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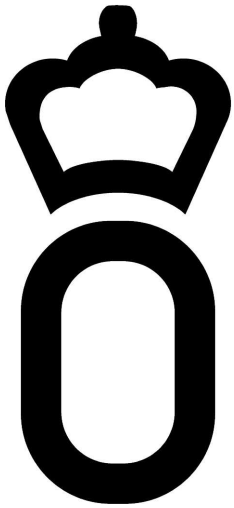
Cross Breeding in the Oldenburger Warmblood Population from 1990 untill 2010



Thesis

of

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Chapter 1

Abstract

Der Verband der Züchter des Oldenburger Pferdes e.V., der Springpferdezuchtverband Oldenburg International e.V. und der Verein zur Absatzförderung des Oldenburger Pferdes e.V. bilden zusammen das Oberhaupt der Oldenburger Warmblut Zucht. Mit zurzeit etwa 6.000 Züchtern, 8.200 eingetragen Zuchtstuten und jährlich etwa 5.000 Fohlen zählt der Oldenburger Verband zu einem der größten Pferdezucht Verbände in Deutschland. Die hohe Qualität der Oldenburger Pferde zeigt sich an zahlreichen Siegen und Platzierungen der letzten Jahrzehnte im Rahmen der Olympischen Spiele, der Welt- und Europameisterschaften sowie der Deutschen Meisterschaften in den Disziplinen Dressur, Springreiten, Fahren und Vielseitigkeit. (Verband der Züchter des Oldenburger Pferdes, 2011)
Die Geschichte des Oldenburger Warmbluts reicht zurück bis ins 16. Jahrhundert. Damals wurden die Oldenburger Warmblüter hauptsächlich für militärische und landwirtschaftliche Zwecke eingesetzt. Im Laufe der Jahrhunderte wurden immer wieder Veredler eingesetzt, vor allem zu der Zeit als die Motorisierung in der Landwirtschaft eintrat und die Oldenburger Warmblüter nunmehr als Reit- und nicht mehr als Nutztiere verwendet werden sollten. Veredler des Oldenburger Warmblüters waren hauptsächlich Araber und Englische Vollblüter. (Hofmeister, 1884), (Henning, 2004)
Ziel der vorliegenden Arbeit ist es, festzustellen, inwiefern sich die Veredlung mit Englischem Vollblut und Arabern von 1990 bis 2010 verändert hat. Desweiteren wird untersucht ob der prozentuale Anteil an Veredlung Auswirkungen auf die Eigenleistung im Turniersport und die Leistung der Nachkommen hat. Grundlage dieser Untersuchung sind 12.507 Hengste, Stuten und Wallache der Oldenburger Rasse. 2.797 dieser Pferde wurden im Jahr 1990 geboren, 4.590 im Jahre 2000 und 5.120 im Jahr 2010. Die Pferde der Geburtsjahre 1990 und 2000 wurden für die Untersuchung über den Einfluss der Veredlung auf Turniererfolge in Betracht gezogen. Die Pferde des Geburtsjahrgangs 2010 konnten für diese Untersuchung nicht verwendet werden, da diese zum Zeitpunkt dieser Untersuchung noch zu jung sind, um auf Turnieren zu starten. Insgesamt wurden 4.047 Pferde hinsichtlich der Turniersportergebnisse untersucht.
Die Studie zeigt, dass es einen prozentualen Rückgang an Arabischem Blut in der Oldenburger Zuchtpopulation von 2,78 % in 1990 auf 1,91 % in 2010 gibt. Der prozentuale Anteil an Englischem Vollblut hingegen ist von 35,9 % in 1990 bis auf 36,7 % in 2000 gestiegen. Von 2000 bis 2010 allerdings wieder leicht gesunken auf 36,5 %. Des Weiteren wurde ein prozentualer Anteil zwischen Starts und Platzierungen bei Dressur und Springprüfungen ermittelt. Diese Ergebnisse zeigen, dass erfolgreichere Pferde in Dressur- und Springprüfungen eine höheren Anteil an Englischen Vollblut besitzen. In den Spring-Aufbauprüfungen zeigte sich jedoch, dass Pferde mit einem geringeren Vollblutanteil erfolgreicher sind. Bei der Untersuchung der Erfolge

der Nachkommen zeigten sich keine Unterschiede zwischen den Erfolgen der Nachkommen der Pferde mit geringem Vollblutanteil und den Nachkommen der Pferde mit hohem Vollblutanteil. Weiterhin konnten keine Unterschiede im Vollblutanteil bei Teilnahme und nicht Teilnahme an Zuchtstutenprüfungen, Veranlagungsprüfungen und Hengstleistungsprüfungen gefunden werden.

Chapter 2

Background information

2.1 The Oldenburger Horse Breeding Association

The Oldenburger Horse Breeding Association is splitted into the "Verband der Züchter des Oldenburger Pferdes e.V.", "Springpferdezuchtverband Oldenburg International e.V" (specialised on show jumping) and the "Verein zur Absatzförderung des Oldenburger Pferdes e.V" (specialized on commercialization). Together they are responsible for the Oldenburger Warmblood Breeding population. Today the association has approximately 550 registered breeding stallions and 8200 registered breeding mares and thereof belongs to one of the largest German Horse Breeding Associations. (FN, 2010)
The high quality of the Oldenburger horses is attested in numerous victories and top positions in the last centuries at Olympic Games, World and European Championships as well as German Championships in Dressage, Showjumping, Driving and Eventing. (Verband der Züchter des Oldenburger Pferdes, 2011)

2.2 The Oldenburger Horse

The history of the Oldenburger horse goes back to the 16th century. The breeding goal at that time was to breed a horse for military and agricultural purposes. The domestic breed at this time was the Frisian horse. It was a relatively large (1.75 m), strong and wide horse with an extreme long back. The colour was mainly black and dark brown. The Frisian horse founded the basis of the Oldenburger Warmblood Breed.
Count Anton Günther von Oldenburg, who run the country from 1603-1667, is deemed to be the founder of the Oldenburger Warmblood Breed. He was the major horse breeder and an excellent horseman at that time and had the most impact on the upgrading of the Oldenburger horses and their reputation as great breed in Europe. His father Johann XVI started to import noble horses, especially stallions, from other countries, but Anton Günther started to make noble horses available for other horse breeders. During his tournaments through Europe in 1606 and 1609, he brought horses from England, Naples, Spain, Poland and Tartaria for the improvement of his studs and later on also for the improvement of the breeding of the Oldenburger breeders. As the Oldenburger Warmblood horse nowadays differs from the Frisian horse, it is the reward of addition of other blood into the Oldenburger Warmblood population, which was done at the

time count Anton Günther von Oldenburg run the country. During the government of count Anton Günther von Oldenburg the Oldenburger horses got famous in Europe because of their beauty, height and power, so that imperators, kings and counts were looking to buy them. So for example imperator Leopold was riding a black Oldenburger horse after his wedding with the Spanish princess at the way to Vienna in 1658.
The coat colour of coach and parade horses was quite important in the 17th century, especially special colours were in great demand. Anton Günther himself was impressed of the grey horse Kranich, which had abnormal long mane and tail. After the death of count Anton Günther von Oldenburg, the studs were rent out and any kind of influence of the national horse breeding stopped.
During the 18th century no further developments in the Oldenburger Warmblood population took place, because of storm floods, which destroyed the landscape and caused the financial ruin in the population. In the beginning of the 19th century primarily young 2- and 3-year old stallions and incorrect mares were used for breeding. Most of the best breeding mares and older stallions were sold to foreign countries. But customers from abroad complained, that more and more hereditary defects came across in the Oldenburger Warmblood population. That was the reason why the government started to make a concept to improve the Oldenburger population. In 1820 the stallion licensing, the distribution of premiums for the best stallions and the fixing of stud fees were implemented. Furthermore the covering of 2-year old mares was forbidden. Because of these regulations the quality of the breeding stallions and mares was getting better. (Hofmeister, 1884)
In 1861 the first register for the strong, elegant carriage horses was implemented. Out of licensing protocols and the register, the farmer Eduard Lübben developed the basis for the first Oldenburger studbook in 1891. The interest of costumers from abroad and from other German provinces caused a big sales volume. Especially at the licensing many 3-year old stallions were sold to foreign countries. The anxiety of the breeders that the best breeding horses were sold out, caused the breeders to inform the ministry. They should minimise the export of the best stallions. (Henning, 2004)
Just until the Oldenburger Horse should mainly be used as a riding horse, the more and more cross breedings with thoroughbred and Anglo-Arabian stallions took place. The first stallions were Lupus xx, in 1935 and Anglo-Norman stallion Condor in 1950. In 1959, another Thoroughbred stallion, Adonis xx was introduced and quickly other stallions followed. That is the reason why the Oldenburger horse breed was switched into the direction of a modern riding horse in the 60's. After the good breeders experience with the upgrading, more stallions of other breeds were used like Furioso II. He was the first Anglo-Norman in modern day breeding in 1967. He had more than 60 licensed sons. Especially his sons Freiherr, Feiner Stern and Feinbrand influenced the Oldenburger Warmblood population strongly. His famous son For Pleasure is his most successful son in sport, he won lots of championship medals with Lars Nieberg and later on with Marcus Ehning.
French Anglo-Arabians such as Inschallah AA were also used with great success in Oldenburg. (Verband der Züchter des Oldenburger Pferdes, 2011), (Henning, 2004).

2.3 The English Thoroughbred

The exact breeding of the Thoroughbred´s forebears is not really known, but it is certain, that during the last quarter of the 17th century and in the first quarter of the 18th century Englishmen bought a number of eastern stallions and crossed them with English mares of mixed pedigree. The most famous three stallions are Byerley Turk (about 1684), Darley Arabian

(about 1704) and Godolphin Arabian (about 1729). They are called the founding fathers of the Thoroughbred. Byerley Turk founded the Herod line, Darley Arabian was responsible for founding the Eclipse line and Godolphin Arabian founded the Matchem line. These lines plus the Highflyer line (Highflyer was a son of Herod) are the four principle tail-male lines of the modern Thoroughbred.
Nowadays about 80 % of all Thoroughbreds worldwide go back to these 3 stallions. In 1793 the General Stud Book was introduced and since that time a horse was classed as Thoroughbred when both of its parents are entered the General Stud Book or in an equal official stud book in another country. (Draper, 1997), (von Steglin,1994), (Löwe & Bruns, 1988)
There are three basic types of Thoroughbreds. The sprinter is a very fast, tall horse with a long body, the stayer is a smaller horse with a shorter body and has a good stamina. The middle distance Thoroughbred is shorter, has a well-sloped shoulder and a sloping croup, which makes him well suited for eventing.
The English Thoroughbred has been and is used to improve many other breeds. The goal of crossing Thoroughbreds was to add refinement, endurance, speed and heart. (Hendricks, 1995)

2.4 The Arab

The Arabian horse is the oldest horse breed in the world with the concept of clean breed and is called the noblest horse breed. The history of the Arabian horse goes back to the 2nd century, but only in the 13th century the Arabian horse became famous all over the world. Because of the desert environment in Arabia the horses were selected by the nature, only the strongest horses were able to survive. Since the 13th century Egypt sultans were interested in the Arabian horses and imported them, so the basis for a systematic Arabian horse breed population was founded. As Mahammed Ali brought a large amount of Arabian horses in 1818 to Keiro, his grandson Abbas Pascha undertook the breeding of the Arabian horses. Soon they were famous all over the world. After his death in 1869 lots of horses were sold at an auction to Europe and the USA. Nowadays the breed is mostly concentrated in Egypt, in the Egypt state stud El Zahraa near Keiro about 100 breeding mares are kept to breed. Especially the USA still buys horses at this stud.
The Arabian horse has a height of about 1.50 m, the most characteristic trait is the wide forehead and the dished nose. (Löwe & Hartwig, 1988)

2.5 The Anglo-Arab

The Anglo-Arab is a mix of Arab and Thoroughbred blood. A horse is called Anglo-Arab if one of the parents is Arab and the other one is a Thoroughbred, but also if both are Anglo-Arab or one is Thoroughbred and the other one is Anglo-Arab or if you breed Arab to Anglo-Arab. As there are differences in the percentage of Arab/Thoroughbred blood, the Anglo-Arab population differs in size and appearance. The best mix of Arab crossing Thoroughbred is resulting in an Anglo-Arab with the endurance and stamina of an Arab and the speed and scope of a Thoroughbred. Since the first half of the 19th century France has been a notable producer of Anglo-Arabs. They were used by the France military and as a riding and competition horse. The Anglo-Arab has been an important factor of the development of the France sport horse breed Selle Français.
The French Anglo-Arab traces back to the two stallions Massoud and Aslam from Syria im-

ported, which were crossed with the three imported English Thoroughbred mares Daer, Comus Mare and Selim Mare. The Anglo-Arab has become a highly successful horse in competitive sport, for example Ali-Baba, on whom d´Oriola won his first Olympic title at Helsinki in 1952, and is used to improve other sport breeds. (Draper,1997), (Kidd, 1995), (Hendricks,1995)

2.6 Crossbreeding

Heterosis and breed complementarity are the two main reasons to apply crossbreeding. Heterosis means that the crossbred offspring performs better than the average of the purebred lines. It is caused by dominance and epistasis. The interaction between alleles at the same locus is called dominance, whereas the interaction between alleles at different loci is called epistasis. When parental lines are used that differ in certain characteristics, it is called breed complementarity. It is used to either breed individuals with intermediate values for one trait or to merge two different traits into one animal. (Van Arendonk et.al., 2006)
Crossbreeding in sport horse populations is mostly done with English Thoroughbreds and Arabian horses. English Thoroughbreds were used because of their conformation and their performance traits. They are only selected by their sport performance at races, so there is a high chance of performance genes in the breed. Arabs are used because of their long breeding tradition with accurate breeding choices and natural selection due to the desert environment, which gives the breed the character of hardness, frugality, stamina, health and capability of resistance. The effect of crossbreeding with Thoroughbreds on the offspring was studied by Brandes in 1926 and the results are that thoroughbreds decrease the bone strengths, the depth and the scope of the chest and the body weight. The height of stallions decreases and the height of mares decreases mostly. (von Velsen-Zerweck, 1968)

2.7 Problem definition

Until now it is not known how the amount of Thoroughbred and Arabian blood changed within the Oldenburger Warmblood population within the time span 1990 till 2010. Furthermore it is not clear if the percentage of Thoroughbred/Arabian blood correlates with the performance level of the horses.

2.8 Research objective

This research is aiming to investigate the changes in the amount of Thoroughbred and Arabian blood within the Oldenburger Warmblood population from 1990 till 2010 to see how the Oldenburger Warmblood population changed. Furthermore the sport results of the Oldenburger horses born in 1990 and 2000 will be analysed to investigate if there is a correlation between the percentage of English Thoroughbred/Arabian blood in the Oldenburger Warmblood horses and their performance in sport.

2.9 Research questions

2.9.1 Main question

How did crossbreeding with Thoroughbreds and Arabians develops within the Oldenburger Warmblood population within the time span 1990 till 2010 and did it have an effect on the performance ability of the horses?

2.9.2 Sub question

1. Did the percentage of Thoroughbred and Arab blood in the pedigree of Oldenburger horses change over the mentioned time span and if yes how did it change?
2. Does the percentage of Arabian and Thoroughbred blood in the pedigree of horses correlates with their performance in sport?
3. Does the percentage of Arabian and Thoroughbred blood in the pedigree of horses correlates with the sport performance of their offspring?
4. Does the percentage of Arabian and Thoroughbred blood in the pedigree of horses correlates with their results in performance tests?

Chapter 3

Methodology

3.1 Research design

The research is conducted in form of a desk research using data of the past 20 years of the Oldenburger studbook, as well as horse breeding books and scientific articles.

3.2 Data Collection

Data was collected through the "Rechenzentrum VIT" in Verden, which stores all the horse breeding data in Germany.

3.3 Data processing and analysis

The data is analysed with SPSS. For questions 2,3 and 4 first the data is analysed on gender and year of birth for correction purposes. After that, based on outcomes, statistical models like the ANOVA, Bonferroni post hoc test and independent sample t-test will be performed in order to investigate the influence of the percentage of Arabian and English Thoroughbred blood on various performance parameters.

3.4 Description of data-set

The data-set consists of 12,507 mares, stallions and geldings, that all are registered at the Oldenburger studbook.
For every horse the following data is in the data-set:

- Gender
- Year of birth

- Percentage of Arabian blood in the pedigree of the horse
- Percentage of English Thoroughbred blood in the pedigree of the horse
- Percentage of Oldenburger blood in the pedigree of the horse
- Percentage of Hannoverian blood in the pedigree of the horse
- Percentage of Holstein blood in the pedigree of the horse
- Percentage of other warmblood types in the pedigree of the horse
- Percentage of other blood types in the pedigree of the horse
- Percentage of unknown blood in the pedigree of the horse

The analysis of the percentage goes back to the founders.

Plus, if available, for every horse

- Percentage of placements related to starts in dressage, in competitions
- Percentage of placements related to starts in dressage, in young horse competitions
- Percentage of placements related to starts in show jumping, in competitions
- Percentage of placements related to starts in show jumping, in young horse competitions
- Yes or No if they ever did a performance test (mare performance test, 30-days test, stallion performance test)

Plus, if available, for the offspring of every horse

- Percentage of placements related to starts in dressage, in competitions*
- Percentage of placements related to starts in dressage, in young horse competitions*
- Percentage of placements related to starts in show jumping, in competitions*
- Percentage of placements related to starts in show jumping, in young horse competitions*

*The percentage is calculated by dividing the placements from the starts. If a horse has more than 1 offspring starting at a competition, the total amount of placements from all offspring is divided by the total number of started offspring.

2,797 of the total amount of horses are born in 1990 (22.4 %), 4.590 horses are born in 2000 (36.7 %) and 5,120 are born in 2010 (40.9 %).

The data provides, that 11.7 % of the horses are geldings (1458), 38.1 % are stallions (4765) and 50.2 % are mares (6281). These horses are taken into account for the analysis of the development of Arabian and English Thoroughbred blood percentage in the Oldenburger Warmblood population.

The percentage of the different blood percentages was analysed in table 3.1.

	Mean (in %)	Standard Deviation	Minimum (in %)	Maximum (in %)
Arabian	2.43	3.47	0	30.86
English Thoroughbred	35.78	11.58	3.49	90.14
Oldenburg	5.19	6.49	0	50.05
Hannoverian	13.84	7.92	0	59.33
Holstein	6.34	8.12	0	53.03
Other Warmblood	10.31	7.00	0	56.67
Other	0.75	2.59	0	56.25
Unknown	25.35	7.57	0.83	72.17

Table 3.1: *Descriptives Blood.*

To describe the performance of sport of the Oldenburger Warmblood horses according to their Arab blood percentage, the horses are splitted up into 5 groups as shown in table 3.2.

Group	Percentage of Arabian blood
Group 1	0.00 - 0.49
Group 2	0.50 - 0.99
Group 3	1.00 - 1.99
Group 4	2.00 - 4.99
Group 5	≥ 5.00

Table 3.2: *Grouping Arabs.*

To describe the performance in sport within the Oldenburger Warmblood population according to their English Thoroughblood percentage, the horses are splitted up into 6 groups as shown in table 3.3.

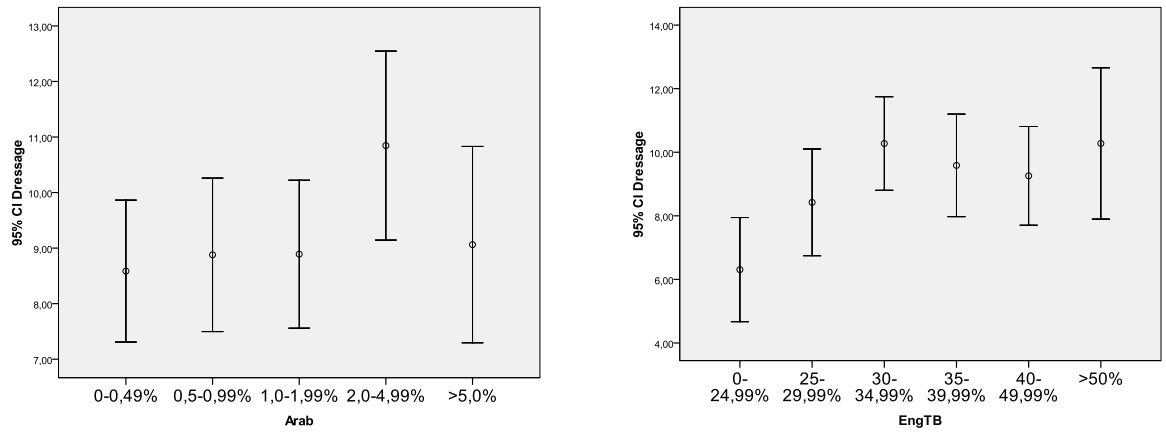
Group	Percentage of English Thoroughbred blood
Group 1	0.00 - 24.99
Group 2	25.00 - 29.99
Group 3	30.00 - 34.99
Group 4	35.00 - 39.99
Group 5	40.00 - 49.99
Group 5	≥ 50.00

Table 3.3: *Grouping English Thoroughbred.*

3.4.1 Performance in sport

The horses born in 1990 and 2000 are taken into account for analysing the effect on the performance in sport. The horses born in 2010 are not taken into account, because they do not have sport results as they are now too young to compete. 4,047 horses were analysed according to their performance in sport in relation to their percentage of English Thoroughbred and Arabian blood. 40.97 % of the total amount of horses (1,658) started at a dressage competition and 64.66 % of them (1,072) were placed. 29.23 % of the total amount of horses (1,183) started at a dressage competition for young horses and 52.41 % of them (620) were placed. 46.31 % of the total amount of horses (1,874) started at a show jumping competition and 73.91 % of them (1,385) were placed. 42.80 % of the total amount of horses (1,732) started at a dressage competition for young horses and 66.69 % of them (1,155) were placed.

3.4.1.1 Dressage



(a) Arab

(b) English Thoroughbred

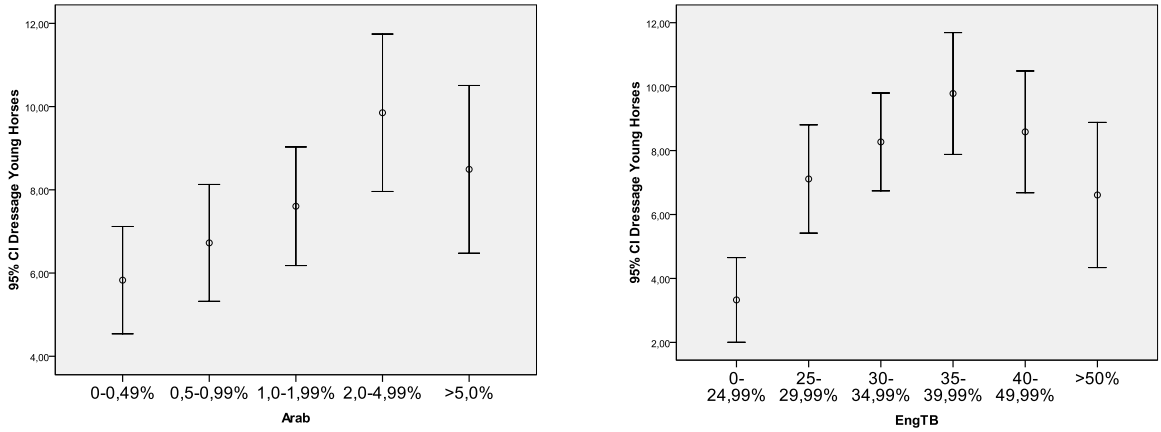
Figure 3.1: *Differences in dressage competition results*

Figure 3.1 describes the differences in dressage competition results according to the Arab and English Thoroughbred blood percentage in the Oldenburger Warmblood population. The dressage competition results are build up by the percentage of placements in relation to starts at competitions.

Arab
The mean of group1 is 8.59 with a standard deviation of 17.667.
The mean of group2 is 8.88 with a standard deviation of 19.084.
The mean of group3 is 8.89 with a standard deviation of 18.453.
The mean of group4 is 10.85 with a standard deviation of 20.512.
The mean of group5 is 9.06 with a standard deviation of 17.849.
In total all 5 groups have a mean of 9.19 with a standard deviation of 18.737.
According to the ANOVA no significant difference at a 0.05 level was found (p=0,235).

English Thoroughbred
The mean of group1 is 6.31 with a standard deviation of 15.965.
The mean of group2 is 8.42 with a standard deviation of 18.873.
The mean of group3 is 10.27 with a standard deviation of 19.952.
The mean of group4 is 9.59 with a standard deviation of 18.875.
The mean of group5 is 9.26 with a standard deviation of 17.807.
The mean of group6 is 10.28 with a standard deviation of 18.941.
According to the ANOVA a significant difference of 0.023 was found.
The Bonferroni post hoc test shows a significant differnence at a 0.05 level between the groups 1 and 3 (p=0.014).

3.4.1.2 Dressage Young Horses



(a) Arab (b) English Thoroughbred

Figure 3.2: *Differences in dressage competition results for young horses*

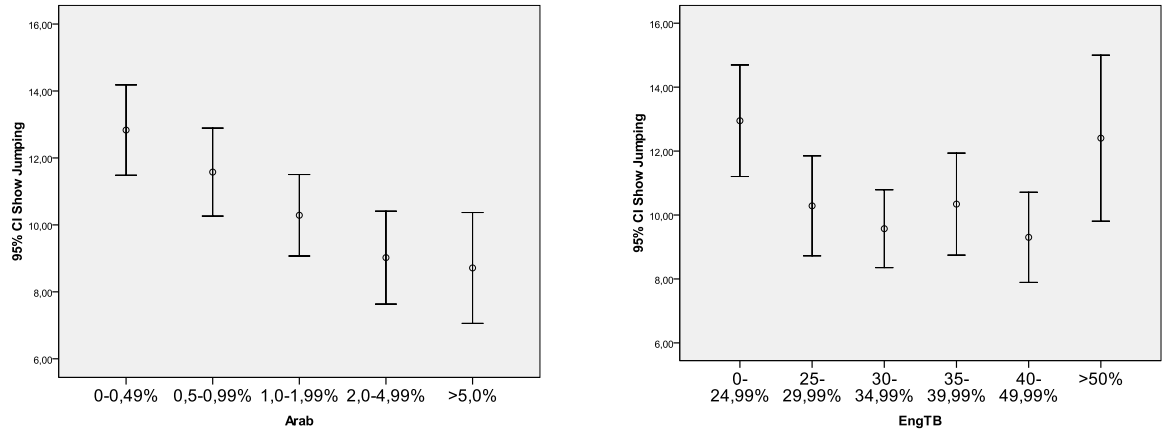
Figure 3.2 describes the differences in dressage competition results for young horses according to the Arab and English Thoroughbred blood percentage in the Oldenburger Warmblood population.

Arab
The mean of group1 is 5.83 with a standard deviation of 17.832.
The mean of group2 is 6.72 with a standard deviation of 19.389.
The mean of group3 is 7.61 with a standard deviation of 19.748.
The mean of group4 is 9.85 with a standard deviation of 22.810.
The mean of group5 is 8.49 with a standard deviation of 20.350.
In total all 5 groups have a mean of 7.50 with a standard deviation of 19.936.
According to the ANOVA a significant difference of 0.004 was found.
The Bonferroni post hoc test shows a significant differnence at a 0.05 level between the groups 1 and 4 (p=0.003).

English Thoroughbred
The mean of group1 is 3.33 with a standard deviation of 12.902.
The mean of group2 is 7.11 with a standard deviation of 19.041.
The mean of group3 is 8.27 with a standard deviation of 20.767.
The mean of group4 is 9.79 with a standard deviation of 22.292.

The mean of group5 is 8.59 with a standard deviation of 21.847.
The mean of group6 is 6.61 with a standard deviation of 18.079.
According to the ANOVA a significant difference of 0.000 was found.
The Bonferroni post hoc test shows a significant differnence at a 0.05 level between the groups 1 and 3 (p=0.002), groups 1 and 4 (p=0.000) and group 1 and 5 (p=0.002).

3.4.1.3 Show jumping



(a) Arab (b) English Thoroughbred

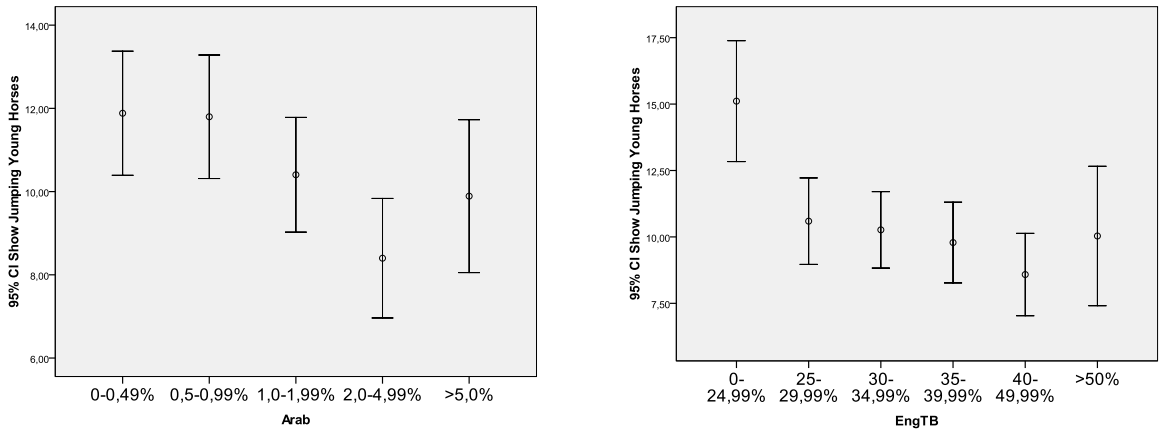
Figure 3.3: *Differences in show jumping competition results*

Figure 3.3 describes the differences in show jumping competition results according to the Arab and English Thoroughbred blood percentage in the Oldenburger Warmblood population.

Arab
The mean of group1 is 12.83 with a standard deviation of 18.652.
The mean of group2 is 11.58 with a standard deviation of 18.150.
The mean of group3 is 10.29 with a standard deviation of 16.865.
The mean of group4 is 9.02 with a standard deviation of 16.737.
The mean of group5 is 8.71 with a standard deviation of 16.717.
In total all 5 groups have a mean of 10.76 with a standard deviation of 17.611.
According to the ANOVA a significant difference of 0.000 was found.
The Bonferroni post hoc test shows a significant differnence at a 0.05 level between the groups 1 and 4 (p=0.001) and group 1 and 5 (p=0.002).

English Thoroughbred
The mean of group1 is 12.95 with a standard deviation of 16.997.
The mean of group2 is 10.29 with a standard deviation of 17.583.
The mean of group3 is 9.57 with a standard deviation of 16.530.
The mean of group4 is 10.34 with a standard deviation of 18.662.
The mean of group5 is 9.30 with a standard deviation of 16.180.
The mean of group6 is 12.40 with a standard deviation of 18.694.
According to the ANOVA a significant difference of 0.013 was found.
The Bonferroni post hoc test shows a significant differnence at a 0.05 level between the groups 1 and 3 (p=0.041) and the groups 1 and 5 (p=0.036).

3.4.1.4 Show jumping Young Horses



(a) Arab (b) English Thoroughbred

Figure 3.4: *Differences in show jumping competition results for young horses*

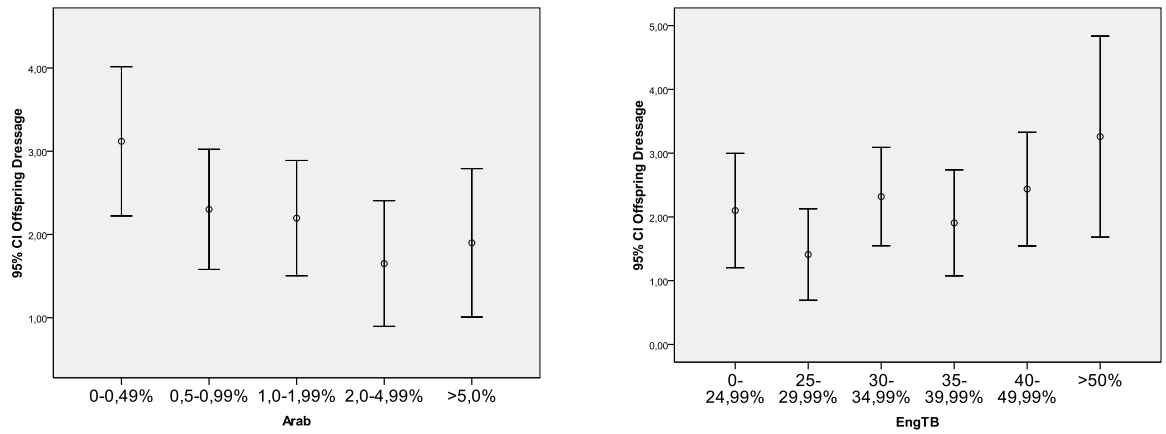
Figure 3.4 describes the differences in show jumping competition results for young horses according to the Arab and English Thoroughbred blood percentage in the Oldenburger Warmblood population.

Arab
The mean of group1 is 11.88 with a standard deviation of 20.621.
The mean of group2 is 11.80 with a standard deviation of 20.497.
The mean of group3 is 10.40 with a standard deviation of 19.010.
The mean of group4 is 8.40 with a standard deviation of 17.320.
The mean of group5 is 9.89 with a standard deviation of 18.551.
In total all 5 groups have a mean of 10.65 with a standard deviation of 19.464.
According to the ANOVA a significant difference of 0.008 was found.
The Bonferroni post hoc test shows a significant differnence at a 0.05 level between the groups 1 and 4 (p=0.014) and group 2 and 4 (p=0.018).

English Thoroughbred
The mean of group1 is 15.11 with a standard deviation of 22.167.
The mean of group2 is 10.59 with a standard deviation of 18.295.
The mean of group3 is 10.27 with a standard deviation of 19.521.
The mean of group4 is 9.79 with a standard deviation of 17.779.
The mean of group5 is 8.58 with a standard deviation of 17.789.
The mean of group6 is 10.03 with a standard deviation of 20.897.
According to the ANOVA a significant difference of 0.000 was found.
The Bonferroni post hoc test shows a significant differnence at a 0.05 level between the groups 1 and 2 (p=0.010), the groups 1 and 3 (p=0.001), the groups 1 and 4 (p=0.001), the groups 1 and 5 (p=0.000) and the groups 1 and 6 (p=0.020).

3.4.2 Sport Performance of the offspring

3.4.2.1 Dressage



(a) Arab (b) English Thoroughbred

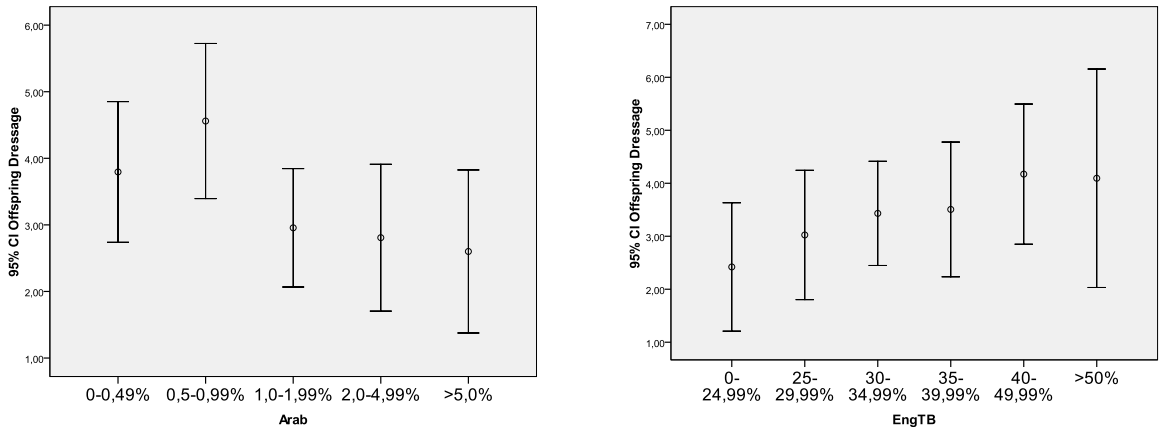
Figure 3.5: *Differences in dressage competition results in the offspring*

Figure 3.5 describes the differences in dressage competition results according to the Arab and English Thoroughbred blood percentage in the offspring of the Oldenburger Warmblood population.

Arab
The mean of group1 is 3.12 with a standard deviation of 12.398.
The mean of group2 is 2.30 with a standard deviation of 9.969.
The mean of group3 is 2.20 with a standard deviation of 9.601.
The mean of group4 is 1.65 with a standard deviation of 9.105.
The mean of group5 is 1.90 with a standard deviation of 9.003.
In total all 5 groups have a mean of 2.30 with a standard deviation of 10.260.
According to the ANOVA no significant difference at a 0.05 level was found (p=0,107).

English Thoroughbred
The mean of group1 is 2.10 with a standard deviation of 8.743.
The mean of group2 is 1.41 with a standard deviation of 8.056.
The mean of group3 is 2.32 with a standard deviation of 10.480.
The mean of group4 is 1.91 with a standard deviation of 9.725.
The mean of group5 is 2.44 with a standard deviation of 10.231.
The mean of group6 is 3.26 with a standard deviation of 12.554.
According to the ANOVA no significant difference at a 0.05 level was found (p=0,239).

3.4.2.2 Dressage Young Horses



(a) Arab

(b) English Thoroughbred

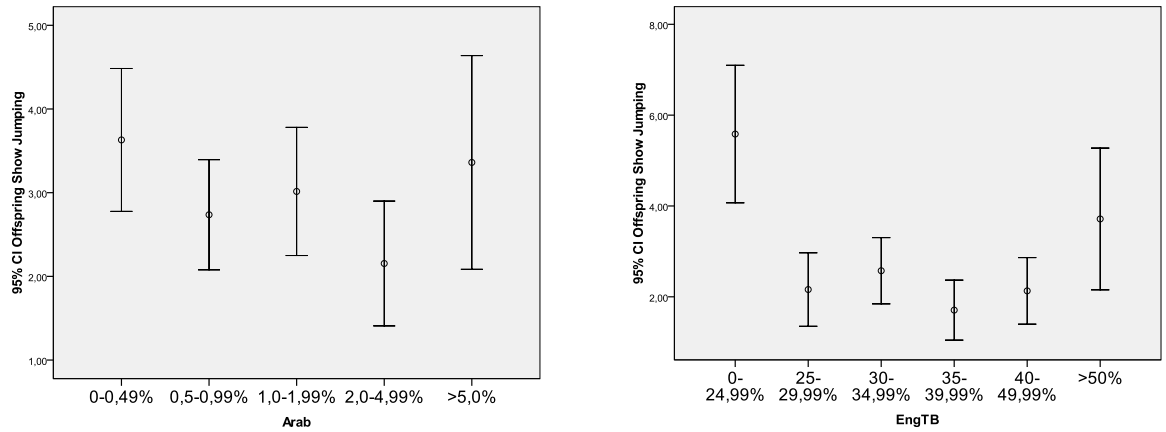
Figure 3.6: *Differences in dressage competition results for young horses in the offspring*

Figure 3.6 describes the differences in dressage competition results for young horses according to the Arab and English Thoroughbred blood percentage in the offspring of the Oldenburger Warmblood population.

Arab
The mean of group1 is 3.80 with a standard deviation of 14.608.
The mean of group2 is 4.56 with a standard deviation of 16.089.
The mean of group3 is 2.96 with a standard deviation of 12.322.
The mean of group4 is 2.81 with a standard deviation of 13.297.
The mean of group5 is 2.60 with a standard deviation of 12.362.
In total all 5 groups have a mean of 3.45 with a standard deviation of 13.994.
According to the ANOVA a significant differnence at a 0.05 level was not found (p=0,071).

English Thoroughbred
The mean of group1 is 2.42 with a standard deviation of 11.802.
The mean of group2 is 3.02 with a standard deviation of 13.724.
The mean of group3 is 3.43 with a standard deviation of 13.345.
The mean of group4 is 3.51 with a standard deviation of 14.875.
The mean of group5 is 4.17 with a standard deviation of 15.174.
The mean of group6 is 4.09 with a standard deviation of 16.417.
According to the ANOVA a significant differnence at a 0.05 level was not found (p=0,517).

3.4.2.3 Show jumping



(a) Arab (b) English Thoroughbred

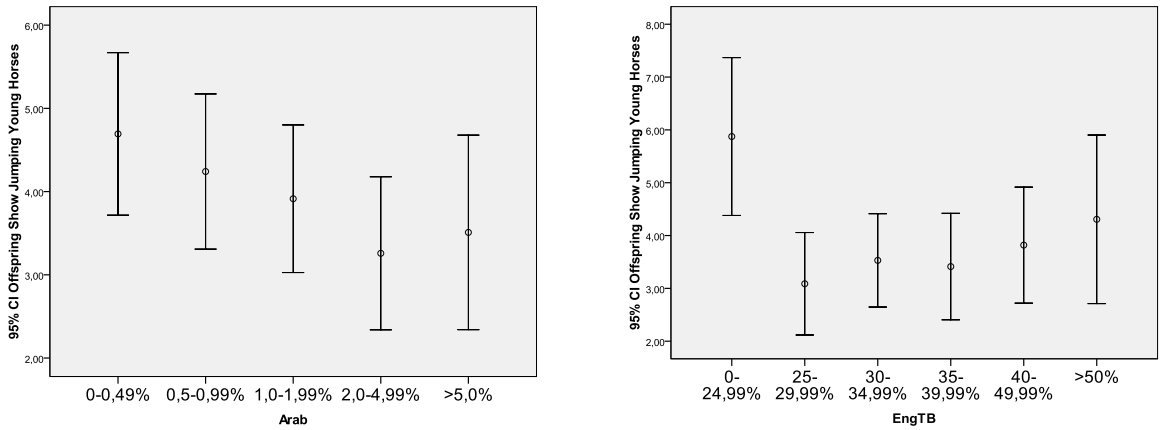
Figure 3.7: *Differences in show jumping competition results in the offspring*

Figure 3.7 describes the differences in show jumping competition results according to the Arab and English Thoroughbred blood percentage in the offspring of the Oldenburger Warmblood population.

Arab
The mean of group1 is 3.63 with a standard deviation of 11.805.
The mean of group2 is 2.74 with a standard deviation of 9.089.
The mean of group3 is 3.01 with a standard deviation of 10.609.
The mean of group4 is 2.15 with a standard deviation of 8.991.
The mean of group5 is 3.36 with a standard deviation of 12.892.
In total all 5 groups have a mean of 2.98 with a standard deviation of 10.630.
According to the ANOVA a significant differnence at a 0.05 level was not found (p=0,133).

English Thoroughbred
The mean of group1 is 5.58 with a standard deviation of 14.751.
The mean of group2 is 2.16 with a standard deviation of 9.094.
The mean of group3 is 2.57 with a standard deviation of 9.898.
The mean of group4 is 1.71 with a standard deviation of 7.727.
The mean of group5 is 2.13 with a standard deviation of 8.405.
The mean of group6 is 3.71 with a standard deviation of 12.428.
According to the ANOVA a significant difference of 0.000 was found.
The Bonferroni post hoc test shows a significant differnence at a 0.05 level between the groups 1 and 2 (p=0.000), the groups 1 and 3 (p=0.000), the groups 1 and 4 (p=0.000) and the groups 1 and 5 (p=0.000).

3.4.2.4 Show jumping Young Horses



(a) Arab (b) English Thoroughbred

Figure 3.8: *Differences in show jumping competition results for young horses in the offspring*

Figure 3.8 describes the differences in show jumping competition results for young horses according to the Arab and English Thoroughbred blood percentage in the offspring of the Oldenburger Warmblood population.

Arab
The mean of group1 is 4.69 with a standard deviation of 13.500.
The mean of group2 is 4.24 with a standard deviation of 12.875.
The mean of group3 is 3.91 with a standard deviation of 12.289.
The mean of group4 is 3.26 with a standard deviation of 11.089.
The mean of group5 is 3.51 with a standard deviation of 11.803.
In total all 5 groups have a mean of 4.00 with a standard deviation of 12.464.
According to the ANOVA a significant differnence at a 0.05 level was not found (p=0,269).

English Thoroughbred
The mean of group1 is 5.87 with a standard deviation of 14.552.
The mean of group2 is 3.09 with a standard deviation of 10.900.
The mean of group3 is 3.53 with a standard deviation of 11.986.
The mean of group4 is 3.41 with a standard deviation of 11.791.
The mean of group5 is 3.82 with a standard deviation of 12.598.
The mean of group6 is 4.31 with a standard deviation of 12.706.
According to the ANOVA a significant difference of 0.021 was found.
The Bonferroni post hoc test shows a significant differnence at a 0.05 level between the groups 1 and 2 (p=0.016), the groups 1 and 3 (p=0.046) and the groups 1 and 4 (p=0.049).

3.4.3 Performance tests

The data set consists of 2,171 mares, 1,220 geldings, 656 stallions and describes if the mares did a mare performance test, if the stallions did a 30-days test and if they did a stallion performance test. 667 of the 2,171 mares did a performance test, which are 30.7 %. 71 of the 1,876 geldings and stallions did a stallion performance test which are 3.8 % and 52 stallions did a 30-days test (2.8 %). Geldings are also taking into account as they could be castrated after the tests.

Chapter 4

Results

4.1 Development of Arabian and English Thoroughbred blood percentage

4.1.1 Arab

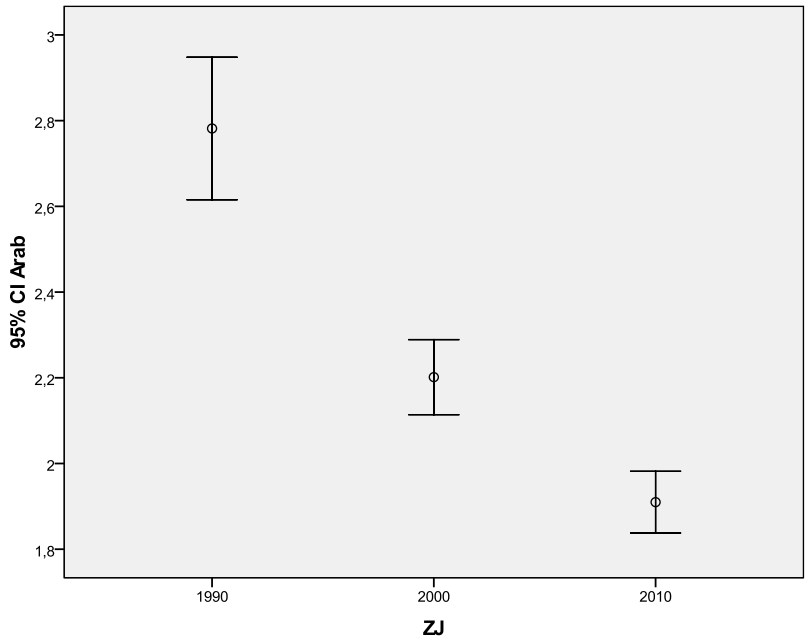


Figure 4.1: *Development of Arabian blood in the Oldenburger Warmblood population*

Figure 4.1 describes the development of Arab blood in the Oldenburger Warmblood population. The basis for analysing are all Oldenburger horses born in 1990, 2000 and 2010. In total 2,797 Oldenburger horses were born in 1990, 4,590 horses were born in 2000 and 5,120 in 2010. The mean of the percentage of Arabian blood of all Oldenburger horses born in 1990 is 2.78 with a standard deviation of 4.484. The mean of the percentage of Arabian blood of all Oldenburger horses born in 2000 is 2.20 with a standard deviation of 3.026 and the mean of the percentage of Arabian blood of all Oldenburger horses born in 2010 is 1.91 with a standard deviation of

2.626. According to the Bonferroni post hoc test, a significant differnence of 0.00 was found between all three years.

4.1.2 English Thoroughbred

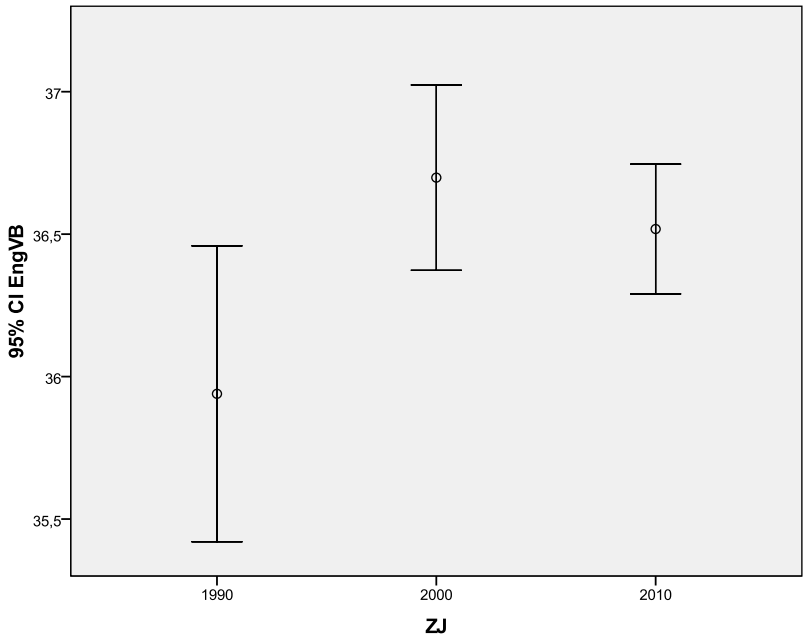


Figure 4.2: *Development of English Thoroughbred in the Oldenburger Warmblood population*

Figure 4.2 describes the development of English Thoroughbred blood in the Oldenburger Warmblood population. The basis for analysing are all Oldenburger horses born in 1990, 2000 and 2010. The mean of the percentage of English Thoroughbred blood of all Oldenburger horses born in 1990 is 35.94 with a standard deviation of 14.008. The mean of the percentage of English Thoroughbred blood of all Oldenburger horses born in 2000 is 36.70 with a standard deviation of 11.241 and the mean of the percentage of English Thoroughbred blood of all Oldenburger horses born in 2010 is 36.52 with a standard deviation of 8.308.
According to the Bonferroni post hoc test, a significant differnence at a 0.05 level was found between the years 1990 and 2000 with a significance of 0.011. A significant difference between 1990 and 2010 was not found (p=0.072).

4.2 Performance in sport

Before analysing the influence of the percentage of Arabian and English Thoroughbred blood in the pedigree of the Oldenburger Warmblood population on the performance in sport, it must be checked if the performance parameters are following a normal distribution. Otherwise they can not be the variable in the analysis. As about half of the horses in the data-set did not started in dressage or show jumping competitions, the performance parameters are not normal distributed. Another option to analyse is to use the Arabian and English Thoroughbred percentage as variable. So the Kolmogorov-Smirnov Test was performed to check if the percentage of Arabian and English Thoroughbred blood is following a normal distribution to

use them as the variable of the following analysis. The percentage of Arabian blood is not following a normal distribution, so no further analysis on this can be made. The percentage of English Thoroughbred blood is following a normal distribution and will be analysed in the following paragraph. Furthermore the influence of gender and year of birth on the performance parameters is analysed. If they show a significance, the outcome is corrected on this parameter.

The performance parameters are grouped as follows:

Group	Percentage of performance
Group 1	0.00
Group 2	0.01 - 24.99
Group 3	25.00 - 49.99
Group 4	$\geq$ 50.00

Table 4.1: *Grouping Performance.*

4.2.1 Dressage

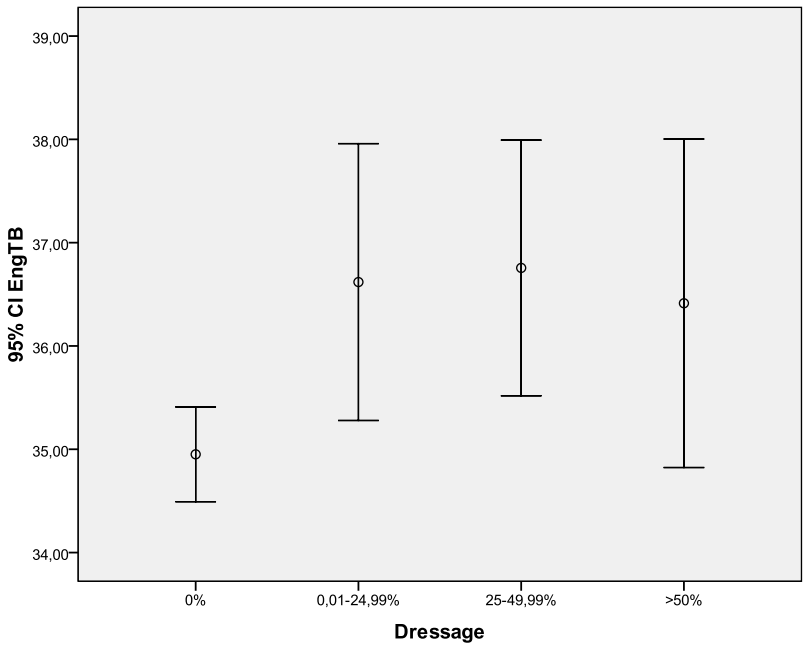


Figure 4.3: *Influence of English Thoroughbred percentage on dressage performance*

Figure 4.3 describes the differences in the English Thoroughbred blood percentage according to dressage performance in the Oldenburger Warmblood population. No significant influence of gender and year of birth was found, so they are not included in the model.

The Univariate Test shows a significance of 0.004 on the dressage performance. According to the Bonferroni post hoc test a significant difference between group 1 and group 3 (p=0.042) was found.

Group	Mean (in %)
Group 1	34.951
Group 2	36.619
Group 3	36.755
Group 4	36.413

Table 4.2: *Means Dressage.*

4.2.2 Dressage Young Horses

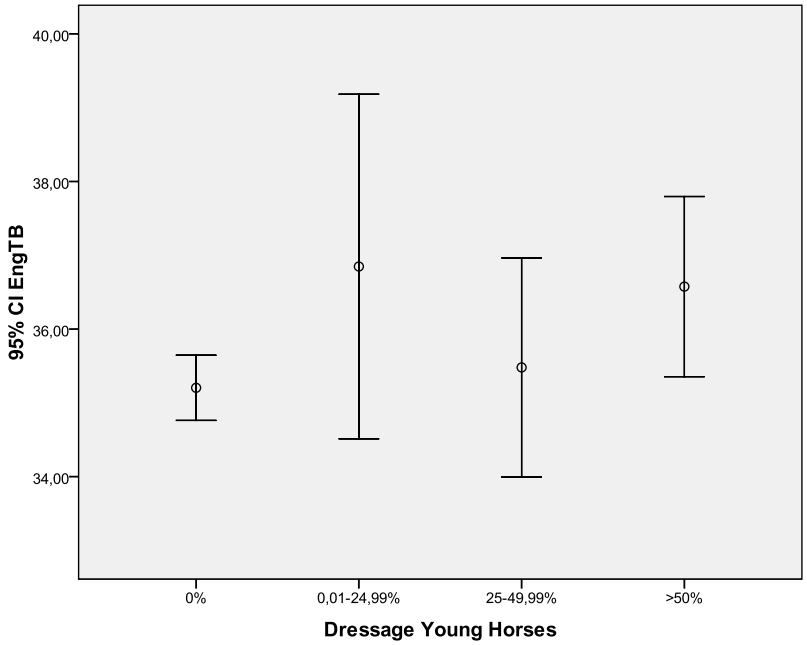


Figure 4.4: *Influence of English Thoroughbred percentage on dressage performance for young horses*

Figure 4.4 describes the differences in the English Thoroughbred blood percentage according to dressage performance for young horses in the Oldenburger Warmblood population. No significant influence of gender and year of birth was found, so they are not included in the model.

Group	Mean (in %)
Group 1	35.204
Group 2	36.848
Group 3	35.480
Group 4	36.575

Table 4.3: *Means Dressage Young Horses.*

The Univariate Test shows no significance on the dressage performance for young horses (p=0.158).

4.2.3 Show Jumping

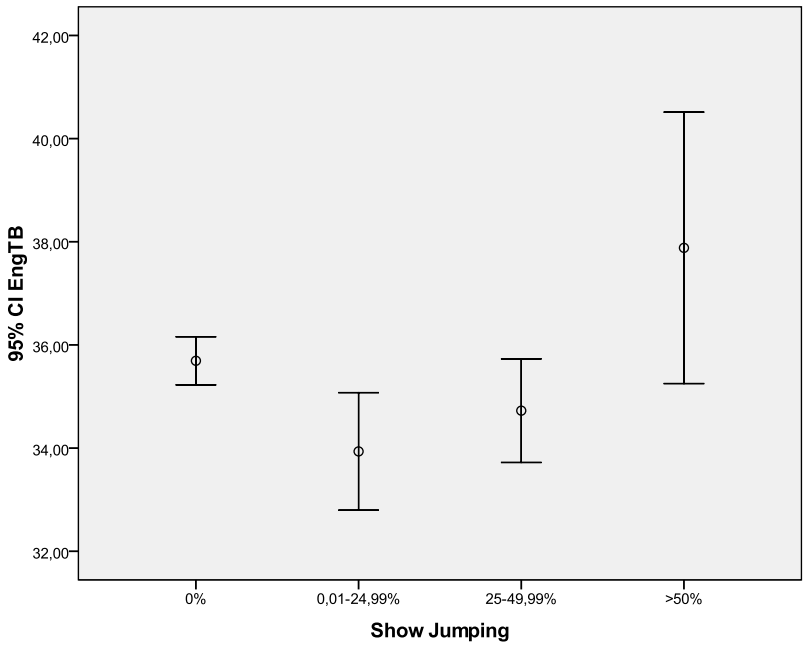


Figure 4.5: *Influence of English Thoroughbred percentage on show jumping performance*

Figure 4.5 describes the differences in the English Thoroughbred blood percentage according to show jumping performance in the Oldenburger Warmblood population. No significant influence of gender and year of birth was found, so they are not included in the model.

Group	Mean (in %)
Group 1	35.692
Group 2	33.936
Group 3	34.725
Group 4	37.882

Table 4.4: *Means Show Jumping.*

The Univariate Test shows a significance of 0.001 on the show jumping performance. According to the Bonferroni post hoc test a significant difference between group 1 and group 2 (p=0.021), group 2 and group 4 (p=0.003) and group 3 and group 4 (p=0.028) was found.

4.2.4 Show Jumping Young Horses

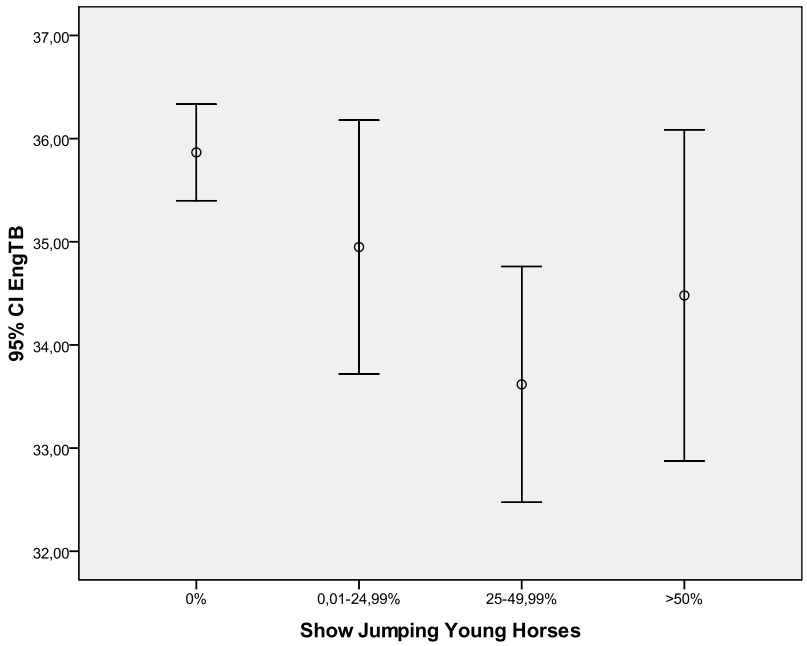


Figure 4.6: *Influence of English Thoroughbred percentage on show jumping performance for young horses*

Figure 4.6 describes the differences in the English Thoroughbred blood percentage according to show jumping performance for young horses in the Oldenburger Warmblood population. A significant influence of the year of birth was found, so this is included in the model (p=0.045) and the means are corrected on this parameter.

Group	Mean (in %)
Group 1	35.708
Group 2	34.728
Group 3	33.450
Group 4	34.318

Table 4.5: *Means Show Jumping Young Horses.*

The Univariate Test shows a significance of 0.016 on the show jumping performance for young horses. According to the Bonferroni post hoc test a significant difference between group 1 and group 3 (p=0.001) was found.

4.3 Performance of the offspring

The analysis of the performance of the offspring is done in the same way as the analysis of the peformance of the horses in sport, described in 4.2.

The performance parameters of the offspring are grouped as follows:

Group	Percentage of performance
Group 1	0.00
Group 2	0.01 - 24.99
Group 3	25.00 - 49.99
Group 4	$\geq$ 50.00

Table 4.6: *Grouping Performance Offspring.*

4.3.1 Dressage

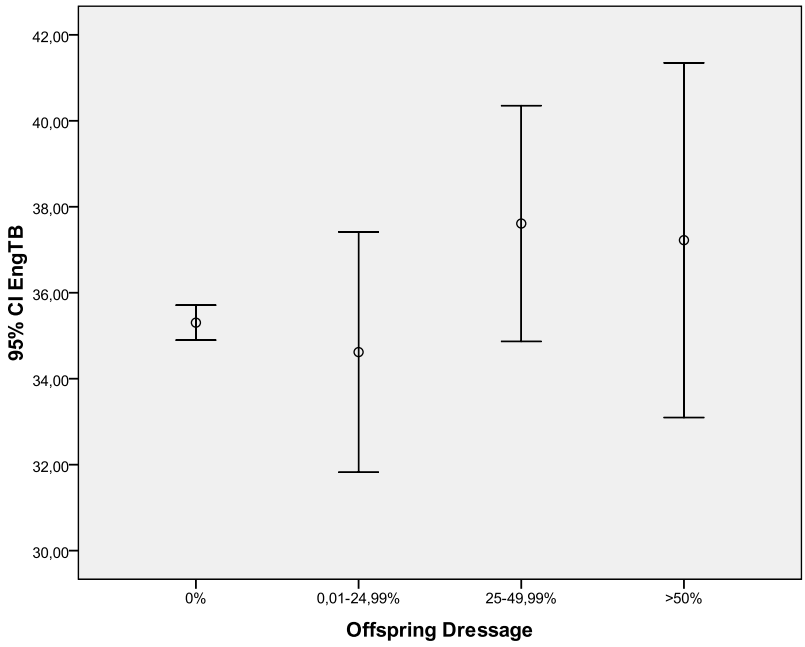


Figure 4.7: *Influence of English Thoroughbred percentage on dressage performance of the offspring*

Figure 4.7 describes the differences in the English Thoroughbred blood percentage according to dressage performance of the offspring in the Oldenburger Warmblood population. No significant influence of gender and year of birth was found, so they are not included in the model.

The Univariate Test shows no significance on the dressage performance of the offspring (p=0.172).

Group	Mean (in %)
Group 1	35.304
Group 2	34.619
Group 3	37.610
Group 4	37.223

Table 4.7: *Means Offspring Dressage.*

4.3.2 Dressage Young Horses

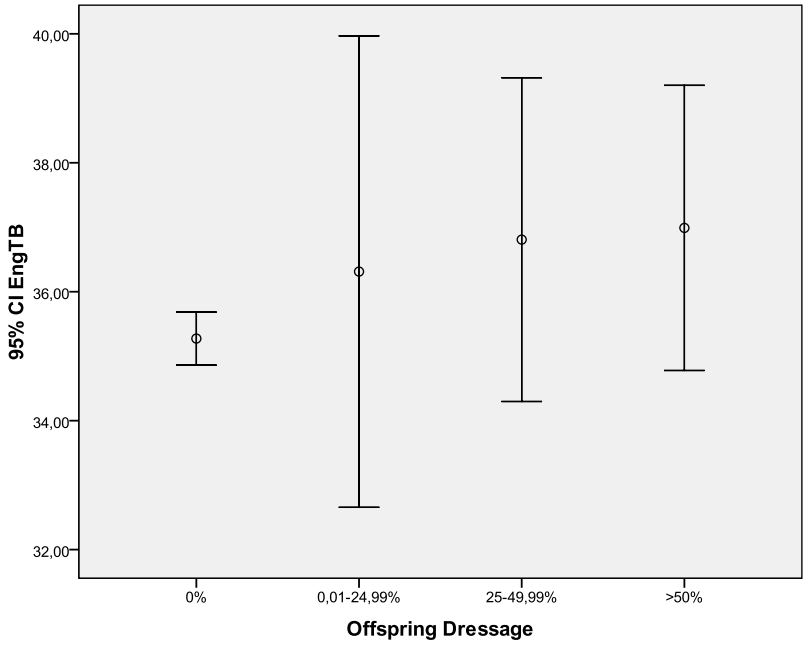


Figure 4.8: *Influence of English Thoroughbred percentage on dressage performance for young horses of the offspring*

Figure 4.8 describes the differences in the English Thoroughbred blood percentage according to dressage performance for young horses of the offspring in the Oldenburger Warmblood population. No significant influence of gender and year of birth was found, so they are not included in the model.

Group	Mean (in %)
Group 1	35.273
Group 2	36.312
Group 3	36.808
Group 4	36.990

Table 4.8: *Means Offspring Dressage Young Horses.*

The Univariate Test shows no significance on the dressage performance for young horses of the offspring (p=0.274).

4.3.3 Show Jumping

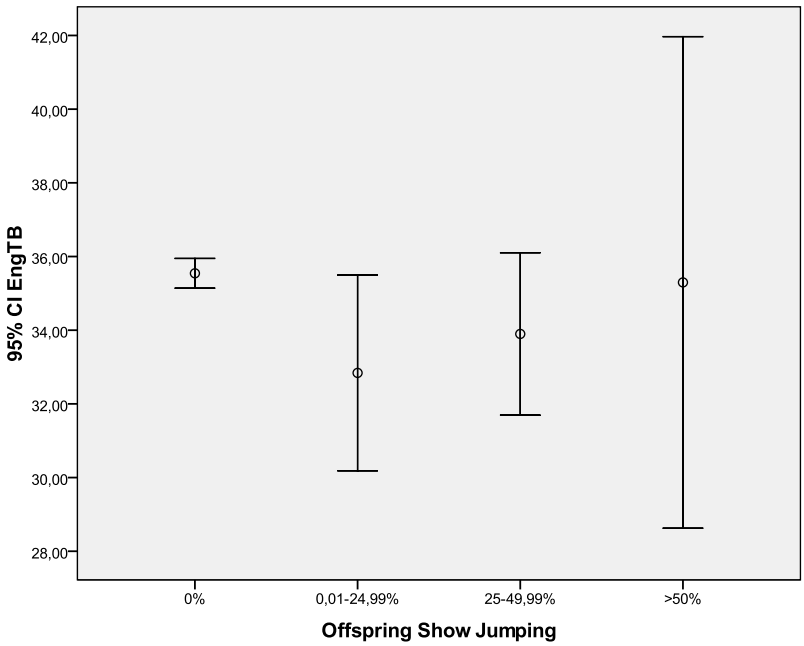


Figure 4.9: *Influence of English Thoroughbred percentage on show jumping performance of the offspring*

Figure 4.9 describes the differences in the English Thoroughbred blood percentage according to show jumping performance of the offspring in the Oldenburger Warmblood population. No significant influence of gender and year of birth was found, so they are not included in the model.

Group	Mean (in %)
Group 1	35.544
Group 2	32.841
Group 3	33.898
Group 4	35.297

Table 4.9: *Means Offspring Show Jumping.*

The Univariate Test shows no significance on the show jumping performance of the offspring (p=0.148).

4.3.4 Show Jumping Young Horses

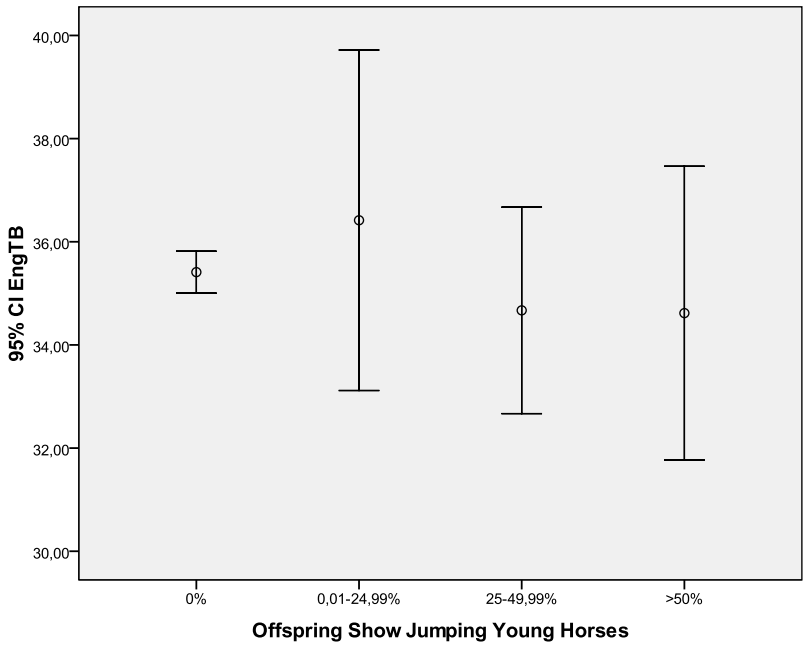


Figure 4.10: *Influence of English Thoroughbred percentage on show jumping performance for young horses of the offspring*

Figure 4.10 describes the differences in the English Thoroughbred blood percentage according to show jumping performance for young horses of the offspring in the Oldenburger Warmblood population. No significant influence of gender and year of birth was found, so they are not included in the model.

Group	Mean (in %)
Group 1	35.411
Group 2	36.417
Group 3	34.670
Group 4	34.617

Table 4.10: *Means Offspring Show Jumping Young Horses.*

The Univariate Test shows no significance on the show jumping performance for young horses of the offspring (p=0.597).

4.4 Performance Tests

4.4.1 Mare Performance Test

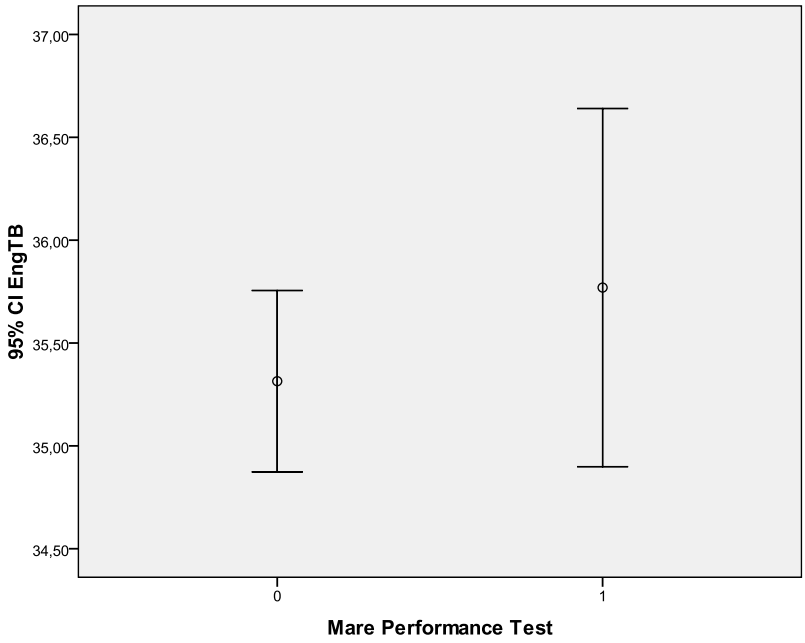


Figure 4.11: *Influence of English Thoroughbred percentage on the mare performance test*

Figure 4.11 describes the differences in the mare performance test according to the English Thoroughbred blood percentage in the Oldenburger Warmblood population. In total 667 of the 2,171 mares in the data-set did a mare performance test (30.7 %).
No significant influence of gender and year of birth was found, so they are not included in the model. The mean percentage of English Thoroughbred blood in the pedigree of the mares that did a performance test is 35.31 and the mean of mares that did not do a mare peformance test is 35.77.
According to the Univariate Test test, a significant differnence at a 0.05 level was not found between the mares that did a performance test and those who did not do a performance test according to their percentage of English Thoroghbred blood (p=0.422).

4.4.2 30-days test

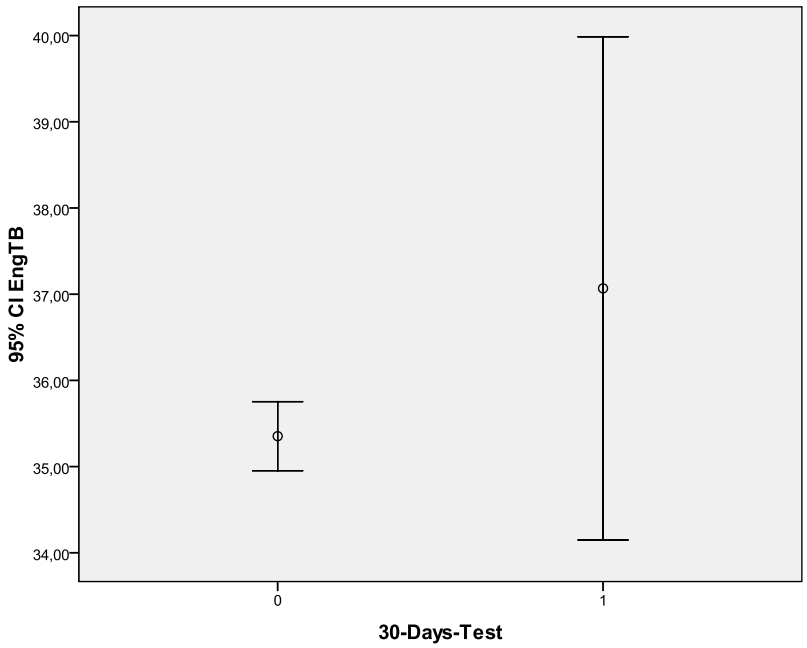


Figure 4.12: *Influence of English Thoroughbred percentage on the 30-days test*

Figure 4.12 describes the differences in 30-days test according to the English Thoroughbred blood percentage in the Oldenburger Warmblood population.
In total 52 of the 1,876 stallions and geldings in the data-set did a 30-days test (2.8 %). A significant influence of 0.032 of the year of birth was found, so this was included in the model and the means are corrected on this parameter, no significant influence of gender was found.
The mean percentage of English Thoroughbred blood in the pedigree of the stallions that did a 30-days test is 36.67 and the mean of stallions that did not do a 30-days test is 35.20.
According to the Univariate Test test, no significant differnence at a 0.05 level was found between the stallions that did a 30-days test and those who did not do a 30-days test according to their percentage of English Thoroghbred blood (p=0.342).

4.4.3 Stallion performance test

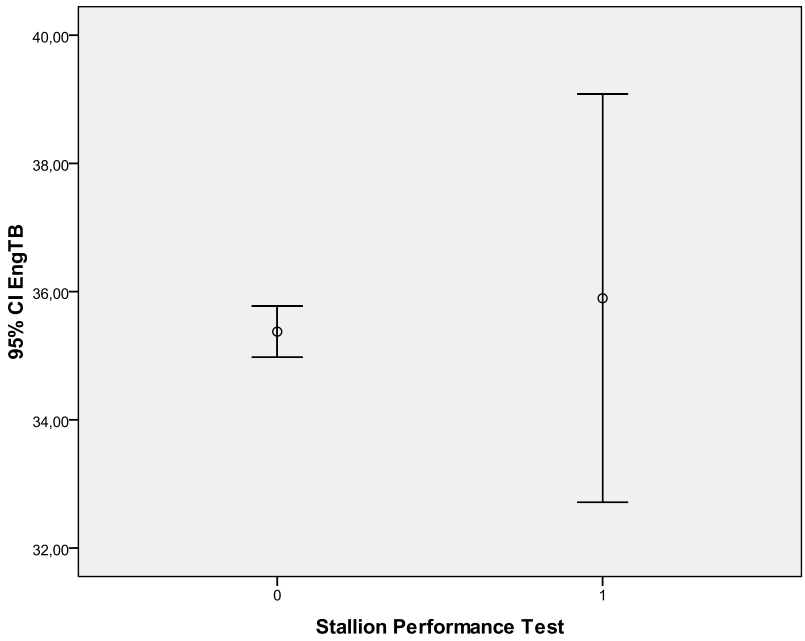


Figure 4.13: *Influence of English Thoroughbred percentage on the stallion performance test*

Figure 4.13 describes the differences in the stallion performance test according to the English Thoroughbred blood percentage in the Oldenburger Warmblood population. In total 72 of the 1,876 stallions and geldings in the data-set did a stallion performance test (3.8 %). No significant influence of gender and year of birth was found, so they are not included in the model.
The mean percentage of English Thoroughbred blood in the pedigree of the stallions that did a performance test is 35.90 and the mean of stallions that did not do a performance test is 35.38.
According to the Univariate Test test, no significant differnence at a 0.05 level was found between the stallions that did a performance test and those who did not do a performace test according to their percentage of English Thoroghbred blood (p=0.618).

Chapter 5

Discussion

The study shows that the Arab percentage in the Oldenburger Warmblood population constantly decreases from 1990 till 2010. The English Thoroughbred percentage is significantly increasing from 1990 till 2000 and slightly decreasing from 2000 till 2010. A comparable study of Florian Sitzenstock in 2008 came to the conclusion that the percentage of Thoroughbred in the Hannoverian studbook also describes an increased percentage of Thoroughbred blood in the Hannoverian Warmblood population. He took 217,475 Hannoverian foals from 1980 until 2006 into account and describes a proportion of 20 % in 1980 and an increase up to 25 % in 2006. He describes that the percentage of horses with no Thoroughbred blood dropped from 40 % to 4 %. The influence of two Hannoverian stallions Prince Thatch xx and Lauries Crusador xx is mentioned as reason for the increase. As the two stallions in 1990 joined the Landgestüt Celle, 29 % half-bred foals were produced and in 2006 61 % of all the half-bred Hannoverian foals were by Lauries Crusador. (Sitzenstock, 2010)
The increase can be explained by breeding part Thoroughbred to part Thoroughbred, which will end up in a foal with the average Thoroughbred percentage of the parents. The increasing percentage is then explained by bringing new Thoroughbred blood in the population. Another explanation is that the unknown percentage of blood in this study is that high (average 25 %) that it falsifies the results. To get a clearer result the pedigree of the horses should be corrected according to their unknown blood or only the first generations should be taken into account for calculating the blood percentages.
A significant difference in the dressage competitions results according to the Thoroughbred blood percentage is found. Horses with more success have a significantly higher percentage of Thoroughbred blood. In the dressage competition results for young horses no differences were found. In the study of Florian Sitzenstock the FN breeding values are analysed according to the Thoroughbred blood percentage in the Hannoverian Warmblood population. He concludes that the proportion of Thoroughbred blood strongly relates to performance ability for dressage and show jumping. An increased percentage of Thoroughbred blood will positively influence the dressage breeding value. (Sitzenstock, 2010)
In this study the percentage of placements in relation to starts was analysed. It would also be important to split the sport results into competing levels so that the relation to the difficulty of the sport results can be made. Further research on international or highly national competing horses in comparison to horses competing at basic level might provide more information on the influence on Thoroughbred blood in the Warmblood population.
Significant differences in the show jumping competition results are found in the study. The most successful show jumping horses have a significantly higher percentage of Thoroughbred

blood than the less successful horses. But horses with 0 % of placements at show jumping competitions have a significantly higher percentage of Thoroughbred blood than horses with a percentage of 0.01 till 24.99 % of placements. In contrast to that more successful horses have a lower Thoroughbred percentage than those who are not placed in show jumping competitions for young horses.
Florian Sitzenstock concludes in his study that the horses with 25 % Thoroughbred showed better show jumping breeding values than horses with a higher percentage. In his study horses with 0.1-12.5 % showed the highest value, horses with 12.5-25 % had a higher value than horses with 0 % of Thoroughbred and horses with more than 25 % of Thoroughbred blood has an negative impact on the jumping index. (Sitzenstock, 2008) The different results might be caused by not splitting dressage and show jumping horses in the data-set. The dressage horses do not count show jumping placements and the other way around. To get a clearer result the dressage and show jumping horses should be analysed separately.
The analysis of the offspring in dressage and show jumping competitions according to their English Thoroughbred percentage does not show significant differences. But a tendency that horses with a higher percentage of Thoroughbred have more successful offspring in dressage competitions was recognizable.
Furthermore the data-set was analysed if the horses did take part at a mare performance test, a 30-days test and a stallion performance test. No significant differences in the percentage of Thoroughbred blood were found. For further research on this topic the results of these tests should be taken into account and not only if the horses did take part or not. The number of stallions that take part at the stallion tests in the data set was too low to find significant differences. For further research stallions of other years should also be included in the data-set.
In total it can be said, that the percentage of Arabian blood decreases. Breeders use English Thoroughbred blood to ennoble their horses instead of Arabian blood. The percentage of English Thoroughbred blood in the Oldenburger population increases from 1990 till 2000 and horses with a higher percentage of Thoroughbred blood have more success in dressage competitions. Further research should be done according to competing levels in relation to Thoroughbred blood percentage in the pedigree. Thoroughbreds are still an important breed to ennoble the horses, they should be used with the necessary consequence to keep a certain percentage of Thoroughbred in the population. But Thoroughbreds should be carefully selected according to their abilities to ennoble the Warmblood horses.

Chapter 6

Conclusion

This research is aiming to investigate the changes in the amount of Thoroughbred and Arabian blood within the Oldenburger Warmblood population from 1990 till 2010 to see how the Oldenburger warmblood population changed. Furthermore the sport results of the Oldenburger horses born in 1990 and 2000 will be analysed to investigate if there is a correlation between the percentage of English Thoroughbred/Arabian blood in the Oldenburger Warmblood horses and their performance in sport. The data-set consists of 12,507 mares, stallions and geldings, that all are registered at the Oldenburger studbook. They were analysed according to the percentage of English Thoroughbred and Arabian blood. The horses born in 1990 and 2000 are taken into account for analysing the effect on the performance in sport. 4,047 horses were analysed according to their performance in sport in relation to their percentage of English Thoroughbred and Arabian blood. The data is analysed with SPSS. With this program several the statistical tests ANOVA, Bonferroni post hoc tests and independent sample t-test will be performed in order to investigate the collected data towards the research questions. The study shows that the Arab percentage in the Oldenburger Warmblood population constantly decreases from 1990 till 2010. The English Thoroughbred percentage is significantly increasing from 1990 till 2000 and slightly decreasing from 2000 till 2010. Furthermore a percentage between placements and starts at competitions was calculated to analyse the sport results of the horses. The results of the study show that more successful horses in show jumping and dressage competitions have a higher percentage of English Thoroughbred. In the offspring no significant differences according to the English Thoroughbred percentage and success in dressage and show jumping competitions was found. Furthermore the data-set was analysed if the horses and their offspring did take part at a mare performance test, a 30-days test and a stallion performance test. No significant differences in the percentage of Thoroughbred blood in their pedigree were found.

Chapter 7

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