ENERGY-EXPENDITURE RATE OF PREPARTAL SOWS AND GILTS

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SUMMARY

Energy-expenditure rate (EER) of six cross-bred gilts and four crossbred, second-litter sows was measured at 5-min intervals, from about 110 days of gestation until farrowing, at an ambient temperature of either 20.5 C or 29.8 C. The animals averaged 183 kg body weight at 109 days postcoitum. A multiple-regression model, including an exponential function to describe time-lag of the open-circuit indirect calorimeter used, and regression coefficients for sitting, standing, parturition and eating activities, was fitted to EER measurements for each animal. Energy costs for sitting-up, sitting (min) \(^{-1}\), standing-up and standing (min) \(^{-1}\) were (mean \(\pm\) SE): 4.22 \(\pm\) 1.0, 1.95 \(\pm\) 1.1, 5.83 \(\pm\) 1.1 and 4.06 \(\pm\) .6 kcal, respectively, and were affected by neither ambient temperature nor parity. These activities accounted for 19% of the mean EER of 210 kcal hr\(^{-1}\). Because parturial behavioral activities, such as grunting, champing and nest-building, appeared to be energetically more expensive than sitting or standing quietly, a heat increment due to prepartal activity (HIPA) was included in the model. Near parturition, HIPA while sitting was (mean \(\pm\) SE): 8.98 \(\pm\) 2.2, 1.35 \(\pm\) 1.2, -2.51 \(\pm\) 1.0 and .65 \(\pm\) 1.6 kcal (min) \(^{-1}\) for thermoneutral gilts (TG), thermoneutral sows (TS), heat-stressed gilts (HG) and heat-stressed sows (HS), respectively. This heat increment together with the EER for sitting (1.95 kcal min\(^{-1}\)) represents the total energy expenditure for sitting in the prepartal female. Near farrowing, HIPA when standing was 3.77 \(\pm\) .8 kcal (min) \(^{-1}\) and was unaffected by treatment. All activities near parturition combined to increase the mean EER by 99, 76, 64 and 74% for TG, TS, HG and HS, respectively. Diurnal waves in EER had amplitudes around \(\pm\)16 kcal hr\(^{-1}\) and generally peaked during late afternoon. The additional energy cost of eating was small. (Key Words: Sitting, Standing, Prepartal Behavior, Energy-Expenditure Rate, Heat Stress.)

INTRODUCTION

Energy-expenditure rate (EER) increases during the last day of gestation in dogs (Muffin, 1910), rabbits (Pommerenke et al., 1930), and humans (Carpenter and Murlin, 1911). Other studies with prepartal women show little change in EER during late gestation (Root and Root, 1923; Sandiford and Wheeler, 1924), or report EER with less detail near parturition (Rowe et al., 1925; Rowe and Boyd, 1932). Verstegen et al. (1971) found that EER of swine was about 90% greater during the last week of gestation than during the previous 3 weeks. Energy-expenditure rate in ewes also rises shortly before parturition (Graham, 1964).

Prepartal sows and gilts seem to be especially susceptible to heat stress (Cox et al., 1964). In a field study in Jamaica, 25% of the heat-stroke cases observed in sows occurred at parturition (Fraser, 1970). Steinbach (1971) reported that heat stroke in swine occurred only during the hotter months, and death only during the terminal stage of pregnancy. Activity rates also rise as parturition approaches (Kelley and Curtis, 1978) and vigorous prepartal behavior is manifested (Jones, 1966). Rising rectal temperature in prepartal sows and gilts (Kelley and Curtis, 1978) suggests that these increases in the amount and kind of activity combine to increase the metabolic heat load.

This study was designed to quantitate the effect of prepartal activities and elevated ambient temperature on the EER of sows and gilts shortly before parturition.

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MATERIALS AND METHODS

Respiration Chamber. A 2 m long x 1.4 m high stainless-steel farrowing unit with solid sides extending .5 m above the solid floor was modified to serve as the respiration chamber. It was mounted on a steel frame and contained a farrowing crate with removable, totally slotted floors. Water was supplied by nipple valve, and wasted feed and excreta were removed by a water-flush system beneath the slotted floor.

A steel frame, protected with rust-resistant paint, was attached to the farrowing unit and used to support a .32-cm-thick plexiglass canopy. Silicone rubber caulk was used to seal the plexiglass to the frame. Styrofoam insulation (7.6 cm) was atop the chamber and on the stainless-steel slides, and on the bottom (5 cm). Two 20.3-cm-diameter access ports were incorporated in each side of the chamber. They were closed with plexiglass sheets, which were held in place and sealed with stopcock grease. The chamber door, .6 m high x .9 m wide, was held in place with machine screws and sealed with stopcock grease. It was mounted at one end of the chamber and fitted with a rubber glove/sleeve to permit measurement of rectal temperature by a telethermometer with a thermistor probe.

Humidity inside the chamber was controlled with a 1465 w air conditioner. Water vapor was condensed from the chamber air and the heat was released outside the respiration chamber by the heat-dissipating unit of the air conditioner. Air leaving the conditioner inside the respiration chamber passed over a 1650 w electric heater. Heater current was modulated by an electronic circuit connected to a thermistor placed .6 m above the chamber's slotted floor. As air temperature inside the chamber rose, current flowing to the electric heater was reduced by the electronic circuit.

This negative feed-back system controlled the occupied chamber's temperature within ±1 C from 20 C to 32 C, and maintained a dew-point temperature of less than 27 C. Dew-point and dry-bulb temperatures were monitored inside the chamber by probes placed .6 m above the slotted floor.

Air-flow through the Calorimeter. Room air was drawn into the front of the respiration chamber through an adjustable 4-cm opening. Air pressure inside the chamber was maintained approximately 1 cm of water below atmospheric pressure. The difference varied slightly as the air-conditioner condenser cycled on and off. The slight negative pressure was monitored with a small U-tube and was maintained by adjusting air-inlet size.

Chamber dew-point temperature was used to correct exhaust air volume to standard conditions of dry air. Barometric pressure was recorded with a calibrated mercury barometer. Dry-bulb temperature of exhaust air was measured near the dry-bellows-type flowmeter. Exhaust air passed from the flowmeter through a 208 l pulse stabilizer, which dampened small fluctuations in flow rate. A mechanical 4-vane pump operated by a 560 w electric motor pulled air through the entire system. Flow rate was adjusted by a valve on the pump inlet. It was around 150 l minute⁻¹. Exhaust air was discharged outside the room.

Respiratory Gases Analyses. An aliquot of exhaust air was passed through calcium sulfate by negative pressure. It then passed through an infrared carbon dioxide analyzer and paramagnetic oxygen analyzer by positive pressure, thus reducing contamination of the sample with room air. A chart recorder printed relative values of percent carbon dioxide and oxygen. Standard gases were used to calculate actual percentages of each gas in air entering and air leaving the chamber.

During standardization, accuracy of each gas analyzer was determined by using a standard gas as an unknown. Standard deviations of 231 analyses of one standard gas were .0051% for oxygen and .0018% for carbon dioxide, both less than the .007% suggested as being necessary for an accuracy of ±1% for a 1% increment of carbon dioxide or decrement of oxygen (Blaxter, 1962). Because flow rate was relatively constant once set, the increment of carbon dioxide and decrement of oxygen during animal experiments seldom fell below .4% and seldom exceeded .9%. Two ethanol lamps were used simultaneously during calibrations, but the oxygen decrement nevertheless usually fell.
short of .4% at these times. Thirteen calibrations at air temperatures around 19 C or 30 C yielded recoveries (mean ± SD) for oxygen and carbon dioxide of 99.6 ± 2.2% and 99.3 ± 1.6%, respectively. The respiratory quotient (RQ) averaged .665 ± .02 (theoretical RQ for ethanol combustion is .667).

During experiments, the oxygen and carbon dioxide analyzers were ordinarily standardized three times daily: morning, afternoon and late evening. If standard-gas readings drifted less than 2% from the previous standardization, rates of actual oxygen consumption for times between these two standardizations were calculated from oxygen and carbon-dioxide measurements recorded every five minutes. If the drift was larger, an average RQ was determined for the first hour after the earlier standardization. For subsequent measurements before the next standardization, rate of oxygen consumption was estimated by dividing the rate of carbon-dioxide production by that average respiratory quotient.

Energy-expenditure rate was calculated from the rate of oxygen consumption (actual or estimated) according to the Brouwer (1965) equation. An estimate of urinary nitrogen excretion (17.71 g day⁻¹) was determined on the basis of metabolism studies of sows and gilts in late gestation (Rippel et al., 1965; Miller et al., 1969). The diet fed in this study was the same as that used by Rippel et al. and fed at the same level.

Animals. Crossbred gilts or second-litter sows were studied; two gilts at an air temperature of 20.5 C, four at 29.8 C, and two sows at 20.5 C, two at 29.8 C. Management during gestation has been described (Kelley and Curtis, 1978). Around 110 days of gestation, each female was weighed and placed in the calorimeter. They seemed to adapt readily to the respiration chamber, so EER measurements generally began on the same day the animal was placed in the respiratory chamber. While in the chamber they were fed between 1100 and 1300 hours each day.

Statistical Analysis. A multiple-regression model was fitted to EER separately for each animal by an iterative, least-squares method, and the regression coefficients were analyzed for temperature and parity effects.

The model included a constant representing an average basic EER, to which the effects of activity were additive. As muscular activity increased EER, regression coefficients for sitting-up, sitting, standing-up and standing were included in the model. Each type of activity was monitored continuously by photocells, recorded, and summarized in 15-min segments (Kelley and Curtis, 1978).

Because respiratory-gas changes caused by a particular activity did not appear immediately in the analyzer output, two models, which we thought might describe this time-lag, were tried. One model was the function xeᵃˣ, and the other x²eᵃˣ (figure 1), where x is the time interval in hours between the activity and EER measurement and a is an empirically derived constant. The time-lag function, x²eᵃˣ is in hr⁻², since x is in hr, a in hr⁻¹.

We assumed that an EER at any given time R was essentially unaffected by activities occurring more than about 1.25 hr before R. Thus, the calculations used all the activities during the four complete 15-min periods next preceding the period in which a specific EER was observed and a share of all the activities in the fifth 15-min period prorated according to the time at which the EER was observed. The four activity types (sitting-up, sitting, standing-up, standing) were summed to give their total effect on the observed energy-expenditure rate. This period of between 0 and 1.25 hr included 75% of the total area of the time-lag function. For example, an EER estimate at 0910 hr presumably might have been affected by all the activities in the four complete 15-min periods between 0800 and 0900 hr and two-thirds of all those between 0900 and 0915 hours.

Energy-expenditure rate rose to very high levels soon after feeding, so another term was included in the model to account for the effects of activities of eating, such as masticating, salivating and swallowing. This effect of eating was modeled as a triangle, with the maximum altitude 40 min after the start of feeding and falling to zero 120 min after feeding. Altitude of the triangle was proportional to the amount of feed consumed. This approximately triangular shape after feeding was observed in other studies (Blaxter and Joyce, 1963; Hörnicke, 1970; Osuji et al., 1975).

Behavioral activities near parturition include grunting, champing and nestbuilding (Jones, 1966). The record of sitting and standing

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11Expressed 17.71 g day⁻¹ using reciprocal notation.
included no indication of behavioral activities while sitting or standing. Therefore, two additional regression coefficients were included to account for the heat increment of prepartal activity (HIPA) while sitting or standing. Hence, we included factors, ((48 hr - (P-R hr)) (48 hr)^-1)^2, where P is time of the first piglet’s birth. These factors were limited to the period from 48 hr before birth of the first pig to 1.25 hr after. They were applied to sitting and to standing activity, with separately evaluated coefficients, to represent the increase in EER because of prepartal activity.

A sinusoidal wave was also fitted to account for diurnal variation in energy-expenditure rate. Finally, an additive constant was included to evaluate the bias of using a fixed RQ for estimating energy-expenditure rate.

The model may be represented symbolically by the following equation:

\[
\text{EER} = b_0 + b_1 X_1 + b_2 X_2 + b_3 X_3 + b_4 X_4 + b_5 X_5 + b_6 X_6 + b_7 X_7 + b_8 X_8 + b_9 X_9 + b_{10} X_{10},
\]

where:

- \( \text{EER} \) = estimated energy-expenditure rate (kcal hr\(^{-1}\));
- \( b_0 \) = additive constant for mean basic EER (kcal hr\(^{-1}\));
- \( b_1 \) = coefficient of regression of EER on an act of rising from lying on the floor to the sitting position (“sit-up”) (kcal hr\(^{-3}\) [no. sit-ups\(^{-1}\)];
- \( X_1 \) = [(no. of sit-ups in preceding 1 to 1.25 hr) \( (x^2 e^ax) \)];
- \( b_2 \) = coefficient of regression of EER on remaining in the sitting position (“sitting”) for 1 min (kcal hr\(^{-3}\) [min sitting\(^{-1}\)];
- \( X_2 \) = [(min sitting in preceding 1 to 1.25 hr) \( (x^2 e^ax) \)];
- \( b_3 \) = coefficient of regression of EER on an act of rising from the sitting position to the standing position (“stand-up”) (kcal hr\(^{-3}\) [no. stand-ups\(^{-1}\)];
- \( X_3 \) = [(no. of stand-ups in preceding 1 to 1.25 hr) \( (x^2 e^ax) \)];
- \( b_4 \) = coefficient of regression of EER on remaining in the standing position (“standing”) for 1 min (kcal hr\(^{-3}\) [min standing\(^{-1}\)];
- \( X_4 \) = [(min standing in preceding 1 to 1.25 hr) \( (x^2 e^ax) \)];
- \( b_5 \) = coefficient of regression of EER on the product, (kg consumed) (hr after eating) (kcal kg\(^{-1}\) hr\(^{-2}\));
- \( X_5 \) = [(kg consumed) (hr after eating)];
- \( b_6 \) = coefficient of regression of EER on HIPA while sitting for 1 min during the period between 48 hr before and 1.25 hr after first piglet delivered (kcal hr\(^{-3}\) min sitting during that period);
- \( X_6 \) = [(min sitting in preceding 1 to 1.25 hr during the period between 48 hr before and 1.25 hr after first piglet delivered) \( (x^2 e^ax) (1-0.208(P-R))^2 \)];
- \( b_7 \) = coefficient of regression of EER on HIPA while standing for 1 min during the period between 48 hr before and 1.25 hr after first piglet delivered (kcal hr\(^{-3}\) min standing during that period);
- \( X_7 \) = [(min standing in preceding 1 to 1.25 hr during the period between 48 hr before and 1.25 hr after first piglet delivered) \( (x^2 e^ax) (1-0.208(P-R))^2 \)];
- \( b_8 \) = coefficient of regression of EER on the cosine of ((15) (hour of the day)) during the prepartal period (kcal hr\(^{-1}\));
- \( X_8 \) = cosine of ((15) (hour of the day)) during the prepartal period;
- \( b_9 \) = coefficient of regression of EER on the sine of ((15) (hour of the day)) during the prepartal period (kcal hr\(^{-1}\));
- \( X_9 \) = sine of ((15) (hour of the day)) during the prepartal period;
- \( b_{10} \) = coefficient of regression of EER on the bias due to using a fixed RQ for estimating EER (kcal hr\(^{-1}\)); and
- \( X_{10} \) = additive constant for estimation bias.

Contributions of \( b_0, b_1 X_1, b_2 X_2, b_3 X_3, b_4 X_4, b_5 X_5 \) and \( b_{10} X_{10} \) to EER were estimated from observations before, during and after parturition. Those of \( b_6 X_6, b_7 X_7, b_8 X_8 \) and \( b_9 X_9 \) were estimated only from prepartal measurements.

**RESULTS AND DISCUSSION**

Approximate standard errors for both models (including those instances in which coefficients accounting for partal and postpartal effect were included (Kelley et al., 1978) ranged from ±14 to ±30 kcal hr\(^{-1}\). Models using the lag functions, \( xe^{ax} \) and \( x^2 e^{ax} \), fitted equally well, so only regression coefficients for the equations in which the function \( x^2 e^{ax} \) was used are reported here. Because the two curves
differ most near the time of the EER observation, lack of detail in the activity data during the 15-min interval in which EER was observed may account for lack of significant differences between these two models.

Females averaged 183 kg body weight at 109 days postcoitum. Their weight was unaffected by parity (P>.05), suggesting that little error was introduced by not analyzing EER on the basis of metabolic body size. The constant representing average basic EER was 210 ±8.6 kcal hr\(^{-1}\), or 101 kcal day\(^{-1}\) W\(^{-1}\)Ts, and was unaffected by parity or ambient temperature (P>.05). This constant is difficult to compare with values in the literature because it represents neither basal metabolic rate nor EER of full-fed animals. However, as expected, it exceeded the value of 70 kcal day\(^{-1}\) W\(^{-1}\)Ts used to estimate basal metabolic rate (Kleiber, 1975) and was less than the EER of active, fed sows or gilts in late gestation (Brody, 1938; Verstegen et al., 1971). In agreement with the scheme presented by Kleiber (1975), moderate heat stress did not influence energy-expenditure rate.

The energy cost of standing-up was considered to consist of two components: (1) an energy cost for rising from floor level to a sitting position and (2) an energy cost for rising from a sitting position to a standing position. Energy cost for standing was also assumed to consist of two parts: (1) an energy cost to remain in a sitting position and (2) an additional energy cost to remain in the standing position. Heat stress and parity did not affect the regression coefficients for postural activities, so combined estimates are given (table 1). Sitting-up, standing-up and standing activities increased EER (P<.01). Blaxter and Joyce (1963) reported that standing did not significantly increase oxygen-consumption rate in sheep. The discrepancy probably owes to methods of determining the energy cost of standing.

The regression coefficient and energy cost (mean ± SE) for standing for 1 min at term were, respectively, 79.41 ± 14.4 kcal hr\(^{-1}\) and 3.77 ± .8 kcal (P<.01). Neither was affected by treatment. During strenuous prepartal activity, perhaps sows and gilts incurred an oxygen debt. Since the recovery process extends over the...
TABLE 1. COEFFICIENTS OF REGRESSION OF ENERGY-EXPENDITURE RATE ON POSTURAL ACTIVITIES OF PERIPARTAL SOWS AND GILTS\textsuperscript{a} AND ENERGY COSTS

<table>
<thead>
<tr>
<th>Item</th>
<th>Sit-up\textsuperscript{b}</th>
<th>Sit\textsuperscript{c}</th>
<th>Stand-up\textsuperscript{b}</th>
<th>Stand\textsuperscript{c}</th>
</tr>
</thead>
<tbody>
<tr>
<td>Regression coefficient\textsuperscript{d}</td>
<td>90.45h ± 25.8</td>
<td>41.86 ± 23.0</td>
<td>122.90h ± 32.1</td>
<td>85.47h ± 15.4</td>
</tr>
<tr>
<td>Exponential constant\textsuperscript{e}</td>
<td>3.50h ± .1</td>
<td>3.50h ± .1</td>
<td>3.48h ± .1</td>
<td>3.48h ± .1</td>
</tr>
<tr>
<td>Energy cost\textsuperscript{f}</td>
<td>4.22g ± 1.0</td>
<td>1.95 ± 1.1</td>
<td>5.83h ± 1.1</td>
<td>4.06h ± .6</td>
</tr>
</tbody>
</table>

\textsuperscript{a}Average ± SE for 10 sows and gilts weighing 183 ± 5 kg at 109 days of gestation.
\textsuperscript{b}per sit-up or stand-up.
\textsuperscript{c}Minutes of sitting or standing.
\textsuperscript{d}kcal hr\textsuperscript{-3} (activity)\textsuperscript{-1}.
\textsuperscript{e}hr\textsuperscript{-1}.
\textsuperscript{f}kcal (activity)\textsuperscript{-1}.
\textsuperscript{g}Mean greater than zero (P<.01).
\textsuperscript{h}Mean greater than zero (P<.001).

next hour in humans (Bullard, 1971), these estimates may slightly underestimate the cost of prepartal activities.

An attempt was made to ascertain a daily cycle in the pigs' EER, independent of the influences of the other variables included in the regression model. Analysis of sine and cosine coefficients found that four waves were heterogeneous (P<.01) (figures 2 and 3). Amplitudes did not differ, averaging about ±16 kcal hr\textsuperscript{-1} (P<.001). This accounted for less than 10% of the average basic energy-expenditure rate. The time of maximum EER was 1554 hours for gilts and 1838 hours for sows, the difference being significant (P<.05).

It has been suggested that a diurnal cycle in EER occurs in pigs (Cairnie and Pullar, 1959; Holmes and Mount, 1967; Hörnicke, 1970), birds (Barott et al., 1938; Deighton and Hutchinson, 1940) and humans (Bailey et al., 1973). Hörnicke (1970) found a maximum EER after each feeding time at 0900 and 1700, and a minimum around 0500 and 0700. This cycle seemed to correspond to changes in standing activity.

As the energy costs of sitting and standing were accounted for by separate regression coefficients in our data, reasons for the remaining diurnal cycle remain unclear. The RQ was generally higher in the afternoon than during the night, perhaps because feeding was near noon. Hence, the greater heat equivalent of oxygen at the higher RQ was partly responsible for these diurnal trends. However, even if RQ varied from 1.0 in late afternoon to .7 in early morning, this effect would account for only ±3% of the general mean, or around ±6 kcal hr\textsuperscript{-1}. Other causative factors could be atmospheric effects, caretaker activity or peculiarities of our laboratory.

The average error of estimating EER from the respiratory quotient was ±.9 ± 1.8 kcal hr\textsuperscript{-1} (mean ± SE). It appears this method can be used to circumvent problems with oxygen.
TABLE 2. EFFECT OF AMBIENT TEMPERATURE ON REGRESSION COEFFICIENTS AND ADDITIONAL ENERGY COSTS OF PREPARTAL BEHAVIOR AT TERM IN SOWS AND GILTS

<table>
<thead>
<tr>
<th>Ambient temperature</th>
<th>Parity</th>
<th>No. of animals</th>
<th>HIPA sitting regression coefficient&lt;sup&gt;a&lt;/sup&gt;</th>
<th>Exponential coefficient&lt;sup&gt;b&lt;/sup&gt;</th>
<th>Energy cost&lt;sup&gt;c&lt;/sup&gt;</th>
</tr>
</thead>
<tbody>
<tr>
<td>20.5 C</td>
<td>Gilts</td>
<td>2</td>
<td>220.06 ± 26.4&lt;sup&gt;d&lt;/sup&gt;</td>
<td>3.66 ± .27</td>
<td>8.98 ± 2.2</td>
</tr>
<tr>
<td>20.5 C</td>
<td>Sows</td>
<td>2</td>
<td>29.25 ± 26.4</td>
<td>3.51 ± .27</td>
<td>1.35 ± 1.2</td>
</tr>
<tr>
<td>29.8 C</td>
<td>Gilts</td>
<td>4</td>
<td>-56.66 ± 21.6</td>
<td>3.56 ± .22</td>
<td>-2.51 ± 1.0</td>
</tr>
<tr>
<td>29.8 C</td>
<td>Sows</td>
<td>2</td>
<td>10.76 ± 26.4</td>
<td>3.21 ± .27</td>
<td>.65 ± 1.6</td>
</tr>
</tbody>
</table>

<sup>a</sup>kcal hr<sup>-3</sup> (HIPA minute sitting)<sup>-1</sup>.  
<sup>b</sup>hr<sup>-1</sup>.  
<sup>c</sup>kcal (HIPA minute sitting)<sup>-1</sup>.  
<sup>d</sup>Mean ± SE.  
<sup>e</sup>Parity × Temperature Interaction (P<.01).

analyis if RQ does not vary markedly between standardizations.

**GENERAL DISCUSSION**

To determine how EER near parturition is affected by parity and elevated ambient temperature, several factors were estimated separately as regression coefficients in a multiple-regression model. This was complicated in the open-circuit indirect calorimeter we used because of the inherent time-lag between the occurrence of an activity inside the respiration chamber and the time this change in metabolism appeared in the gas analyzer output. This problem was discussed years ago by Forbes et al. (1927). It was dealt with here by adopting an exponential, \( x^2 e^{ax} \), to approximate the time-lag. This permitted evaluation of the effects of several types of activity on an individual EER measurement.

Hörnicke (1970) followed this procedure, without analytic integration, by using a planimeter. The standard errors of estimate for our model were around 10% of the overall mean, suggesting that it fit reasonably well. Furthermore, the overall mean is in general agreement with the expected metabolic rate of sows and gilts in late gestation.

Standing-up appeared to cost more than sitting-up, and standing tended to be more expensive than sitting, although neither difference was significant. The energy cost of standing...
for the pig appears to be at least ten times
greater than for cattle or sheep, but it may
decline with length of time standing (Hörnicke,
1970). There may be an energy-conserving
adaptation in cattle and sheep. More likely,
however, the standing pig engages in activities
which are energetically more expensive.

The additional energy cost of eating was
small and nonsignificant. Since sows and gilts
generally stood-up to ingest the daily meal,
perhaps the act of standing accounted for the
rapid rise in EER after feeding. Osuji et al.
(1975) suggested that the total energy cost of
eating is related to the time taken to eat the
meal. Furthermore, when a sheep was fed via
fistula, added EER was only 2% to 8% of that
during oral feeding. This indicates that the
increase in EER immediately following a meal
is more nearly related to the energy cost of
standing to eat than to the chemical or digestive
energy costs. Blaxter and Joyce (1963) report-
ed that oxygen-consumption rate was increased
in sheep merely by bringing food into the
room. They did not speculate as to why this
prefeeding increase occurred, but anticipation
of a meal undoubtedly resulted in prefeeding
behavior activities (e.g., as with Pavlov’s dogs),
including standing-up and remaining standing.
They also found that oxygen-consumption rate
increased as much as 65% within 5 to 10 min
after feeding began and fell when eating stop-
ped, and Hörnicke (1970) found that maximal
EER in pigs occurred during the feeding period.
Higher metabolic rates due to heats of fer-
mentation and nutrient metabolism presumably
would require a longer time to be manifested
and would be of longer duration, whereas
standing would imply an immediate increase in
energy-expenditure rate.

A few days before parturition, sows and gilts
used an additional 19% of the basic EER for
sitting-up, sitting, standing-up and standing
during a 24-hr period. As parturition approach-
ed, increasing rates of these activities and the
additional heat increment of sitting and stand-
ing due to prepartal behavior combined at the
time the first piglet was born to increase this
percentage estimate to around 99, 76, 64 and
74% for gilts and sows at thermoneutrality and
those under moderate heat stress, respectively.

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