Determination of factors affecting the length of racing career of Arabian horses in Turkey*

Doğukan ÖZEN[1], Ismayil Safa GÜRCAN[1]

[1] Ankara University, Faculty of Veterinary Medicine, Division of Animal Husbandry and Animal Nutrition, Department of Biostatistics, 06110, Diskapi, Ankara, Turkey.

Summary: The purpose of this study was to estimate survival functions and the average length of racing career of Arabian racehorses in Turkey in different circumstances. In addition, it was aimed to determine the risk factors that affect the length of racing career of Arabian horses and to create a model including these factors. In this study, the information of 3354 Arabian racehorses that was born in or after 2003 were used. Kaplan Meier analysis was used to estimate the average length of racing career for each selected factors. Cox regression was used to determine the risk factors affecting the length of racing career as well as creating a model using those factors. Results showed that the mean length of racing career of Arabian horses was 22.74 months (95% CI: 22.04-23.44). Also, 'age', 'sex', 'type of stud farm', 'racing on single type of track surface' and 'earnings' variables were found statistically significant risk factors that affect the length of racing career.

Keywords: Arabian horse, racing career, risk factors, survival analysis.

Türk safkan Arap atlarında yarış hayatına etki eden faktörlerin belirlenmesi

Özet: Bu çalışmanın amacı farklı nitelikteki Türk Safkan Arap atlarının yaşam fonksiyonları ile ortalama yarış hayatı sürelerinin hesaplanmasıdır. Bunun yanısıra, Arap atlarının yarış hayatı uzunluğunda etkili olabilecek risk faktörlerini belirlemek ve bu faktörlerin yer aldığı bir model oluşturmak hedeflenmiştir. Çalışmanın materyalini 2003 ve daha sonraki yıllarda doğan 3354 safkan Arap atı oluşturmaktadır. İncelenen her bir faktör için ortalama yarış hayatı uzunluğunun hesaplanmasında Kaplan-Meier analizi kullanılmıştır. Yarış hayatına etki eden risk faktörlerinin belirlenmesi ve bu faktörlerden yararlanılarak bir model oluşturulmasında ise Cox regresyonundan yararlanılmıştır. Çalışma sonucunda, Arap atlarının ortalama yarış hayatı uzunluğu 22.74 ay (%95GA: 22.04- 23.44) olarak bulunmuştur. Ayrıca, "yaş", "cinsiyet", "yetiştiği hara tipi", "tek tip yarış pistinde yarışma" ve " kazanç" değişkenlerinin yarış hayatı uzunluğunda istatistiksel açıdan anlamlı etkisi bulunmuştur.

Anahtar sözcükler: Arap atı, risk faktörleri, yarış kariyeri, yaşam analizi.

Introduction

Racehorse breeding is a global industry and it is a sector of great importance for all over the World. In Turkey, official horse-racing is organized by Turkish Jockey Club at 9 racecourses all around Turkey in which track surfaces vary with turf and dirt. Flat racing is the most common form of racing. Every year, a total of approximately 4,000 races are organized separately for Arabian and Thoroughbred horses of which Arabian breed compete in almost half of them (35).

Length of racing career is of economic importance in racing industry because of money and time invested in breeding, keeping and training. It is also considered as a performance outcome since it can provide insight into racing populations by providing statistics on how long horses are racing (3, 31, 36). Therefore, it is important to understand the role of risk factors that affect the length of racing career which may allow equine professionals to manage their business.

Many studies have been conducted to estimate the career duration of race horses of different breeds. Although no study was found in literature review that investigated career duration of Arabian racehorses, the median career duration of Standardbred and Thoroughbred horses was estimated to be around 2-4 years (27, 33, 35, 36). There are various factors influencing the length of racing career of horses. Although musculoskeletal injuries are considered to be

the major reason for career ending (2, 3, 26, 38), studies showed that many other risk factors such as age at first start (37), gender (14), exercise intensity (14, 24), race distance (25), track condition (1) are also related with career ending.

With regard to the Arabian racehorses, there have been only a limited number of studies. These studies mainly focus on the inheritance of performance (6, 8, 32) and breeding value estimates of Arabian horses (18, 30). However, no scientific study has been carried out to estimate the career duration of Arabian racehorses. Moreover, no study was examined the factors upon the length of racing career of Arabian horses in Turkey. The purpose of this study was to estimate the survival and hazard functions as well as the average length of racing career of Arabian racehorses in Turkey. In addition, it was aimed to investigate the risk factors upon the time of career ending of Arabian horses in Turkey.

Materials and Methods

Study design and the enrollment of the study cohort: Individual racing information of horses are recorded by Turkish Jockey Club in Turkey (35). Although all race records are open to access for public use, a confirmation letter for using the data from Turkish Jockey Club was obtained (date: 28/02/2012, document number: 367).

The dataset used consisted of 3354 Arabian horses that was born in or after 2003 and raced at least once until 15 March 2012. Horse was the unit of interest and the information available for each horse included sex,

age at first start, ownership status, type of stud farm, racing on the same type of track surface and earnings. Detailed information for each variable were given in Table 1.

In this study, first start date of professional racing career for each horses born in or after 2003, was defined as origin of follow up. Failure time (event) was defined as the end of racing career (retirement) for each horses. Horses without any record of racing at least one year after their last recorded racing date were considered as retired. Data was considered as right censored, if the horse was still in competition at the end of period of observation (by 15 March 2013). According to competition rules in Turkey, Arabian horses may start racing from 3 years of age. So, to avoid left censoring, horses that started their racing career before 2006 were excluded from analysis (Figure 1).

Data analysis: Initially data were examined using frequency distributions. The 'Earnings' variable categorized into three groups (low-medium-high) using 33rd percentiles since the effect of this continuous variable to log hazard function was found to be non linear. 'Age group' also categorized into two groups (≤3.5 years; >3.5 years) using median values.

Length of racing career of Turkish Arabian racehorses were calculated using Kaplan Meier analysis and the significance level for each variable were assessed using log rank (Mantel-Cox) statistics. Variables associated at p<0.20 were investigated for further analysis by Cox proportional hazards regression model (15). After determining the candidate variables for the

Table 1. Description of variables used for survival analysis in which time to culling for Arabian horses that joined the competitions between 2006 and 2012 in Turkey was measured.
Tablo 1. Türkiye'de 2006-2012 yılları arasında yarışlara katılan ve Arap atlarının yarış kariyerinin sona erme zamanının ölçüldüğü yaşam analizlerinde kullanılan değişkenlerin açıklamaları.

Variable Name	Category	N	N%	Information
Age group	<=3.5 years	2954	88.1%	Age at first start to proffesional racing career
	>3.5 years	400	11.9%	
Ownership status	Sole-ownership	3234	96.4%	If the horse owned by a single person or a partnered firm/organization
	Joint-ownership	120	3.6%	
Sex	Male	1784	53.2%	Sex of the horse
	Female	1570	46.8%	
Type of stud farm	State	1152	34.3%	Information about origin of the horse
	Private	2202	65.7%	
Racing on a single type of track surface	Yes	264	7.9%	Did the horse keep racing on same type of track surface (turf/dirt)?
	No	3090	92.1%	
Earnings	<11000 $*	1125	33.5%	Total earnings of a horse at the end of the follow-up time
	11001-35700 $	1130	33.7%	
	>35700 $	1099	32.8%	

* US$; According to indicative exchange rates of Central Bank of the Republic of Turkey on 15 March 2013.
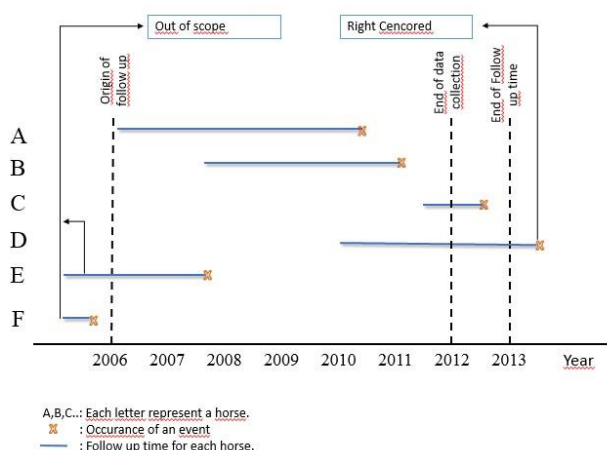
Figure 1. Schematic diagram of dataset used in the study. Schematic shows that Arabian horses that took part in a competition between 2006 and 2012 was included for the analysis and followed up until 2013. Horses still competing in racing arena at the end of follow up time considered as right censored and horses started their career before 2006 considered as left censoring.

Şekil 1. Çalışmada kullanılan veri setine ait şema. Şema, 2006-2012 yılları arasında yarışlara katılap, 2013 yılına kadar takip edilen ve analize dahil edilen Arap atlarını göstermektedir. Takip süresinin sonunda halen yarış hayatı devam eden atlar sağdan sansürlü, 2006 yılından önce yarış hayatı başlayan atlar ise soldan sansürlü olarak kabul edilmiştir.

Cox model, these variables were modelled using backward elimination method with a criteria of 0.10 for both p_{entry} and p_{stay} in multivariable analysis. The significance of each separate interaction was assessed by adding it to the main effects model and using partial likelihood ratio test. All interactions significant at the 5 percent level were then added jointly to the main effects model (15). To assess the goodness of fitness for Cox models, -2 log likelihood ratios were calculated. Chi-square test was used to assess any significant difference between the Cox models. The significance of individual coefficients in the models was based on Wald test. The proportional hazards assumption was tested by assessing the patterns in the graphs of '-log-log(S(t)) versus survival time' and 'scaled Schoenfeld residuals versus rank of survival time' for each variable. The variables failed to assure the assumptions were included to analysis as time-dependent variable. Survival analysis methods were conducted using SPSS 14.01, and the proportional hazard assumptions were checked using Stata 12/MP4 statistical software.

Results

The population consisted of 1784 (53.2%) males and 1570 (46.8%) females. State stud farm originated horses accounted for 34.3% (1152/3354) of the horses that raced. Horses that start their racing career above 3.5 years of age were 12% (400/3354) of the study cohort.

There were 264 (8%) horses that raced on a single type of track surface during career. A total of 120 (3.6%) horses were owned by a partnered firm or organization (Table 2). Distribution of the horses that was born in each year between 2003 and 2008 was as 14.2% (n=475), 16.6% (n=556), 18.4% (n=616), 17.5% (n=588), 16.8% (n=564), 16.5% (n=555), respectively. Within the study cohort, 978 (29.2%) out of 3354 horses were defined as censored. Mean number of starts for the study cohort was 26 ± 0.36 (Median: 19, Range: 158). Mean length of racing career was estimated as 22.74 ± 0.36 (95% CI: 22.04-23.44) months (Median: 16.57, 95% CI: 16.04-17.10). According to the cumulative survival function, 75% of the study cohort still remained in competition after 10 month of racing career. After 16 months, only half of the population were able to continue racing. The probability of being active in competition after 29 month was decreased only to 25% (Figure 2).
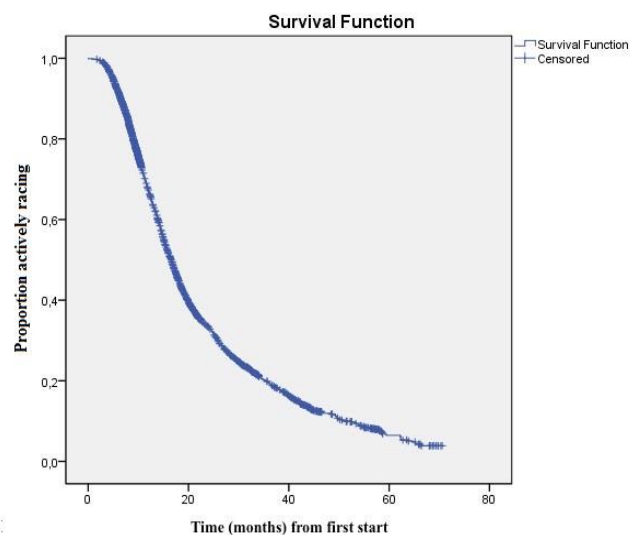

Figure 2. Kaplan-Meier survival curve of racing career lengths for Arabian horses racing in Turkey between 2006 and 2012. '+' indicates censoring.

Şekil 2. Türkiye'de 2006-2012 yılları arasında yarışlara katılan Arap atlarına ait Kaplan-Meier yaşam fonksiyonu. '+', sansürlü verileri göstermektedir.

Results of the log rank (Mantel-Cox) statistics showed that all variables except 'ownership status' had a significant effect on survival (Table 2). However, p value of ownership status (p=0.143) was below the determined criteria of p<0.20 so that it was also qualified to be candidate for a Cox regression model.

Results of the preliminary analysis which were carried out to find any possible interaction terms that could improve the model, showed a significant effect of 'sex*type of stud farm', and 'sex*earnings' on length of racing career. Subsequent to inclusion of the candidate variables and the interaction terms, Cox regression analysis using backward elimination method were concluded

Table 2. Estimated mean career duration of Arabian horses that joined the competitions between 2006 and 2012 in Turkey. Results were obtained from Kaplan Meier analysis for each categories of factors investigated.

Tablo 2. Türkiye'de 2006-2012 yılları arasında yarışlara katılan Arap atları için hesaplanan ortalama kariyer süreleri. Sonuçlar her bir değişken için Kaplan Meier analizi yardımıyla hesaplanmıştır.

Variable	Category	N	%	Estimated (t)	Std. Error	95% CI L.B.	95% CI U.B	p
Age group	<=3.5 years	2954	88.1%	23.22	0.39	22.46	23.99	<0.001
	>3.5 years	400	11.9%	19.38	0.89	17.64	21.12	
Ownership status	Sole-ownership	3234	96.4%	22.8	0.36	22.08	23.51	0.143
	Joint-ownership	120	3.6%	21.02	1.92	17.27	24.77	
Sex	Male	1784	53.2%	26.99	0.56	25.9	28.08	<0.001
	Female	1570	46.8%	18.03	0.4	17.25	18.81	
Type of stud farm	State	1152	34.3%	27.15	0.67	25.84	28.46	<0.001
	Private	2202	65.7%	20.32	0.4	19.53	21.11	
Racing on a single type of track surface	Yes	264	7.9%	14.83	0.98	12.9	16.76	<0.001
	No	3090	92.1%	23.34	0.38	22.6	24.07	
Earnings	<11000 $*	1125	33.5%	10.63	0.18	10.28	10.97	<0.001
	11001-35700 $	1130	33.7%	16.52	0.26	16.01	17.04	
	>35700 $	1099	32.8%	39.71	0.69	38.36	41.05	

*(t)=month., * US$.*

Table 3. Results of the extended Cox model of risk factors upon the time of career ending for Arabian horses that joined the competitions between 2006 and 2012 in Turkey.

Tablo 3. Türkiye'de 2006-2012 yılları arasında yarışlara katılan Arap atlarına ait genişletilmiş Cox modeli ile hesaplanan ve yarış hayatlarına etki eden risk faktörleri.

Variable	Category	β	Std. Error	p	e^β	95% CI LB	95% CI UB
Age group	<=3,5 year (Ref.)						
	>3,5 year	0.16	0.06	0.007	1.18	1.05	1.33
Sex	Male (Ref.)						
	Female	0.28	0.09	0.002	1.33	1.11	1.58
Type of stud farm	State (Ref.)						
	Private	0.26	0.06	<0.001	1.30	1.14	1.47
Racing on a single type of track surface	Yes (Ref.)						
	No	-0.37	0.08	<0.001	0.69	0.60	0.81
Earnings	<11000 $ (Ref.)						
	11001-35700 $	-1.97	0.14	<0.001	0.14	0.11	0.18
	>35700 $	-4.40	0.21	<0.001	0.01	0.01	0.02
Sex x Type of stud farm	Male x State (Ref.)						
	Female x Private	-0.22	0.09	0.015	0.81	0.68	0.96
Sex x Earnings	Male x <11000 $ (Ref.)						
	Female x 11001-35700 $	0.19	0.09	0.047	1.21	1.02	1.46
	Female x >35700 $	0.35	0.11	0.002	1.41	1.14	1.75
Earnings x T_COV_	<11000 $ (Ref.)						
	11001-35700 $ x T_COV_	0.08	0.01	<0.001	1.08	1.06	1.10
	>35700 $ x T_COV_	0.10	0.01	<0.001	1.11	1.08	1.13

T_COV=t (Month); CI= Confidence Interval; LB= Lower Bound; UP= Upper Bound; Ref= Reference, $=US$.

in two steps. Based on comparing likelihood ratios of the models at each steps, all of the factors, except for 'ownership status' significantly improved the fit, indicating that they had a significant effect on length of racing career (Table 3). The fitted model was checked in terms of proportional hazards (PH) assumptions and the it was revealed that the 'earnings' variable did not satisfy the assumption, hence it included to the fitted model with a time-covariate interaction term.

Results of the fitted model indicated that horses start their career earlier was independently associated with longer career duration after adjusting for the other factors. In particular, horses start their career above 3.5 years of age had 1.18 times (95% CI: 1.05-1.33) the hazard of career ending compared with those start at and below 3.5 years of age after adjusting for other factors. Main effect of the 'type of stud farm' showed that horses raised in private stud farms were 1.30 times (95% CI: 1.14-1.47) more likely to experience career ending than the horses raised in state stud farms. The estimated hazard ratio for females was 1.33 times (95% CI: 1.11-1.58) that of males after adjusting for the other factors. However, interaction effect of sex and 'type of stud farm' showed that the males raised in private farm had increased hazard ratio when compared to the females. Racing on a single type of track surface increased the hazard 1.44 times (95% CI: 1.24-1.68) in comparison to racing on both type of track surfaces.

Since the earnings variable was included to the model with a time covariate, its hazard ratio could be estimated for any given time. Nevertheless, results showed that increase in earnings decreased the career ending, as expected. However the hazard ratio decreases when the time had passed by, since the effect of time covariate on earnings was conversely. The effect of earnings was also influenced by sex. Considering the interaction between sex and earnings, it could be concluded as females within the same earning category had increased hazard ratio as compared to males.

Discussion and Conclusion

Population based studies are useful in assessing health and performance related issues of equine such as racetrack injuries (8, 9, 21), training failure (2, 19). These studies also can be used to develop a career profile (27). This study presents a career profile of Arabian racehorses in Turkey and examines factors that affect length of racing career of these horses.

Although the career length of show jumping or dressage horses were found around 3-4 years (5, 10, 29), studies showed that it was relatively shorter for Standardbred and Thoroughbred racing horses as being 2-4 years (27, 33, 34). This study showed that mean career length of Arabian horses was 22.74 months which is slightly shorter than the other breeds.

The positive association between age at first start and career length has been evaluated in several studies with Thoroughbreds (13, 31) and Standardbreds (27). This study also showed that Arabian horses start racing at earlier age had longer careers. Age at first start depend on many factors such as musculoskeletal system, genetic structure, maturity as well as anticipation of the breeders, and racing calendar. One of the reasons for a late start might be health problems or musculoskeletal immaturity which can directly effect negatively to time to career ending. Moreover, horses have a tendency for fatal injuries with increased age (3). Henley et al. (13) supports the evidence that risk of fatal injury increased with age and decreased with racing intensity, but starting to compete at an older age has a negative effect on length of racing career. Some studies causally explained this situation as horses that began their careers early have a tendency of being physically developed better (31). In consideration of the evidences of both this study and the previous studies, it is convenient for Arabian horses to start their careers as early as they reach physical maturity for a longer career.

The relationship between track surface and career duration can be associated with musculoskeletal injuries. For instance, some studies evaluate the track type (21, 23, 37) and track conditions (1) as important risk factors for musculoskeletal injuries. However, there was no consensus about which type of track has higher risk factor for injuries. Although the approach of this study on effect of type of track was quite different from the previous studies, it was found that the horses that keep racing at same type of track surface (dirt or turf) have shorter career duration when compared to horses that change type of track surface from race to race. Considering the findings, it might be thought as changing the type of track surface have a positive impact on musculoskeletal development of horses and this situation reflect positively on career length implicitly. On the other hand, one may think that owners test their horses in different type of track surfaces for better race results and this situation makes a positive contribution to career duration.

This study showed that Arabian horses originated from state stud farms have a longer career than horses originated from private stud farms. Although there was no study on effects of origin to career duration for Arabian horses in the literature, Ekiz et al. (8) showed that horses originated from state stud farm show better performance comparing to private stud farm originated horses which supports the findings of the study. Besides, excessive genetic background of state stud farms due to their deep-rooted history in Turkey and their better developed breeding services might have an explanatory role for the findings of the study.

The influence of earnings upon the career length studied in many studies (20, 22, 31). It is normally expected that horses, which have better racing performance, hence, better earnings, have a longer career. Results of this study supports this expectation. However since earnings variable were modeled with a time covariate, its risk ratio vary in time. Results of the study showed that although risk of career ending for a horse in high earnings group lower than being in low earning group, difference in risk ratios decrease as time passes by. There might be several reasons for this situation: (i) Successful horses are kept for breeding and (ii) horses with high performance might have tendency for injuries as these animals might face with higher intense training programs and racing Schedule. Furthermore, according to Cheetham et al. (4), average earnings decrease as the time passes by, since young horses have supplemented purses. Results of the study also showed a significant interaction of earnings and sex. This situation indicated that the earnings have a different effect upon career ending for male and female horses. It was found that female horses have a higher risk for career ending than males in the similar earning group. Previous studies showed that male horses are better at winning races, ranking in races and earning income per race than female horses (16, 20). Likewise, studies conducted with different horse populations showed that male horses have a longer career duration than females (1, 17, 22, 28, 31). Several factors might influence this situation. Considering the breeding value, females are more likely to be withdrawn from training when training or health problems are encountered (11, 31). On the other hand, males are physically stronger and their competing desire overweigh compared to females (12) thus, end up with higher earnings and longer career duration.

There were no study regarding the effect of ownership status in the literature. Considering the fact that culling might be voluntary and depend on the owner's the desired level of performance, ownership status of a horse was also thought be a risk factor upon the time of career ending. However, results showed that there were no statistical difference of career duration between horses with single ownership and joint ownership, although length of racing career of horses with single ownership was higher.

There are various reasons that effect the length of racing career. Since the factors evaluated in this study were based on available data, risk factors that effect upon the time of career ending were evaluated within the frame of mainly environmental factors. Some of the horse- and prior racing history- related risk factors such as castration status, exercise intensity, shoeing, or race-related risk factors, such as race distance, hippodrome, jockey, trainer, could not be evaluated due to (i) restrictions due to confidentiality of veterinary services (ii) horses expose some of these variables more than one time, which could be considered as a potential limitation for this study. Inclusion of these factors in future studies would improve precision of the model.

Knowledge of risk factors that influence career length is vital as they may be considered as preventive measures. It could be also useful for optimizing the training methods to reduce wastage in racing industry. A broad investigation of the role of these factors may give important information to breeders, trainers and other staff in industry to optimize the performance of the horses under their care. Also the information obtained from this study may to be useful in implemention of appropriate intervention strategies following the horses own racing performance.

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Address for correspondence:
Doğukan ÖZEN, DVM, PhD
Ankara University, Faculty of Veterinary Medicine,
Division of Animal Husbandry and Animal Nutrition,
Department of Biostatistics, 06110,
Diskapi, Ankara, Turkey
e-mail: ozen@ankara.edu.tr; dogukanozen@yahoo.com
fax: +90 312 317 60 17
phone: +90 312 317 03 15 / 4274