SUITABILITY OF PARAMETERS OF GLUCOSE TOLERANCE TEST (GTT) FOR THE ADDITIONAL EVALUATION OF YOUNG BULLS

L. Panicke[1], E. Fischer[2], R. Staufenbiel[3] and Z. Reklewski[4]

[1] Research Institute for the Biology of Farm Animals, 18196 Dummerstorf, Germany
[2] Univ. Rostock, Faculty of Agricult. and Environment. Sciences, 18051 Rostock Germany
[3] Free University Berlin, Clinic of cattle and pigs, 14163 Berlin, Germany
[4] Institute of Genetics and Animal Breeding, 05-551 Mrokow Jastrzebiec, Poland

INTRODUCTION

The growth of heifers influences the performance of cows. A high milk performance connected with a sound health regarding metabolism and a sufficient fertility in dairy cows depends on a well balanced distribution of energy in the body. The insulin has a central position in the regulation of the energy-metabolism in cattle. There are close relations between the insulin as a controlling and glucose as controlled parameter. The glucose-level in the ruminants blood is kept almost constant at 35 - 55 mg Glucose/100 ml for the undisturbed course of body-functions (Kirchgessner, 1997). Extensive investigations of Staufenbiel (1993) prove the balance between catabolism and anabolism particularly in the fat-metabolism. The measurement of the insulin-reaction during the induced stressing of the metabolism is one possibility for the quantification of the cattles' metabolic ability of reaction (Burkert, 1998). A stress situation takes place by the intravenous injection of hormones or metabolites like GRF, adrenaline, arginine, glucagone und glucose (Mackenzie *et al.,* 1988 ; Reinicke *et al.,* 1993 ; Løvendal *et al.,* 1995 ; Burkert 1998 ; Sørensen *et al*., 2000 ; Panicke *et al.,* 2001a ; Panicke *et al.,* 2001b). There are no continuous investigations with a wide spectrum of traits for cattle of different age classes or same and or similar animals over a period longer than five years. The function of insulin may be recorded by means of the intravenous glucose tolerance test (GTT).
The aims of the investigation are the derivation of suitable parameters for young sires by the indirect performance test, the estimation of heritability coefficients and the correlation coefficients connected to the estimated breeding value (EBV) and the survey of the age at the time of testing for an additional contribution to the assessment of breeding bulls before the conventional offspring's test starts.

MATERIAL AND METHODS

The intravenous glucose test (GTT) was carried out by Burkert (1998) at 6 breeding stations using 329 bulls of German Holstein. The GTT of bulls was done in a way that representative animal numbers were distributed over the regarded age-groups. Bulls of different ages ranging from 1 to 5 years were examined simultaneously by GTT. They were divided in 10 age groups of 6 months respectively. Each group corresponds to a certain life half years of the investigated bulls.
Bulls receiving only water since their last feeding on the day before were injected 1 g Glucose/kg^{0,75} (40 % glucose solution, body warm) within 1 to 3 minutes after positioning a closeable flexyle into the V. jugularis and taking a blood sample for determination of basic

values of glucose– and insulin concentration. After the infusion of glucose 9 more blood samples were taken in intervals of 7 minutes to record of the glucose and insulin reaction. Besides the basic concentration of insulin (I0) and glucose (G0), the glucose half-life (GHWZ), the insulin area equivalent (IA) and the glucose area equivalent (GA) between each course of concentration and basic level and the quotient of the area equivalents IA/GA were determined for each animal. The animal effects for each parameter of GTT were estimated using PEST (Groeneveld *et al.,* 1998) on the basis of the values by Burkert (1998). The variance components for animal, residual and also coefficients of heritability were estimated using VCE 4.2 (Groeneveld, 1998). Results from the estimation of offspring's breeding values are so far available from 292 bulls tested in GTT. Correlation coefficients between the animal effects of the tested bulls and the offspring's breeding values (VIT Verden Germany) were calculated.

RESULTS AND DISCUSSION

The test parameters were transformed by logarithmic function because of being not normally distributed. The estimated coefficients of heritability point to a genetic background of parameters of the glucose tolerance test. Coefficients from 0.12 to 0.20 were estimated for the parameters showing the concentration of glucose and degradation of glucose (Table 1).

Table 1. Parameter of the glucose tolerance test in German Holstein bulls (n = 329)

Parameter		Absolute parameter		Logarith. Naturalis		h^2	$SE(h^2)$
		mean	s %	mean	s %		
G0	(mmol/l)	4.2	13	1.43	9	0.12	0.10
GMAXI	(mmol/l)	11.7	7	2.45	3	0.18	0.10
GA		34.6	21	3.52	7	0.17	0.09
GHWZ	(min)	57.9	36	4.00	9	0.20	0.12
I0	(µU/ml)	14.0	59	2.50	21	0.00	0.00
IMAX	(µU/ml)	116.5	57	4.58	14	0.11	0.09
IA		596.7	62	6.20	10	0.10	0.09
IA/GA		18.9	74	2.68	28	0.20	0.10

The half-life of glucose (GHWZ) and the maximal concentration of insulin (IMAX) depend on the age. The minimum of GHWZ and the maximum of IMAX is reached in the 3^{rd} year of age. The age of the breeding sires at the time of the investigation effects the glucose tolerance test (GTT) considerably. Investigating younger bulls, correlation coefficients between the GTT-parameters and the breeding values from the offspring's test (EBV) up to 0.50 were obtained, whereas no significant correlations were found in older sires. Especially the calculated correlations of the bulls in their third life half year show, that the glucose half-life (GHWZ) and glucose area (GA) are suitable parameters for milk yield, fat yield and protein yield (Table 2). The closest relation between GHWZ and performance yield were shown in this life section.

Table 2. Correlations between the GTT-parameter glucose half-life (lnGHWZ) and the offspring's breeding values of bulls according to age (in half years)

Age (in half years)	n	0ffspring's breeding value (EBV)					
		Milk-yield	Fat-yield	Prot.-yield	Fat-%	Protein-%	RZM [1)]
1	7	– 0.62	– 0.30	– 0.50	+ 0.28	+ 0.24	– 0.44
2	42	+ 0.02	+ 0.01	– 0.08	– 0.01	– 0.12	– 0.06
3	**28**	**– 0.52****	**– 0.43***	**– 0.40***	**+ 0.26**	**+ 0.46***	**– 0.44***
4	25	+ 0.36	+ 0.23	+ 0.29	– 0.13	– 0.22	+ 0.29
5	37	– 0.22	– 0.32	– 0.17	– 0.04	+ 0.21	– 0.21
6	45	– 0.12	– 0.08	+ 0.01	+ 0.08	+ 0.28	– 0.01
7	35	+ 0.03	+ 0.19	+ 0.09	+ 0.16	+ 0.11	+ 0.12
8	28	+ 0.18	+ 0.17	+ 0.20	– 0.04	– 0.04	+ 0.20
9	24	+ 0.02	– 0.27	+ 0.05	– 0.28	+ 0.02	– 0.04
>=10	21	+ 0.15	+ 0.41	+ 0.19	+ 0.16	+ 0.01	+ 0.24
total	292	– 0.07	– 0.06	– 0.02	+ 0.02	+ 0.11	– 0.04

[1)] The RZM is a selection index combining the total breeding values of fat and protein yield by relative economic weights of 1:4.

The glucose half-life is superior to insulin concentration for the estimation of the predicted yield. The controlled glucose concentration, which is phenotypically measured, suggests a closer connection with the estimated breeding value from the offspring's test than the controlling element.

On the basis of multiple linear (GA+GHWZ) and nonlinear regression between pedigree- (PBV) as well as GTT-information (CBV) and the estimated breeding value of the offspring's (EBV), an additional recommendation can be given before the start of the offspring's test by the use of the GTT-parameters. The correlation coefficients between the estimated (EBV) and the calculated breeding value (CBV) with respect to RZM of the bulls (Table 3) are similar for pedigree- and GTT-information with r = 0.3 - 0.4. The glucose half-life reaches r = –0.5 in the third half year life. To increase the certainty of the recommendation both the GHWZ and the GA were included (Table 3). The correlations coefficient between pedigree breeding value (PBV) and GTT-parameters are less 0.1. Therefore we can expect an additional information about the valuation of the breeding bulls from the GTT.

Table 3. Correlations between the predicted calculated breeding values (CBV), the pedigree breeding value (PBV) and the offspring's breeding values (EBV) with respect to selection traits (life half year 2 and 3; station 1 and 2; n = 52)

Trait	Offspring's breeding value (EBV)					
	Milk yield	Fat yield	Prot. yield	Fat-%	Protein-%	RZM
ln GA	– 0.33*	– 0.30*	– 0.26	+ 0.10	+ 0.25	– 0.29*
ln GHWZ	– 0.37**	– 0.33*	– 0.36**	+ 0.10	+ 0.17	– 0.38**
ln GA+GHWZ	+ 0.48**	+ 0.31*	+ 0.45**	– 0.23	– 0.24	+ *0.44***
PBV	+ 0.70**	**+ 0.38****	**+ 0.48****	+ 0.52**	+ 0.54**	**+ 0.35***
CBV	+ *0.83***	**+ 0.65****	**+ 0.70****	+ 0.73**	+ 0.67	**+ 0.67****

CONCLUSION

The contrary glucose- and insulin reactions and their relations to the breeding values of the offspring's test are dependent on the age. The estimated heritability coefficients point to a genetic determination of single parameters of the intravenous GTT. In the third half-year of life correlation coefficients around r = –0.3 to r = –0.5 between the parameters glucose half-life or glucose area equivalent respectively and the breeding values from the offspring's test are gained. The examined parameters glucose half-life and glucose area equivalent changed nonlinearly with the protein production. Physiological characteristics are to be optimised. The GTT-parameters vary in a relatively independent way in relation to the pedigree-breeding value. The combined evaluation of the pedigree breeding value and the GTT-parameters can significantly improve the exactness of the young sires' indirect performance test to r^2 =0.5. Important requirements are a standardized demand- and animal-welfare appropriate environment of the companions in the shed as well as the time of investigation. If the present results were confirmed, an additional recommendation for the evaluation of the breeding bulls before the start of the test could be given. The test capacity could be extended or the costs for testing bulls could be lowered.

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