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Genetic correlations between indications of imbalance and performance patterns in Warmblood horses

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Background

- quality of gaits as important selection criterion in riding horses
  → gaits directly considered in genetic evaluations
  (gait scores, e.g. from performance tests of mares and stallions)
- detailed movement evaluations of foals and mares as valuable sources of information (Becker et al. 2011)
  → new movement traits
  - specific and descriptive rather than global and valuating,
  - favorable and unfavorable movement characteristics,
  - relevant genetic determination,
  - indications of significant genetic correlations with performance (mare performance test data)

Study approach

maximum use of available information on specific movement characteristics and performance of riding horse
→ analyses based on estimated breeding values (EBV)

- study on detailed movement evaluations (DME):
  EBV for new movement traits reflecting
  unfavorable movement characteristics in foals and mares
- German integrated genetic evaluation for riding horses:
  EBV for dressage and jumping performance and
  derived measures of performance patterns

interpretation of unfavorable movement characteristics
seen in juvenile and adult horses
with regard to the performance of riding horses

Detailed movement evaluations

- data
  regular breeding events, i.e. foal registrations and mare shows,
  of the Oldenburg horse breeding societies (OLD, OS) in 2009 and 2010
  - foals (N=3,374) from 463 sires with 1-136 (Ø 7.3) offspring
  - mares (N=2,844) from 741 sires with 1-98 (Ø 3.8) offspring
- genetic evaluation
  - traits (foals, mares; h^2 = 0.04-0.12): TTP = irregular tail tone and/or posture, IMB = indications of imbalance*
  - BLUP single-trait animal model
  - EBV for 1,065 sires of foals and/or mares with DME information

* irregular tail tone and/or posture (TTP) and/or irregular motion pattern in hind legs and/or irregularity in general motion pattern and/or pace [foals] (Becker et al. 2011)

Riding horse performance

- data
  sport via young horse and regular competitions (1995-2011), breeding via performance tests of mares (1986-2011) and stallions (1986-2011, ability tests 2000-2011)

Integrated genetic evaluation (IGE) 2011

	TC J	TC D	YHC J	YHC D	MPT / SAT	SPT
Horses with perf.	219,226	193,458	163.971	112.402	78.756	7.276
No. of perf. records	8.46 mio.	3.89 Mio.	2,34 Mio.	0,60 Mio.	78.756	7.276

⇒ **in total: 428,309 horses with perf. records (15.38 mio. of perf. records)**

J = jumping, D = dressage; TC (YHC) = tournament (young horse) competition, MPT = mare performance test, SAT = stallion ability test (30 days), SPT = stallion performance test (70+ days)

- genetic evaluation (on behalf of the German FN)
  - BLUP multiple-trait repeatability animal model
  - traits referring to dressage (N=10) and jumping (N=5)
  - 15 EBV → indices → total indices (J, D)

Performance patterns

- gait heterogeneity (data basis: breeding, i.e. MPT / SAT and SPT)
  - difference between EBV for trot and walk
    $dTW = EBV_{trot} - EBV_{walk}$
  - difference between EBV for trot and canter
    $dTC = EBV_{trot} - EBV_{canter}$
  - variance of EBV for gaits
    $vWTC = [std(EBV_{walk}, EBV_{trot}, EBV_{canter})]^2$
- performance stability (data basis: sport)
  - difference between EBV for YHC and TC
    $dYC = EBV_{YHC} - EBV_{TC}$

Genetic correlation analyses

- Pearson correlation coefficients (r)
- EBV for unfavorable movement characteristics vs. EBV for dressage and jumping performance and EBV-derived measures of performance patterns

Detailed movement evaluations (DME)	Integrated genetic evaluation
TTP foals, IMB foals; TTP mares, IMB mares	sport: TC D, YHC D, TC J, YHC J; breeding: MPT / SAT walk, trot, canter, rideability, MPT / SAT index D; MPT / SAT free jumping (= MPT / SAT index J); SPT walk, trot, canter, rideability, SPT index D; SPT free jumping, jumping under rider, SPT index J; total index D, total index J
	gait heterogeneity: dTW MPT / SAT, dTW SPT, dTC MPT / SAT, dTC SPT, vWTC MPT / SAT, vWTC SPT; performance stability: dYC D, dYC J

EBV distributions

Group of horses	Total no. of horses	No. of horses with EBV for perf. (IGE2011)	
		Own EBV	Pedigree EBV (sire+dam)
Mares with DME	2,844	2,135 (75%)	613 (22%)
Foals with DME	3,374	0	2,518 (75%)
Sires of foals and/or mares with DME	1,065	1,046 (98%)	11 (1%)
Sires with ≥ 5 DME foals	150	148 (99%)	2 (1%)
Sires with ≥ 5 DME mares	124	124 (100%)	0

Sires with DME offspring + EBV from IGE2011 (N=1,057)

Trait group	No. of offspring	EBV mean (range)
Dressage (D)	97.9 (0 - 2,200)	106.1 (44 - 171)
Jumping (J)	104.8 (0 - 1,810)	106.3 (27 - 169)
DME	5.86 (1 - 159)	
DME foals	3.17 (0 - 136)	TTP 99.6 (62 - 120)
	[→ 25.0 (5 - 136)]	IMB 99.2 (51 - 121)
DME mares	2.7 (0 - 98)	TTP 100.2 (69- 124)
	[→ 15.3 (5 - 98)]	IMB 100.1 (67 - 125)

Variable	MPT / SAT	SPT
dTW	0.7 (-40 to +45)	1.4 (-29 to +37)
dTC	-1.8 (-28 to +28)	-1.5 (-22 to +17)
vWTC	64.8 (0.0 - 558.3)	40.6 (0.0 - 482.3)
	sport D	**sport J**
dYC	+0.6 (-27 to +19)	+0.2 (-35 to +19)

EBV correlations (I)

All Sires with DME offspring (N=1,057)
and with ≥ 5 DME offspring (N_{F5} = 150, N_{M5} = 124)

Trait group	IMB (Foals)*		IMB (Mares)*	
	ALL	F5	ALL	M5
Total index D	**-0.05**	**-0.03**	**-0.24**	**-0.30**
TC D	**-0.03**	**-0.03**	**-0.23**	**-0.25**
YHC D	**-0.03**	**-0.03**	**-0.23**	**-0.32**
MPT / SAT D	**-0.05**	**-0.03**	**-0.21**	**-0.31**
Walk	-0.07	-0.04	-0.25	-0.26
Trot	-0.09	-0.06	-0.23	-0.28
Canter	0.00	-0.04	-0.15	-0.29
Rideability	-0.01	0.00	-0.17	-0.30
SPT D	**-0.07**	**-0.01**	**-0.27**	**-0.29**
Walk	-0.11	-0.02	-0.32	-0.29
Trot	-0.09	-0.02	-0.28	-0.28
Canter	-0.03	0.00	-0.23	-0.29
Rideability	-0.04	0.00	-0.23	-0.28

* consistent results for TTP and IMB

Trait group	IMB (Foals)*		IMB (Mares)*	
	ALL	F5	ALL	M5
Total index J	**+0.28**	**+0.19**	**+0.33**	**+0.22**
TC J	**+0.19**	**+0.09**	**+0.29**	**+0.19**
YHC J	**+0.24**	**+0.17**	**+0.27**	**+0.17**
MPT / SAT J = Free jump.	**+0.29**	**+0.20**	**+0.35**	**+0.23**
SPT J	**+0.29**	**+0.20**	**+0.33**	**+0.22**
Free jump.	+0.29	+0.20	+0.34	+0.23
Rider jump.	+0.29	+0.20	+0.31	+0.20

<u>dressage and jumping performance:</u>
genetic potential for dressage ↑
↔ genetic disposition for TTP / IMB ↑
genetic potential for jumping ↑
↔ genetic disposition for TTP / IMB ↓

Stock et al. (EAAP 2012, Bratislava / Slovakia) 8

EBV correlations (II)

All Sires with DME offspring (N=1,057)
and with ≥ 5 DME offspring (N_{F5} = 150, N_{M5} = 124)

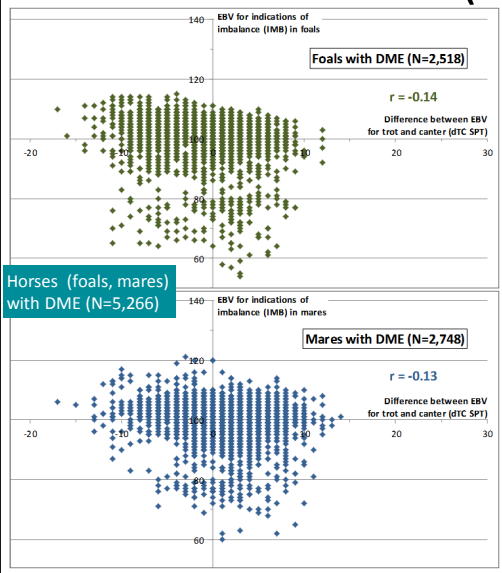
	IMB (Foals)*		IMB (Mares)*	
	ALL	F5	ALL	M5
Gait heterogeneity				
dTW (MPT / SAT)	-0.05	-0.05	-0.03	-0.07
dTW (SPT)	+0.03	-0.02	+0.05	+0.02
dTC (MPT / SAT)	-0.18	-0.07	-0.20	-0.07
dTC (SPT)	-0.20	-0.09	-0.21	-0.11
vWTC (MPT / SAT)	-0.01	+0.04	+0.02	-0.07
vWTC (SPT)	+0.01	-0.01	+0.10	-0.02
Performance stability				
dYC D	+0.02	-0.01	+0.01	-0.13
dYC J	+0.11	+0.21	-0.10	-0.08

* consistent results for TTP and IMB

<u>gait heterogeneity :</u>
genetic potential trot > canter ↑
↔ genetic disposition for TTP / IMB ↑
<u>performance stability:</u>
genetic potential for sport success
(TC-D > YHC-D) ↑
↔ genetic disposition for TTP / IMB (Mares) ↓

Stock et al. (EAAP 2012, Bratislava / Slovakia) 9

EBV correlations (II)



Horses (foals, mares) with DME (N=5,266)

All Sires with DME offspring (N=1,057) and with ≥ 5 DME offspring (N_{F5} = 150, N_{M5} = 124)

	IMB (Foals)*		IMB (Mares)*	
	ALL	F5	ALL	M5
Gait heterogeneity				
dTW (MPT / SAT)	-0.05	-0.05	-0.03	-0.07
dTW (SPT)	+0.03	-0.02	+0.05	+0.02
dTC (MPT / SAT)	-0.18	-0.07	-0.20	-0.07
dTC (SPT)	-0.20	-0.09	-0.21	-0.11
vWTC (MPT / SAT)	-0.01	+0.04	+0.02	-0.07
vWTC (SPT)	+0.01	-0.01	+0.10	-0.02
Performance stability				
dYC D	+0.02	-0.01	+0.01	-0.13
dYC J	+0.11	+0.21	-0.10	-0.08

* consistent results for TTP and IMB

gait heterogeneity :
genetic potential trot > canter ↑
↔ genetic disposition for TTP / IMB ↑

performance stability:
genetic potential for sport success (TC-D > YHC-D) ↑
↔ genetic disposition for TTP / IMB (Mares) ↓

Conclusions

CAVE
limited phenotype data (2 years of DME),
few stallions with reliable EBV for the new traits

- confirmation of unfavorable genetic correlations between new movement traits and performance traits (dressage):
  - performance traits not reflecting breeding progress with regard to specific movement characteristics (balance)
  - no reduction of unfavorable movement characteristics (TTP, IMB) through selection based on single performance traits
- significant correlations between new movement traits and performance patterns
  - gait heterogeneity ↑ (outstanding trot) ↔ balance ↓
  - mares: balance ↑ ↔ performance stability dressage ↑

Implications

- need for deeper understanding of unfavorable movement characteristics (juvenile and adult horses) and their correlations with performance in riding horses
- benefits from refined recording and systematic use of foal data (early availability, limited pre-selection)
  → revision of the traditional scoring system in conformation and performance evaluations for breeding purposes:
  linear profiling for a broad spectrum of traits including specific (favorable and unfavorable) movement characteristics

current R&D work in the Oldenburg horse breeding societies (OL, OS):
implementation pilot using a mobile device in 2012 (foal registrations, mare shows, mare performance tests, ...)

Stock et al. (EAAP 2012, Bratislava / Slovakia) 12

Thank you!