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EFFECT OF BODY WEIGHT GAIN ON THE SKELETTON GROWTH IN THE SPORT HORSES

Trillaud-Geyl, C.[(1)], Fleurance, G.[(1)], Donabedian, M.[(2)], Perona, G [(3)], Bigot, G.[(2)], Arnaud, G.[(1)], Dubroeucq, H.[(2)], Martin-Rosset, W.[(2)]*

[(1)] Haras Nationaux – Experimental Station – 19370 Chamberet, France.
[(2)] INRA – Center for research of Clermont-Ferrand/Theix – 63122 Saint-Genès Champanelle, France.
[(3)] Faculty of veterinary medicine, University of Torino, 1095 Grugliasco, Italy.

*Corresponding author : wrosset@clermont.inra.fr

Abstract:
2 groups of 12 foals of french breeds were subjected to a high (H group) or limited (L group) growth from weaning to 3years of age. In each group, 6 foals were either of heavy (h)or light (l) body weigth (BW) at weaning. The foals were adjusted to H or L growth according to INRA 1990 nutritional models ; and groups of the foals were adjusted to meet the same BW at 4 years according to a linear (L) :$BW=a+bX$ or a curvilinear (H) :$BW=aX^c$ models.Variations in body size and their components were determined by photometry.
At 3 years of age BW were : 559kg (Hh) ; 515kg (Lh) ;492kg (Hl) and 473kg (Ll). Heigth at withers(HW) and at croup (HC)of Hl are lower than those of other groups. HW and HC growth curves are highly correlated to BW curves in all cases. HW gain of Hl is statistically lower than in other groups and namely for Ll group. Similar figures are observed for all the other parameters either in the forelimb or hind limb. The thickness of the right fore cannon is 9p100 higher in h group than in l group but there is no influence of BW curve.
Skeletton development is highly related to BW curve with a strong interaction of BW met at weaning.
Key words :Horse, growth, body weight, body size

INTRODUCTION

Since the last decade breeding cycle of sport horses is shortening in most european countries. Young horses are in training and competing earlier and more intensively. As a result early high growth and feeding level are requested to match this challenge. It has been highlighted through longitudinal growth analyses in horses subjected to limited or high feeding that skeletton growth could be affected (see reviews of Martin-Rosset 1983, 2004). Body weight gain and skeletton growth are reduced or maximised by limited or high feeding respectively. There are strong interactions between periods where horses are fed limited then ad libitum or conversely feeding levels. Body weight and skeletton growth to be met at adult age can be reached using different body curves and related feeding levels depending on the risk of the occurrence of bone growth disorders (see review of Mc Ilwraith 2001). Nutrient allowances have been designed by NRC 1989 or INRA 1990 according to these scientific data.
But the optimum growth to be matched to breed healthy yearlings of sport breeds (and moreover of race breeds) devoted to early and intensive training and competition is to be determined using the new data obtained on growth (see review of Martin-Rosset 2004) and on physiopathology of bone (see review of Mc Ilwraith 2001; Van Wieren 2004).
An experiment was conducted by INRA and Haras Nationaux (HN) to investigate the effect of two different body curves on the skeletton growth : a linear model vs a curvilinear model in sport horses fed two feeding levels adjusted to meet the same body weight and skeletton growth at 4 years of age.

MATERIALS AND METHODS

Experimental design

24 foals (11 males and 13 females) of French sport breeds (Anglo-arab and Selle Français) were splitted at weaning in two homogeneous groups according to their sex, breeds, body weight and height at withers.
One group was fed to perform an optimal growth according to a curvilinear model from weaning to 36 months of age : «*curvilinear group* » (figure 1). The other group was fed to perform a limited and constant growth according to a linear model during the same period : « *linear group* » (figure 1).
Both groups were expected to meet close body weight and skeletton growth between 40 to 46 months of age (figure 1).
In addition, each group was splitted in two subgroup according to the weight of the foals at weaning : heavy vs. light e. g. « *heavy subgroup* » and « *light subgroup* ».

Feeds and feeding

The foals were fed different proportions of hay, wheat straw and concentrate (ground corn and soya bean meal) according to the age and the goal of daily gain to be met. 50 or 100g of the same mineral and vitamins supplement were supplied to all the foals before and after 18 months of age respectively.
Nutrient allowances were supplied and simultaneously adjusted every 14 days in both groups according to the recommandations of INRA 1990 and INRA nutritional models (table 1).

Management

The foals were conducted in groups of six animals housed in pens. 12 to 72m² were progressively allocated to each animal from weaning to 42 months of age.
The hoofs of all the animals were periodically (6 months) submitted to farrier's inspection and intervention if requested.

Data collection and analyses

Chemical composition of feedstuffs was monthly analysed to determine their nutritive value and to calculate the nutrient supply according to INRA 1990 systems.
Dry matter intake was daily measured to control the nutrient intake referring to the nutrient supply predetermined according to INRA model (Martin-Rosset et al. 1994).
The foals were weighted every 14 days. Skeletton growth was determined every 6 months using a photographical procedure (Bigot et al. 1988). Six measurements were determined : height at withers (HW) and at croup (HC), width at shoulders (WS) and at hocks (WH), deep of chest (DC) and the thickness of the fore right cannon (TC) at latero-medial point. The variation of the different segments of the fore limb and the hind limb were analysed using the pictures taken at different ages.

Statistical analyses

The data of body weight and skeletton growth were subjected to linear or curvilinear regression using SAS software (1975).

RESULTS

Nutrients intake

The energy intake of foals managed according to the two experimental models expressed as a ratio to intake of foals which would be raised at maximum growth : e.g. close to the potential of such breeds, range (table 2) :
-for the foals of the *curvilinear groups* between 80 and 103 p100 according to the age ;
-for the foals of the *linear groups* between 71 and 104 p100 according to the age .
The protein intake expressed according to similar ratio, range (table 2) :
-for the foals of the *curviliniear groups* between 80 and 106 p100 according to the age ;
-for the foals of the *linear groups* between 57 and 115 p100.

Minerals and vitamins were supplied to meet the appropriate requirements through each growth model at each age according to INRA 1990 .

Body weight

The body weight (BW) rises according to a curvilinear or linear curve as expected :

- for curvilinear group :

$BW=17Age^{0.51}$ for heavy subgroup
$BW=17Age^{0.49}$ for light subgroup

- for linear group :

BW=224+0.296Age for heavy subgroup
BW=161+0.336Age for light subgroup

At 36 months of age the body weight of the *heavy curvilinear subgroup* is 559kg which is 44kg higher than the body weight of the *heavy linear subgroup*, but the difference is not statistically significant. The body weights of *light linear subgroup* and *light curvilinear subgroup* are 492kg and 473kg respectively, which is not statistically different (table 3).

The ratio between experimental average daily gain (ADG) of *curvilinear group* to potential ADG (e.g. maximum) for such breeds rises from 75 to 127 p100 from 6 to 24 months of age and then decreases from 115 to 67 p100 from 24 to 36 months of age. The ratio between experimental ADG *of linear group* to potential ADG rises from 38 to 400 p100 from 6 to 36 months of age.

Body size

The variation in body size of *light curvilinear subgroup* is lower than those of all other subgroups namely for HW, HC : the differences are significant but the variation of WS and WH are very close (table 3)
The variation in body size of *light linear subgroup* is higher than those of *heavy curvilinear or linear subgroups*, the difference is significant for HW but not for the other skeletton parts (table 3).
For all the foals, HW rises according to a similar curve to that of the body weight (figure 2). The variation is similar for all the other body parameters of fore limb and hind limb. The length of the shoulder and of the fore arm rise significantly more than the length of the arm (figures 3-4). Comparing the variation in the length of the pelvis, and of the tight (femur) to the length of the hock (tibia) in the hind limb the variation are similar as those observed previously.
The body size of the *light curvilinear subgroup* met at 36 months of age is lower than those of all other subgroup as pointed out by the evolution observed for HW (figure 2) and for the other different skeletton parts of the fore limb (figures 3-4). The decrease takes place for HW at 20 months of age whereas it occurs between 20 to 30 months of age for the different parts of the fore limb (and hind limb).
The thickness of fore cannon (TC) average 4.3cm for all the foals at 36 months of age. The gain is 1.5cm on average. There is no significant difference between the groups whereas TC is lower in the *light subgroups* than in the *heavy subgroups* whatever the model of the growth curve.

DISCUSSION-CONCLUSION

In this experiment, a strong relationship between skeletton development and body weight variation is pointed out in growing horse as previously observed by other workers (Witt & Lhose 1965, Trillaud-Geyl et al. 1986, Bigot et al. 1987, Cymbaluk et al. 1990). Skeletton growth is directly proportional to body weight variation in growing horse. Indeed, equation for predicting body weight from skeletton development parameters were designed in growing horse by INRA 1990.
Body weight and skeletton growth variation are highly flexible as far as growth curve obtained in this experiment can be curvilinear or linear from 6 to 42 months. Compensatory growth can occur until 42 months of age in sport breeds as pointed out in the foals managed according to a linear model. As a result the same body weight and skeletton growth can be met at about the same age as far as the growth curve is curvilinear and linear. But the linear growth should not be too much limited (over 50% of potential growth) in the early stage. It supports previous observations of Witt & Lhose 1965, Trillaud-Geyl et al. 1986, Bigot et al. 1987. Indeed, a

relationship between the body growth of two subsequent periods where limited then compensatory growth are obtained, was determined previously in heavy breeds (Martin-Rosset et al. 1984).
The body weight and skeletton growth met at weaning is of high concern for the growth variation during the subsequent period (6-48 months in sport breeds) according to the level of the nutrient allowances offered to the foals.
Body weight and skeletton compensatory growth can be obtained during the post weaning period in light foals supplied with continuous and moderate nutrients at 4 years of age but restricted foals reach the same body weight as non restricted ones a few months later. But skeletton growth is long lasting affected during the post weaning period in foals weighing 15% less than the normal weight of the breed at weaning, and fed a high level of nutrients. Comparing light to heavy foals between 6 to 36 months, there is no compensatory skeletton growth for HW in the light group whatever the growth model (e.g. nutrient allowances) but a fair compensation for the length of the shoulder, fore arm, and the tight or the hock. It is consistent with basical knowledge of the growth in equines : HW growth is very early and rapid during pregnancy and suckling periods whereas the growth of other skeletton parts take place later (see reviews of Martin-Rosset 1983 and 2004) . Comparing the light to heavy foals at weaning between 6 to 36 months managed according to a curvilinear or a linear models, skeletton growth is significantly reduced at 2 years of age by 5 to 10%, and there is no compensatory growth in the light foals fed high level of nutrients.
Optimal body weight gain and skeletton growth from birth have to be determined in young horse to meet the suitable body weight and development at adult age for each breed which is to be determined as well. The optimal growth and related nutrient allowances should be determined too to prevent from rising bone disorders as pointed out by Savage et al. (1993a ,1993b).
Physiological mechanisms involved in such process should be highlighted in equines as in other animal species in the very next future to improve our understanding and management of young horses devoted to early training and competing.

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Table 1 : Requirements for growth according to INRA nutritional models (Martin-Rosset et al. 1994)

Energy : relationship between daily energy intake and liveweight and growth in young horses of light breeds[1]

$UFC/day/kgW^{0.75}=a+bG^{1.4}$

Ages (months)	a	b
6-12	0.0602	0.0183
12-18	0.0598	0.0217
18-24	0.0594	0.0252
24-30	0.0594	0.0252
30-36	0.0594	0.0252

Protein : relationship between daily protein intake and liveweight and growth in young horses of light breeds

$gMADC/day=aW^{0.75}+bG$

Ages (months)	a	b
6-12	3.5	450
12-18	3.2	360
18-24	2.8	270
24-30	2.8	270
30-36	2.8	270

[1] from INRA 1990
a : coefficient of maintenance
G : average daily gain (kg/day)

Table 2 : Nutrient allowances during the experiment

Heavy curvilinear

	UFC (/day)		MADC (g/day)	
Age (months)	Experimental(1)	% of potential(2)	Experimental(1)	% of potential(2)
6-12	5.33	90	540	84
12-18	6.30	96	508	98
18-24	6.65	103	385	106
24-30	6.87	104	369	105
30-36	6.86	103	341	102

Heavy linear

	UFC (/day)		MADC (g/day)	
Age (months)	Experimental(1)	% of potential(2)	Experimental(1)	% of potential(2)
6-12	4.80	81	399	62
12-18	5.62	85	370	72
18-24	5.83	90	336	92
24-30	6.40	97	361	103
30-36	6.95	104	385	115

Light curvilinear

	UFC (/day)		MADC (g/day)	
Age (months)	Experimental(1)	% of potential(2)	Experimental(1)	% of potential(2)
6-12	4.71	79	508	79
12-18	5.80	88	524	91
18-24	6.11	94	362	100
24-30	6.37	96	347	99
30-36	6.39	96	319	95

Light linear

	UFC (/day)		MADC (g/day)	
Age (months)	Experimental(1)	% of potential(2)	Experimental(1)	% of potential(2)
6-12	4.22	71	368	57
12-18	5.05	77	342	66
18-24	5.28	82	312	86
24-30	5.87	89	338	96
30-36	6.44	97	362	108

(1) nutrients allowances during the experiment
(2) ratio between nutrients allowances during the experiment/ nutrients allowances for potential growth (maximal)

Table 3 : Variation of body weight (kg) and skeletton growth (cm) from 6 to 36 months

	Variation during the experiment				At the end of experiment			
	Heavy		Light		Heavy		Light	
	Curvilinear	Linear	Curvilinear	Linear	Curvilinear	Linear	Curvilinear	Linear
Duration of experiment (days) / Age (days)	840				1090±18	1090±19	1087±36	1061±15
Body weight	246	205	205	235	559±48[a]	515±48[a,b]	473±23[b]	492±30[b]
Height at withers	22[a]	21[a]	19[a]	26[b]	165±4[a]	164±3[a]	156±3[b]	161±3[a]
Height at croup	18[a,b]	19[a,b]	16[b]	22[a]	165±5[a]	164±3[a]	155±3[b]	160±4[a]
Width of shoulders	8[a]	7[a]	8[a]	8[a]	44±2[a]	43±2[a]	42±2[a]	41±1[a]
Width of hock	15[a]	14[a]	14[a]	15[a]	58±3[a]	56±3[a]	54±2[a]	54±4[a]
Deepth of chest	17[a]	15[a]	15[a]	17[a]	77±2[a]	75±2[a]	73±1[a]	73±2[a]
Thickness of right cannon	1.4[a]	1.6[a]	1.5[a]	1.7[a]	4.6±0.3[a]	4.4±0.2[a]	4.1±0.1[a]	4.2±0.1[a]

Data with different superscript letter are significantly different ($p < 0.10$)

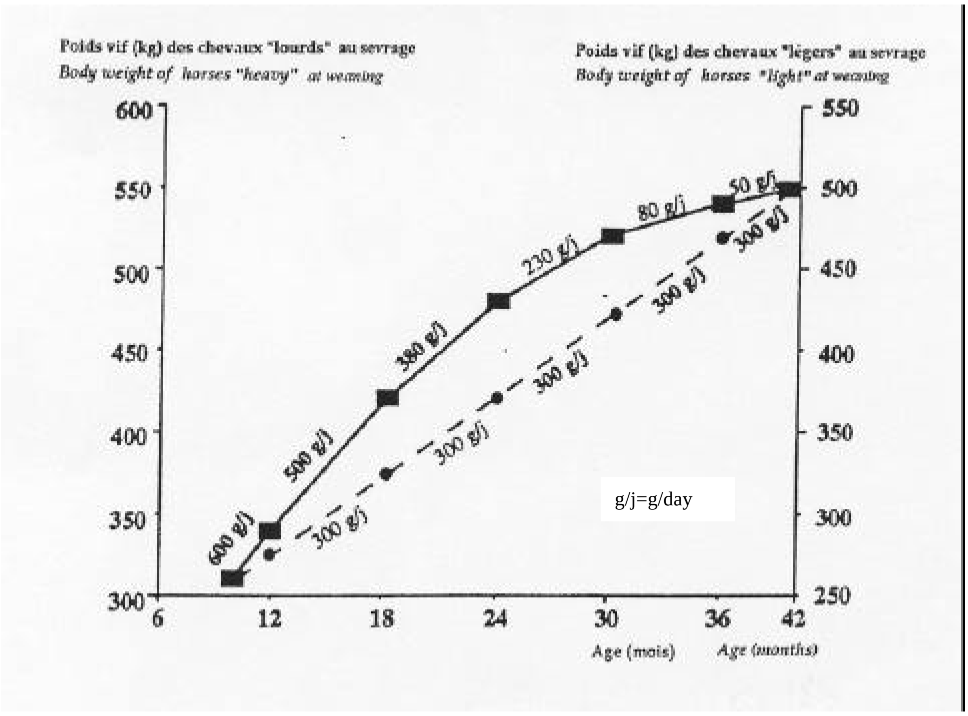

Figure 1 : Body weight models of curvilinear group (___) and linear group (- - -)

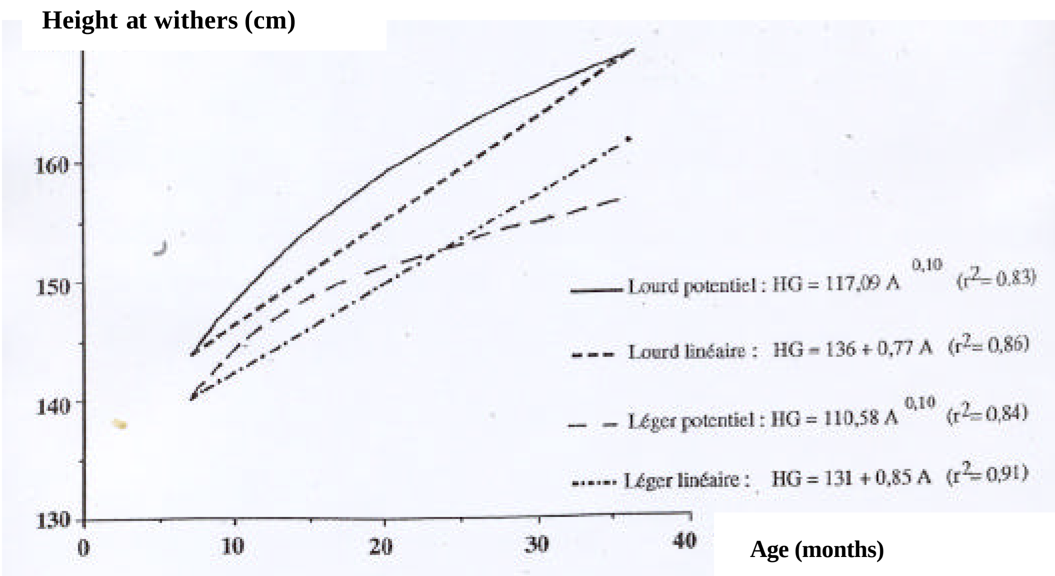

Figure 2 : Growth of height at withers with age (A)

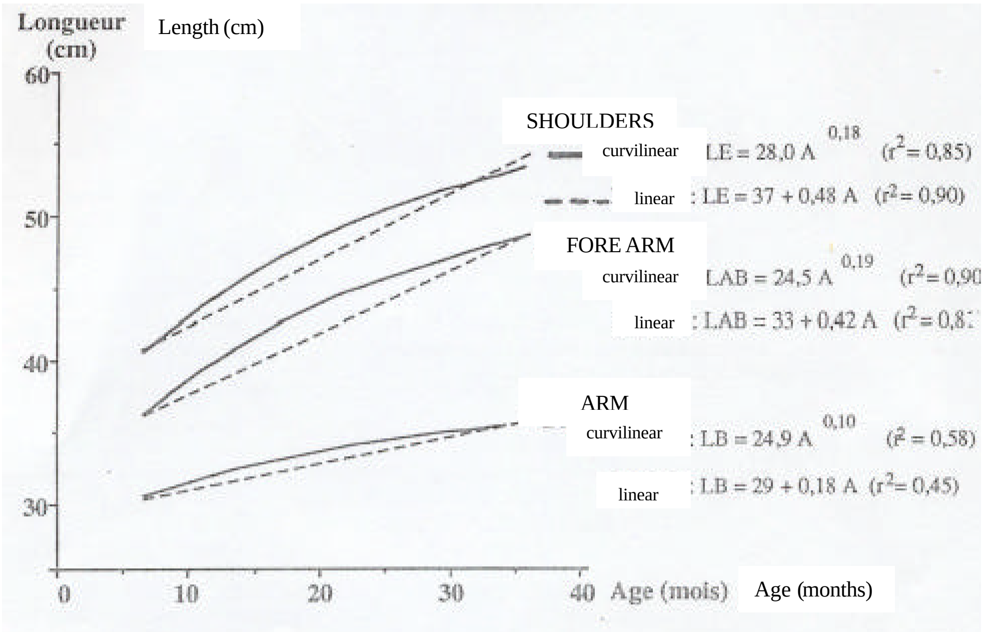

Figure 3 : Variation of the different parts of the fore limb in heavy subgroups (curvilinear —— or linear - - -)

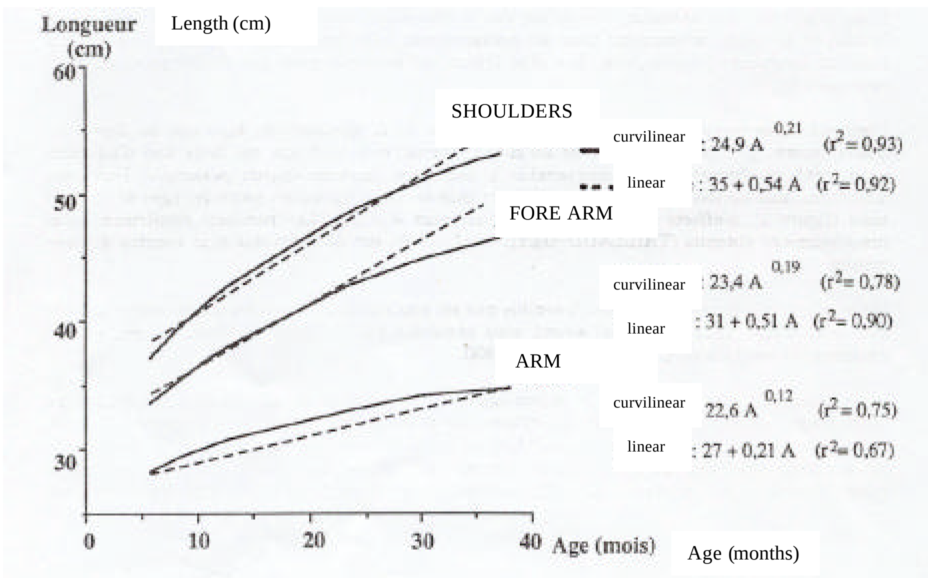

Figure 4 : Variation of the different parts of the fore limb in light subgroups (curvilinear —— or linear - - -)