

Pattern of Development in Foals from Four Different Breeds between Birth and Weaning

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Abstract

Several studies have shown a major development in height and cannon bone circumference in foals from birth to weaning and from different breeds. However, in Brazil, there is little information about foal development. For this reason, this study has used data on foals from seven different farms in Pernambuco, Northeast Brazil, where horses have a major economic importance. The aim of this study was to compare foal's development from four breeds and to develop a regression formula in order to estimate such development. It was used data from 210 suckling foals (Arabs n = 18, Campolina n = 86, Mangalarga Marchador n = 42 and Quarter Horses n = 64), raised in similar management practices. Their height at withers, heart girth, and cannon bone girth were measured monthly from birth to weaning. Data were reanalyzed by ANOVA and Tukey Test, with P established in 5%. The highest mean of height at withers was observed in the Arabian foals, and it was similar to Campolina and Mangalarga Marchador foals. The last breed presented a higher percentage of gain in height (~36%) and higher heart girth. On the other hand, Campolina foals had the highest mean of cannon bone girth. There was a significant interaction between breed and development phase in heart and cannon bone girths. All regression for mules obtained from this data was very significant, and it was showed that they can predict height at withers in the four breeds studied. Heart and cannon bone girths showed medium value of R² and large significance. It is important to highlight that fetal programming produces significant impact on foal development, even after weaning. So, this study would have observed some more changes if its scope had been extended beyond this phase.

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Keywords

Equine, Body Measurement, Horse Breeds, New Born Foals

1. Introduction

Studies in different countries with foals showed large body development between they born and just before the weaning principally in their height at withers and foals' weight [1]-[4]. Also other studies had been demonstrated influence over foal's growth by the dam, date of birth, and nutrition status [5] [6]. However, there is little information about variation of foals' pattern of development in Brazil [3] [7] [8] and results of these researches found similar development pattern that other ones developed in different countries. However, because there is large number of horses in different countries, patterns of foal's growth are not well understood, principally in Tropical areas.

Horse population in Pernambuco is around 150,000 plus 100,000 donkeys and mules. These animals have large economical importance in different parts of this state and in Brazil [9] [10]. Because there is little information about foals' development in Pernambuco, it was used data from foals that were raised in seven different horse farms of Pernambuco. The aim of this study was to compare foals development between four breeds and develop regression formula to estimate foal development. This information will help the horse owners to characterize and understand their animals' development.

2. Material and Methods

2.1. Animals

It was used data from 210 suckling foals from four breeds (Arabians n = 18 foals, Campolina n = 86, Mangalarga Marchador n = 42, Quarter-Horses n = 64). These young horses were raised in seven different farms (Arabians n = 1, Campolina n = 2, Mangalarga Marchador n = 2, Quarter Horse n = 2) in the State of Pernambuco, Brazil, between 1998 and 2002. All farms were located at Agreste region in Pernambuco and had similar management practice, where mares and their foals received supplementation with pellets during late gestation and lactation, following NRC [11] recommendations. Mares and foals had free access to pasture during rain season (winter) and supplementation with grass hay and Elephant grass during dry season (summer). All horses had free access to water and mineral salt.

2.2. Measurements

Foals' measurements were made monthly, starting immediately after the foals' born and finished when they had 6 months old (weaning). In these foals it was measured: height at wither, heart girth and cannon bone girth. All measurements were made following techniques described by Costa *et al.* [7].

2.3. Statistical Analysis

Data were submitted to one-way ANOVA and two-way ANOVA (breed and phase of development), with $P < 5\%$. Post hoc test was Tukey, when were needed and with $P < 5\%$. Also linear regressions were developed to produce formulas that can be used to estimate each breed growth curve. Sigma Stat 3.0 was used to all statistical analysis. Results were expressed in mean \pm standard error medium.

3. Results and Discussion

The results of this study showed that Arabians foals had large mean of height at withers when compared with Quarter Horse ($P < 0.05$) but was similar to Campolina and Mangalarga Marchador ($P > 0.05$) (Table 1). During suckling period Mangalarga Marchador got large percentage of gain in height (~36%), and was followed by Arabian (~34%), Campolina (~33%) and Quarter Horses (~33%) (Table 2). In other hand, Mangalarga Marchador had large mean heart girth when compared with other tree breeds ($P < 0.05$) (Table 1). Arabian, Campolina, Mangalarga Marchador and Quarter Horse gained 60%, 55%, 60% and 48%, respectively, between they born

Table 1. The average of body measurements in four different breeds in Pernambuco, between birth and 6 months old (weaning).

Body measurements	Breed			
	Arabian	Campolina	Quarter Horse	Mangalarga Marchador
Height at withers	112.80 ± 0.54 A	111.30 ± 0.23 AB	107.50 ± 0.30 C	112.69 ± 0.32 AB
Heart girth	110.04 ± 0.86 B	108.48 ± 0.37 B	108.81 ± 0.42 B	113.99 ± 0.54 A
Cannon bone girth	13.40 ± 0.09 D	14.19 ± 0.04 A	14.03 ± 0.04 B	13.80 ± 0.05 C

Observations: different letter at same line represents $P < 0.05$ by Tukey test.

Table 2. Results of foal's height at withers from four different breeds, between birth and 6 months old (weaning).

Breed	Foal age						
	At birth	1 month	2 months	3 months	4 months	5 months	6 months
ARB	94.87 ± 1.43 A	105.56 ± 1.43 B	110.31 ± 1.43 C	114.68 ± 1.43 D	118.12 ± 1.43 DE	121.18 ± 1.43 EF	124.68 ± 1.43 F
CAMP	93.55 ± 0.54 A	102.24 ± 0.57 B	108.14 ± 0.59 C	112.96 ± 0.62 D	117.15 ± 0.63 E	120.54 ± 0.65 F	124.48 ± 0.66 G
MM	93.71 ± 0.90 A	102.05 ± 0.90 B	108.47 ± 0.90 C	114.47 ± 0.90 D	119.33 ± 0.90 E	123.55 ± 0.90 F	127.26 ± 0.90 G
QH	90.66 ± 0.68 A	98.82 ± 0.70 B	104.18 ± 0.70 C	109.03 ± 0.71 D	112.67 ± 0.71 E	116.58 ± 0.72 F	120.46 ± 0.72 G

Observations: ARB: Arabian; CAMP: Campolina; MM: Mangalarga Marchador; QH: Quarter Horse; Different letters at same line represents $P < 0.001$ using Tukey test.

and weaned in their heart girth (**Table 3**). Campolinas presented large mean of cannon bone girth when compared with all other tree breeds ($P < 0.05$) (**Table 1**), and this body measurement was the only one that in all breeds presented different pattern of development ($P < 0.05$). Arabian, Campolina, Mangalarga Marchador and Quarter Horse gained 36%, 25%, 36% and 25%, respectively, between they born and weaned in their cannon bone girth (**Table 4**).

In this study were observed significant interactions between breed and phase of development in heart and cannon bone girths ($P < 0.05$) but not in height at withers (**Table 5**). All regression formulas obtained from these suckling foals data are very significant ($P < 0.001$), showing that formulas can predict height at withers in all four breeds. Regression formulas from heart and cannon bone girth have medium value for R^2 but they are significant ($P < 0.001$) (**Table 6**).

The body measurement average in this study detected that Arabians foals had large mean of height than Quarter Horse but similar to Campolinas and Mangalarga Marchador. However some of this result was not expected, because Campolinas horses have between 150 and 160 cm height at withers when they are adult animals [12]. This horse breed is taller than all other three breeds studied in this project. Also it is important to remember that breed also have blood lines and typical Quarter Horse bloodline in Pernambuco is working horses, and this fact may explain why Quarter horses had small average of height at withers in this research. However, Allen *et al.* [6] comment that foals' linear growth is completed when their growth plates are closed and some potential plasticity in height could be achieved only before this process.

Because this potential plasticity in horse's height some researchers work with a percentage of adults height to better understand foals development, however adult height are not well defined in some breeds. Studies with Mangalarga Marchador suckling foals showed that breed obtain more percentage of adults height than Campolinas, ~85% and 75% respectively, before weaning [7]. Also Hintz *et al.* [5] commented that Crossed Arabs and Quarter Horses reached ~83% of the mature height around the weaning period or six months old. Gain in height at withers was very similar between all four horses, despite of some difference observed at birth and following months, but in this actual research different values of height was not compare with final adult height.. Finally, it is important observe that the National Association of Campolina and Mangalarga Marchador breeds have rigid control of the adult's height since 1950s, contributing to these measurements in both breeds, with is not common in Arabians and Quarter Horses in Brazil.

Mangalarga Marchador horses had large heart girth when compared with all other three breeds. Values of heart girth can be used to determine body mass and foals during lactation this parameter got large increase when compared with gain in height at wither. Mangalarga Marchador and Arabians gain near 60% in this parameter

Table 3. Results of foal's heart girth from four different breeds, between birth and 6 months old (weaning).

Breed	Foal age						
	At birth	1 month	2 months	3 months	4 months	5 months	6 months
ARB	81.06 + 2.26 A	96.37 + 2.2 B	105.31 + 2.26 C	113.25 + 2.26 D	119.25 + 2.26 E	124.25 + 2.26 EF	130.75 + 2.26 G
CAMP	82.55 + 0.86 A	95.03 + 0.9 B	103.72 + 0.93 C	110.54 + 0.98 D	117.02 + 0.99 E	124.22 + 1.03 F	126.26 + 1.04 G
MM	85.02 + 1.43 A	98.55 + 1.4 B	107.42 + 1.43 C	116.47 + 1.43 D	124.07 + 1.43 E	130.15 + 1.43 F	136.22 + 1.43 G
QH	85.34 + 1.08 A	95.34 + 1.1 B	105.51 + 1.11 C	110.10 + 1.13 CD	116.71 + 1.13 E	122.00 + 1.14 F	126.62 + 1.14 F

Observations: ARB: Arabian; CAMP: Campolina; MM: Mangalarga Marchador; QH: Quarter Horse; Different letters at same line represents $P < 0.001$ using Tukey test.

Table 4. Results of foal's cannon bone girth from four different breeds, between birth and 6 months old (weaning).

Breed	Foal age						
	At birth	1 month	2 months	3 months	4 months	5 months	6 months
ARB	11.09 ± 0.23 A	12.31 + 0.23 B	12.93 + 0.23 BC	13.56 + 0.23 CD	14.31 + 0.23 E	14.53 + 0.23 EF	15.06 + 0.23 F
CAMP	12.13 + 0.09 A	13.20 + 0.09 B	13.88 + 0.09 C	14.33 + 0.10 CD	14.86 + 0.10 E	15.27 + 0.10 EF	15.67 + 0.11 F
MM	11.35 + 0.15 A	12.50 + 0.15 B	13.31 + 0.15 C	14.10 + 0.15 D	14.66 + 0.15 DE	15.15 + 0.15 EF	15.53 + 0.15 F
QH	12.23 + 0.11 A	13.03 + 0.11 B	13.72 + 0.11 C	14.21 + 0.12 D	14.64 + 0.12 E	15.02 + 0.12 EF	15.33 + 0.12 F

Observations: ARB: Arabian; CAMP: Campolina; MM: Mangalarga Marchador; QH: Quarter Horse; Different letters at same line represents $P < 0.001$ using Tukey test.

Table 5. Results of body measurements in foals by two-way ANOVA with repeated measurements, between birth and 6 months old (weaning).

Body measurement	Foal age	Breed	Interaction between foal age and breed
Height at withers	$P < 0.001$	$P < 0.001$	$P > 0.05$
Heart girth	$P < 0.001$	$P < 0.001$	$P = 0.034$
Cannon bone girth	$P < 0.001$	$P < 0.001$	$P = 0.024$

Table 6. Regression formulas for height at withers, heart girth, and cannon bone girth in foals from four different breeds, between birth and 6 months old.

Measurement	Formula	R	R ²	P value
Arabians				
Height at withers	HW = 94.420 + (4.589 * Age)	0.904	0.818	<0.001
Heart girth	HG = 78.786 + (7.813 * Age)	0.935	0.875	<0.001
Cannon bone girth	CBG = 10.871 + (0.633 * Age)	0.868	0.754	<0.001
Campolina				
Height at withers	HW = 91.152 + (5.032 * Age)	0.864	0.746	<0.001
Heart girth	HG = 78.936 + (7.378 * Age)	0.817	0.668	<0.001
Cannon bone girth	CGB = 11.913 + (0.571 * Age)	0.729	0.531	<0.001
Mangalarga Marchador				
Height at withers	HW = 90.621 + (5.518 * Age)	0.918	0.842	<0.001
Heart girth	HG = 80.639 + (8.338 * Age)	0.915	0.837	<0.001
Cannon bone girth	CGB = 11.057 + (0.686 * Age)	0.837	0.701	<0.001
Quarter Horse				
Height at withers	WH = 88.341 + (4.786 * Age)	0.815	0.664	<0.001
Heart girth	HG = 81.768 + (6.758 * Age)	0.822	0.675	<0.001
Cannon bone girth	CBG = 11.988 + (0.510 * Age)	0.780	0.608	<0.001

Observations: Foal age in months; WH = height at withers; HG = heart girth; CBG = cannon bone girth.

between birth and weaning, differently from Campolina and Quarter Horses, but in this parameter we did not obtain the percentage from adult horse. Hintz *et al.* [5] showed that Thoroughbred foals with 6 months old had only 45% of adult weight and 85% of adult height at withers. Manso Filho *et al.* [13] detected in Standard bred suckling foals significant changes in fat mass only after 1 months old, but also do not inform percentage of the weight at six months old from adults horses. Interestingly, adult Mangalarga Marchador horses (~400 Kg) are lighter than Campolinas (~480 Kg) [13], and we did not expect that suckling foals of both breed had significant difference during suckling period.

The cannon bone girths are associated to bone characteristic and the average of this parameter in this research showed significant difference between all three breeds. Interesting, Campolina, which are heavier breed developed in Brazil, had large cannon bone girth followed by Quarter Horse, Mangalarga Marchador and Arabs ($P < 0.05$).

Different factors are associated with modulation of the development in young horses and breeds's of horses. All animals in this actual research were raised in pasture and are supplemented with concentrate, which follow NRC 1987 suggestions, and during dry season (summer) farm owners supplemented their animals with Tifton and Cost-Cross hay and Elephant grass. Horse can be raised on pasture with supplementation with grain have normal growth and development [14] and normal growth was expected for all animals used in this research. However the nutritional level can change some parameter used to determine foals development and Resende *et al.* [3], using Mangalarga Marchador foals with different levels of supplementation of protein (18% PB versus 16% PB, but isocaloric), showed difference in height at withers but not at heart girth when these foals had near 6 months-old (202 days). In contrast, Ott *et al.* [5], studying two different levels of protein supplementation (~18% PB versus ~15% PB), observed that Thoroughbred and Quarter Horses have normal growth when they received correct amount of Lysine supplementation. All these researches demonstrated that foals can growth normally if they have a good nutritional support but the genetic background have important impact in this process.

The fetal programing produces significant impact on foals' development independently of their breed. Different research had shown the importance of fetal development and programing to postnatal development and metabolism [15]. In this actual research suckling foals where evaluated between birth and weaning, and some differences observed at height at withers may change after this period, because there is some plasticity of growth [6]. Finally, it is important to recorder that results presented here represent growth characteristic in suckling foals in tropical conditions at the Agreste region in Pernambuco, Brazil. These information can be used in different conditions but more foals' body measurement analysis are needed to better understand equine development during its first six months of life.

4. Conclusion

In this study, there was a significant interaction between breed and development phase for heart girth and cannon bone girth measurements. Also, the regression formula obtained with the suckling foal data can be used to predict height at withers for the four studied breeds. Finally, as fetal programing may influence postnatal development, there may be some differences in after-weaning measurements. Therefore, we suggest that more measurements in this period be done in order to complete and improve the understanding of equine development.

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