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Genetic analyses of linear conformation and performance traits in Warmblood horses

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Background

- conformation & performance evaluations of studbooks
  → valuating scores
  - PRO: easy to use / fast, clear ranking
  - CONTRA: subjective, loss of detailed information
- high reputation of linear profiling
  - PRO: more objective, specific trait definition, better discrimination
  - CONTRA: requirements of time (increased no. of traits) / personnel

  → intense R&D activities on how to implement linear profiling in the Warmblood horse – different approaches:
  1) simplified linear schemes
  2) documentation assistance for selected events
  3) efficient documentation in (all) regular breeding events

Linear profiling in Oldenburg

- 'quasi-linear' descriptive notes
  - common / necessary (requests to comment on individual horses)
  - personal style (extent, detailedness, form)
- development of own linear system
  - extensive scheme (no compromise concerning spectrum of traits)
  - adherence to individual extent of documentation (own responsibility)
  - linear profile as part of the official assessment (judging commission + documentation assistance, no extra-time)
  - mobile device for recording (tablet PC)
- routine linear profiling at regular breeding events of the Oldenburg horse breeding societies (OL, OS) since 2012

Aims

- estimation of genetic parameters for linear conformation and performance traits
- assessment of opportunities / conditions of including linear data from different age groups in future breeding programs

Data

- linear profiles (N=2,902) of juvenile and adult horses presented at regular breeding events of OL/OS in 2012 and 2013
  - foal registrations,
  - mare shows, mare performance tests, stallion inspections & approvals
- uniform linear scheme
  - definition of performance traits considering presentation conditions
  - average expression [0] as default, active documentation of deviations from average expression

Trait group	No. of full scale linear traits [-3 to +3]	No. of half scale linear traits [0 to +3]
Conformation (CONF)	56	15
Movement in hand (HMOV)	15	2
Free movement & free jumping (FMOV)	26	8
Movement under rider (RMOV)	24	7

Genetic analyses

- trait definition within age group: juvenile (J), adult (A)
- single records per horse:
  N_J=1,755 (885 , 870), N_A=1,037 (754 , 283)
- estimation of genetic parameters with REML / VCE6 in linear animal models for selected traits
  - within age group (univariate)
  - bivariate across age groups

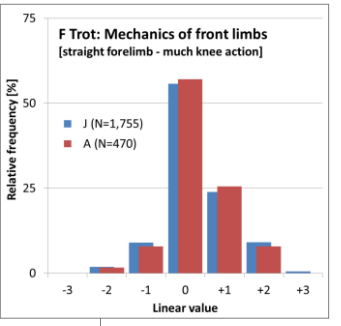
Trait group	UNIVARIATE	BIVARIATE
Conformation (CONF)	J 21 / A 33	18
Performance (HMOV, FMOV, RMOV)	J 10 / A 44	9

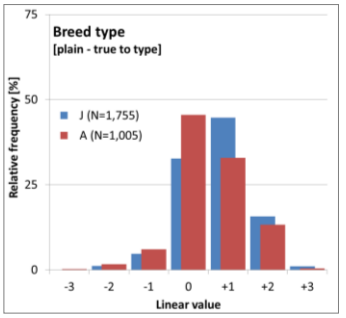
- relationship matrix comprising 14,113 horses (8 generations)

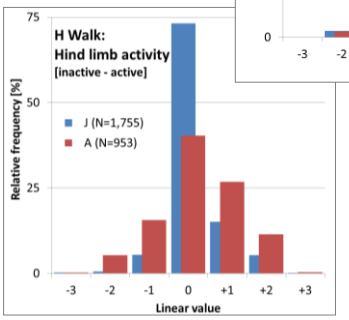
$$y_{ijkl} = \mu + \text{Event X Team}_i + \text{Sex}_j + a_k + e_{ijkl} \quad (J)$$
$$y_{ikl} = \mu + \text{Event X Team}_i + a_k + e_{ikl} \quad (A)$$

Distribution of linear traits

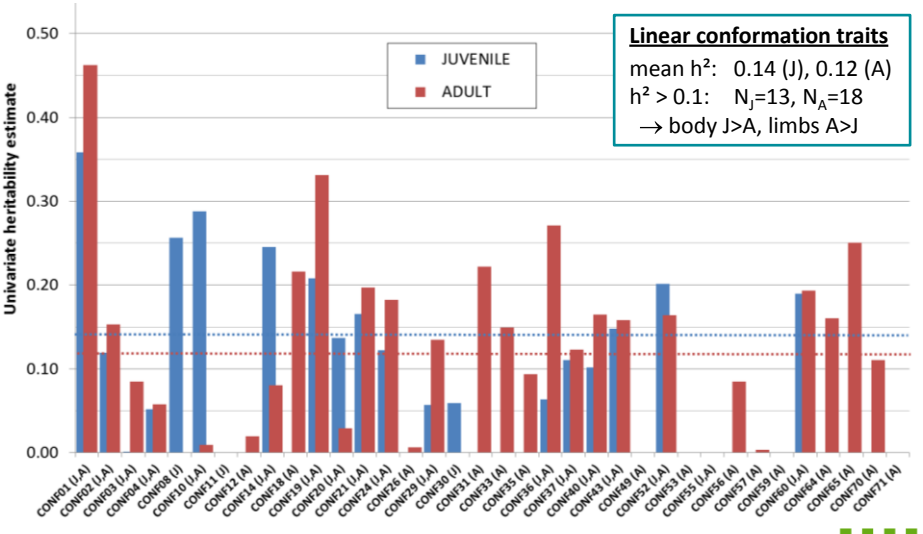
Parameter	JUVENILE	ADULT
Conformation traits (N_J=21, N_A=33)		
Mean	0.06 (-0.16 to +0.72)	0.03 (-0.14 to +0.51)
Std.	0.52 (0.32 to 0.86)	0.50 (0.30 to 0.89)
Performance traits (N_J=10, N_A=44)		
Mean	0.14 (-0.11 to +0.54)	0.11 (-0.28 to +0.50)
Std.	0.64 (0.34 to 0.92)	0.70 (0.34 to 1.04)







Heritability estimates (I)



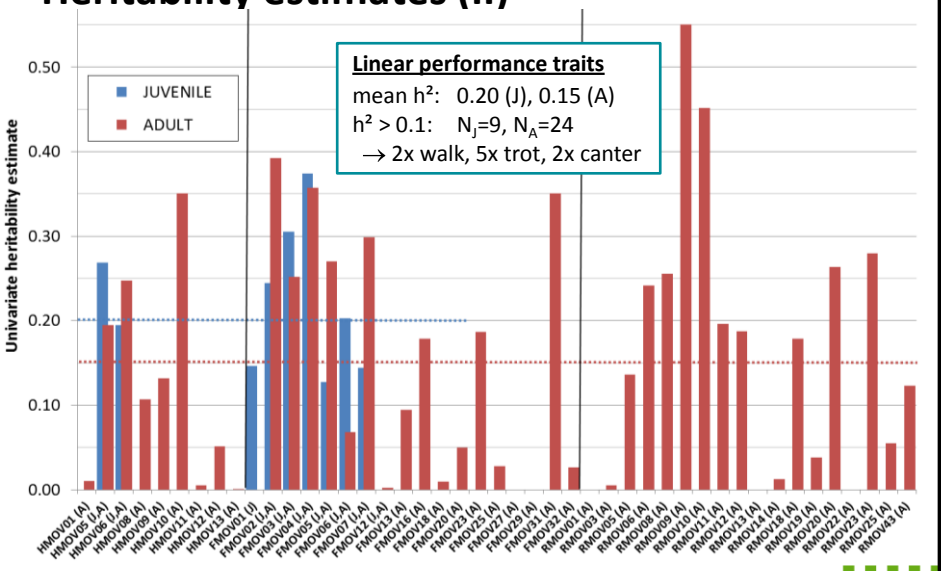
Linear conformation traits

mean h^2: 0.14 (J), 0.12 (A)

$h^2 > 0.1$: N_J=13, N_A=18

→ body J>A, limbs A>J

Heritability estimates (II)



Genetic correlations

Linear trait	JUVENILE (N=1,755)		ADULT (N_{CONF}=1,005; N_{HMOV}=953; N_{FMOV}=470)		JUVENILE - ADULT		
	h^2	SE_{h^2}	h^2	SE_{h^2}	r_g	SE_{rg}	r_p
Breed type	**0.35**	0.079	**0.45**	0.130	**0.58**	0.185	**0.23**
Gender expression	**0.11**	0.057	**0.15**	0.080	**0.54**	0.492	**0.07**
Head coarseness	**0.23**	0.062	**0.06**	0.024	**0.96**	0.241	**0.12**
Stance of forelimb pastern	**0.12**	0.057	**0.13**	0.075	**0.42**	0.429	**0.05**
Hock angulation	**0.22**	0.064	**0.20**	0.093	**0.87**	0.270	**0.18**
Toe stance of forelegs	**0.19**	0.071	**0.26**	0.119	**1.00**	<0.001	**0.22**
H Walk: Length of stride	**0.26**	0.071	**0.19**	0.090	**0.12**	0.277	**0.03**
H Walk: Hindlimb activity	**0.19**	0.058	**0.24**	0.077	**0.19**	0.247	**0.04**
F Trot: Length of stride	**0.29**	0.079	**0.50**	0.220	**0.71**	0.245	**0.27**
F Trot: Mechanics of front limbs	**0.32**	0.073	**0.26**	0.118	**1.00**	<0.001	**0.29**
F Trot: Impulsion	**0.36**	0.070	**0.34**	0.181	**0.97**	0.246	**0.34**
F Trot: Thrust / hind limbs activity	**0.14**	0.052	**0.27**	0.155	**0.77**	0.434	**0.15**

H = movement in hand (foals: walk at the side of their dams), F = free movement

Summary of results

- consistent results of uni- and bivariate analyses (mostly $\Delta h^2 \leq 0.02$)
- genetic determination of linear traits in both age groups
  - for majority of trait $h^2 = 0.1 - 0.4$
  - similarities in h^2 pattern, e.g.
    highest estimates for CONF (Breed type) and FMOV (Trot: Impulsion)
- additive genetic correlations of mostly $r_g > 0.5$
  between corresponding traits in juvenile and adult horses
- indications of required further harmonization of application of the linear scheme

preliminary results to be verified with more data

Conclusions & prospects

- feasibility of linear profiling in regular breeding events
  using an extensive linear scheme across age groups
  → increased quality of routinely available phenotype data
- usability of linear data for breeding purposes
  - detailed information for breeders
  - subset of traits for future genetic evaluations
    → new perspectives for breeding
- further research & development
  - optimization of trait definitions (training of judges, repeatability tests)
  - promotion and support of wider use of linear profiles in horse breeding
  - model development to make best use of improved information basis

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Thank you!