

## ANALYSIS OF MEASUREMENTS OF LATVIAN WARBLOOD AND LATVIAN HEAVY WARBLOOD SIRES

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### Abstract

The objective of the study was to analyze measurements of the sires used in Latvian Warmblood (LWB) and Latvian Heavy Warmblood (LHWP) breeding programs in the period 2003 – 2017, two major horse populations in Latvia included in one studbook. The Latvian Warmblood has an open studbook for breeding sport horses, whereas the Latvian Heavy Warmblood is a partly closed studbook. Measuring information for all sires with at least one foal born (n=834) in the respective time period was retrieved from the Latvian horse database, with 673 stallions measured at least once. The data consisted of direct measurements – height at withers, chest circumference and cannon bone circumference – and two calculated indices – massivity index and boniness index. Average values of adult stallions were analyzed in four groups – LWB, LHWP, ‘other warmbloods’ and refining breeds, with LWB and ‘other warmbloods’ showing similar average values. Sires were divided by use in breeding into 3-year periods to observe a possible change in the breeding objective and stallion choice, however, no significant differences were found in LWB or LHWP. Average measurements of stallions used in the LWB breeding program (different breeds) were 168.6 ± 4.3 cm for height at withers, 194.4 ± 6.6 cm for chest circumference, 21.8 ± 1.0 cm for cannon bone circumference, massivity index 115.5 ± 3.1, boniness index 13.0 ± 0.5. Average measurements of stallions used in the LHWP breeding program (only LHWP stallions) were 167.6 ± 4.6 cm, 201.4 ± 7.3 cm, 23.7 ± 1.0 cm, respectively, and massivity index 120.0 ± 5.0, boniness index 14.1 ± 0.6. Significant differences between LWB and LHWP stallions were observed in all parameters, except height at withers, and between measurements at the age of 2, 3, 4 years and adult (5 and more years).

**Key words:** horse, body measurements, body indices, breed development.

### Introduction

The Latvian Warmblood is a horse breed reared in the territory of Latvia. The Studbook includes two sections – the Latvian Warmblood (LWB, also called sport type) and the Latvian Heavy Warmblood (LHWP, also called carriage type). The LWB is a warmblood horse suitable for classic equestrian sports and is an open studbook. The Latvian Heavy Warmblood belongs to heavy warmblood breeds and is a partly closed studbook – influx of only a few other breeds is allowed and in a small percentage. The breeding of both LWB and LHWP is regulated by state breeding programs. The choice of stallion for mating is made by the mare owner solely and based on his or her preference, knowledge and financial resources (Orbidāne & Jonkus, 2016). Stallion approvals are organized by horse breeding organisations, but it is not forbidden to use non-approved stallions (Latvijas zirgu..., 2016). The use of LHWP stallions for breeding of LWB is permitted without restrictions, and several LWB stallions have been approved for use in LHWP if they conformed to several criteria. Artificial insemination has been barely available until 2016, therefore the influx of stallions stationed abroad is small, and Latvia-based stallions have been used by natural covering. The number of offspring per stallion is low and population is inhomogeneous, which is also a problem in other small studbooks with undeveloped artificial insemination like the Czech Warmblood (Makovská Krčová, 2012) and the Polish halfbred horse (Lewczuk, 2005).

Internationalization and the pursuit of current trends in global sport horse breeding are increasing

in LWB because of availability of information and artificial insemination, thus making it more similar to other sport horse breeds/ studbooks. The same processes occur elsewhere, as described in the Swedish Warmblood, where 80% of mares are covered by foreign stallions or their semen (Thorén Hellsten *et al.*, 2008), and other European countries (Koenen, Aldridge, & Philipsson, 2004).

In a study concerning changes of measurements and indices in LWB and LHWP broodmares born in the years 1988 – 2013 (Veidemane & Jonkus, 2018), it was concluded that measurements of LWB broodmares significantly differ between years, with a tendency for younger mares to be of lighter sport horse type than older mares. The most significant parameters were cannon bone circumference and boniness index. Measurements of LHWP broodmares showed no influence of birth year on these parameters. Average heights at withers in LWB broodmares were 166.9 ± 4.1 cm and 166.1 ± 4.3 cm in LHWP.

Height at withers is one of the main criteria used by the potential horse purchasers, with the most desired value being at least 167 cm at withers for warmbloods in Germany (Gille & Spiller, 2010).

The objective of the study was to analyze measurements of sires used in LWB and LHWP breeding programs in 2003 – 2017.

### Materials and Methods

Data about LWB and LHWP registered foals born in the years 2002–2017 (n=6721) and their respective sires (n=834) were retrieved from the Agricultural Data

Centre and the Latvian Horse Breeders Association's database. Only sires of breeds allowed for LWB and LHWB with ancestors known in 4 generations have been recorded.

For each stallion having at least one registered offspring during this time period, information about measuring was retrieved from the database of the Latvian Horse Breeders Association. Data included three direct measurements – height at withers, chest circumference and cannon bone circumference. From the direct measurements two indices were calculated, using formulas (1) and (2).

$$\text{Boniness index} = \frac{\text{cannon bone circumference}}{\text{height at withers}} \times 100 \quad (1)$$

$$\text{Massivity index} = \frac{\text{chest circumference}}{\text{height at withers}} \times 100 \quad (2)$$

Two hundred twenty five stallions were measured as adults (5 years old or older), while additional 50 stallions had records of height at withers as adult. 299 stallions were measured as two-year olds, 219 as three-year olds and 103 as four-year olds. One stallion was measured four times, 20 – three times, 180 – twice, 468 – once, but 165 stallions did not have any measurement record at all. As most stallions are approved as 3-year-olds (until 2015 as 2-year-olds), there are insufficient measurements for older horses. Imported adult stallions constituted 34% of the adult stallions group.

An analysis of average values of stallions belonging to different breed groups at adult age was carried out. Stallions were arranged in 4 groups: LWB, LHWB, other warmblood breeds and refining breeds. Other warmblood breed group consisted of 23 Holsteiners, 10 Oldenburgers, 8 Hanoverians, 7 Westphalians, 7 Danish Warmbloods, 7 Dutch Warmbloods (KWPN), 2 Swedish Warmbloods, 1 Estonian Sport Horse, 1 Selle Francais, and 1 Rheinlander. The Refining breeds group consisted of 17 Trakehners, 9 Thoroughbreds and 3 Arabians.

The sires of registered LWB and LHWB foals born in the years 2003 – 2017 were grouped in periods of 3 years – 2003 – 2005, 2006 – 2008, 2009 – 2011, 2012 – 2014 and 2015 – 2017 – regardless of the exact number of foals. The data consisted of 165 full records with 50 more records of height at withers. Not all sires of warmblood foals born in Latvia in the respective year were included in the study, as some foals are registered with the Oldenburg or Zangersheide studbooks, or due to the sire's pedigree deficiencies (less than 4 generations, influx of non-allowed breeds). A measurement analysis for sires used in each 3-year period was conducted to calculate mean values and standard deviation and compared between 3-year periods to determine a possible change in choice of stallion in making a modern sport type horse.

The statistical analysis of average values of LWB and LHWB stallion measurements at the age of 2, 3, 4 and adult (age 5 and older) was carried out and compared. We examined the influence on measurements of two independent factors – breed (LWB or LHWB) and age at measuring – with a two-way analysis of variance.

The statistical analysis was performed on 'R' and Microsoft Excel. For the analysis of impact of one influencing factor one-way ANOVA was used, but for the impact of two influencing factors we used two-way ANOVA.

## Results and Discussion

The data analysis showed a difference between measurements in four breed groups (Table 1). LWB stallions and 'other warmblood breeds' (imported) stallions were similar in both direct measurements and body indices. Both groups are closely related and have the same breeding objective – a horse for the classic equestrian sports of showjumping, dressage and eventing. Higher variability in the LWB group can be explained by different selection – it includes non-approved stallions (too small or too refined/heavy to get the breeding approval), while most other warmblood breed stallions were selected, bought and imported for breeding at an adult age. It corresponds to the data of the Polish warmblood breeds, where offspring of the historic Polish warmblood breed Wielkopolski and Malopolski stallions showed greater variability in measurements than offspring of sport breed stallions (Lewczuk, 2005).

The LHWB has a significantly higher chest circumference, cannon bone circumference, massivity index and boniness index than other group stallions, but smaller height at withers than the LWB and other warmbloods. Height at withers is nevertheless higher than in other breeds belonging to the heavy warmblood group – Schweres Warmblut in Germany (minimum requirement 158 cm) (Zuchtprogramme..., 2009) and the Groningen horse in Netherlands, where the minimum requirement for a stallion is 158 cm at the age of 3 and 160 cm at the age of 4 (Keuringsreglement, 2014). When compared with the Silesian breed, LHWB has a higher height at withers (167.0 cm in LHWB versus 162.1 cm in the Silesian), a bigger chest circumference (201.2 cm versus 199.2 cm), a bigger cannon bone circumference (23.7 cm versus 23.2 cm), but smaller massivity index (120.5 versus 122.9) and boniness index (14.2 versus 14.3) (Walkowicz *et al.*, 2013), which characterizes the LHWB as a taller heavy warmblood horse with some sport horse features. The fourth group, refining breeds, has lower average values for measurements and indices. Higher variability can be explained by the fact that several breeds were included in the group,

Table 1

**The average measurements of sires belonging to different breed groups**

Breed groups	N	Height at withers		Chest circumference		Cannon bone circumference		Massivity index		Boniness index	
		cm	V, %	cm	V, %	cm	V, %	index	V, %	index	V, %
LWB	68	169.7 ± 3.6 <sup>c</sup>	2.1	195.8 ± 6.1 <sup>b</sup>	3.1	22.3 ± 0.9 <sup>b</sup>	4.1	115.4 ± 3.3 <sup>a</sup>	2.9	13.1 ± 0.5 <sup>b</sup>	3.7
LHWP	59	167.0 ± 4.5 <sup>b</sup>	2.7	201.2 ± 9.2 <sup>c</sup>	4.5	23.7 ± 1.2 <sup>c</sup>	4.9	120.5 ± 5.4 <sup>b</sup>	4.5	14.2 ± 0.6 <sup>c</sup>	4.3
Other warmblood breeds	68*	169.1 ± 3.0 <sup>c</sup>	1.7	195.5 ± 5.2 <sup>b</sup>	2.7	21.9 ± 0.6 <sup>b</sup>	2.9	115.7 ± 2.9 <sup>a</sup>	2.5	13.0 ± 0.4 <sup>b</sup>	3.0
Refining breeds	29	164.3 ± 7.2 <sup>a</sup>	4.3	188.9 ± 7.7 <sup>a</sup>	4.1	20.6 ± 1.2 <sup>a</sup>	5.9	115.0 ± 3.3 <sup>a</sup>	2.9	12.6 ± 0.4 <sup>a</sup>	3.3

\* Height at withers, n=118

<sup>a, b, c</sup> – significant differences have been observed between breed groups, p<0.05.

with the Arabians being lower at the withers than the Trakehners and the Thoroughbreds.

An analysis of measurements of stallions used in each 3-year period was carried out to evaluate the mare owner's choice of stallions in the LWB and the LHWP. No significant differences between periods were observed (Table 2). The average height at the withers for breeding stallion in the LWB is 168.6 ± 4.3 cm, which coincides with studies in different sport warmblood breeds with the same origin as the LWB (Lewczuk, 2005; Catalano *et al.*, 2016). The average chest circumference was 194.4 ± 6.6 cm and the average cannon bone circumference was 21.8 ± 1.0 cm. However, there is a deficiency of information about current average measurements in many related sport horse breeds (Bene *et al.*, 2015), with most of it coming from Eastern and Central European small studbooks.

Although no signs of breeding progress or change of breeding objective by use of different types of stallion can be observed, these aims could be reached also by a change in preferences for broodmares. A gradual refinement of the LWB mare type was

observed in our previous study (Veidemane & Jonkus, 2018), with younger mares having significantly lower average values for cannon bone circumference and boniness index. Furthermore, the time period used in this study (16 years) is probably too short for revealing a change in the breeding objective, even if this study concerns the actual use of stallions, not its results. The generation interval for warmblood sport horses is estimated to be longer than 10 years – 12.0 years for males, 11.5 for females in the Selle Français (Dubois & Ricard, 2007), 11.1 years for males, 10.3 years for females in the Swedish Warmblood (Viklund, 2010), 10 ± 0.06 in Trakehner (Teegen, Edel, & Thaller, 2009).

No significant difference was found in measurements of LHWP sires used in the years 2003 – 2017 (Table 3). Average values have been 167.6 ± 4.6 cm for height at the withers, 201.4 ± 7.3 cm for chest circumference and 23.7 ± 1.0 cm for cannon bone circumference. These measurements make the LHWP potentially unique among other horse breeds as being the tallest from the heavy warmblood breed group, with the Alt-Oldenburger being the most similar

Table 2

**Comparison of measurements of sires used in 3-year periods in LWB breeding program**

Period	Sires, n*	Sires, n**	Height at withers, cm	Chest circumference, cm	Cannon bone circumference, cm	Massivity index	Boniness index
2003-2005	87	233	168.2 ± 4.9	195.0 ± 6.9	21.7 ± 1.0	116.0 ± 3.3	12.9 ± 0.5
2006-2008	76	267	168.2 ± 5.3	194.4 ± 7.2	21.7 ± 1.2	115.8 ± 3.9	12.9 ± 0.4
2009-2011	72	266	168.6 ± 4.6	194.1 ± 6.5	21.7 ± 1.0	115.2 ± 3.2	12.9 ± 0.5
2012-2014	64	233	168.5 ± 5.6	192.9 ± 7.2	21.7 ± 1.2	114.6 ± 3.2	12.9 ± 0.5
2015-2017	43	189	169.2 ± 3.1	194.7 ± 4.8	21.9 ± 0.7	114.8 ± 2.7	12.9 ± 0.4
Average	165	707	168.6 ± 4.3	194.4 ± 6.6	21.8 ± 1.0	115.5 ± 3.1	13.0 ± 0.5

\* Number of stallions with at least one foal in a 3-year period and adult measurement record.

\*\* Total number of stallions with at least one foal in a 3-year period.

Table 3

**Comparison of measurements of sires used in 3-year periods in LHWB breeding program**

Period	Sires, n*	Sires, n**	Height at withers, cm	Chest circumference, cm	Cannon bone circumference, cm	Massivity index	Boniness index
2003-2005	31	43	167.2 ± 4.9	201.3 ± 8.1	23.6 ± 1.3	119.9 ± 6.3	14.1 ± 0.7
2006-2008	42	63	167.6 ± 4.3	201.8 ± 7.1	23.7 ± 1.2	120.4 ± 4.6	14.2 ± 0.7
2009-2011	41	63	167.9 ± 4.5	201.0 ± 6.9	23.6 ± 1.0	119.8 ± 4.8	14.1 ± 0.6
2012-2015	31	45	168.8 ± 4.8	201.5 ± 6.2	23.7 ± 1.1	119.5 ± 4.1	14.0 ± 0.7
2015-2017	28	44	168.9 ± 4.6	201.1 ± 7.2	23.6 ± 1.1	119.1 ± 4.2	14.0 ± 0.6
Average	69	126	167.6 ± 4.6	201.4 ± 7.3	23.7 ± 1.0	120.0 ± 5.0	14.1 ± 0.6

\* Number of stallions with at least one foal in a 3-year period and adult measurement record.

\*\* Total number of stallions with at least one foal in a 3-year period.

in stallion measurement requirements (Übernahme des Original..., s.a).

A comparison with the results of the LWB and the LHWB mare measurement analysis (Veidemane & Jonkus, 2018), reveals clear sexual dimorphism, with mares having lower average height at the withers and cannon bone circumference, but a higher average value of chest circumference. This difference has a secondary effect on both indices, with massivity index being higher in mares than stallions, but the boniness index being higher in stallions than in mares. Sexual dimorphism is concluded also by other studies, with mares being lower at the withers and exhibiting a smaller cannon bone circumference (Alagic *et al.*, 2002; Kapron *et al.*, 2013).

The analysis of LWB and LHWB stallions was carried out for stallions aged 2, 3 and 4 years, with the adult group including all stallions measured at least 5 years old (Table 4). Significant differences between measurements of LWB and LHWB sires were observed in chest circumference, cannon bone circumference, massivity index and boniness index. The height at

the withers at different ages is similar in LWB and LHWB sires. The only peculiarity is in the adult horse group, as this measurement for LHWB is lower than in 4-year old LHWB horses. This could be explained by the influx of old stallions after the beginning of the preservation of the LHWB as a genetic resource in 2004. These stallions were first measured only as adults (Orbidāne *et al.*, 2014). Significant differences were found between measurements and indices at different ages in both LWB and LHWB.

**Conclusions**

Comparison of measurements of adult stallions among Latvian Warmblood, Latvian Heavy Warmblood, other allowed warmblood breeds and refining breeds revealed that the Latvian Warmblood is similar in parameters to other warmblood breeds, but measurements of Latvian Heavy Warmblood and refining breed stallions were significantly different.

Possible signs of a change in the breeding objective and stallion choice were not reflected in the body measurements and indices of interest. Average values

Table 4

**Measurements of Latvian Warmblood and Latvian Heavy Warmblood stallions at different ages**

Age, years	Sires by group	n	Height at withers, cm	Chest circumference, cm	Cannon bone circumference, cm	Massivity index	Boniness index
2	LWB	228	162.8 ± 4.5 <sup>a</sup>	184.8 ± 7.4 <sup>Aa</sup>	21.4 ± 0.9 <sup>Aa</sup>	113.5 ± 3.5 <sup>Aa</sup>	13.1 ± 0.5 <sup>Aa</sup>
	LHWB	32	161.8 ± 3.5 <sup>a</sup>	184.0 ± 7.9 <sup>Ba</sup>	22.1 ± 1.0 <sup>Ba</sup>	114.3 ± 4.4 <sup>Ba</sup>	13.7 ± 0.5 <sup>Ba</sup>
3	LWB	136	166.6 ± 4.0 <sup>b</sup>	190.4 ± 6.4 <sup>Ab</sup>	21.7 ± 0.9 <sup>Ab</sup>	114.3 ± 3.0 <sup>Ab</sup>	13.0 ± 0.4 <sup>Aa</sup>
	LHWB	33	166.3 ± 3.1 <sup>b</sup>	195.1 ± 7.2 <sup>Bb</sup>	22.9 ± 0.8 <sup>Bb</sup>	117.3 ± 3.3 <sup>Bb</sup>	13.8 ± 0.5 <sup>Ba</sup>
4	LWB	63	168.3 ± 3.7 <sup>c</sup>	193.8 ± 5.5 <sup>Ac</sup>	22.0 ± 0.8 <sup>Ab</sup>	115.2 ± 3.1 <sup>Ab</sup>	13.1 ± 0.4 <sup>Aa</sup>
	LHWB	13	168.3 ± 4.4 <sup>c</sup>	200.0 ± 4.6 <sup>Bc</sup>	23.5 ± 0.6 <sup>Bb</sup>	118.9 ± 2.4 <sup>Bb</sup>	14.0 ± 0.4 <sup>Ba</sup>
Adult	LWB	68	169.7 ± 3.6 <sup>d</sup>	195.8 ± 6.1 <sup>Ad</sup>	22.3 ± 0.9 <sup>Ac</sup>	115.4 ± 3.3 <sup>Ac</sup>	13.1 ± 0.5 <sup>Ab</sup>
	LHWB	60	167.0 ± 4.5 <sup>d</sup>	201.2 ± 9.1 <sup>Bd</sup>	23.7 ± 1.1 <sup>Bc</sup>	120.6 ± 5.4 <sup>Bc</sup>	14.2 ± 0.6 <sup>Bb</sup>

<sup>A, B</sup> – significant differences have been observed between breed types,  $p < 0.05$ .

<sup>a, b, c, d</sup> – significant differences have been observed between measuring age,  $p < 0.05$ .

of measurements of sires were similar in the period 2003 – 2017 and coincide with the recommendations in the breeding program.

The data on measurements in adult stallions is insufficient, many of them are entered in Studbook measured as 2- and 3-year-old horses. The

recommendation is to measure breeding stallion repeatedly until at least 5 years old to obtain adult horse measurements for Studbook entry.

Further studies on growth dynamics in Latvian Warmblood and Latvian Heavy Warmblood should be done to determine the age of maturing in this breed.

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