

Growth, development and size of Icelandic toelter horses

THORVALDUR ÁRNASON

IHBC AB, Knubbo S-74041 Morgongåva, Sweden

and

THORKELL BJARNASON

Agricultural Society of Iceland, P.O. Box 7080, IS-127 Reykjavík, Iceland

SUMMARY

The paper describes statistical analysis of 4882 series of 13 body measurements (cm) of Icelandic toelter horses in the age range of 6 to 78 months. The mean height at withers was found to be 110.4 at 6 months, 123.6 at 18 months, 128.6 at 30 months, 130.9 at 42 months, 132.5 at 54 months, 133.0 at 66 months and 133.2 at 78 months of age. In comparison with standardbred trotters, Icelandic toelters are short-footed and of a relatively heavier body type. Relative to wither height, height at back and croup together with circumference of limbs (knee and cannon) decrease during the growth phase, while width, depth and length of body measurements increase with age. In general, males were found to be somewhat larger than females. However, females were found to have larger circumference of chest over the entire growth phase and larger width of pelvis from 18 months of age. The average heritability estimate for the body measurements was 0.46, being highest for the youngest and oldest age groups studied and lowest when the horses aged 30 months. Multiple linear regressions were fitted for predicting adult size on the basis of earlier body measurements. Additional material of 260 weight records was used to develop allometric equations for estimation of body weight of Icelandic toelters when only body measurements are available.

Key words: body measurements, body weight, heritabilities, prediction equations.

YFIRLIT

Vöxtur, þroski og stærð íslenskra hrossa

Rannsókuð voru skrokkmál folalda og tryppa. Markmiðið var að öðlast þekkingu á meðaltölum og breytileika mála hrossa á ýmsum aldri, breytingum í skrokkhlutföllum á vaxtarferlinum, arfgengi mála á mismunandi aldursskeiðum, fylgni milli skrokkmála, sambandi milli fullorðinsstærðar og mála í æsku, og sambandi milli þunga og skrokkmála.

Gögnin innihéldu 13 skrokkmál (í sm) af 4882 skepnum á aldrinum 6–78 mánaða. Niðurstöður gáfu til kynna að meðalhæð á herðar (stangarmál) íslenskra hrossa sé u.þ.b. 110, 124, 129, 131 og 133 sm við 6, 18, 30, 42 og 54 mánaða aldur. Í samanburði við erlenda veðreiðabrokkara eru íslensku hrossin hlutfallslega lágfætt og bolþung. Miðað við fullorðin hross eru folöldin háfætt, bolstutt, bollétt og há að aftan (lág á herðar). Flest mál eru meiri fyrir hesta en fyrir hryssur. Undantekning er brjóstmálið sem er meira hjá hryssum, óháð aldri, og breidd um mjaðmarhorn og lærleggstoppa sem er sömuleiðis meiri hjá hryssum eftir 18 mánaða aldur (kynþroska).

Í samræmi við fyrri rannsóknir reyndist hátt arfgengi á skrokkmálum (0,46 að meðaltali). Áhrif erfða á breytileika á málum í hlutfalli við umhverfisáhrif eru mest folaldshaustið og aftur þegar hrossin eru uppkomin, en minnst (arfgengið lægst) við tveggja vetra aldur (30 mánaða).

Fleirþættar línulegar aðhvarfslíkingar voru þróaðar til þess að spá um fullorðinsstærð á grundvelli fyrri mælinga. Á Stóðhestastöð ríkisins mátti tengja 260 vígtanir á stóðhestum í uppeldi við mál á sömu hestum. Líkingar, sem meta þunga sem fall af skrokkmálum, voru leiddar út.

INTRODUCTION

Growth and development in horses in general have been reviewed by Green (1961), and Martin-Rosset (1983). Heritability estimates for body measurements in adult Icelandic toelter horses have previously been calculated by Árnason (1977; 1984). Hintz *et al.* (1978) estimated heritabilities for weight, height and forelimb cannon circumference of growing thoroughbreds in different age groups. Saastamoinen (1990a) estimated heritabilities and the phenotypic correlation structure among eight body measurements recorded at six month intervals in Finnhorses in the age range of 6 to 48 months.

The objective of this study was to analyze 13 body measurements and body weight of Icelandic toelter horses in different ages in order to gain knowledge about the following items:

1. Means and variation in body measurements at different ages.
2. Developmental proportional changes in body measurements during the growth phase.
3. Heritability of body measurements at different ages.
4. Correlations between the various body measurements.
5. Association between adult wither height and body measurements obtained earlier in live.
6. Relationship between weight and body measurements.

MATERIAL AND METHODS

The material was obtained from two Icelandic studs (Hólar and Kirkjubær), one breeding organization (Skuggafélag) and the state owned stallion station. The distribution of records on complete series of 13 body measurements according to age of the horses and

location is displayed in Table 1. A part of the material was tabulated and published by Thorkelsson (1978). On the basis of Thorkelsson's tables, Árnason (1978) fitted regression equations for predicting height at withers of grown-up horses on the basis of earlier wither height.

The majority of the Icelandic toelter horse foals are born in the early summer (May–July) (Hugason *et al.*, 1985). The horses which constitute the material in this study have been measured annually in November–December. The 13 body measurements are exhibited in Table 2. A more thorough description of the body measurements can be found in the booklet **Kynbótadómar og sýningar** (Agricultural Society of Iceland, 1992).

Genetic parameters for the body measurements in each age group up to 54 months were estimated by fitting the following linear model to the data:

$$y_{ijkl} = \mu + s_i + k_j + f_k + e_{ijkl}$$

where y_{ijkl} is the observed measurement on the l -th horse, μ is the generalized least-squares mean, s_i is the effect of the i -th sire, k_j is the effect of the j -th sex, f_k is the effect of the k -th stud/year, e_{ijkl} is a random residual term.

Saastamoinen (1990b) reported significant effects of birth month on growth of young Finnhorses. Birth date was not registered in this material. Therefore the inclusion of terms for birth month, and exact age at measuring in the statistical model was not possible, although feasible.

The variance/covariance components for sire and residual terms were estimated by the Restricted Maximum Likelihood method using the EQREML programs of Meyer (1987).

Prediction equations for adult sizes of young horses were found by fitting multiple linear regressions to the material. As an alternative to linear relationship, a log linear model was

Table 1. Distribution of records across studs and age. Weight records within parenthesis.
1. tafla. Dreifing mála (og vigtana) yfir bú og aldurshópa.

Approximate age of the horses, months <i>Aldur, mán.</i>	Hólar	Kirkjubær	Studs— <i>Bú</i> Skuggafélag	Stallion station <i>Stóðhestastöð</i>	Total <i>Summa</i>
	1969–90	1970–90	Years— <i>Ár</i> 1970–90	1973–90 (1985–90)	
6	273	411	363	101 (39)	1148
18	290	263	290	197 (65)	1040
30	257	232	242	196 (81)	927
42	240	166	220	155 (53)	781
54	185	66	210	110 (29)	571
66	91	21	127	34	273
78	51	7	76	8	142
Total— <i>Summa</i>	1387	1166	1528	801 (267)	4882

Table 2. Presentation of the 13 body measurements included in this study.
2. tafla. Yfirlit um mál þau sem rannsóknin fjallar um.

Tape measurements	<i>Bandmál</i>
1. Height at withers	1. <i>Hæð á herðar</i>
2. Circumference of girth	2. <i>Ummál um brjóst</i>
3. Circumference of forelimb knee	3. <i>Ummál um framhné</i>
4. Circumference of forelimb cannon	4. <i>Ummál um framfótlegg</i>
Square (beam) caliper	<i>Skíðmál</i>
5. Width of forelimb cannon	5. <i>Hliðarbreidd framleggs</i>
Outside-adjusting caliper	<i>Bogmál</i>
6. Width of breast	6. <i>Breidd um bóghnútur</i>
7. Width of pelvis (hips)	7. <i>Breidd um mjaðmarhorn</i>
8. Width of pelvis (thighs)	8. <i>Breidd um lærleggstopp</i>
Rod (stick, rule) measurements	<i>Stangarmál</i>
9. Height at withers	9. <i>Hæð á herðar</i>
10. Height at back	10. <i>Hæð á bak</i>
11. Height at croup	11. <i>Hæð á lend</i>
12. Depth of chest	12. <i>Brjóstskýpt</i>
13. Length of body	13. <i>Bollengd</i>

fitted for height at withers, thus giving allometric prediction equations (Huxley, 1932).

Weight records were available on the colts raised at the stallion station. Total of 260 weight records had been obtained on the same occasion as the body measurements were taken. This offered a good opportunity to relate the weight and body measurements for Icelandic

toelter stallions over the whole growth-phase. A log linear model was fitted for multiple regression of weight on the 13 body measurements.

RESULTS AND DISCUSSION

The means and standard deviations of the 13 body measurements for the different age groups are presented in Table 3.

Table 3. Statistical description of the data on 13 body measurements and weight. Body measurements are expressed in cm. Weight records are expressed in kg.

3. tafla. Tölfræðileg lýsing gagna. Skrokkmálin eru skráð í sm og þungi í kg.

	Age in months—Aldur í mánuðum						
	6	18	30	42	54	66	78
Means—Meðaltöl							
Height at:							
withers (tape)	117.7	131.8	137.5	140.1	141.9	142.3	142.9
withers (rod)	110.4	123.6	128.6	130.9	132.5	133.0	133.2
back	107.2	119.0	122.8	124.4	125.5	125.8	125.8
croup	113.2	125.5	129.6	131.3	132.5	133.1	133.1
Circumference of:							
girth	123.9	146.3	157.8	163.2	166.8	167.5	169.4
knee	24.8	26.8	27.9	28.3	28.5	28.3	28.4
cannon	15.0	16.6	17.5	17.8	17.9	18.0	18.0
Width of:							
cannon	5.1	5.7	6.0	6.2	6.2	6.2	6.3
breast	28.6	32.5	34.7	35.8	36.8	37.2	37.4
hips	33.6	41.2	44.9	46.8	48.0	48.6	48.7
thighs	32.2	38.0	41.5	43.0	44.0	44.4	44.7
Depth of chest	45.5	55.4	59.6	61.5	62.8	63.4	63.9
Length of body	109.4	128.4	136.4	140.1	142.4	143.6	145.0
Weight	174.4	281.6	323.4	354.3	363.8		
Standard deviation—Meðalfrávik							
Height at:							
withers (tape)	4.29	4.32	3.90	3.74	3.61	3.15	3.07
withers (rod)	4.04	3.99	3.88	3.64	3.52	3.20	3.20
back	3.94	3.61	3.50	3.31	3.19	3.02	2.86
croup	3.82	3.84	3.67	3.45	3.38	2.99	3.01
Circumference of:							
girth	6.08	6.79	6.28	6.43	6.88	7.29	7.24
knee	1.04	1.11	1.31	1.49	1.47	1.30	1.27
cannon	0.84	0.86	0.84	0.88	0.91	0.87	0.85
Width of:							
cannon	0.30	0.29	0.29	0.30	0.29	0.26	0.25
breast	1.84	2.09	2.12	2.12	2.11	2.13	2.07
hips	2.18	2.32	2.25	2.21	2.33	2.21	2.62
thighs	2.08	2.19	1.90	1.84	2.01	2.01	1.97
Depth of chest	2.56	2.64	2.47	2.34	2.27	2.24	2.17
Length of body	5.59	5.57	4.86	4.43	4.24	4.24	4.13
Weight	17.94	26.03	27.26	25.36	23.27		

The results of this study indicate that the mean height of wither of adult Icelandic toelter horses is about 133 cm. The height at croup

of adults are equal to the wither height, while height at back is ca 7 cm less. Adults are rectangular in shape as they are 10–12 cm longer

Table 4. Thirteen body measurements of Icelandic toelter horses expressed as a percentage of height at withers.

4. tafla. Þrettán skrokkmál sýnd sem hlutfall af stangarmálshæð á herðar.

	Age in months—Aldur í mánuðum						
	6	18	30	42	54	66	78
Height at:							
withers (tape)	106.7	106.6	106.9	107.1	107.1	107.1	107.3
withers (rod)	100.0	100.0	100.0	100.0	100.0	100.0	100.0
back	97.2	96.3	95.5	95.1	94.8	94.6	94.5
croup	102.6	101.5	100.8	100.3	100.0	100.1	100.0
Circumference of:							
girth	112.3	118.3	122.7	124.8	126.0	126.0	127.3
knee	22.5	21.7	21.7	21.6	21.5	21.3	21.3
cannon	13.6	13.4	13.6	13.6	13.5	13.5	13.5
Width of:							
cannon	4.6	4.6	4.7	4.7	4.7	4.7	4.7
breast	25.9	26.3	27.0	27.4	27.8	27.9	28.0
hips	30.4	33.4	34.9	35.8	36.2	36.5	36.6
thighs	29.2	30.8	32.3	32.9	33.2	33.4	33.5
Depth of chest	41.3	44.8	46.3	47.0	47.4	47.7	48.0
Length of body	99.1	103.9	106.1	107.1	107.6	108.0	109.0

than their wither height. Magnusson (1985) found that standardbred trotters had quadratic form, which generally applies to race horse breeds. In comparison with standardbred trotters, Icelandic toelter horses are short-footed and of relatively heavier body type. The difference in the body proportions between 4-year-old Icelandic toelter horses and standardbred trotters in Sweden at the same age is illustrated by Table 4. According to the results of this study the girth of grown-up Icelandic toelters is 127% of wither height (the corresponding figure was found to be 113% in the standardbreds), the chest dept is 48% (46% in standardbreds) and the with of hips is 36.5% of wither height (34% in standardbreds).

The half year old foals were found to be quadratic in shape, with relatively long legs compared with adults and about 3 cm higher at the croup than they were at the withers. The developmental changes in proportions revealed in Tables 5 and 6 are in good agree-

Table 5. Size of 4-year-old (54 months) Icelandic toelter horses as a percentage of the corresponding body measurement on standardbred trotters. The body measurements on the trotters were obtained from Magnusson (1985).

5. tafla. Samanburður á hlutfallslegri stærð (í %) fullvaxinna íslenskra hrossa miðað við sænska veðreiðarbrokkara.

Height at:	
withers (rod)	84.8
back	84.9
croup	85.5
Circumference of:	
girth	94.2
knee	90.2
cannon	93.2
Width of:	
cannon	88.2
breast	90.2
hips	90.1
Depth of chest	87.3
Length of body	91.5

Table 6. Thirteen body measurements of Icelandic toelter horses expressed as percentage of the corresponding measurement at 6.5 years age (78 months).

6. tafla. Þrettán skrokkmál íslenskra hrossa sem hlutfall af fullorðinsstærð þeirra.

	Age in months—Aldur í mánuðum						
	6	18	30	42	54	66	78
Height at:							
withers (tape)	82.4	92.2	96.2	98.0	99.3	99.6	100.0
withers (rod)	82.9	92.8	96.5	98.3	99.5	99.8	100.0
back	85.2	94.6	97.6	98.9	99.8	100.0	100.0
croup	85.0	94.3	97.4	98.6	99.5	100.0	100.0
Circumference of:							
girth	73.1	86.4	93.2	96.3	98.5	98.9	100.0
knee	87.3	94.4	98.2	99.6	100.4	99.6	100.0
cannon	83.3	92.2	97.2	98.9	99.4	100.0	100.0
Width of:							
cannon	81.0	90.5	95.2	98.4	98.4	98.4	100.0
breast	76.5	86.9	92.8	95.7	98.4	99.5	100.0
hips	69.0	84.6	92.2	96.1	98.6	99.8	100.0
thighs	72.0	85.0	92.8	96.2	98.4	99.3	100.0
Depth of chest	71.2	86.7	93.3	96.2	98.3	99.2	100.0
Length of body	75.4	88.6	94.1	96.6	98.2	99.0	100.0

ment with the established knowledge about changes in body conformation of horses (Eriksson, 1927; Green, 1961; Hesse, 1957). Length, and especially thickness of bones in the limbs, measure relatively early maturing body tissues, while the body skeleton (ribs, pelvis and spinal cord) as expressed in body girth, depth of chest, width of body and body length are relatively late maturing. As an interesting complement to Table 6 one could summarize the results of Sveinsson (1990), who estimated weight and some body measurements of 50 new-born Icelandic toelter foals. The average height at withers (tape) was 90.2 cm (63% of adult height), girth 72.8 cm (43% of adult girth), length 66.7 cm (46% of adult length) and weight 38.0 kg (11% of adult weight).

The estimated sex difference in the body measurements is shown in Table 7. Colts were found to be higher than fillies, the difference was of the order of ca 2 mm at 6 months of age and increased to about 13 mm at the age of 54 months. Corresponding difference in

height at croup was 1 mm and 8 mm respectively. The fillies were found to have larger circumference of girth than colts. The difference was estimated to be ca 6 mm at 6 months and had increased to 19 mm at 54 months of age. The males had thicker forelimbs than females already at 6 months of age and this difference increased by age within the age interval under this study. Colts were also found to have wider breast than the fillies. Females, on the other side, were wider over the pelvis after 18 months of age. The sex determined difference in conformation found in this study is in good agreement with earlier findings in the Icelandic toelter horse breed (Árnason, 1977) as well as in other horse breeds (Magnusson, 1985).

The heritability estimates are listed in Table 8. Since the material is limited in size, the sampling errors on the heritability estimates are quite large. However, a more serious consideration is that the distribution of sires across studs and years is too limited for the creation of good connections in the material. Possible

Table 7. Generalized least-squares estimates (\pm SE) of female sex effects for 13 body measurements of Icelandic toelter horses. The solutions are expressed as deviations (cm) from the corresponding male GLS-estimates.

7. tafla. Metin frávik mála (sm) hryssa frá mótsvarandi málum hesta.

	Age in months—Aldur í mánuðum				
	6	18	30	42	54
Height at:					
withers (tape)	-0.231 (\pm .231)	-0.616 (\pm .258)	-0.802 (\pm .257)	-0.963 (\pm .273)	-1.468 (\pm .333)
withers (rod)	-0.241 (\pm .213)	-0.575 (\pm .237)	-0.980 (\pm .252)	-0.929 (\pm .263)	-1.267 (\pm .323)
back	-0.339 (\pm .206)	-0.704 (\pm .221)	-0.938 (\pm .232)	-0.747 (\pm .259)	-0.906 (\pm .306)
croup	-0.101 (\pm .208)	-0.271 (\pm .236)	-0.752 (\pm .246)	-0.689 (\pm .257)	-0.798 (\pm .314)
Circumference of:					
girth	0.631 (\pm .349)	1.118 (\pm .404)	1.197 (\pm .429)	1.195 (\pm .504)	1.866 (\pm .592)
knee	-0.443 (\pm .055)	-0.571 (\pm .064)	-1.150 (\pm .069)	-1.342 (\pm .084)	-1.540 (\pm .097)
cannon	-0.227 (\pm .044)	-0.339 (\pm .050)	-0.634 (\pm .052)	-0.791 (\pm .058)	-0.903 (\pm .074)
Width of:					
cannon	-0.066 (\pm .017)	-0.097 (\pm .018)	-0.216 (\pm .019)	-0.266 (\pm .020)	-0.261 (\pm .023)
breast	-0.253 (\pm .101)	-0.104 (\pm .128)	-0.860 (\pm .133)	-0.718 (\pm .152)	-0.897 (\pm .192)
hips	-0.020 (\pm .115)	0.552 (\pm .136)	0.390 (\pm .149)	0.581 (\pm .164)	0.622 (\pm .202)
thighs	-0.013 (\pm .113)	0.526 (\pm .131)	0.467 (\pm .128)	0.335 (\pm .142)	0.375 (\pm .183)
Depth of chest	0.112 (\pm .134)	-0.059 (\pm .161)	-0.110 (\pm .170)	-0.262 (\pm .178)	0.012 (\pm .206)
Length of body	-0.078 (\pm .299)	0.274 (\pm .335)	-0.165 (\pm .334)	-0.484 (\pm .342)	-0.409 (\pm .416)

systematic environmental effects of stud/year may therefore be insufficiently adjusted for by the REML method. An upward biased estimation of the sire variance components is probably to be expected. Nevertheless, the heritability estimates provide a basis for some interpretations. In good agreement with earlier studies the heritabilities of body measurements were estimated to be moderate to high (Árnason, 1977, 1984; Hintz *et al.*, 1978;

Thafvelin, 1990; Saastamoinen, 1990a). Environmental effects on the variation in the body measurements seems to be largest when the horses were at the age of one to three years (18–42 months). Higher heritability estimates were on the average obtained for this measurements when the horses were either young or grown-up (6 and 54 months).

Estimates of genetic and phenotypic correlations were in general high and positive.

Table 8. Heritability estimates of 13 body measurements of Icelandic toelter horses.
8. tafla. Arfgengismat 13 skrokkmála.

	Age in months—Aldur í mánuðum					Average h ² Meðaltal
	6	18	30	42	54	
No. sires Fjöldi feðra	93	92	82	82	67	
No. offspring Fjöldi afkvæma	1030	883	777	657	478	
Height at:						
withers (tape)	0.54±.14	0.49±.14	0.17±.10	0.41±.15	0.69±.20	0.46
withers (rod)	0.40±.11	0.32±.11	0.19±.11	0.27±.13	0.54±.17	0.34
back	0.41±.11	0.28±.10	0.32±.12	0.24±.13	0.30±.12	0.31
croup	0.57±.14	0.43±.13	0.11±.08	0.31±.14	0.60±.18	0.40
Circumference of:						
girth	0.66±.16	0.43±.14	0.19±.10	0.31±.15	0.56±.21	0.43
knee	0.45±.12	0.48±.15	0.47±.16	0.30±.15	0.60±.23	0.46
cannon	0.56±.14	0.23±.08	0.45±.16	0.27±.13	0.52±.23	0.41
Width of:						
cannon	0.39±.11	0.33±.11	0.14±.08	0.45±.18	0.73±.25	0.41
breast	0.81±.17	0.33±.10	0.46±.15	0.60±.19	0.76±.23	0.59
hips	0.64±.15	0.57±.15	0.34±.15	0.32±.12	0.72±.22	0.52
thighs	0.70±.15	0.50±.15	0.42±.16	0.52±.15	0.48±.17	0.52
Depth of chest	0.55±.13	0.37±.12	0.14±.08	0.28±.11	0.97±.26	0.46
Length of body	0.85±.17	0.61±.15	0.31±.14	0.92±.21	0.39±.17	0.62
Average h ² —Meðaltal	0.58	0.41	0.29	0.40	0.60	0.46

The sampling error on the genetic correlation coefficients was naturally high, however, and interpretation of single coefficient estimates is quite meaningless.

In Table 9 multiple linear regressions for predicting adult size (54 month) on the basis of earlier measurements are presented. Height measurements and cannon circumference of adult horses can be predicted from measurements on 6 month-old foals with an accuracy corresponding to a correlation of the order of at least 0.5. Other measurements on the foals give unreliable prediction of adult measurements.

Application of higher order terms in addition to linear effects in the regression model might have improved the accuracy of prediction (Draper and Smith, 1981). Simplicity of

the equations is important for potential practical application of the prediction equations, however. Alternatively an allometric equation form might take care of possible non-linear growth effects. Log linear regression analysis was performed for wither height (tape). Following allometric equations were estimated for predicting adult height (y) on the basis of earlier measurements (x_i):

$$y = 23.4801 x_1^{0.3769} \quad R^2=0.30$$

$$y = 7.6653 x_1^{0.1064} x_2^{0.4937} \quad R^2=0.47$$

$$y = 3.4102 x_1^{0.0550} x_2^{0.0611} x_3^{0.6431} \quad R^2=0.66$$

$$y = 2.2338 x_1^{-0.0064} x_2^{-0.0127} x_3^{0.2887} x_4^{0.5708} \quad R^2=0.74$$

Table 9. Multiple regressions of 4-year-old (54 months) body measurements on earlier measurements. 9. tafla. Fleirþætt aðhvarf mála fjögurra vetra hrossa á fyrri mál.

	Intercept	Age in months—Aldur í mánuðum				R ²
		6 b ₁	18 b ₂	30 b ₃	42 b ₄	
Height at:						
withers (tape)	22.37	-0.011	-0.012	0.300	0.578	0.74
	33.79	0.064	0.067	0.665		0.66
	55.79	0.129	0.537			0.48
	87.80	0.457				0.30
withers (rod)	16.39	0.000	0.025	0.272	0.595	0.72
	30.91	0.007	0.161	0.627		0.63
	48.82	0.056	0.625			0.49
	84.45	0.432				0.27
back	23.30	0.006	0.120	0.241	0.461	0.61
	34.08	0.029	0.201	0.523		0.53
	51.28	0.116	0.516			0.42
	82.88	0.394				0.25
croup	12.70	-0.027	0.026	0.341	0.574	0.73
	22.87	-0.003	0.107	0.744		0.66
	46.59	0.063	0.626			0.48
	80.42	0.457				0.26
Circumference of:						
girth	41.10	0.043	0.063	0.181	0.507	0.43
	65.58	0.112	0.134	0.432		0.30
	96.33	0.214	0.303			0.18
	119.54	0.383				0.12
knee	-0.70	0.050	0.267	0.279	0.458	0.73
	-2.07	0.136	0.426	0.563		0.64
	0.71	0.286	0.764			0.53
	10.88	0.700				0.29
cannon	1.98	0.009	0.205	0.216	0.484	0.50
	3.63	0.089	0.303	0.452		0.37
	6.85	0.175	0.505			0.27
	12.70	0.343				0.10
Width of:						
cannon	0.85	0.023	0.193	0.218	0.461	0.61
	1.55	0.010	0.310	0.473		0.50
	2.37	0.099	0.583			0.36
	4.58	0.320				0.09
breast	13.67	0.026	0.072	0.110	0.444	0.39
	18.88	0.081	0.126	0.320		0.23
	23.38	0.174	0.246			0.14
	27.45	0.311				0.10
hips	12.03	0.063	-0.016	0.065	0.669	0.57
	21.73	0.075	0.064	0.464		0.33
	27.29	0.108	0.407			0.24
	35.16	0.374				0.14
thighs	16.46	0.093	-0.135	-0.043	0.729	0.41
	29.11	0.146	-0.078	0.316		0.12
	36.14	0.184	0.050			0.06
	37.09	0.213				0.06
Depth of chest	19.52	0.001	0.085	0.260	0.375	0.43
	26.22	0.044	0.181	0.413		0.35
	37.91	0.073	0.390			0.24
	51.92	0.237				0.08
Length of body	40.03	-0.002	-0.035	0.192	0.577	0.57
	58.46	0.046	0.101	0.484		0.43
	88.76	0.112	0.324			0.26
	114.19	0.258				0.12

Seemingly the allometric equations do not provide any advantage above simple linear relationship for the predictions of wither height.

On the other side the allometric relationship between the body measurements and weight was found to give much closer fit to the data, than provided by only linear relationship. The determination coefficient (R^2) of the order of 0.96 was obtained for the log linear relationship. For comparison $R^2=0.6-0.8$ were found when linear relationship within age groups were studied. The allometric equation for estimation of weight on the basis of the 13 body measurements is presented below:

$$\text{Weight (kg)} = e^{-7.6675239} x_1^{0.5870833} x_2^{0.5551441} x_3^{0.0092568} x_4^{-0.3120990} x_5^{0.4007813} x_6^{0.3177220} x_7^{0.0947089} x_8^{0.5107203} x_9^{0.0725582} x_{10}^{-0.3945743} x_{11}^{0.3140792} x_{12}^{0.1943534} x_{13}^{0.7474807} \quad (R^2=0.96)$$

In 1991 changes in the practice of measuring the Icelandic breeding horses were introduced. The number of body measurements registered were reduced to 11 for stallions and 4 for mares. Correspondingly deducted versions of the equation above might therefore be of practical value.

A reduced allometric equation for estimation of weight on the basis of 11 body measurements (stallions) is presented below:

$$\text{Weight (kg)} = e^{-7.0078371} x_3^{0.0132616} x_4^{-0.2886477} x_5^{0.4953467} x_6^{0.3628687} x_7^{0.1835418} x_8^{0.6156548} x_9^{0.3623536} x_{10}^{-0.2451247} x_{11}^{0.4982869} x_{12}^{0.3603766} x_{13}^{0.7848069} \quad (R^2=0.95)$$

A further reduction to match the measurements presently registered on mares leads to the following equation:

$$\text{Weight (kg)} = e^{-9.2219019} x_3^{1.1573730} x_4^{-0.2374253} x_9^{1.5658792} x_{12}^{1.0014551} \quad (R^2=0.91)$$

It should be noticed, however, that these equations are developed from a material on growing stallions. Their applicability for predicting the weight of mares (with considerably thinner legs) has not been confirmed so

far. If the measurements on circumference of girth (2) and length of body (13) can be added to the four body measurements included in the last equation above the accuracy of estimated weight will be enhanced to $R^2=0.94$. The corresponding equation including 6 body measurements is as follows:

$$\text{Weight (kg)} = e^{-9.7281207} x_2^{1.0353137} x_3^{0.4425671} x_4^{-0.2827031} x_9^{0.4681472} x_{12}^{0.3976195} x_{13}^{1.1487190} \quad (R^2 = 0.94)$$

These equations are easily programmed and computed by personal computers.

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