-neck perimeter	NS	NS
Neck-body perimeter	$y = -0,0017x^2 + 0,4216x - 25,9589$	NS
Chest girth	NS	NS
Femur length	NS	NS
Body length	NS	NS
Shoulder angle	NS	NS
Hoof angle	NS	$y = 0,0034x^2 - 1,2312x + 110,5166$
Hip joint angle	NS	NS
Hock Joint angle	NS	$y = 0,006x^2 - 1,8907x + 149,917$
X-Ray forelimb fetlock angle	NS	NS
X-Ray forelimb hoof angle	NS	NS
X-Ray hindlimb fetlock angle	NS	NS
X-Ray hindlimb hoof angle	NS	NS
X-Ray hock angle	NS	NS
X-Ray stifle angle	NS	NS

NS meaning not significant

 Equations present have a significance of $P \leq 0.05$

4.5 Show jumping star rating versus jumping measurements

Similar to section 4.4, the GLM stepwise regression procedures were used to determine the predictive models that could best predict the dependent variables in this section (the star ratings). Taking the star ratings at the different heights, comparisons were made to see if there were any jumping measurements which could be used to best predict the star ratings. Table 4.43 (a), (b) and (c) present the prediction models for the star rating equations at 80cm, 100cm and 120cm respectively.

At 80cm a number of jumping measurements showed significant predictive equations for the star ratings (Table 4.43 (a)). For both mares and geldings, the forelimb angle had useful equations ($P \leq 0.05$) for geldings free-jumping and mares under-saddle.

At 100cm a number of equations ($P \leq 0.05$) were observed (Table 4.43 (b)) for mares while there was only one for geldings. To predict a gelding's star rating using jumping measurements while jumping 100cm under-saddle, the FLFL stride distance were the best predictors. In order to predict the star rating of mares, the linear HRMCP for both under-saddle and free-jumping at 100cm were used. The only jumping measurement that was able to predict for both 80cm and 100cm was the front left to front left jumping measurement however at the 80cm jumping height, the FLFL was used to predict geldings free-jumping while at the 100cm jumping height, the FLFL was used to predict geldings under-saddle.

At 120cm free-jumping, there were only two equations ($P \leq 0.05$) that could be used to predict the star rating of a horse. For geldings, the take-off distance of the hindlimb jumping measurement and for mares the time that the mare was airborne could be used as predictors. This time airborne equation for mares had a high significance with $P < 0.0001$.

Although fewer predictive models were observed in this section compared to the stationary and jumping measurement section, a number of important observations were made.

Table 4.43 (a) Predictive regression models for the dependent variable: show jumping star rating at 80cm

Jumping Measurement	Gelding		Mare	
	Under-saddle	Free-jumping	Under-saddle	Free-jumping
Front left to front left	NS	$y = 0,0302x - 6,4521$	NS	NS
Jump Distance	$y = -0,0017x^2 + 1,2047x - 206,818$	NS	NS	NS
Height of left forelimb	NS	NS	NS	$y = -1,2873x^2 + 90,5653x - 1589,8723$
Elevation of withers	NS	NS	$y = 0,0136x^2 - 3,158x + 185,2673$	NS
Middle head angle	NS	$y = -0,0305x + 6,1052$	NS	NS
Middle femorotibial angle	$y = -0,002x^2 + 0,2805x - 6,7742$	NS	NS	NS
Forelimb angle one	NS	$y = -0,0151x^2 + 2,4683x - 98,3991$	$y = 0,0124x^2 - 2,06x + 87,5002$	NS
Forelimb angle two	NS	$y = -0,0125x^2 + 2,1604x - 90,8699$	NS	NS

NS meaning not significant

 Equations present have a significance of $P \leq 0.05$

Table 4.43 (b) Predictive regression models for the dependent variable: show jumping star rating at 100cm

Jumping Measurement	Gelding		Mare	
	Under-saddle	Free-jumping	Under-saddle	Free-jumping
Front outside to back inside	NS	NS	$y = 0,0654x - 12,1042$	NS
Front left to front left	$y = -0,0098x + 5,8923$	NS	NS	NS
Height of right hindlimb	NS	NS	$y = 0,0027x^2 - 0,1241x + 3,4267$	NS
Height of left hindlimb	NS	NS	$y = 0,0027x^2 - 0,12401x + 3,4267$	NS
Elevation of head	NS	NS	NS	$y = -0,0017x^2 + 0,3766x - 17,9162$
Linear HRMCP ¹	NS	NS	$y = -0,1866x^2 + 16,4232x - 356,2534$	$y = 0,021x^2 - 1,9355x + 46,6205$
Middle femorotibial angle	NS	NS	NS	$y = 0,0055x^2 - 0,4691x + 12,0305$
Forelimb angle three	NS	NS	$y = 0,0944x - 6,1969$	NS

NS meaning not significant

Equations present have a significance of $P \leq 0.05$

¹ Distance between the humeroradial and the metacarpophalangeal joints

Table 4.43 (c) Predictive regression models for the dependent variable: show jumping star rating at 120cm in free-jumping

Jumping Measurement	Gelding	Mare
Take-off distance of hindlimb	$y = 0,0017x^2 - 0,503x + 39,3972$	
Time airborne		$y = 97,1817x^2 - 96,8902x + 26,0058^*$

NS meaning not significant

Equations present have a significance of $P \leq 0.05$

*Equation had a significance of $P < 0.0001$

Chapter 5: Discussion and Conclusions

The sport of showjumping represents a captivating mixture of athleticism, precision and the partnership between horse and rider and the skill and passion of the sport has captivated people all around the world. Understanding the factors that influence the performance of showjumping horses is therefore of paramount importance to athletes, trainers, and breeders in the equestrian industry. This chapter discusses and concludes the findings of this study that was done on Warmblood horses in South Africa.

Throughout this master's dissertation, an in-depth study was conducted into the stationary and jumping measurements of twenty Warmblood horses, aiming to find the correlation and prediction models of what makes up a good showjumping horse. This discussion examines the results obtained in this study which is found in the previous chapter and draws comparisons with existing literature in the equine sciences.

The study by Koenen *et al.* (2004) shows the importance of show jumping to breeders of Warmblood horses. From Table 2.1, we can clearly see how important the show jumping discipline is with 11 out of the 12 organisations ranking show jumping with a score of eight or higher out of ten when it comes to the importance of this trait. It is therefore important to know what makes a good show jumping horse and what physical traits classify a horse as a good show jumper.

One of the physical traits that was focused on by Becker *et al.* (2013), was the importance of a rectangular frame to help with the movement of the back. Shown in the results chapter of this study, we can see in Table 4.3 that the withers and croup height had a very strong positive correlation of 0.946 ($P < 0.0001$) showing that the topline of a horse stays constant which would form the top of the rectangular frame. From the description by Holmstrom *et al.* (1990), a rectangular frame describes a horse that has a smaller wither height than their body length. Shown in Table 4.1, the horses in this study had a rectangular frame e.g. geldings had a wither height and body length of 166.51cm and 172.55cm respectively and mares had a wither height and body length of 161.65cm and 168.02cm respectively. Based on these results, the horses in this study had a good frame to help with the movement of the back while jumping.

Taking a further look at the stationary measurements of a horse, the wither height of Thoroughbred horses in the study by Matsuura *et al.* (2021) was 157.5 (± 2.5) cm, and the wither height of Arabian horses in the study by Sadek *et al.* (2006) was 149 (± 0.29) cm in the mares and 150 (± 0.5) cm in the stallions. The Warmblood horses in South Africa from this study showed a wither height of 166.51 (± 0.6380) cm in the geldings and 161.65 (± 0.7814) cm in the mares. Since Thoroughbred horses and Arabian horses are both hot-blood breeds, the taller height of the Warmblood breed therefore most likely comes from the cold-blooded percentage present in the particular Warmblood breed. Similar to the study by Holmstrom *et al.* (1990), the present study found that mares were shorter at the withers compared to the geldings, but unlike this 1990 study, the mares also tended to have shorter bodies. Another stationary measurement that was mentioned in the study by Holmstrom *et al.* (1990), was the fetlock angles in the hindlimb and this study showed that the mares had a

larger hindlimb fetlock angle. The present study agrees with this statement as the Warmblood mares had a significantly larger ($P \leq 0.05$) mean of 153.58 (± 0.7118) cm than the Warmblood geldings which had a mean of 151.94 (± 0.5812) cm.

In the study by Holmstrom *et al.* (1990), it was shown that the height of the withers was not related to the length of the stride in horses in any of their gaits, however from this study the height of the withers was related to a few other jumping measurements. Chest girth showed many interesting correlations and predictions to other stationary measurements as well as the jumping measurements, meanwhile in the study by Langlois *et al.* (1978), it was found that a greater chest girth were associated with horses that were not the best showjumpers. This shows that a smaller chest girth is preferable and with these new findings, we are now able to predict how well the horses will jump based on this chest girth measurement.

The hock angle, another stationary measurement, was shown by Holmstrom *et al.* (1990) to be an important measurement to look at as horses with small hock angles are unable to support themselves and horses with large hock angles put strain on their joints. From this present study we can see that there are a number of jumping measurements that can be predicted from this hock angle which in the end can be beneficial to breeders, as not only will they be able to see if the horse will be a show jumper or a dressage horse in the future, but will also be able to see how well the horse will be able to jump based on the prediction models found in this study.

Moving on to the jumping measurements, in the study by Ducro *et al.* (2007), it was shown that take-off has a heritability of 0.45 and a genetic correlation with show jumping of 0.92. By using this information from this 2007 study, the information of take-off that was discovered in this present study regarding the take-off angle and take-off distances can be used to determine further information about the genetics of show jumping performance.

Unlike the study done by de Godoi *et al.* (2016), the stationary linear traits in this study did show to be of importance when looking at predictions of showjumping performance. From this same study, one of the most important kinematic traits was the length of the horses' stride before the jump, and from the results of this present study where eight different measurements were taken on the stride before the jump, it is possible to predict these stride measurements based on the stationary measurements that were significant. The distance from the fence that the horse took off from was also an important measurement that determined successful or unsuccessful jumps in the study by de Godoi *et al.* (2016). However, in this present study, the take-off distance did not have as much significance as originally presumed. Although this measurement can be used to predict successful jumps there were not many stationary measurements that could be used to predict this jumping measurement. The third important measurement that this study found was the height of the forelimbs above the jump, so from this present study it follows that a few stationary measurements can be used to predict this jumping measurement.

In the study by de Godoi *et al.* (2016), it was also shown that the femorotibial-angle of the hindlimb could be used to predict successful jumps. From this master's study, it is clear that a number of stationary measurements can be used to predict this angle while the horse is jumping. The most common stationary measurement that can be used to predict the femorotibial angle of the hindlimb among 80cm and 100cm being the neck-body perimeter, shoulder angle and the X-ray hock angle.

In the study by Santamaría *et al.* (2006), the distance between the humeral-radial joint and the fetlock in the forelimb is described as the flexion grade of the front legs and that a higher flexion of these forelimbs resulted in better jumpers. This present study measured a similar trait – the linear and vertical distances between the humeroradial and the metacarpophalangeal joints. Santamaría *et al.* (2006) showed that this angle needs to be small as it means that the horse is picking up its feet while jumping. From Table 4.7, we can see that more than half of the linear distances were below 45cm and the highest value was 50.68 (± 1.8453) cm. For this same linear measurement, de Godoi *et al.* (2016) found the range to be 0.2-0.6m (shown in Table 2.7) showing that the results from this study fell within the same range.

In the study by Huizinga *et al.* (1991) and as can be seen from Table 2.3, a genetic correlation of free-jumping to show jumping performance of the offspring of 0.95 was found. Free-jumping is therefore an excellent way to determine performance of offspring. Free-jumping was an important part of this present study and so by using the results of free-jumping and the results from the study by Huizinga *et al.* (1991), one is able to take a horse free-jumping and determine future performance.

Since this is the first study that determined model equations to link stationary and jumping measurements, there were no comparisons to be made to see if what this study found was similar to past trials. What can be seen from this trial is that stationary measurements are linked to jumping measurements and can be used to determine future jumping performance. Although less results were obtained from the star ratings, it is possible to use stationary measurements to determine the final discipline performance of a Warmblood horse in South Africa.

While this study provides valuable insights for the equine industry, there is some follow up research that could be done to improve these findings. These horses could be tracked later in life to monitor their performance on the equine sport circuit. By doing this, their performance later in life can then be linked to their measurements at four years of age that was tested in this present study. Additionally, following on the under-saddle section of this paper, a study could be done on how different riders affect the same horse's performance and jumping measurements. This type of follow up research can expand on the findings of this study and therefore provide the equine sport industry with valuable knowledge.

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