The Balancing Act of Growing a Sound, Athletic Horse

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Introduction

The genetic makeup, or genotype, contributes to a horse's performance ability by determining ultimate size and influencing conformation and athletic potential. Growth rate is not predestined and is affected by factors such as the environment, nutrition, and management.

Latest research shows that "bigger is better," as heavy and tall Thoroughbreds sold for the highest prices at yearling sales and when raced had the most earnings, graded stakes wins and grade-1 stakes wins (Pagan et al., 2005; Brown-Douglas and Pagan, 2006). Horses are therefore grown to be as large as possible at a young age, despite not achieving their mature weight and height until around four or five years of age. Unlike meat-producing animals, achieving maximal size in the least amount of time is undesirable in the horse as there are many career-ending developmental conditions such as osteochondritis dissecans (OCD) that occur in rapidly growing horses. Growing a foal too slowly, however, can prevent the animal from ever reaching its mature size. Optimal growth rate results in a desirable body size with the least amount of developmental problems, making the art of raising a successful athlete a sensitive balancing act.

Kentucky Equine Research (KER) has studied Thoroughbred growth and development over the last 20 years. Body weight and height data have been collected from foals born and raised in the major Thoroughbred-producing countries of the world including the United States, England, Ireland, Australia, New Zealand, South Africa, and India. Using this database of over 15,000 Thoroughbred foals, KER has compiled detailed reference growth curves for breeders to use when monitoring their horses' growth. Using Gro-Trac, KER's innovative growth and ration management software, breeders can track and compare the growth rates of their horses to the average growth parameters of a chosen reference peer group. KER studies have also focused on the effects of nutrition and management on equine growth. This paper will review the major results of KER's growth and development research and discuss the various management factors that influence the growing horse from foal to athlete.

Gro-Trac and Percentiles

Traditionally, Gro-Trac has provided some indication of how a horse is growing by comparing it to a reference population and indicating the percentage of reference. This method is useful, but it does not take into account the spread of the data around the average. For example, there is a much wider range for a horse's body weight than for wither height at a particular age. Body weights can differ by as much as 110 pounds (50 kg), whereas differences in height will be only a few centimeters. A horse that is plus four percent of reference body weight is not that much heavier than the average, but if he is plus four percent of reference height then he is a lot taller! Percentiles deal with this spread issue and allow a more relative comparison with the entire population. Furthermore, this method allows horses to be compared regardless of gender and age. Using percentiles, breeders can assess if there are any abnormalities in the growth pattern and adjust nutritional and conditioning regimens as necessary. The use of percentiles is not a new concept in growth studies and is commonly used in pediatrics. However, this is the first time such a

large equine data set has been acquired to create reference populations from which percentiles can be calculated for Thoroughbred horses.

Nature versus Nurture

Thoroughbreds share a fairly narrow genetic base, so geography has a significant influence on growth patterns in young Thoroughbreds. Body weight data collected from the major Thoroughbred-breeding countries revealed that Australian and New Zealand Thoroughbreds tend to be larger than American Thoroughbreds, which in turn are larger than those reared in England (Brown-Douglas and Pagan, 2006). Indian Thoroughbreds are smaller than all other populations (Figure 1). Thoroughbreds in all countries except India showed seasonal changes in daily weight gain in winter and spring that coincided with changes in pasture quality and availability. English Thoroughbreds are as much as four percent below the American average and seven percent below the Australian reference. In percentile terms, English Thoroughbreds are in the 30th-40th (body weight) and 40th-45th (body weight) percentiles on average when compared with Australian and American Thoroughbreds respectively. American Thoroughbreds average in the 40th-45th percentile for body weight when compared with Australian Thoroughbreds, but there is little difference in height between these two populations.

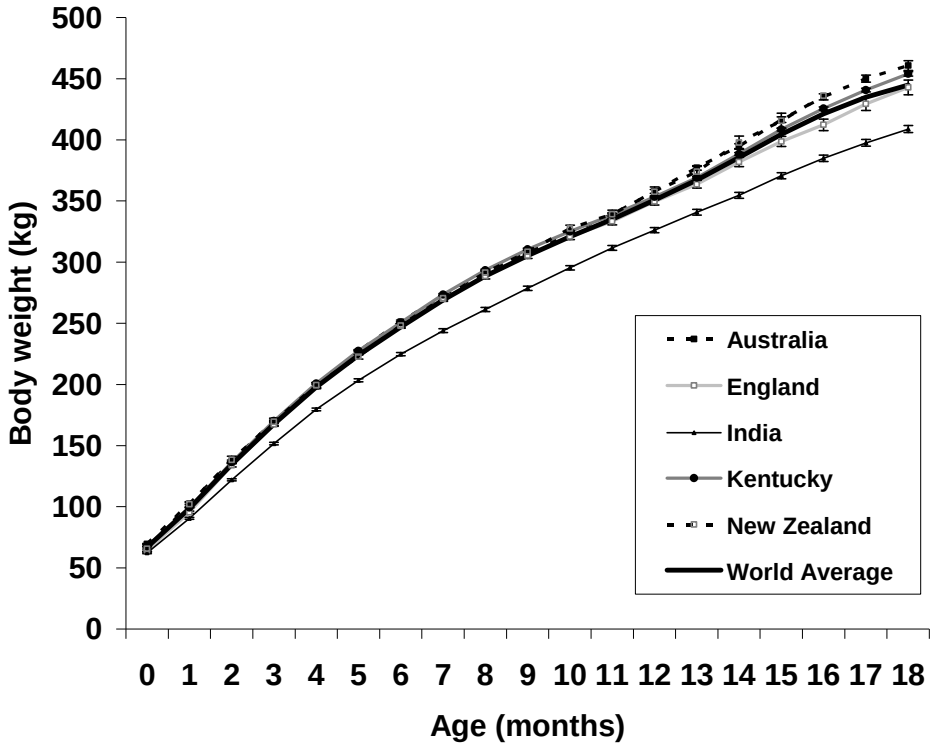

Figure 1. Body weight ± 95% confidence interval (kg) of Thoroughbreds reared in Australia, England, India, America and New Zealand compared with the world average (Brown-Douglas and Pagan, 2006).

Indian Thoroughbreds are smaller than all other populations, averaging 7-11% below the reference curve of English and American Thoroughbreds and falling in the 5th-10th percentile for

weight. The observed differences in weight and height between other populations of Thoroughbreds are probably due to the different environments in which they are reared as well as varying management factors during the growth and development period.

Is Growth Important to a Horse's Career?

Growth management of the young foal will vary depending on the commercial endpoint. A large, well-grown Thoroughbred yearling is desirable when offered for sale at public auction as selling price is influenced by body size. Yearlings that sold higher than the median of the session in which they were sold were heavier and taller, but not fatter, than yearlings which sold below the session median (Pagan et al., 2005). Sold yearlings were also heavier and taller than those listed as RNA (reserve not attained), and fewer lightweight yearlings (those in the lowest weight quartile) were sold compared with the heaviest yearlings (Brown-Douglas et al., 2007). Early rapid growth may not be favored in Thoroughbreds that are "bred to race" with no intention of being prepared for sale as weanlings or yearlings. Many breeders selling horses at public auction aim to produce early-born foals to maximize growing time before a July or September sale. This practice may not be that advantageous as foals born in the central Kentucky winter (January and February) were smaller at birth and grew slower during the first two months compared with spring-born foals (Figure 2), but compensated by growing faster later in lactation so that by 5 months of age there was no difference between body weights in any of the groups (Pagan et al., 2006). April- and May-born yearlings at 16 months of age are also taller and heavier than winter-born yearlings (Brown-Douglas et al., 2006). September sale yearlings are between 16-20 months of age, so buyers may mistake January-born yearlings for the largest when in fact they are only the oldest.

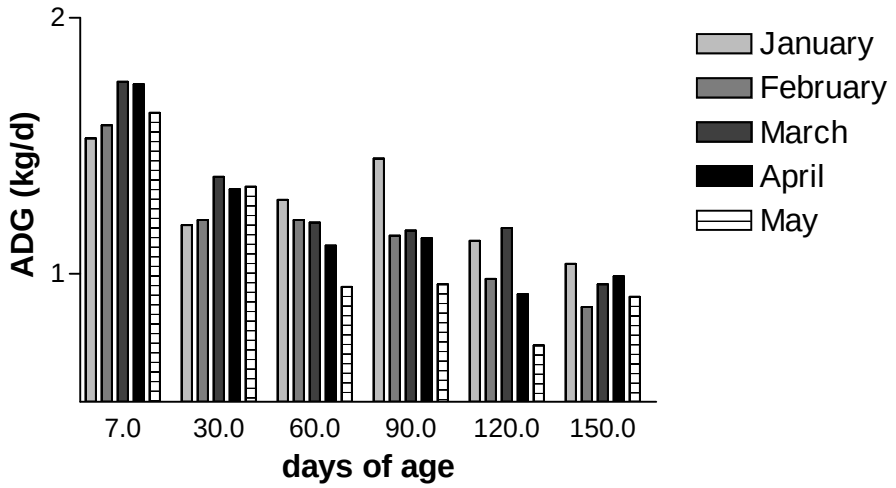

Figure 2. ADG (kg/d) of Kentucky foals separated by month of birth (Pagan et al., 2006).

Furthermore, recent research at KER has shown that yearling size does not necessarily predict athletic success (Brown-Douglas et al., 2006). KER recently analyzed the growth and racing performance records of nearly 4,000 American Thoroughbreds to determine if certain growth characteristics affect the odds of success as a racehorse. Findings suggest some significant trends between growth and racing success.

Horses that started as two-year-olds were shorter and weighed less as foals and yearlings than those that did not, regardless of birth month. However, fewer May-born yearlings started as two-year-olds compared with earlier-born yearlings. It is generally accepted that faster-maturing, heavier horses are more likely to be raced as two-year-olds, but these results suggest just the opposite; smaller horses are more likely to run early. Furthermore, smaller horses had more career starts, suggesting that smaller horses are sounder.

Conversely, stakes winners, graded stakes winners, grade-1 stakes winners, and millionaires were heavier and taller than average as yearlings. Interestingly, the 21 millionaires in the study were, on average, taller than 79% of the population as yearlings.

These results indicate different growth characteristics for different performance outcomes. If one wants an early-starting horse that races for longer, then a smaller horse is more desirable. If, however, one wishes a stakes winner and high earner, then bigger is better, although there is a greater risk of the horse not starting at all. Furthermore, a greater percentage of two-year-old starters were born in March and April and a greater percentage of stakes winners were born in March.

To further evaluate the relationship between size and racing performance, the yearlings were divided into four groups (quartiles) based on weight and height so that the lightest or shortest yearlings were in the lowest quartile, and the heaviest and tallest in the highest quartile. This method allowed comparison among all horses regardless of age or gender and ranks the relative position of an individual in a population by indicating what percent of the reference population that individual will equal or exceed for each measurement. Yearlings in the lowest weight quartile (those that weighed less than 75% of the population) had lower sales prices, and went on to have lower earnings, fewer stakes wins, and a lower sire index than the rest of the population (Table 1 and Figures 3 and 4). Sire index was examined to account for genetic variation and indicates the average racing class of foals sired by a stallion. However, yearlings below the 50th weight and height percentiles were more likely to start as two-year-olds and had more career starts than those above the 50th percentile.

Table 1. Median sale price of yearlings compared with average sire index, percent stakes winners and average and median career earnings; letters indicate significant differences within factor ($p<0.05$) (Brown-Douglas et al. 2007).

Yearling weight quartile	1 (percentiles 0-25)	2 (percentiles 26-50)	3 (percentiles 51-75)	4 (percentiles 76-100)
Median Sale price ($)	$21,500	$30,000	$40,000	$50,000
Sire index	2.09 ± 0.03a	2.16 ± 0.03a	2.33 ± 0.03b	2.45 ± 0.03c
Stakes winners (%)	4.64a	8.68b	8.44b	8.26b
Average career earnings ($)	$51,226 ± 4480a	$86,443 ± 4964b	$69,339 ± 5236c	$72,606 ± 2221bc
Median earnings	$13,795	$17,058	$19,050	$18,081

Yearlings that weighed less than half the population had lower sire indexes than those in the heavier quartiles indicating that successful sires tend to produce larger yearlings. Interestingly, foals in the second quartile (between the 25th and 50th weight percentiles) had as many stakes wins and greater earnings than the larger yearlings even though they were by sires with significantly lower sire indexes. This suggests that these moderately lighter yearlings outperformed their pedigrees.

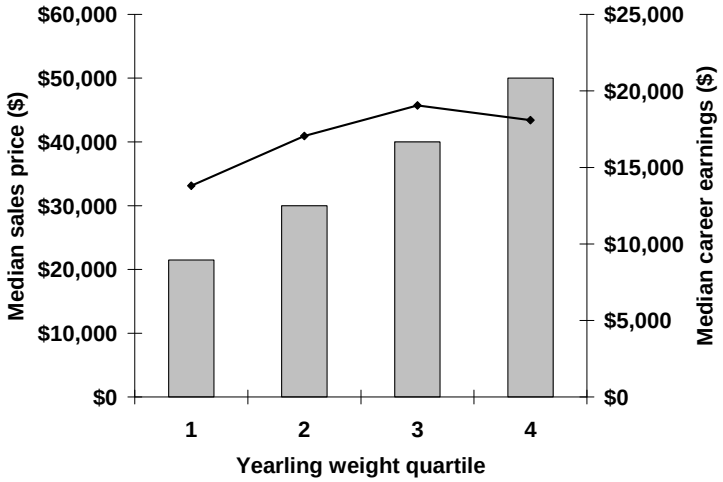

Figure 3. Median sales price (■) and median career earnings (-♦-) in each weight quartile (Brown-Douglas et al. 2007).

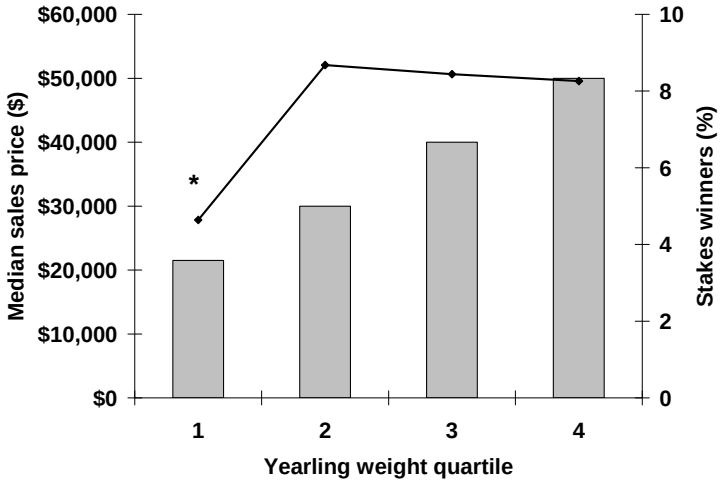

*Figure 4. Median sales price (■) and percent stakes winners (-♦-) in each weight quartile; * indicates point is significantly different from all others within factor p<0.05 (Brown-Douglas et al. 2007).*

These data provide insight into managing horses for different strategies. Smaller horses are more likely to start as two-year-olds and have more career starts; however, elite performers (graded stakes winners, grade-1 stakes winners, and millionaires) tend to be taller and heavier.

Nutrition of the Young, Growing Horse

Because of the premium price paid for mass, young Thoroughbreds prepared for sale are grown rapidly to achieve maximal size. To fuel maximum growth, these young horses are often fed large amounts of grain. Extremely rapid growth by overfeeding energy has been implicated in developmental orthopedic disease (DOD). Periods of slow or decreased growth followed by growth spurts are also risky. Therefore, nutrition mistakes made during a foal's early growth can lead to developmental problems that limit performance later in life.

The best way to evaluate the success of a feeding and conditioning program of young horses is through assessment of body weight, height, and condition. Regular monitoring of weight allows farm managers to maintain a steady growth rate while preventing the animal from becoming too heavy.

During the first few months of life, foals grow rapidly, quadrupling their body weights by 5 months of age (Pagan et al., 1996; Lawrence, 2003; Brown-Douglas and Pagan, 2006). During this time, foals derive the energy, protein, and minerals necessary to support rapid growth from a combination of mare milk, pasture, supplemental grain, and mineral stores in the foal's liver. If the broodmare has received a correctly fortified feed during late pregnancy and is producing adequate milk, in most cases it is unnecessary to supplement the foal with grain until it reaches 90 days of age.

Proper nutrient intake is vital during the weanling stage as the skeleton is most vulnerable to disease. Most types of DOD are unlikely to form after 12 months of age. Lesions that become clinically relevant after this age have typically been formed at a younger age; nevertheless, correct nutrient balance is important in the growing yearling (Pagan, 2003).

The amount of supplementary grain required to maintain a desired growth rate varies, and it is important to feed each horse as an individual. "Easy-keeping" yearlings should be prevented from becoming fat by being fed a low-intake, low-calorie source of essential protein, vitamins, and minerals. On the other hand, yearlings that are large-framed with much growth potential can consume normal amounts of fortified concentrate.

Nutrition plays an important role in the pathogenesis of DOD in horses as deficiencies, excesses, and imbalances of nutrients affect the incidence and severity of physitis, angular limb deformity, wobbler syndrome, and osteochondritis dissecans (OCD) (Pagan, 2003). The most common feeding errors attributed to DOD are excessive grain intake, feeding an inappropriate grain for the forage being fed, and inadequate fortification of grain. These three scenarios are easily fixed by feeding an appropriate grain mix fortified for the young, growing horse and feeding it at the correct intake. Young horses already suffering from DOD should have their energy intakes reduced while maintaining correct levels of protein, vitamins, and minerals.

It is now commonly accepted that excessive energy intake can lead to rapid growth and increased body fat, which is thought to increase the incidence of certain types of DOD in Thoroughbred foals. Yearlings with OCD of the hock and stifle were large at birth, grew rapidly from 3 to 8 months of age, and were heavier than the average population as weanlings (Figure 5) (Pagan, 1998).

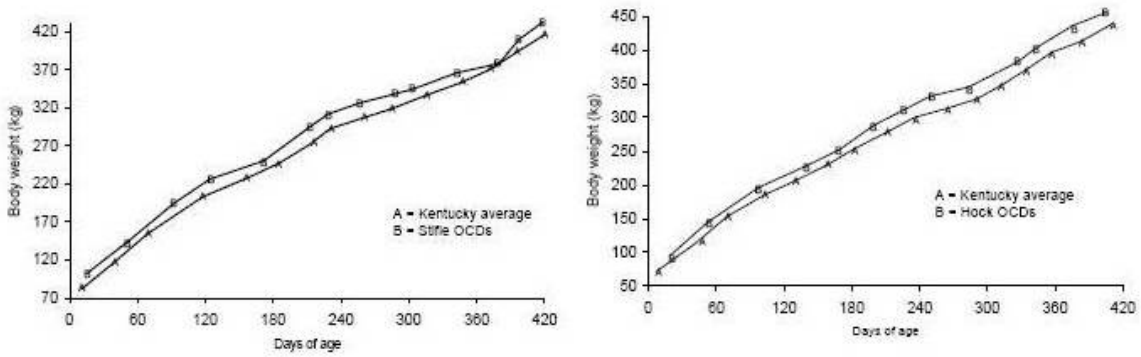

Figure 5. Body weights of foals with stifle (left) and hock (right) OCD compared with the Kentucky average (Pagan, 1998).

In addition to excessive energy, the source of calories for young horses may also be important. Foals that experience an exaggerated and sustained increase in circulating glucose or insulin in response to a carbohydrate (grain) meal may be predisposed to OCD. Research conducted by KER suggests that hyperinsulinemia may influence the incidence of OCD (surgically treated) in Thoroughbred weanlings (Pagan et al., 2001). In a large field trial, a high glucose and insulin response to a concentrate meal was associated with an increased incidence of OCD. Plasma glucose and insulin 2 h post feeding were significantly higher in weanlings with OCD than in unaffected foals ($p < 0.05$). Insulin/glucose ratios, however, were not significantly different (Table 2).The incidence of OCD was significantly higher in foals whose glucose and insulin values were greater than one standard deviation above the mean for the entire population (both OCD and unaffected) in the study (Table 3). Elevated insulin/glucose ratios did not appear to be correlated with an increased incidence of OCD. Glycemic responses measured in the weanlings were highly correlated with each feed's glycemic index (GI), suggesting that the GI of a farm's feed may play a role in the pathogenesis of OCD. Hyperinsulinemia may affect chondrocyte maturation, leading to altered matrix metabolism and faulty mineralization or altered cartilage growth by influencing other hormones such as thyroxine (Jeffcott and Henson, 1998). Based on the results of this study, it would be prudent to feed young horses concentrates that produce low glycemic responses such as feeds in which energy is supplied by fat and fermentable fiber sources (beet pulp and soy hulls).

Table 2. Plasma glucose, insulin, and insulin/glucose ratio two hours post feeding in weanling Thoroughbreds on 6 Kentucky farms (Pagan et al., 2001).

	Glucose (mg/dl)		Insulin (pmol/l)		Insulin/Glucose Ratio	
	OCD (n=25)	Unaffected (n=193)	OCD (n=25)	Unaffected (n=193)	OCD (n=25)	Unaffected (n=193)
Mean ± SE	150.1 ± 7.1	134.2 ± 1.9	130.3 ± 12.8	106.0 ± 3.4	0.85 ± 0.06	0.78 ± 0.02
Significance	p<0.01		p<0.05		p>0.10	

Table 3. The relationship between glucose, insulin, and insulin/glucose ratio and the incidence of OCD in weanling Thoroughbreds on 6 Kentucky farms (Pagan et al., 2001).

Standard Deviations from Mean	Glucose		Insulin		Insulin/Glucose Ratio	
	% Population	% OCD	% Population	% OCD	% Population	% OCD
< 1 SD	11.0	0.0	10.1	0.0	15.1	6.0
± SE	72.9	10.1	78.0	11.2	68.3	12.1
> 1 SD	16.1	25.7	11.9	23.0	16.5	13.9

Mineral deficiency and/or excess of calcium, phosphorus, copper, and zinc may lead to DOD (Pagan, 2003). The ration of a growing horse should be properly fortified because commonly fed cereal grains and forages contain insufficient quantities of several important minerals. A ration of grass hay and oats would only supply about 40% and 70% of a weanling's calcium and phosphorus requirement, respectively, and less than 40% of its requirement for copper and zinc. It is important to provide a balanced ration as the ratio of certain minerals (calcium to phosphorus; copper to zinc) is extremely important. The ideal ratio of calcium to phosphorus in the ration of young horses is 1.5:1 and should never fall below 1:1 or exceed 2.5:1. Too much calcium may affect phosphorus status, particularly if the level of phosphorus in the ration is marginal; conversely, high levels of phosphorus in the ration will inhibit the absorption of calcium and will lead to a deficiency, even if the amount of calcium present was normally adequate. Forage diets with high calcium levels should be supplemented with phosphorus. The ratio of zinc to copper should be 3:1 to 4:1.

Conclusion

Kentucky Equine Research (KER) has studied the growth and development of the equine athlete for nearly 20 years. The company's researchers have identified considerable differences among Thoroughbred growth patterns around the world, indicating that reference growth curves specific to location are important. Breeders aim to produce a fully-grown individual with minimal skeletal problems. To achieve this goal, reference growth curves have been formulated to help breeders monitor growth rates. Reference curves from horses raised in the same environment under similar conditions are more appropriate for breeders who wish to track the growth of their young stock than a general "Thoroughbred" curve. In addition, the use of percentiles to assess individual growth gives a much more useful comparison within a population and allows breeders to adjust nutrition and conditioning practices as necessary to affect growth.

Managing the growth and development of the athletic horse is a balancing act between achieving maximal physiological size and preventing developmental orthopedic disease. Maintaining a steady growth rate by providing appropriate amounts of correctly balanced, low-starch rations intended for growing horses and regularly weighing and measuring horses during the growth period is recommended to help maximize athletic potential before entering training.

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