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Genetic analyses of movement traits in German Warmblood horses

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Background

- movement evaluations as integral part of selection processes in the Warmblood horse
- remarkable breeding progress in key features of riding horse performance with regard to the gaits (e.g., impulsion, ground cover and expression in trot)
- unfavorable movement characteristics as long-known phenomenon with rare, but regular occurrence in horses of different age
  → sparse knowledge about quantitative and qualitative importance, causative factors, ...

Information on movement

- routine gait evaluations
  - regular breeding events
  - free movement, movement under rider
  - subjective scores (1-10)
- detailed movement evaluations
  - regular breeding events
  - (primarily) free movement
  - documentation of specific favorable and unfavorable movement characteristics

Study approach

- detailed movement evaluations
  from regular breeding events of the Oldenburg horse breeding societies (OLD, OS) in 2009 and 2010
  - foal registrations (foals and mares)
  - mare shows (mares)
- routine gait evaluations
  - studbook inspections (SBI) of OLD+OS in 2009
  - mare performance tests (MPT) of OLD+OS in 2000-2008

genetic correlation analyses
to learn more about the role of unfavorable movement characteristics seen in juvenile and adult horses

Detailed movement evaluations

- foals (n=3,374)
  - mean age of 2.3 months
  - free movement at the side of their dams
  - descending from 476 sires with 1-137 (Ø 7.1) offspring
- mares (n=2,844)
  - mean of 9.2 years (3.2 years in the show mares, 10.8 in the active broodmares)
  - presented in walk and trot at hand
  - descending from 1,197 sires with1-126 (Ø 3.5) offspring

Movement traits

- new movement traits from detailed movement evaluations
  - irregular tail tone and/or posture (TTP)
  - irregular motion pattern in hind legs
  - irregularity in general motion pattern
  - pace in foals

  } indications of imbalance (IMB)
- standard traits from SBI and MPT
  - walk, impetus & elasticity, correctness of gaits
  - walk, trot and canter during free movement, walk, trot and canter under rider, rideability, free jumping

Distributions and heritabilities

Movement trait	Foals (n=3,374)		Mares (n=2,844)	
	Prev.	$h^2 \pm SE_{h^2}$	Prev.	$h^2 \pm SE_{h^2}$
TTP (irregular tail tone and/or posture)	3.97%	0.076 ± 0.030 (0.395 ± 0.158)	4.89%	0.043 ± 0.019 (0.194 ± 0.088)
IMB (indications of imbalance)	6.22%	0.117 ± 0.035 (0.457 ± 0.137)	5.49%	0.052 ± 0.022 (0.220 ± 0.094)

results from bivariate analyses of corresponding traits in foals and mares with heritabilities on observed scale (first line) and underlying liability scale (second line)

SBI trait (n=1,987)	Mean ± SD (range)
Walk	6.60 ± 0.67 (5.0-9.0)
Impetus & elasticity	6.58 ± 0.74 (5.0-9.0)
Correctness of gaits	6.22 ± 0.67 (3.0-8.0)

h^2=0.3-0.6 for most SBI and MPT traits (exceptions: Correctness of gaits h^2=0.1, and rideability h^2=0.2)

MPT trait (n=2,758)	Mean ± SD (range)	
	Free	Under rider
Walk	7.23 ± 0.57 (5.5-9.0)	7.24 ± 0.64 (5.0-10.0)
Trot	7.39 ± 0.60 (5.5-9.5)	7.11 ± 0.69 (5.0-10.0)
Canter	7.24 ± 0.54 (5.5-9.0)	7.34 ± 0.61 (5.0-9.5)
Rideability		7.38 ± 0.67 (5.0-9.5)
Free jumping	7.13 ± 0.82 (4.5-10.0)	

Genetic correlation analyses (I)

Estimation of genetic parameters

- Residual Maximum Likelihood (REML) / VCE6
- bivariate linear animal models
  - movement trait (binary)
  - SBI or MPT trait (quasi-continuous)

→ additive genetic correlations (r_g)

Prediction of breeding values

- Best Linear Unbiased Prediction (BLUP) / PEST
- univariate linear animal models

→ Pearson correlation coefficients (r_{EBV})

Genetic correlation analyses (II)

Pedigree data

- unified animal ownership database (vit)
- relationship matrix with 44,158 horses

Models

- MoveF, MoveM

  $y_{iklpst} = \mu + b*age\_m_i + BMON_k + JUDGE_l + eventM_p + a_s + e_t$

  $y_{jklmpst} = \mu + b*age\_j_j + BMON_k + JUDGE_l + ETYPE_m + eventM_p + a_s + e_t$

- SBI, MPT

  $y_{knqst} = \mu + BMON_k + SBI\_AGE_n + eventSBI_q + a_s + e_t$

  $y_{korst} = \mu + BMON_k + MPT\_AGE_o + eventMPT_r + a_s + e_t$

Genetic correlations

Additive genetic correlations with $r_g < -0.1$ (favorable) $r_g > 0.1$ (unfavorable) and Pearson correlations between breeding values (r_{EBV}) of sires*

SBI or MPT trait	Foals		Mares	
	TTP	IMB	TTP	IMB
Walk	0.092	0.048	0.338	0.312
Impetus & elasticity	0.054	0.032	0.495	0.450
Correctness of gaits	0.004	0.103	0.239	0.211
Walk - free	0.105	0.133	0.314	0.275
- under rider	0.155	0.088	0.449	0.427
Trot - free	-0.042	0.006	0.310	0.320
- under rider	-0.018	0.095	0.220	0.196
Canter - free	-0.166	-0.075	0.165	0.181
- under rider	-0.103	-0.079	0.262	0.275
Rideability	-0.044	0.004	0.344	0.366
Free jumping	-0.106	-0.176	-0.315	-0.308

TTP = irregular tail tone and/or posture; IMB = indications of imbalance

* r_{EBV} for sires with ≥5 offspring with detailed movement evaluations or SBI / MPT and offspring in each of the trait groups (MoveF, MoveM, SBI: n=94; MoveF, MoveM, MPT : n=73)

Conclusions

- genetic variability in the new movement traits (TTP, IMB) reflecting unfavorable movement characteristics:
  possible use of detailed movement information (foals > mares) to select for better balance in movement
- indications of unfavorable genetic correlations between the new movement traits and standard traits from SBI and MPT:
  - SBI/MPT traits
    no measures of breeding progress with regard to specific movement characteristics (balance)
  - TTP, IMB
    no reduction of unfavorable movement characteristics through selection based on subjective scores from routine gait evaluations

Implications

- need for deeper understanding of unfavorable movement characteristics, particularly in adult horses
  (refined recording including evaluation conditions)
- benefits from systematic use of foal data
- unfavorable movement characteristics as another argument for revising the traditional scoring system
  in conformation and performance evaluations for breeding purposes
  → linear scoring reflecting (favorable and unfavorable) specific movement characteristics

Thank you!