Effect of moderate indoor exercise on carcass composition, meat quality and muscle enzyme activities in pigs

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SUMMARY: An experiment was carried out with 40 crossbred pigs to study the effect of enforced exercise on carcass and meat quality characteristics. During the fattening period (22 to 103 kg) the pigs were divided into two groups, two pens with ten pigs in each. The 20 pigs given exercise were made to run/walk along the passage in the pig house 5 days a week. The daily distance was about 500 meters. The pigs were restrictedly fed twice a day. After slaughter at approximately 103 kg live weight the carcasses were assessed for lean meat and fat content and meat quality of M. longissimus dorsi and M. biceps femoris. No significant differences between the two groups were observed in the parameters studied. The muscle size and relative distribution seems to be very consistent and may not be influenced by this rather weak exercise. For most of the parameters, a significant effect of litter was found.

INTRODUCTION: Most slaughter pigs are reared indoors in narrow pens, giving the pigs limited possibilities for exercise and motion. The practice to give the pigs more space outdoors in paddocks or other ways of increased motion has become one way to promote the welfare of the pig. It has also been a selling argument, with emphasis on healthier pigs with better meat quality compared to confined pigs. The aim of this experiment was to study the effect of moderate indoor exercise on performance, carcass characteristics, meat quality and muscle enzyme activities of Swedish crossbred slaughter pigs.

MATERIAL AND METHODS: **Animals.** 40 crossbred pigs (Hampshire boars mated to Sw. Landrace x Sw. Yorkshire sows) were used. The pigs were reared in four pens, two of which contained five gilts and five castrates and the other two six gilts and four castrates. The pens had concrete floors with straw and had a 7.7 m² sleeping area and 5.3 m² dunging area. The 20 pigs from two pens were given moderate indoor exercise by running/walking together in groups, five days a week in the pig house. The pigs were made to follow a narrow passage in the house and the distance on each occasion was, on average, 500 m. The other pigs, used as a control group, were kept in their pens. The pigs were sent for slaughter the week their live weight was at least 103 kg.

The pigs were restrictedly fed twice a day in automatic feeders, with a ration based mainly on barley, oats, soyabean meal and fish meal (16.0 % crude protein, 0.85% lysine, 3.6 % crude fat, energy 12.3 MJ ME/kg). From 60 kg live weight the daily ration was restricted to 34.1 MJ ME/day. Water was given at free access via bite nipples placed in the dunging area.

Slaughter and carcass assessment. The pigs were slaughtered according to the normal procedure at the commercial abattoir in Uppsala. After at least two hours of rest in the lairage the pigs were stunned with low voltage electricity on the floor. At the time of bleeding, blood samples were collected in heparinized tubes. After bleeding the pigs were scalded in a tank for 5 min. Muscle samples for histochemical and biochemical analyses were taken from M. longissimus dorsi at the last rib and from M. biceps femoris and placed in liquid nitrogen. The carcasses reached the cooling room within 60 min after bleeding.

After cooling for 46 hours the carcasses were assessed for lean meat content by partial dissection of the right sides. The estimation of lean meat percentage was calculated with an equation in which the proportions of defatted ham and back were used. The ham and back were dissected in the following muscles; M. biceps femoris (BF), M. quadriceps femoris, M. semitendinosus, M. semimembranosus et adductor, M. gluteus, and M. longissimus dorsi (LD).

Ultimate meat quality measurements were carried out at time of cutting at the last rib in LD and in the middle part of BF. Meat colour was measured as surface reflectance with EEL reflectance spectrophotometer (EEL; Evans Electroselenium Ltd., Halstead, UK) using three different filters; 400-700 nm, 550 nm and 680 nm, respectively. Water-holding capacity was evaluated as drip loss, measured as the percentage weight loss of a 2.5 cm thick slice of muscle hung for four days in a polyethene bag at 2 °C (HONIKEL, 1987).

Intramuscular fat content (IMF) in LD and BF was analysed using the Soxtex System H⁺ equipment (Tecator AB, Höganäs, S). The shear force value was taken with a Warner Bratzler-instru-

ment on samples from LD and BF after cooking the meat to an internal temperature of 68 °C.

Biochemical analyses were made on muscle samples freeze-dried overnight and then dissected free of surrounding tissues. The activites of the following enzymes were analysed on 1-2 mg of the freeze-dried muscle at 25 °C with fluorimetric techniques, according to ESSÉN at al. (1980) and ESSÉN-GUSTAVSSON et al. (1984): Lactate dehydrogenase (LDH) for the anaerobic glycolytic capacity, Citrate synthase (CS) for the oxidative capacity, Hexokinase (HK) for glucose phosphorylation and 3-OH-acyl-CoA dehydrogenase (HAD) for the β-oxidation of fatty acids.

Statistical analyses. Data were analysed with the Statistical Analysis System (SAS Institute Inc., 1985), using the GLM procedure. All effects were regarded as fixed. The models used included the effects of sex and litter besides the effect of exercise. The interaction between sex and exercise was included when significant. The regression of carcass weight and slaughter order was included as a covariate. The sample size was included as a covariate when drip loss was studied.

RESULTS AND DISCUSSION: The live weights of the piglets at the start of the experiment were 22.8 kg and 22.7 kg on average in the two groups. The exercised pigs grew a little faster, 791 grams per day compared to 776 grams in the control group. As for feed conversion, this was not statistically significant. The pigs did not refuse to do the enforced exercise, but it should probably have been more intensive to get a better effect. MURRAY et al. (1974) found no effect of forced exercise on a treadmill three times a week for nine weeks on feed intake and feed efficiency. They suggested that the degree of exercise was too low to influence energy expenditure.

For most of the traits studied there were significant differences between gilts and castrates and the effect of sex has been accounted for in the statistical model. The effect of litter was also included in the model. Least-squares means for registered carcass traits are shown in Table 1. The lean meat percentage of the carcasses was the same in the two groups. No effect of exercise was obtained either on the total lean meat percentage or on different muscles studied. Neither was there any influence on the proportion of lean meat+bone in back (76.0-76.5 %) and in ham (82.5 %), used for the estimate of lean meat percentage. Interactions between sex and treatment were only found for a few carcass traits. Exercised gilts had a heavier ham with a greater M. gluteus compared to non-exercised gilts, while no effect was obtained on castrates. The exercise decreased the subcutaneous fat amount in the ham of castrates while no effect on this trait was found in gilts. The weight of individual muscles in the ham are shown in Table 2 and no effect of exercise was obtained except for the size of M. gluteus in gilts, as mentioned above. These results generally agree with earlier studies. Moderate exercise (walking or running) on a treadmill had no significant effect on different muscles or the total lean meat content (FITTS et al.,1973; MURRAY et al.,1974; HALE et al.,1986). Walking exercise (1.2 km/day) had no effect on carcasses in the experiment of ANDAYA et al. (1972) and SKJERVOLD et al. (1963) got no effect of forcing the pigs to stand up on their hind legs while eating. Exercise for 22 min a day had no effect on performance of confined pigs (MORRISON et al. 1968).

No significant effect of exercise was found on the quality traits studied. The results are shown in Table 3. The meat from exercised pigs had slightly higher drip loss and reflectance values in both muscles studied but the differences were not significant. There was a significant effect of intramuscular fat on the tenderness of LD. One percentage unit increase in IMF decreased the shear force value by 0.64 unit. The shear force values of the muscles were not affected by the exercise. WARRIS et al. (1983) found no effect of rearing conditions (indoor compared to outside in paddocks) on the water-holding capacity of the meat. No effect of exercise was found by ZENIA et al.(1974). RÜLCKER (1968) obtained a positive effect of training the pigs on a treadmill twice a week on LD muscle colour and drip loss. None of the other quality parameters studied in the present experiment (pH, reflectance at different wavelengths and subjective assessment of wetness) were influenced by the exercise enforced.

The eating quality of the meat is influenced by IMF. There was a significant interaction between sex and exercise on IMF in both LD and BF in this study, but the effect was inconsistent for the muscles. Exercise increased the IMF in LD of castrates while no effect was found in gilts. In contrast, exercise decreased IMF in BF of gilts while it did not affect the cast-

rates (Table 4). For most of the pigs, the IMF-values were low. The over-all mean was 1.69 % in LD and 1.65 % in BF, indicating that the IMF content was generally rather low.

No significant effect of exercise or sex was found on the muscle enzyme activities and muscle glycogen (Table 5). The interactions between sex and treatment were also non-significant. The non-significant effect of exercise indicated that the moderate exercise enforced on the pigs was too light to change the physiological function of the muscles. There was no significant effect of stunning order on muscle enzyme activities, glycogen or blood lactate. Other studies showed that the oxidative capacity increased during moderate exercise (FOGD-JÖRGENSEN & NYLDGAARD-JENSEN, 1975; ESSÉN-GUSTAVSSON et al.,1988). Moderate exercise also reduced the blood lactate at slaughter (ESSÉN-GUSTAVSSON & LINDHOLM, 1983).

CONCLUSIONS: The moderate exercise enforced on the pigs during their rearing period from 23 kg to 103 kg live weight had negligible effect on daily gain and feed conversion as well as on carcass composition, quality traits and muscle metabolism. These findings are in agreement with results obtained in other experiments with pigs given moderate exercise in paddocks, fed indors but given exercise on treadmills or just walking around. Exercise can be of great value for the welfare of the pigs, especially if they are reared indoors in small pens. Therefore it is of great economic importance that the enforced exercise did not deteriorate the pig performance and carcass composition and quality. This indicates that pig producers can give their pigs, reared in small pens, moderate indoor exercise without expecting any negative influences on the production traits and economy.

To get an effect of exercise it seems to be necessary to use a much heavier exercise than used in this experiment. It is doubtful, however, if this is a realistic way of rearing slaughter pigs in a commercial situation.

Table 1. Least-squares means for daily growth and main carcass characteristics

	Controll	exercise
Daily gain, g/day	776	793
Carcass weight, kg	78.2	78.2
Lean meat, %		
Ham, %	62.7	62.8
Lean+bone in ham, %	27.7	28.0
Lean+bone in back, %	82.5	82.5
	76.5	76.0

None of the traits were sign. different.

Table 2. Least-squares means for size (kg) and distribution of different muscles (in % of lean meat in ham)

	Control		Exercise	
	kg	%	kg	%
M. biceps femoris	1.45	20.8	1.48	20.8
M. quadriceps femoris	1.15	16.5	1.18	16.6
M. semimbranosus and adductor	1.50	21.4	1.51	21.3
M. semitendinosus	0.44	6.3	0.45	6.3
M. gluteus	0.59	8.5	0.61	8.6
M. longissimus dorsi	2.36		2.31	
	gilt	cast	gilt	cast
Ham (with fat), %	27.8[a]	27.7[a]	28.5[b]	27.6[a]
Subcutaneous fat in M. ham, kg	1.67[a]	1.81[a]	1.78[a]	1.74[a]
M. gluteus, kg	0.59[a]	0.60[a]	0.63[b]	0.59[a]
M. gluteus, % of lean meat in ham	8.29[a]	8.72[a]	8.75[a]	8.49[a]

Table 3. Least-squares means for different quality parameters in M. longissimus dorsi (LD) and M. biceps femoris (BF)

	Control	Exercise
Drip loss, %		
LD	5.89	6.58
BF	5.16	5.48
Reflectance, 400-700 nm		
LD	18.3	19.8
BF	18.3	18.6
Shear force, lb		
LD	3.2	3.0
BF	4.2	4.8

None of the traits were sign. different between groups.

Table 4. Least-squares means for percent IMF in M. longissimus dorsi (LD) and M. biceps femoris (BF)

	Control		Exercise	
	gilts	castr	gilts	castr
LD	1.51[a]	1.67[a]	1.50[a]	1.92[b]
BF	1.79[a]	1.65[a]	1.44[b]	1.56[a]

In Tables 2 and 4 means with the same letter are not sign. different ($p>0.05$). In Table 2 means that are underlined are different ($p<0.10$).

Table 5. Least-squares means for different enzyme activities (mmol*kg^{-1}*min^{-1}) and glycogen (mmol*kg^{-1})in M. longissimus dorsi and M. biceps femoris

	Control	Exercise
M. longissimus dorsi		
CS	11.3	10.4
HAD	18.8	17.6
LDH	2390	2430
HK	0.54	0.51
Glycogen	505	495
M. biceps femoris		
CS	17.7	18.1
HAD	18.1	17.7
LDH	2085	1978
HK	0.47	0.56
Glycogen	473	478

None of the traits were sign. different.

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