# Comparison of live weight and body measurements of adult brood mares from different genotypes in Hungary

# Különböző genotípusú kifejlett tenyészkancák élősúlyának és testméreteinek összehasonlítása Magyarországon

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## Abstract

Live weight and 21 body measurements of 110 Thoroughbred, 75 Gidran, 109 Nonius, 97 Hungarian Sport Horse, 172 Hungarian Cold Blooded Horse and 20 Murinsulaner type adult brood mares in 28 studs were evaluated in Hungary. One way ANOVA was used to compare the genotypes. Some body measure indices were determined. Phenotypic correlation coefficients between the live weight and body measurements were estimated. Regression equations were developed to estimate the live weight from body measurements. Significant differences were found between the live weight and 21 body measurements of different genotypes. The rank of the investigated genotypes according to live weight was as follows: Hungarian Cold Blooded Horse (742.1 kg), Murinsulaner type (649.3 kg), Nonius (614.9 kg), Hungarian Sport Horse (600.9 kg), Gidran (563.4 kg) and Thoroughbred (542.0 kg). The results of girth measurements for the warm blooded breeds were similar to the data found in the literature. Considerable difference was found between the genotypes in body measure indices. The absolute and relative body size values prove clearly and objectively, that there are significant differences in the conformation of Thoroughbred, Gidran, Nonius, Hungarian Sport Horse, Hungarian Cold Blooded Horse and Murinsulaner type adult brood mares. The most close relationship with the live weight ($r=0.89-0.92$; $P<0.01$) was shown the body condition and nutritional status related measurements (heart girth, 2$^{nd}$ width of rump). For the estimation of live weight with regression model the necessary data are as follows: hearth girth, 2$^{nd}$ width of rump and length of body ($R^2=0.91$; $P<0.01$).

**Keywords**: brood mare, genotype, live weight, body measurement, live weight estimation

## Összefoglalás

A Szerzők 110 angol telivér, 75 gidrán, 109 nóniusz, 97 magyar sportló, 172 magyar hidegvérű és 20 muraközi típusú, kifejlett tenyészkanca élősúlyát és 21 testméretét egytényezős varianciaanalízissel hasonlították össze 28 magyarországi ménesben. Munkájuk során néhány testarány indexet is kiszámították. Az élősúly és a testméretek között fenotípusos korrelációs együtthatókat határoztak meg. Az élősúly testméreti adatokból történő becsléséhez regresszió-analízist alkalmaztak. A hat vizsgált genotípus élősúlya, és mind a 21 felvett testmérete egymástól szignifikánsan különbözött. A kifejlett tenyészkancák élősúlyának sorrendje a következő volt: magyar hidegvérű (741,2 kg), muraközi típus (649,3 kg), nóniusz (614,9 kg), magyar sportló (600,9 kg), gidrán (563,4 kg), angol telivér (542,0 kg). A körméretekre kapott eredmények a melegvérű fajták esetén egyezőek voltak a szakirodalmi adatokkal. A legfontosabb testarány indexekben számottevő különbséget találtak a genotípusok között. Az abszolút és relatív testméreti értékek segítségével egyértelműen és objektíven bizonyítható, hogy az angol telivér, gidrán, nóniusz, magyar sportló, magyar hidegvérű és muraközi típusú kancák küllemében jelentős eltérések vannak. Az élősúllyal a legszorosabb kapcsolatot (r=0,89-0,92; P<0,01) a kondícióval, tápláltsági állapottal összefüggő testméretek (övméret, far II. szélesség) mutatták. Az élősúly becslésére szolgáló regressziós egyenlethez az övméret, a far II. szélesség és a törzshosszúság ismerete szükséges ($R^2$=0,91; P<0,01).

**Kulcsszavak**: tenyészkanca, genotípus, élősúly, testméret, élősúlybecslés

## Introduction and literature review

The conformation scoring of horses serves useful pieces of information for breeder which is not replaceable with other examination. However, conformation is a little bit subjective, but together with body measurements and measurement-indices it can be an objective source of character of the animal. Relationship exists between conformation, performance and feasibility in all species of farm animals especially in case of horse. The conformation, constitution, the ratio of different parts of body is important for moving, riding, jumping and draught (Mihók, 2004).

Different breeds of horses have different conformation in most of cases. A breed has special characters such as colour, conformation, etc. which are features of a breed. These features together with most important data of a breed are listed in breed standard. Since breeds are changing through breeding program and selection, the information in breed standard have to be updated in a given periods.

However, sport horses are tested worldwide, there is lack of information about conformation and body measurements of different breeds of horses in international literature (Holmström et al., 1990; McManus et al., 2005; Molina et al., 1999; Kashiwamura et al., 2001; Zechner et al., 2001; Kavazis and Ott, 2003; Cabral et al., 2004; Sadek et al., 2006; Smith et al., 2006; Batista Pinto et al., 2008; Druml et al., 2008; Ringler and Lawrence, 2008). About a few well known breeds (Thoroughbred etc), there are some peaces of research results, but the small, native breeds are without comparable experimental data. Especially a little information about conformation of different breeds in native literatures (Mihók and Jónás, 2005; Gulyás et al., 2007; Posta and Komlósi, 2007ab; Posta et al., 2007ab; Bene et al., 2009, 2013).

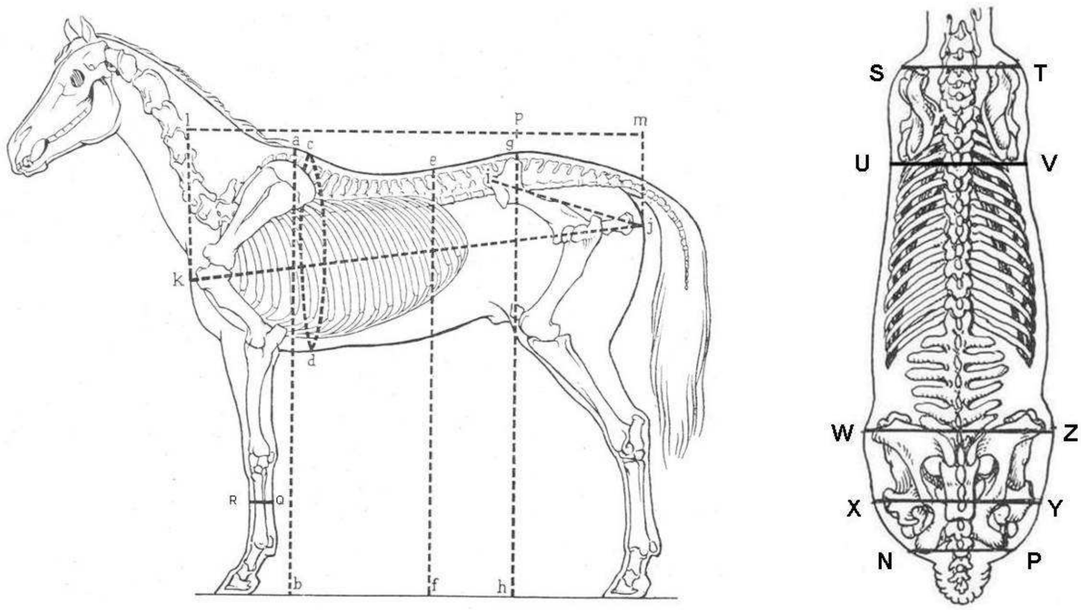
Based on the cited literature above the aim of this study was to take body weight, body measurements, calculate relative body measurements and measurement-indices of adult mares of six genotypes, and make comparison between them. Also, we wanted to study the possibility of body weight estimation based on body measurements.

## Material and methods

Live weight and 21 body measurements of 583 adult (over the age of 4.0 years, of cold blooded, and 4.5 years of warm blooded) brood mares from six genotypes (110 Thoroughbred, 75 Gidran, 109 Nonius, 97 Hungarian Sport Horse, 172 Hungarian Cold Blooded Horse and 20 Murinsulaner type of Hungarian Cold Blooded Horse) in 28 studs - Agostyán, Bak, Csákvár, Csordakút, Diószpuszta, Enying-Sáripuszta, Gölle, Gyűrűs, Hobol, Hortobágy-Máta, Kaposvár, Kerteskő, Keszthely, Lulla, Magyarkeresztúr, Marócpuszta, Mány, Mezőhegyes, Nyőgér, Őriszentpéter, Pápa-Törzsökhegy, Pókaszepetk, Rádiháza, Sárbogárd, Solt-Nagymajor, Söjtör, Tiszaföldvár and Vakola - in Hungary were evaluated.

Live weight was measured by transportable digital animal scale (type: ICONIX F1, measuring accuracy over 500 kg was ±2 kg). The body measurement data was collected by traditional recording devices, such as measuring stick, tape measure and caliper (Figure 1).

Figure 1. Recording body measurements on horse Schandl (1955)
1. ábra. A testméretek felvétele a lovon Schandl (1955)




a-b: height at withers; e-f: height of back; g-h: height of rump: l-m: length of body; k-j: diagonal length of body; p-m: length of rump; i-j: diagonal length of rump; c-d: hearth girth; d-b: height of bieler-point; R-Q: cannon girth; S-T: width of breast; U-V: width of chest; W-Z: 1st width of rump (width of hips); X-Y: 2nd width of rump; N-P: 3rd width of rump (width of sitter bulbs)

Since there was no statistically verifiable effect of the former age on the evaluated traits, one way ANOVA (F-test) was used to compare the genotypes and analyze the correlation between live weight and body measurement data. In cases where the F-test showed significant difference, Tukey-test (for different number of elements) was used to reveal the differences between genotypes.

Some body measurement indices and relative (in percentage of height at withers measured with stick) body measurements were also determined. The calculation method of body measurement indices is shown in Table 1 (Bodó and Hecker, 1992; Cabral et al., 2004; Druml et al., 2008).

Table 1. Calculation of body measure indices*
1. táblázat. A testarány indexek számítása*

| Name of body measurement index | | Calculation |
|---|---|---|
| Quadratic index | = | Height at withers / length of body x 100 |
| Weight index | = | Depth of chest / height at withers x 100 |
| Weight index by *Röhrer* | = | Live weight / height at withers x 100 |
| Caliber index | = | (Hearth girth / height at withers) x (cannon girth / height at withers) 0x 1000 |
| Overbuilt index | = | Height at rump / height at withers x 100 |
| Stubby index | = | Hearth girth / diagonal length of body x 100 |
| Body index | = | Length of body / hearth girth x 100 |
| Chest index | = | Width of chest / hearth girth x 100 |
| Conformation index | = | (Hearth girth)$^2$ / height at withers / 100 |
| The index of head | = | Length of head / width of head x 100 |
| Spannung | = | Hearth girth - height at withers |

*Bodó and Hecker (1992), Cabral et al. (2004), Druml et al. (2008)

Phenotypic correlation values were calculated between live weight and body measurements.

Based on the data of 568 mares three linear regression equations, a “theoretical”, a “practical” and a “general” were developed for body weight estimation from body measurement data.

Live weight was estimated from body measurement data by multivariate linear regression equation using the backward, stepwise and enter methods (dependent variable was the actual, with scale measured live weight; independent variables were the body measurements). Such information may be particularly valuable in studs, where it is not possible to measure the weight of horses.

Data preparation was made by the Microsoft Excel 2003 program, and the SPSS 9.0 (1998) program package was used to evaluate the database.

## Results and discussion

Table 2 shows the live weight, the height-, the width- and the girth measurements of head and chest of the evaluated adult mares. There were significant differences

(P<0.01) in all cases, without exception, between the studied genotypes. The highest body weight (741.2 kg), as it was expected, was shown by Hungarian Cold Blooded Horse. Murinsulaner type of Hungarian Cold Blooded Horse was by 100 kg lighter (649.3 kg), than the previously mentioned one. Among warm blooded genotypes Nonius had the highest live weight (614.9 kg) followed with a little difference by the Hungarian Sport Horse (600.9 kg). Gidran showed significantly higher, 563.4 kg, weight than the lightest Thoroughbred (542.0 kg) mares. The results for live weight of this study shoe the same tendency of the results available as seen in literature (Schandl, 1955; Ócsag and Fehér, 1976; Hintz et al., 1978, 1979; Bodó and Hecker, 1992), but our data are a little bit higher than those found in literature.

Table 2. Body measurements of different genotype adult brood mares
2. táblázat. A különböző genotípusú kifejlett tenyészkancák testméretei

| Body measure-ment | Genotype | | | | | | Total | P |
|---|---|---|---|---|---|---|---|---|
| | THO | GID | NON | HSH | HCB | MUT | | |
| LW (kg) | $^{a}$542.0 | $^{b}$563.4 | $^{c}$614.9 | $^{c}$600.9 | $^{d}$741.2 | $^{e}$649.3 | 625.1 | <0.01 |
| HW1 (cm) | $^{a}$160.9 | $^{b}$162.5 | $^{c}$164.7 | $^{c}$165.7 | $^{d}$159.8 | $^{e}$153.7 | 162.0 | <0.01 |
| HW2 (cm) | $^{a}$168.8 | $^{a}$167.6 | $^{b}$174.3 | $^{b}$174.8 | $^{c}$170.1 | $^{d}$162.7 | 170.9 | <0.01 |
| HB (cm) | $^{a}$151.9 | $^{b}$154.2 | $^{b}$154.8 | $^{c}$156.1 | $^{a}$151.2 | $^{d}$146.3 | 153.1 | <0.01 |
| HR (cm) | $^{a}$159.9 | $^{b}$161.2 | $^{b}$161.7 | $^{c}$163.0 | $^{a}$160.0 | $^{d}$154.6 | 160.8 | <0.01 |
| DC (cm) | $^{a}$75.5 | $^{a}$75.3 | $^{b}$77.8 | $^{b}$77.8 | $^{c}$79.8 | $^{a}$75.2 | 77.4 | <0.01 |
| HBP (cm) | $^{a}$85.4 | $^{bc}$87.2 | $^{b}$87.0 | $^{c}$87.9 | $^{d}$79.1 | $^{d}$78.5 | 84.5 | <0.01 |
| LB1 (cm) | $^{a}$163.3 | $^{b}$165.7 | $^{c}$171.7 | $^{d}$169.1 | $^{e}$173.4 | $^{ab}$166.1 | 169.1 | <0.01 |
| LB2 (cm) | $^{a}$167.5 | $^{b}$170.3 | $^{c}$175.2 | $^{d}$173.3 | $^{e}$177.4 | $^{bd}$171.1 | 173.0 | <0.01 |
| LN (cm) | $^{a}$93.6 | $^{ab}$93.9 | $^{c}$91.7 | $^{b}$95.3 | $^{d}$89.0 | $^{e}$82.2 | 91.8 | <0.01 |
| LBK (cm) | $^{a}$85.2 | $^{b}$87.9 | $^{c}$91.6 | $^{cd}$90.9 | $^{d}$89.8 | $^{a}$85.0 | 89.0 | <0.01 |
| LR (cm) | $^{a}$49.6 | $^{b}$53.7 | $^{c}$56.8 | $^{d}$58.5 | $^{e}$61.4 | $^{b}$53.9 | 56.6 | <0.01 |
| LH (cm) | $^{a}$59.3 | $^{b}$61.3 | $^{c}$63.5 | $^{d}$62.6 | $^{e}$68.1 | $^{cd}$63.8 | 63.4 | <0.01 |
| WH (cm) | $^{a}$22.9 | $^{a}$23.1 | $^{b}$24.0 | $^{c}$23.7 | $^{d}$26.5 | $^{e}$25.1 | 24.3 | <0.01 |
| WB (cm) | $^{a}$46.0 | $^{b}$43.0 | $^{c}$45.1 | $^{c}$45.2 | $^{d}$54.4 | $^{e}$51.2 | 47.6 | <0.01 |
| WC (cm) | $^{a}$48.0 | $^{a}$47.2 | $^{b}$49.1 | $^{a}$47.7 | $^{c}$57.4 | $^{c}$56.2 | 50.7 | <0.01 |
| WR1 (cm) | $^{a}$56.0 | $^{a}$56.7 | $^{b}$58.6 | $^{b}$58.3 | $^{c}$66.2 | $^{d}$63.4 | 60.3 | <0.01 |
| WR2 (cm) | $^{a}$54.2 | $^{a}$53.4 | $^{b}$56.3 | $^{b}$56.6 | $^{c}$63.7 | $^{d}$60.2 | 57.9 | <0.01 |
| WR3 (cm) | $^{a}$23.2 | $^{a}$22.8 | $^{b}$20.9 | $^{b}$21.5 | $^{c}$25.1 | $^{c}$24.9 | 23.0 | <0.01 |
| HG (cm) | $^{a}$192.1 | $^{a}$192.7 | $^{b}$198.3 | $^{c}$196.3 | $^{d}$212.2 | $^{e}$204.9 | 200.4 | <0.01 |
| CG1 (cm) | $^{a}$19.8 | $^{a}$19.9 | $^{b}$21.1 | $^{c}$20.6 | $^{d}$24.8 | $^{e}$22.2 | 21.5 | <0.01 |
| CG2 (cm) | $^{a}$22.0 | $^{a}$22.4 | $^{b}$23.5 | $^{c}$22.9 | $^{d}$28.3 | $^{e}$24.8 | 24.2 | <0.01 |

THO = Thoroughbred; GID = Gidran; NON = Nonius; HSH = Hungarian Sport Horse; HCB = Hungarian Cold Blooded Horse; MUT = Murinsulaner type of HCB; LW = live weight; HW1 = height at withers with stick; HW2 = height at withers with tape; HB = height of back; HR = height of rump; DC = depth of chest; HBP = height of bieler-point; LB1 = length of body; LB2 = diagonal length of body; LN = length of neck; LBK = length of back; LR = length of rump; LH = length of head; WH = width of head; WB = width of breast; WC = width of chest; WR1 = 1$^{st}$ width of rump; WR2 = 2$^{nd}$ width of rump; WR3 = 3$^{rd}$ width of rump; HG = hearth girth; CG1 = cannon girth front left; CG2 = cannon girth rear left; treatments without the same superscript differ significantly (P<0.05)

As for the height measurements, the highest values were reached by Gidran, Hungarian Sport Horse and Nonius: height at withers by stick 165.7-164.7 cm height at withers by tape 174.8, and 174.3 cm, height of back156.4, and 154.8 cm, height of rump 163.0, and 161.7 cm. Thoroughbred, Gidran and Hungarian Sport Horse showed similar height measurements, but Murinsulaner type had the lowest measurements: (153.7, 162.7, 146.3, and 154.6 cm, respectively).

Contrary to our expectation, Hungarian Cold Blooded Horse had the longest length of body (173.4 cm). Among warm blooded genotypes Nonius showed the longest body length (171.7 cm). The length measurements in our study were generally longer for each genotype than those were found in the literature (Schandl, 1955; Ócsag and Fehér, 1976; Thompson, 1995; Smith et al., 2006). The rank of warm blooded genotypes was as follows: Nonius, Hungarian Sport Horse, Gidran and Thoroughbred. The Hungarian Cold Blooded Horse had longer length measurements than the Murinsulaner.

Also, there were meaningful differences and tendencies in width measurements among the evaluated genotypes. The Hungarian Cold Blooded Horse showed the highest values in each width measurement (width of breast; width of chest; 1st width of rump (width of hips); 2nd width of rump; 3rd width of rump (width of sitter bulbs), (54.4, 57.4, 66.2, 63.7, and 25.1 cm, respectively). The Hungarian Cold Blooded Horse was followed by Murinsulaner (with width measurements: 51.2, 56.2, 63.4, 60.2, ill. 24.9 cm, respectively) which width measurements were significantly higher than the width measurements of warm blooded horse genotypes. Hungarian Sport Horse and Nonius mares had similar width measurements. Thoroughbred and Gidran had similar width measurements, but they were significantly narrower than the other two warm blooded genotypes.

The girth measurements showed the same tendencies among the evaluated genotypes as there were shown by the previously mentioned measurements. The highest hearth girth was shown by Hungarian cold blooded genotype (212.2 cm) follwed by Murinsulaner (204.9 cm), Nonius (198.3 cm), Hungarian Sport Horse (196.3 cm), Gidran (192.7 cm) and Thoroughbred (192.1 cm). Similar rank was found in both left front and left rear cannon girth. Least front cannon girth was found for Thoroughbred (19.8 cm), while the biggest for Hungarian cold blooded genotype largest (24.8 cm). The difference was 5 cm. The same data for rear cannon girth were 22.0 cm, and 28.3 cm, with 6.3 cm difference.

The results for girth measurements for warm blooded genotypes were similar to the data of literature (Ócsag and Fehér, 1976; Hintz et al., 1978; Bodó and Hecker, 1992; Mihók et al., 2001; Jónás et al., 2006; Smith et al., 2006). However, data for cold blooded genotypes in our study were higher than data available in literature (Schandl, 1955; Bodó and Hecker, 1992; Mihók et al., 2001).

Table 3 shows the body measurement-indices of different genotype adult brood mares, which reflect to the ratio of parts of the body having relationship with each other. Similarly to the body measurement data, there were meaningful differences in body measurement-indices among the evaluated genotypes. Quadratic index and body index of cold blooded genotypes were lower than these indices of warm blooded mares. Opposite to these results, the weight index and stubby index, especially the weight index by Röhrer caliber index, were higher for cold blooded genotypes than for warm blooded ones. Between the Hungarian Cold Blooded Horse and Murinsulaner there were differences only in weight index by Röhrer (463.8 and 422.4) and (206.1 and 192.6). The warm blooded breeds could be classified into two groups. The weight index by Röhrer (373.3 and 362.6), caliber index (154.2 and 147.3) and body index (86.6, and 86.1) of breeds in group no 1 (Nonius and

Hungarian Sport Horse) were higher than that of in group no 2 (Thoroughbred and Gidran (336.9 and 346.7; 146.9 and 145.2; 85.0 and 86.0, respectively). The results of stubby index (113.2-114.7) and chest index (22.3-23.9) for warm blooded breeds were similar to the results of McManus et al. (2005) found for Campeiro breed mares. The values of body index were 85.0-86.6%. According to Cabral et al. (2004) when the body index is between 85-88% the conformation of the horse is harmonic. The quadratic index for cold blooded genotypes was by 2.3-2.6% higher than what Druml et al. (2008) has found for Noriker breed. No meaningful differences were found in caliber index between Murinsulaner (192.6%) in our study and Noriker breed (192.0%) obtained by Druml et al. (2008). The difference is only 0.6%. The values of overbuilt index were 101.1-100.6% which is similar to the results (100.0%) of Druml et al. (2008).

Table 3. Body measure indices of different genotype adult brood mares
3. táblázat. A különböző genotípusú kifejlett tenyészkancák testarány indexei

| Name of body measurement index | Genotype | | | | | | Total |
|---|---|---|---|---|---|---|---|
| | THO | GID | NON | HSH | HCBH | MUT | |
| Quadratic index | 98.5 | 98.1 | 95.9 | 98.0 | 92.2 | 92.5 | 95.8 |
| Weight index | 46.9 | 46.3 | 47.2 | 47.0 | 49.9 | 48.9 | 47.8 |
| Weight index by *Röhrer* | 336.9 | 346.7 | 373.3 | 362.6 | 463.8 | 422.4 | 385.9 |
| Caliber index | 146.9 | 145.2 | 154.2 | 147.3 | 206.1 | 192.6 | 164.2 |
| Overbuilt index | 99.4 | 99.2 | 98.2 | 98.4 | 100.1 | 100.6 | 99.3 |
| Index of head | 259.0 | 265.4 | 264.6 | 264.1 | 257.0 | 254.2 | 260.9 |
| Stubby index | 114.7 | 113.2 | 113.2 | 113.3 | 119.6 | 119.8 | 115.8 |
| Body index | 85.0 | 86.0 | 86.6 | 86.1 | 81.7 | 81.1 | 84.4 |
| Chest index | 23.9 | 22.3 | 22.7 | 23.0 | 25.6 | 25.0 | 23.8 |
| Conformation index | 2.3 | 2.3 | 2.4 | 2.3 | 2.8 | 2.7 | 2.5 |
| Spannung | 31.2 | 30.2 | 33.6 | 30.6 | 52.4 | 51.2 | 38.4 |

THO = Thoroughbred; GID = Gidran; NON = Nonius; HSH = Hungarian Sport Horse; HCB = Hungarian Cold Blooded Horse; MUT = Murinsulaner type of HCB

Table 4 contains the correlation coefficient values obtained on the total data of 585 mares of the evaluated different genotypes.

Body weight showed significant correlation with almost every body measurement with exception of the height at withers measured by stick, height of rump and length of neck. The strongest correlation of the body weight was found with the hearth girth ($r=0.92$; $P<0.01$), with the 2nd width of rump ($r=0.89$; $P<0.01$), with the 1st width of rump (width of hips) ($r=0.87$; $P<0.01$); and with the cannon girth ($r=0.83$, and $r=0.82$; $P<0.01$) measured at left front and rear leg.

Table 5 shows the regression equation for estimation of the live weight ($\hat{y}$). As it can be seen, the most accurate (theoretical) estimation equation contains the length of body, length of back, length of rump, width of breast, 2nd width of rump, hearth girth, cannon girth at left rear leg, which measurements had significant effect on body weight.

The value of fitting ($R^2$) is 0.93 ($P<0.01$), which is much higher than the reference 0.70 value. The practical, easy to use, model ($\hat{y}_{prac}$) of the estimation equation contains the hearth girth (HG), 2nd width of rump (WR2) and length of body (LB).

These measurements are easy and quick to take with tape. The practical equation has $R^2$=0.91 (P<0.01) fitting value, which is almost as high as that of the value of the theoretical equation.

Table 4. Correlations between live weight and body measurements
4. táblázat. Az élősúly és a testméretek között számított korrelációk

| r | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | 10 |
|---|---|---|---|---|---|---|---|---|---|---|
| 11 | 0.02 | *0.27 | *0.64 | *0.70 | *0.69 | *0.78 | *0.87 | *0.89 | *0.92 | *0.83 |
| 1 | | *0.82 | *0.32 | *0.28 | *0.26 | *-0.29 | *-0.11 | *-0.12 | 0.01 | *-0.13 |
| 2 | | | *0.52 | *0.45 | *0.43 | 0.00 | *0.13 | *0.16 | *0.27 | *0.16 |
| 3 | | | | *0.56 | *0.56 | *0.44 | *0.60 | *0.61 | *0.70 | *0.60 |
| 4 | | | | | *0.98 | *0.40 | *0.54 | *0.55 | *0.60 | *0.51 |
| 5 | | | | | | *0.41 | *0.53 | *0.54 | *0.59 | *0.52 |
| 6 | | | | | | | *0.76 | *0.80 | *0.83 | *0.67 |
| 7 | | | | | | | | *0.90 | *0.83 | *0.87 |
| 8 | | | | | | | | | *0.86 | *0.84 |
| 9 | | | | | | | | | | *0.79 |

*P<0,01; height at withers (stick) (1); height at withers (tape) (2); depth of chest (3); length of body (4); diagonal length of body (5); width of chest (6); 1st width of rump (7); 2nd width of rump (8); hearth girth (9); cannon girth (front left) (10); live weight (11)

Table 5. Regression models for estimating live weight from body measurements
5. táblázat. Az élősúly becslésére szolgáló regressziós modellek

| Regression models | B | SE | Standard B | P | $R^2$ |
|---|---|---|---|---|---|
| **1, Academic model**+ | | | | | |
| Constant | -998.517 | 32.641 | - | <0.01 | 0.927 P<0.01 |
| Length of body (cm) | 2.100 | 0.231 | 0.162 | <0.01 | |
| Length of back (cm) | 1.049 | 0.259 | 0.061 | <0.01 | |
| Length of rump (cm) | 1.520 | 0.325 | 0.085 | <0.01 | |
| Width of chest (cm) | 2.391 | 0.375 | 0.149 | <0.01 | |
| 2nd width of rump (cm) (9) | 4.187 | 0.544 | 0.217 | <0.01 | |
| Hearth girth (cm) | 3.031 | 0.261 | 0.337 | <0.01 | |
| Cannon girth (rear left) (cm) | 5.060 | 0.769 | 0.146 | <0.01 | |
| **2, Practical model**# | | | | | |
| Constant | -1093.83 | 33.232 | - | <0.01 | 0.907 P<0.01 |
| Hearth girth (HG) (cm) | 4.222 | 0.247 | 0.470 | <0.01 | |
| 2nd width of rump (WR2) (cm) | 7.216 | 0.504 | 0.373 | <0.01 | |
| Length of body (LB) (cm) | 2.722 | 0.224 | 0.210 | <0.01 | |
| **3, General model**@ | | | | | |
| Constant | -986.241 | 55.102 | - | <0.01 | 0.873 P<0.01 |
| Height at withers with stick (cm) | 0.678 | 0.286 | 0.038 | <0.05 | |
| Heart girth (cm) | 6.073 | 0.222 | 0.676 | <0.01 | |
| Cannon girth (front left) (cm) | 13.431 | 1.073 | 0.313 | <0.01 | |

+estimated with “backward” method; #estimated with „stepwise” method; @estimated with „enter” method

Based on these results the suggested equation to estimate the body weight in practice is the next one:

$\hat{y}_{prac}$ = (4.222 x ÖM) + (7.216 x WR2) + (2.722 x LB) - 1093.830

## Conclusions

The results of live weight and 21 body measurements obtained for 583 adult mares of Thoroughbred, Gidran, Nonius, Hungarian Sport Horse, Hungarian Cold Blooded Horse and Murinsulaner breed or genotype in 28 studs in Hungary are partly similar, partly different to data in literature.

Our study serves new data of live weight ad body measurements of the evaluated genotypes. These data can be used for breed characterization, for improving conformation scoring, and provide new information for teaching.

The live weight and body measurements of the evaluated six genotypes differed significantly from each other. The largest frame, as it was expected, was found in case of Hungarian Cold Blooded genotype. Murinsulaner was by 100 kg lighter and was lower and had shorter neck than the Hungarian Cold Blooded genotype.

Among warm blooded genotypes Nonius mares had the largest frame, however the Hungarian Sport Horse was not behind her significantly. These results can be explained with the situation that some Nonius mares were used for improving Hungarian Sport Horse. Live weight, length and girth measurements of Nonius and Hungarian Sport Horse were higher than that of Gidran and Thoroughbred.

Contrary to our expectation Gidran was only a little bit heavier than the Thoroughbred. The difference between two genotypes was realised only in live weight, height and length measurements. Thoroughbred proved to be of smallest framed, with lightest head, shortest rump, and smallest girth measurements.

Also, there were differences in the most important body measurement indices, height measurements taking with stick, and the relative measurements among the evaluated genotypes. Based on the absolute and relative measurements, differences in conformation between the evaluated genotypes, the Thoroughbred, Gidran, Nonius, Hungarian Sport Horse, Hungarian Cold Blooded Horse and Murinsulaner, can be proved.

The strongest relation of the body weight ($r=0.89-0.92$; $P<0.01$) was found with condition related measurements such as hearth girth, width measurements, moreover width of rump and cannon girth ($r=0.82-0.87$; $P<0.01$).

For prediction of body weight from body measurements a practical linear regression equation was developed for which hearth girth 2$^{nd}$ width of rump and length of body have to be known. These measurements can be easy and quick to take, and body weight can be estimated exactly ($R^2=0.91$; $P<0.01$) with their help in case when no scale possibility.

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