

# Influence of age and sex on bone development and athletic career longevity of Thoroughbred racehorses in Brazil – preliminary study

## Influência do gênero e da idade no estágio de desenvolvimento ósseo e longevidade atlética de equinos da Raça Puro Sangue Inglês de corridas no Brasil – estudo preliminar

Marcia Torres Ramos<sup>1\*</sup> , Cleyanne França de Oliveira Silva<sup>2</sup> , Ana Carolina Ferreira da Rocha<sup>3</sup> , Chiara Albano de Araujo Oliveira<sup>4</sup> , Cláudio Vaz Di Mambro Ribeiro<sup>4</sup> , Maria Fernanda De Mello Costa<sup>5</sup> , Marcelo Abidu-Figueiredo<sup>1</sup> 

<sup>1</sup>Universidade Federal Rural do Rio de Janeiro (UFRRJ), Seropédica, Rio de Janeiro, Brazil

<sup>2</sup>Universidade de Lisboa, Lisboa, Portugal

<sup>3</sup>Solutio Medicina Equina, Volta Redonda, Rio de Janeiro, Brazil

<sup>4</sup>Universidade Federal da Bahia (UFBA), Salvador, Bahia, Brazil

<sup>5</sup>Texas A&M University: College Station, Texas, US

\*Corresponding author: [marciatramos@gmail.com](mailto:marciatramos@gmail.com)

### Abstract

The impact of high-speed exercise on the musculoskeletal system of young racehorses has been extensively discussed because of concerns regarding animal health and welfare. This study investigated the correlation between age, degree of ossification of the distal radial epiphysis, sex, and career longevity of Thoroughbred racehorses in Brazil from 2012 to 2015. We performed a retrospective evaluation of 286 dorsopalmar radiographs of the left radiocarpal region of young horses and their racing performance. Distal radial epiphyseal closure was classified into three degrees: A, B, or C. Performance data included the number of races raced, athletic career length, and the number of races per month. The variables were subjected to regression analysis. At the time of radiographic examination, male horses were significantly older than females, and horses with epiphyseal closure degrees differed with age. Age at first race was 33.08±3.81 months, the average of races raced was 18.32±15.14 races, athletic career duration was 20.37±13.82 months, and the number of races raced per month was 0.93±0.46 races. Age influenced ( $P < 0.001$ ) the distal radial epiphyseal closure on racehorses, but sex did not ( $P = 0.218$  for males and  $P = 0.275$  for females). An inverse association was observed between age at the first race, the number of races raced per month, and athletic career duration. The frequency of race and the age at the first race influenced athletic career duration.

**Key words:** Athletic performance; distal radial epiphyseal closure; radiography

### Resumo

O impacto do exercício de alta velocidade no sistema musculoesquelético de cavalos de corrida jovens tem sido amplamente discutido devido a preocupações com a saúde e o bem-estar animal. Este estudo investigou a correlação entre idade, grau de ossificação da epífise radial distal, sexo e longevidade da carreira de cavalos Puro Sangue Inglês de corrida no Brasil de 2012 a 2015. Realizamos uma avaliação retrospectiva de 286 radiografias dorsopalmar da região radiocarpica esquerda de cavalos jovens e seu desempenho de corrida. O fechamento epifisário radial distal foi classificado em três graus decrescentes: A, B ou C. Os dados de desempenho incluíram o número de corridas disputadas, duração da carreira atlética e o número de corridas por mês. As variáveis foram submetidas à análise de regressão. No momento do exame radiográfico, os cavalos machos eram significativamente mais velhos que as fêmeas, e os cavalos com diferentes graus de fechamento epifisário diferiram com a idade. A idade na primeira corrida foi de 33,08±3,81 meses, a média de corridas disputadas foi de 18,32±15,14 corridas, a duração da carreira atlética foi de 20,37±13,82 meses e o número de corridas realizadas por mês foi de 0,93±0,46 corridas. A idade influenciou ( $P > 0,001$ ) o fechamento da epífise radial distal em cavalos de corrida, mas o sexo não ( $P = 0,218$  para machos e  $P = 0,275$  para fêmeas). Uma associação inversa foi observada entre a idade na primeira corrida, o número de corridas disputadas por mês e a duração da carreira atlética. A frequência de corrida e a idade na primeira corrida influenciaram a duração da carreira atlética.

**Palavras-chave:** desempenho atlético; fechamento epifisário distal radial; radiografia

## 1. Introduction

Musculoskeletal system (MS) disorders are the most common cause of lost training days, accounting for approximately 67.6% of all diagnosed conditions and causing significant economic losses to the horse industry<sup>(1)</sup>.

Much has been discussed about the impact of high-speed exercise on young horses, who often participate in races as 2-year-olds<sup>(2,3,4,5)</sup>. However, horses are cursorial and prey animals in nature. Therefore, horses are already born with an advanced MS that is receptive to play behavior at a younger age and exercise at an older age. Scientific

Received: September 27, 2022. Accepted: December 26, 2022. Published: January 18, 2023.



This is an Open Access article distributed under the terms of the Creative Commons Attribution License, which permits unrestricted use, distribution, and reproduction in any medium, provided the original work is properly cited.

<https://revistas.ufg.br/vet/index>

evidence indicates that early controlled exercise bouts allowing bone and cartilage structures to adapt to medium- and high-intensity exercises that the horse will perform later in life<sup>(5,6,7)</sup>.

Radiographic study of distal radius growth plate calcification is still an inexpensive and practical method for evaluating bone maturity in horses, helping to adjust individual training intensities, and preventing injuries that could otherwise compromise the athletic future of horses<sup>(3,8)</sup>. To the best of our knowledge, detailed wastage studies and career evaluations of Brazilian Thoroughbred (TB) horses have not been performed, and there is a great need to increase the welfare of horses by preventing injuries and promoting knowledge to the horse racing industry. Therefore, this study aimed to investigate the correlation between age, the degree of ossification of the distal radial epiphysis, sex, and athletic career longevity of thoroughbred racehorses in Brazil.

## 2. Material and methods

This research was approved by the Ethics and Research Committee for the Use of Experimental Animals of the University of Vassouras (No. 042/2017). A retrospective study of 286 radiographic examinations of the left thoracic limb was performed, using images obtained in dorsopalmar positioning of the left carpus of young TB horses beginning training at Jockey Club Brasileiro, Rio de Janeiro, Brazil, between 2012 and 2015. The images were randomly collected from an existing database of radiographic studies acquired through direct digital radiology using Eklin Mark III (Sound Eklin) and MyRad Equine 70 (Universal Imaging).

The degree of distal radial epiphyseal closure (REC) was classified as "A" when the epiphyseal line is completely calcified, "B" when the center of the epiphyseal line is calcified but not its periphery, and "C" if there is no perceptible calcification on the epiphyseal line<sup>(9)</sup>. Radiographic images were interpreted by two experienced veterinarians, who reached a consensus by discussing their findings.

Horses' inclusion criteria were having a REC control study and having raced at least once after the REC. Only the first REC study was considered in cases in which sequential X-rays were available. The horses age on radiological examination in months (XRAM) were determined by subtracting the date of radiographic examination from the birth date of the animals. Athletic career details, sex, date of the first race, and the total number of raced races were obtained by consulting the public website of the Brazilian Association of Breeders and Owners of Racehorses<sup>(10)</sup>. The age in months at the first race (FRAM), athletic career duration in months (ACDM), and the number of races per month were calculated. The relationship between sex and REC and between REC and

the age on radiological examination in months were evaluated by simple logistic regression. Other variables were subjected to regression analysis and adjusted to linear and quadratic models ( $P < 0.05$ ) using the statistical program JMP (2007)<sup>(11)</sup>.

## 3. Results

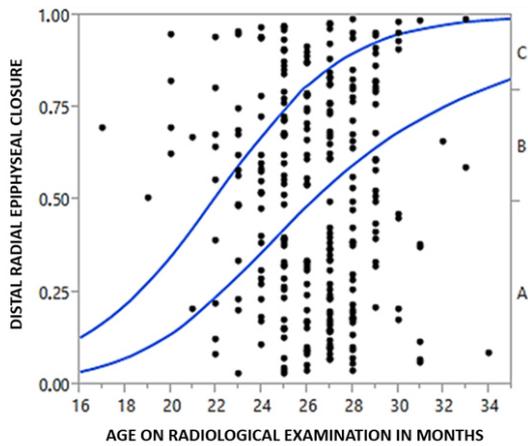
Retrospective radiographic examinations of 286 TB horses with at least one race performed included 130 females (45.45%) and 156 males (54.55%), with mean ages of  $25.9 \pm 2.51$  and  $26.56 \pm 2.26$  months, respectively. Male horses were significantly older than female ones ( $P = 0.019$ ). The REC degree classification is demonstrated in Figure 1.



**Figure 1.** The left radiocarpal region radiographs of the horses in the dorsopalmar position (80 kV, 1.6 mAs and focus film distance of 40 cm) demonstrate the classification of the distal radial epiphyseal closure (REC) (white arrow) according to Adams (1974), classified as "A" when the epiphyseal line is completely calcified, "B" when the center of the epiphyseal line is calcified but not its periphery, and "C" if there is no perceptible calcification on the epiphyseal line.

Horses with REC classification A ( $n = 141$ ), B ( $n = 87$ ), and C ( $n = 58$ ) differed in age ( $P < 0.001$ ), with mean ages of  $26.89 \pm 2.07$ ,  $26.24 \pm 1.95$ , and  $24.76 \pm 3.03$  months respectively. Sex did not affect the REC of males ( $P = 0.218$ ) or females ( $P = 0.275$ ). The population performance variables (means  $\pm$  SD) were FRAM  $33.08 \pm 3.81$  months,  $18.32 \pm 15.14$  raced races, ACDM  $20.37 \pm 13.82$  months, and the number of races per month  $0.93 \pm 0.46$ . The logistic regression analysis showed the influence of the age on radiological examination in months (XRAM) on the degree of REC (Figure 2).

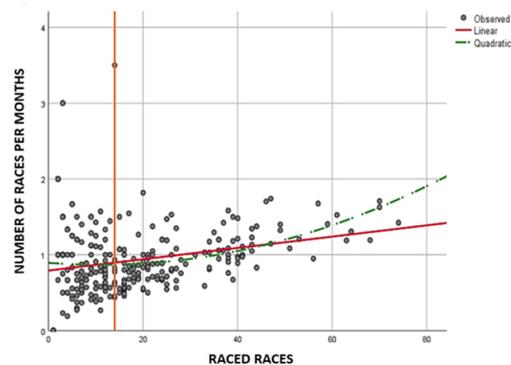
Linear regression analysis demonstrated the influence of FRAM on raced races ( $P = 0.036$ ;  $r^2 = 0.015$ ) and ACDM ( $P = 0.0002$ ;  $r^2 = 0.046$ ), as shown in Figure 3. As illustrated in Figure 4, linear regression also demonstrated the influence of the number of races per month on raced races ( $P < 0.001$ ;  $r^2 = 0.06$ ). Quadratic regression showed that the number of races per month influenced the ACDM ( $P = 0.0003$ ;  $r^2 = 0.06$ ), as demonstrated in Figure 5.



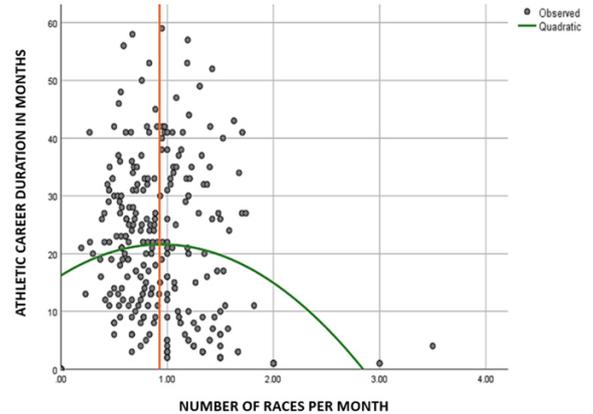
**Fig 1** Relationship between age on radiological examination in months (XRAM) on the probability of distal radial epiphyseal closure (REC), classified as A, B, or C (“A” when the epiphyseal line is completely calcified, “B” when the center of the epiphyseal line is calcified but not its periphery, and “C” if there is no perceptible calcification on the epiphyseal line).



**Fig 2** Relationship between age in months at first race (FRAM) concerning the athletic career duration in months (ACDM).



**Fig 3** Relationship between the number of races per month concerning the number of raced races.



**Fig 4** Relationship between the number of races per month concerning the athletic career duration in months (ACDM).

#### 4. Discussion

Although males were older than females, sex did not influence the degree of REC. These results differed from studies that indicated that females have earlier epiphyseal closure than males<sup>(11,12)</sup>. As expected, horses with REC classified as C were younger than those classified as B, and horses classified as A were the oldest. According to the logistic regression analysis, the older the horse, the more likely it was to present epiphyseal closure.

In this study, TB horses with REC A were 26.89 months old on average, differing from previous studies that reported a mean age of 23 months in females and 25 months in males<sup>(12)</sup>. Differences observed in the REC of horses, and growth parameters, are related to genetics and are influenced by several factors, such as feeding and management practices, country, climate, and sales timing, demonstrating the need for individualized evaluation, respecting the breed and the regimen adopted during breeding and athletic training<sup>(13,14)</sup>. There was an inverse association between FRAM, raced races, and ACDM. Horses in this study that began their athletic careers at a younger age had longer careers and raced more times, concurring with the thoroughbred racehorse population in Australia, Hong Kong, New Zealand, Poland, Hungary, and Turkey<sup>(15,16,17,18,19,20)</sup>.

The age in months at the first race indicated that horses that raced for the first time between 30 and 35 months old had the longest careers, with an ACDM of 20.37 months. According to our results, there was an average of six months between the REC and the horses’ first race. Nevertheless, caution should be exercised with training loads in young horses, particularly those performed at high speeds. Research performed on racehorses in the UK<sup>(2)</sup> observed that 78% of fractures occurred during training, and at least 57% were stress fractures, demonstrating non-adaptation to the training regimen. Besides being a desirable feature in racing, scientific evidence suggests a positive influence of the

early onset of controlled training, allowing the proper bone and cartilage adaptations to exercise<sup>(8,19,21)</sup>, resulting in longer athletic careers<sup>(22,23)</sup>. Regardless of what may be familiar to the TB horse industry, starting a racing career later in life may not diminish the rate of MS injuries. In this study, horses that started racing at over 35 months of age had shorter careers and raced fewer times.

In this study, the mean athletic career duration was 20.33 months and was higher than the average observed in studies on TB racehorses in Australia (18.90 months)<sup>(17)</sup> and Turkey (17.79 months)<sup>(20)</sup> and lower than in Hong Kong (23.36 months)<sup>(16)</sup>. The mean values for athletic career duration<sup>(23)</sup> in horses born in Victoria, Australia, concurred with our findings. The reasons for the end of the Brazilian racehorse's athletic career have not been documented. However, according to prior observations in Australia, the main reasons might be poor performance or injury, where 59% of the trained horses were retired or rehomed because of poor performance or owner request. In comparison, only 28% were retired due to health disorders<sup>(23)</sup>.

Injured horses have been reported<sup>(16)</sup> to be more likely to race less often, decreasing the race of the population and the number of races per month mean values, since they would need a spell period to recover. In addition, horses with higher values of FRAM<sup>(24)</sup> tended to race more often to compensate for the delay in entering an athletic career, which could also influence the population's mean raced race values and number of races per month. First-race age in months and raced races were both found to be risk factors influencing the career length of TB racehorses in Turkey<sup>(20)</sup>.

In this study, the number of races per month positively influenced raced races, such that the higher the number of races per month, the higher the raced races. Even though the raced races mean was 18.32 races per athletic career, a large variation among individual horses was observed, demonstrating high variability of frequency of race entries. The mean raced races observed in our study were higher than those observed in the Australian TB racehorse population, with 14.80 races<sup>(17)</sup> and lower than of those racing in Hong Kong, with mean values of 19.55 races<sup>(18)</sup>. The current study displayed the number of races per month values similar to those described in the literature. Horses that raced approximately once a month, or more precisely performed  $0.93 \pm 0.46$  races per month, had longer career durations demonstrating the influence of the number of races per month on athletic career duration as observed through the quadratic response of the regression analysis.

The benefits of understanding career profiles include developing prevention methods that could advance training methods and increase the performance and life span of racehorses, improving animal welfare, and the community's acceptance of the racehorse

industry's business practices and operating procedures, also known as the social license to operate. This study provides strategic information to the horse industry on how to amend and optimize management practices. Further research is necessary to evaluate larger groups and other parameters that may influence the athletic longevity of racehorses.

## 5. Conclusion

Age influenced distal radial epiphyseal closure in Brazilian Thoroughbred racehorses, but sex did not. The frequency of race and age at the first race influenced athletic career duration. Horses that began racing at younger ages had longer careers and raced more frequently. Horses that raced for the first time between 30 and 35 months and raced approximately once a month had the longest careers.

### Author contributions

*Conceptualization:* M. T. Ramos and M. F. De M. Costa. *Data curation:* M. T. Ramos, C. F. de O. Silva and A. C. F. da Rocha. *Formal Analysis:* C. A. A. de Oliveira and C. V. Di M. Ribeiro. *Investigation:* M. T. Ramos. *Methodology:* M. F. De M. Costa. *Project administration:* M. T. Ramos. *Validation:* C. A. A. de Oliveira, M. F. De M. Costa and M. Abidu-Figueiredo. *Visualization:* C. V. Di M. Ribeiro. *Supervision:* C. A. A. de Oliveira and M. Abidu-Figueiredo. *Writing (original draft):* M. T. Ramos, C. F. de O. Silva and A. C. F. da Rocha. *Writing (review & editing):* M. T. Ramos and M. Abidu-Figueiredo.

### Declaration of conflict of interest

The authors have no conflicts of interest to declare.

### Acknowledgments

The authors acknowledge Bianca Cascardo and Maria Cristina da Fonseca Vieira for the technical support of this research. This study was funded by the Coordenação de Aperfeiçoamento de Pessoal de Nível Superior (CAPES Brazil) under Finance Code 001, by Faperj and by CNPq.

### References

- Rosdale PD, Hopes R, Digby NJ. Epidemiological study of wastage among racehorses 1982 and 1983. *The Veterinary Record*. 1985, 116 (3) 66-69. (<https://doi.org/10.1136/vr.116.3.66>)
- Verheyen KLP, Wood JLN. Descriptive epidemiology of fractures occurring in British Thoroughbred racehorses in training. *Equine Veterinary Journal*. 2004, 36 (2) 167-173. (<https://doi.org/10.2746/0425164044868684>)
- Cogger N, Perkins N, Hodgson DR, Reid SWJ, Evans DL. Risk factors for musculoskeletal injuries in 2-year-old Thoroughbred racehorses. *Preventive Veterinary Medicine*. 2006, 74 (1) 36-43. (<https://doi.org/10.1016/j.prevetmed.2006.01.005>)
- Flash ML, Renwick M, Gilkerson JR, Stevenson MA. Descriptive analysis of Thoroughbred horses born in Victoria, Australia,

in 2010; barriers to entering training and outcomes on exiting training and racing. *PloS One* [Internet]. 2020. [cited 2019 Apr 10];15(10):e0241273. Available from: <https://doi.org/10.1371/journal.pone.0241273>. English.

5 Logan, Alyssa A.; Nielsen, Brian D. Training young horses: the science behind the benefits. *Animals*, v. 11, n. 2, p. 463, 2021. (<https://doi.org/10.3390/ani11020463>)

6 Firth EC. The response of bone, articular cartilage and tendon to exercise in the horse. *Journal of Anatomy*. 2006;208(4):513-526. (<https://doi.org/10.1111%2Fj.1469-7580.2006.00547.x>)

7 Rogers CW, Dittmer KE. Does juvenile play programme the equine musculoskeletal system? *Animals*. 2019;9(9):646. (<https://doi.org/10.3390%2Fani9090646>)

8 Rogers CW, Gee EK, Dittmer KE. Growth and Bone Development in the Horse: When Is a Horse Skeletally Mature? *Animals*. 2021;11(12):3402. (<https://doi.org/10.3390/ani11123402>)

9 Adams OR, Stashak TS. Radiographic determination of bone maturity as a guide to training horse. In: Stashak TS. *Lameness in horse*. 3<sup>rd</sup> ed. Philadelphia: Lea & Febiger, 1974, p. 465-467. English.

10 ABCPCC [Internet]. São Paulo: Associação Brasileira de Criadores e Proprietários de Cavalos de Corrida; 2016-2022 [cited 2021 Mar 02]. Available from: <http://www.abcpcc.com.br/>. Portuguese

11 JMP®, Version <2007>. SAS Institute Inc., Cary, NC, 1989–2021.

12 Vulcano LC, Mamprim MJ, Muniz LM, Moreira AF, Luna SP. Radiographic study of distal radial physeal closure in thoroughbred horses. *Veterinary Radiology & Ultrasound*. 1997;38(5):352-354. (<https://doi.org/10.1111/j.1740-8261.1997.tb02096.x>)

13 Łuszczynski J, Pieszka M, Kosiniak-Kamysz K. Effect of horse breed and sex on growth rate and radiographic closure time of distal radial metaphyseal growth plate. *Livestock Science*. 2011;141(2-3):252-258. (<https://doi.org/10.1016/j.livsci.2011.06.009>)

14 Huntington PJ, Brown-Douglas CG, PAGAN JD. Growth and development of Thoroughbred horses. *Animal Production Science*. 2020;60(18):2093-2102. (<https://doi.org/10.1071/AN19629>)

15 Sobczyńska M. The effect of selected factors on length of racing career in Thoroughbred racehorses in Poland. *Animal Science Papers and Reports*. 2007;25(3):131-14. (<https://www.igbzpan.pl/uploaded/FSiBundleContentBlockBundleEntity->

[TranslatableBlockTranslatableFilesElement/filePath/295/str131-142.pdf](#))

16 Tanner JC, Rogers CW, Firth EC. The relationship of training milestones with racing success in a population of Standardbred horses in New Zealand. *New Zealand Veterinary Journal*. 2011;59(6):323-327. (<https://doi.org/10.1080/00480169.2011.617029>)

17 Velie BD, Wade CM, Hamilton NA. Profiling the careers of Thoroughbred horses racing in Australia between 2000 and 2010. *Equine Veterinary Journal*. 2013;45(2):182-186. (<https://doi.org/10.1111/j.2042-3306.2012.00614.x>)

18 Velie BD, Stewart BD, Lam K, Wade CM, Hamilton NA. Profiling the careers of Thoroughbred horses racing in Hong Kong between 2000 and 2010. *Equine Veterinary Journal*. 2013;45(6):694-699. (<https://doi.org/10.1111/evj.12078>)

19 Bokor A, Lukacs H, Bokor J, Nagy I, ACS V. Examining the racing performance and longevity in the Hungarian Thoroughbred population. *Journal of Central European Agriculture*. 2018;19(4):912-917. (<https://doi.org/10.5513/JCEA01/19.4.2366>)

20 Özen D, Kaya U, Özen H, Ambarcıoğlu P, Ünal N, Gürçan İS. Investigation of Factors Influencing Thoroughbred Horses' Racing Career Length in Turkey. *Journal of Equine Veterinary Science*. 2021;107(103782). (<https://doi.org/10.1016/j.jevs.2021.103782>)

21 Bricca A, Juhl CB, Grodzinsky AJ, Roos EM. Impact of a daily exercise dose on knee joint cartilage—a systematic review and meta-analysis of randomized controlled trials in healthy animals. *Osteoarthritis and Cartilage*. 2017;25(8) 1223-1237. (<https://doi.org/10.1016/j.joca.2017.03.009>)

22 Knight PK, Thomson PC. Age at first start and racing career of a cohort of Australian Standardbred Horses. *Australian Veterinary Journal*. 2011;89(9):325-330. (<https://doi.org/10.1111/j.1751-0813.2011.00816.x>)

23 Flash ML, Crabb HK, Hitchens PL, Firestone SM, Stevenson MA, Gilkerson JR. Factors associated with racing performance and career duration for Victorian-born Thoroughbreds. *Australian Veterinary Journal*. 2021;100(1-2):48-55. (<https://doi.org/10.1111/avj.13128>)

24 Saastamoinen MT, Ojala M. Influence of different combinations of racing years on early career performance in trotters. *Acta Agriculturae Scandinavica A-Animal Sciences*. 1994;44(4):208-213. (<https://doi.org/10.1080/09064709409410900>)