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EFFECTS OF FORCED EXERCISE ON FERTILITY, PARTURITION, MAMMARY
EDEMA, FEED CONSUMPTION, AND MILK PRODUCTION IN TWO-
YEAR-OLD HOLSTEIN DAIRY HEIFERS

by

Brent O. Barker

A thesis submitted in partial fulfillment
of the requirements for the degree

of

MASTER OF SCIENCE

in

Dairy Science

Approved:

UTAH STATE UNIVERSITY
Logan, Utah

1976

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Brent O. Barker

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ABSTRACT

Effects of Forced Exercise on Fertility, Parturition, Mammary
Edema, Feed Consumption, and Milk Production in Two-
Year-Old Holstein Dairy Heifers

by

Brent O. Barker, Master of Science

Utah State University, 1976

Major Professor: Dr. Robert C. Lamb
Department: Dairy Science

Forty-two springer Holstein heifers were grouped in threes by sire, body weight, and due date. One of each group served as a control (no exercise). One of each group was exercised at 5.5 kilometers per hour for 1.6 kilometers per day, 5 days per week beginning 4 weeks before expected calving date. The third member of each group was exercised the same as the second member, but exercise was continued for 10 days after calving. Exercise was in a circular lane with a motor driven gate. Prepartum exercise increased ease of parturition and reduced the length of time from calving to release of the placenta. Exercise resulted in smaller uterine horn diameters at 42 days postpartum, but had no significant effect on measures of fertility such as days open or services per conception. Exercise did not appear to reduce severity of udder edema, but edema was first noticeable in control heifers. Milk production for the first 50 days after calving showed no affect from prepartum exercise, but continuing exercise after calving reduced

milk production 2.4 kg per day ($P < .05$). Grain was fed according to production, hence grain consumption was also significantly lower for the postpartum exercise group. Hay consumption for the prepartum exercise group was significantly lower than for controls. Prepartum exercise significantly increased feed utilization efficiency as compared to postpartum exercise.

(38 pages)

INTRODUCTION

Dairying in the Western United States has developed from a few dairy cows on each of many small farms to large herds on fewer farms. This change has influenced the management of dairy heifers raised for herd replacements. Previously most dairy heifers grazed on pasture part of the year, receiving considerable exercise. Today, more dairy heifers particularly in the West and Southwest are raised in limited areas on paved lots. It seems possible that these dairy heifers are not in the best physical condition for optimum production. Lack of exercise and close confinement has been suggested as a possible cause of calving difficulties among first calf heifers.

A high-producing dairy heifer, like an athlete, requires sound muscle tone and peak efficiency with respect to blood circulation and respiration. The medical profession (31) suggests exercise for pregnant women several weeks prior to birth for easier delivery and better health of the mother afterwards.

The scientific literature contains little information with which to assess the effects of exercise on dairy heifers; therefore, research in this area is applicable and offers great potential.

Possible benefits of improved physical condition due to prepartum exercise of dairy heifers include easier parturition, fewer retained placentas, reduced edema, reduced metritis, faster uterine horn involution, higher conception rate, improved appetite, and increased milk production.

The objective of this research was to use two-year-old dairy heifers to study the effects of prepartum exercise on parturition, mammary edema, uterine horn involution, fertility, feed consumption, feed efficiency, and milk production.

REVIEW OF LITERATURE

Exercise studies with laboratory animals

Numerous experiments have been conducted to determine the effects of forced exercise on laboratory animals (2, 4, 17, 32, 34, 43, 44, 52, 54). Most of these studies have used rats and mice as the experimental animals. Although the purposes of these experiments have varied, some workers have reported on the effects of exercise on feed intake and body weight changes.

Parizkova and Stankova (44) reported that during 200 days of exercise at 18 meters per minute for 50 minutes per day, the weight gains of exercised rats were essentially the same as for non-exercised rats. In a study with Beagle dogs, Konishi and McCay (34) reported essentially no change in body weight due to exercise.

Other workers have reported significant reductions in either feed intake, body weight gains, or both, of exercised rats and mice (2, 4, 13, 17, 32, 43, 52, 54). These workers reported that both an increase in calorie expenditure and a decrease in calorie intake contributed to the lower body weight gains of exercised animals. Stevenson et. al. (52) and Mayer et. al, (43) indicated that where low levels of regular exercise tended to decrease feed intake, higher levels resulted in an increase. This increase, however, did not offset the calorie expenditure of rats exercising at a higher level, since weight gains were still suppressed as compared with controls.

Exercise studies with domestic farm animals

There has been very little information reported in the scientific journals to determine the effects of forced exercise on domestic farm animals.

Swine. The exercise trials with swine have been conducted primarily to improve carcass quality and muscle development (7, 8, 49).

Results from two separate trials by Morrison et al. (4) offer insight to the purpose of this thesis. In the first trial, 8 Duroc gilts averaging 60 kg in weight were exercised a distance of 400 meters per day during a 22 minute period. This trial was initiated in the winter and conducted for 28 days. Two weeks after its initiation two pigs in the exercise group became lame and were removed from the trial. Two pigs of comparable weight were then removed from the 8 animal control group.

In trial 2, 20 Duroc gilts averaging 50 kg in weight were randomly divided into a control group and an exercised group. The procedure, distance exercised, and time spent exercising were the same as for those animals in trial 1. This trial was initiated in the summer and conducted for a 57 day period. The results of the two trials were quite similar. The exercised pigs tended to spend a significantly ($P < .05$) greater percentage of their total time resting (86.9% vs. 83.5% in trial 1; 86.6% vs. 83.9% in trial 2) than did the controls, and a significantly ($P < .05$) lower percentage of their total time eating (10% vs. 11% in trial 1; 9% vs. 10% in trial 2). The exercised pigs also spent less time in activities other than resting or eating (4% vs. 6% in trials 1 and 2). The primary activity other than resting or eating was standing. Very little fighting was observed regardless of treatment.

The average daily weight gain of exercised pigs was significantly lower than the controls in both trials (.62 kg vs. .73 kg in trial I; .60 kg vs. .67 kg in trial 2). The larger difference in trial I was due to lameness of the exercised pigs. Although two lame pigs were removed from the test, two other pigs also exhibited occasional lameness and gained at a slower rate than their pen mates; whereas, in trial 2 none of the pigs showed lameness.

The slower rate of gain of the exercised pigs apparently resulted both from decreased feed intake and increased use of energy for walking. However, there were no significant differences in the amount of feed required per kg of gain, indicating that the energy required for the forced exercise was small. Therefore, decreased feed intake appeared to be the major factor in the slower rate of gain of the exercised pigs. Kaczmarczyk (33) has also reported that pigs with an area to exercise had decreased feed intake and rate of gain when compared with confined pigs.

It has generally been thought that exercise increased feed intake (5, 25); however, the majority of experiments with laboratory animals and some with swine have indicated the opposite. Obviously, the type and amount of exercise affects the amount of feed intake.

Sheep. A few researchers have reported affects of forced exercise on sheep. Clapperton (14) studied the energy metabolism of 2 sheep walking on the level and on gradients of 1 in 22 and 1 in 11. He used walking speeds of 24 meters per minute and 48 meters per minute. When exercised over an 8 hour period followed by 16 hours rest, the sheep spent 88% of the rest period lying down. In a previous

trial Clapperton (15) exercised the same two sheep at a speed of 49 meters per minute and an uphill gradient of 1 in 17. The exercise given each day was subdivided into periods not exceeding 30 minutes and the total time spent per single day in exercising did not exceed 260 minutes. This was equivalent to a forward movement of 12.6 km and an ascent of 742 meters. Findings indicated that the apparent digestibility of the dry matter of the ration was slightly increased by exercise, resulting in a small increase in methane production. This small increase in methane production was possibly due to elevated body temperature which enhanced the rate of fermentation in the rumen. Exercise did not affect the efficiency with which metabolizable energy was used either to meet the maintenance requirements of the sheep or for the production of fat.

The fact that the study by Clapperton (15) involving only two sheep has been reported in the scientific literature indicates the lack of research done in this area.

Research by Spies, et. al. (50) with 144 ewes involving 3 trials over a 3 year period, showed that 2.4 to 7.2 kilometers of daily exercise at 80 meters per minute starting 10 to 30 days prior to breeding until 3 or 20 days post-breeding decreased the percent of fertilized ova ($P < .05$) in 2 of 3 trials. The rectal temperatures and respiration rates of the exercised ewes were significantly ($P < .01$) increased by exercise. Three to 5 hours were required for body temperatures to return to normal after 30 minutes exercise (2.4 kilometers). They felt that possibly the adverse effect of forced exercise on reproductive performance was a result of

near constant high ambient temperatures during the crucial time between breeding and conception.

The amount sheep normally exercise varies considerably. It tends to be least under a farmherd condition and greatest when animals are grazing in range condition. Sheep kept in pastures of 1-2 acres walk about 2.4 kilometers each day (22) and those pastured in areas of 800 acres or more walk about 6.4 kilometers each day (16).

Cattle. Early exercise trials with cattle determined the effects of exercise on carcass quality of beef (10, 37). Later trials (38, 42, 61) compared heat tolerances of breeds and sexes as influenced by exercise.

Cory (16) reported that under range conditions cattle walk an average of 5.3 kilometers per day and spend 56% of their time feeding and 12.5% resting. The first reports of scientific research relating to the effects of long continued muscular training with cattle was conducted by Mitchell and Hamilton (10, 37) in 1929 and 1931. In their first study they divided 8 Hereford steer calves into two lots of 4 each. Four were used as controls and 4 were exercised on a treadmill at a rate of 110 meters per minute for 5.8 kilometers per day for 122 days. The exercised steers were fed ad libitum a ration of shelled corn, cottonseed meal, corn silage, and alfalfa hay. The controls were fed the same ration, but limited in amounts so that their gains would approximate those of the exercised steers. The controls gained 1.2 kg per day vs. 1.0 kg per day for the exercised steers. The exercised steers required 17% more concentrates, 10% more silage, and 10% more alfalfa hay per 45.4 kg of gain than did the controls (10).

The second experiment was the same as the first, except that the exercised steers walked 14.2 kilometers per day at a rate of 83 meters per minute for a period of 131 days. The controls gained 0.77 kg per day vs. 0.73 kg per day for the exercised steers. For 45.4 kg of gain the exercised steers ate 12% more concentrates, 9% more hay, and 4% less silage than the controls (10). From this research it is evident that exercise was expensive from the standpoint of feed costs.

Dairy cattle. There has been very little research reported on the effects of exercising dairy cattle. Results of exercise trials reported by Ellenberger and Schneider (20) indicate slightly higher coefficients of digestibility for all nutrients except nitrogen free extract when dairy cows were moderately exercised. Their differences were slight, however, and were suggested to be of minor importance.

Later, Lepard et al. (36) studied the affect of exercise on the volume and quality of semen from dairy bulls. The 8 bulls studied were fed and managed similarly except for exercise. During the first four weeks, all bulls were tied in stalls. For the next 12 weeks four of the bulls were put on a mechanical exerciser for 40 minutes each day. The other four bulls were left tied in their stalls. Two ejaculates of semen per bull were collected by use of a standard artificial vagina and examined for concentration. Smears of the two ejaculates were made for morphological studies. The semen was mixed with egg yolk dilutor and used for artificial insemination. A portion was also stored at 40 F and motility was read daily at 100 F until no motility was noted.

The volume of semen showed a slight but insignificant advantage to the four exercised bulls. No significant differences were noted between the two groups in the factors of conception rates, morphology, concentration of the sperm, or life of the sperm at 40 F. The author states that these results should not be interpreted as indicating that exercise is of no value to bulls. They only show the value of exercise in relation to the amount and quality of semen for a 16 week trial.

Because of economic pressures, many dairymen have been forced into a program of confinement housing and intensification of their dairy operation. The traditional pasture program has almost completely given way to a trend favoring confinement in concrete lots. Although this trend was accepted rapidly, there has been some concern expressed over the long term effects of this type of environment on dairy cattle. As a safeguard, and because of the lack of data, many dairymen have removed their cows from concrete lots at least during the dry period. Others have moved their cows to pasture or exercise areas to rest their feet, legs, and udder whenever there is an opportunity to do so (3, 51).

Mammary edema

Cause. Physiological edema of the mammary gland (mammary edema) is essentially an accumulation of excess fluids in the tissues of the udder. The origin of these fluids is believed to be the lymph vessels. The exact cause of mammary edema is unknown, however, it is thought to be caused by overtaxing or blockage of the lymph channels at parturition time, accompanied by venous stasis (45, 56, 57, 59). A condition in humans termed "engorgement of breast" is very similar

to mammary edema in cattle and also considered to be caused by venous and lymphatic stasis (19). Most research workers are in agreement that venous and lymphatic stasis are the causes of mammary edema. The case for speculation lies in what causes this stoppage of the flow of blood and lymph in the mammary system. Several workers have suggested that various factors contribute to congestion in the udder at the time of parturition.

Guss (27) states that a protein deficient diet, especially in first calf heifers, is a contributing factor. Excess sodium in the diet has also been shown to cause increased udder congestion (21, 27, 28, 46). Hemken et al. (28) indicates that both excessive water and excessive salt in the diet contribute to udder congestion in the first-calf heifers. Some workers have stated that cows and heifers that have an inheritance for higher-than-average milk production often show the greatest amount of udder edema (35, 46, 59). Edema is greater in high producers because the demands for developing milk producing tissue are greater and, consequently, more blood is routed to the udder in these cows than in average cows. The venous and lymph systems cannot remove the waste blood as fast as it is sent to the udder, which results in a gradual accumulation of fluid in the udder and lower abdomen. Damaged, stretched, or broken down udders, resulting in faulty blood circulation, have also been accused of contributing to udder congestion in dairy cows (28).

For a long time, prepartum grain feeding was considered to be a major contributor to increased mammary edema (58, 59); however, the varied effects of prepartum grain feeding on udder edema (9, 11, 12, 21, 24, 26, 29, 48, 57,

58, 60) still leaves this a matter for speculation. The most recent findings are in general agreement that while prepartum grain feeding may be a contributing factor, it is not the underlying cause.

First-calf heifers usually have a greater amount of swelling in the udder at parturition than do older cows (21, 23, 26, 58, 59). Holman (30) has attempted to explain this by correlating capillary permeability with age. He determined the flow and protein content of subcutaneous lymph in normal dogs of different age groups. Using a correction factor for the weight of the animal, he determined the lymph flow to be about twice as great in growing dogs as it was in adult dogs. It has been suggested that the lymph flow in first calf heifers is about twice that of mature cows (57).

Prevention and treatment. Guss (46) suggests removal of excessive salt and the feeding of adequate protein to prevent udder edema. Several workers (6, 18, 23, 55) have suggested prepartum milking of cows that show excessive congestion; others (1, 23, 46, 58) have not recommended it, except in unusual cases. Woelffer (58) suggests that exercise aids in stimulating circulation to help reduce the swelling. Many of the other methods used to prevent and treat udder edema consist of generalizations and opinions. Morrison (39) states that applying cold water to the udder with a hose, followed by a thorough milking will relieve the congestion. Others (27, 56) report the greatest benefit exists in massaging the udder.

The use of diuretic drugs have also been reported in treating udder edema in freshening cows (47, 58). Although several diuretic drugs and combinations of

these drugs have been reported to be fairly effective treatments for edema, they do not solve the problem of preventing udder edema. They are used as a treatment and not as a preventative. Prepartum and postpartum exercise of freshening heifers offers a possible preventative and treatment for mammary edema in freshening heifers.

Measurement. The fundamental problem of measuring the amount of swelling and inflammation present exists in any study of udder edema. The most extensive work on the measurement of udder edema has been offered by Wilson (57). He tested five methods of measurement including Brody's surface integrator, photography, linear measurements of length and width with a cloth tape measure, visual inspection by experienced judges, and a measure of the elasticity of the udder.

Brody's surface integrator (a mechanical device for calculating distance) was run over the surface of one-half of the udder. A mark was placed on each side of the leg so that a standard area would be covered at each measurement. Three measurements were taken every two days and averaged to determine the measurement for each period.

Photographs were taken of side and rear views of the udder three days postpartum and again twenty-three days postpartum when the udder was considered to have returned to its normal size.

Linear measurements were obtained by the use of a tape to measure the distance between a point marked on the right fore udder and a point marked high in the middle of the rear attachment. Another measurement was taken from a point made on the left pin bone to the previously mentioned point on the right fore udder.

These were begun three days postpartum and taken every four days for a period of twenty days.

The visual inspection test was made by three competent judges who rated the severity of edema on a scale of 0 to 5. Zero indicated no edema was present and five indicated very severe edema. All three judges were not available to score all the cows. The rating was done three days postpartum.

The elasticity of the udder tissue was measured by making an indentation in the lower side of the udder and timing the interval necessary for the udder to return to its original shape. The indentory tool was made by sawing 1 centimeter off the end of a broom handle. This piece of broom handle was nailed onto a flat, 5 centimeter square of plywood. The rounded piece of broom handle was gently forced against the udder until the flat surface of plywood came into contact with the surface of the udder. A standard indentation was made in the udder for one minute, and then the time necessary for the indentation to return to normal was recorded.

In testing these five methods of measuring udder edema, Wilson (57) found linear measurement of the udder with a tape, and rating by visual observation to be the only valid methods. Brody's surface integrator, photographs, and a measure of the elasticity of the udder were unsatisfactory as measurements of udder edema.

Greenhalgh and Gardner (26) added to the results of Wilson (57) by testing the two methods he suggested as being most valid in measuring udder edema. Their first measurement consisted of visual observations with a simple scale in which

1 represented slight edema and 5 represented severe edema. Their second measurement was made with a tape to determine udder length and udder width. The udder was first measured with the tape 3 days after calving and repeated 27 days later.

Their conclusions were that judgement by eye appeared to be a more satisfactory method of assessing the severity of edema than linear measurement of udder length and width. More recent workers (21, 28, 35, 46) who have studied the problem of udder edema in cows have also measured the severity of udder edema on a visual scale ranging from zero to five in preference to taking linear measurements. These findings do not solve the problem of finding an objective measurement, yet they do suggest that judgement by the eye is a fairly satisfactory method of measuring edema.

MATERIALS AND METHODS

Source of data

Forty-two springing Holstein heifers, averaging 24 months of age, at the Utah State University Dairy Farm, Logan, Utah were placed on an exercise study to determine the effect of prepartum exercise on mammary edema, parturition ease, placenta release time, uterine horn involution, fertility, milk production, and feed consumption. During the prepartum period, beginning four weeks prior to expected calving date, these heifers were confined to a concrete corral with access to a loose housing shed. The total area per heifer averaged 11 square meters.

Following calving each heifer was housed in an experimental unit where individual daily feed consumption was collected on each animal. This experimental unit was a paved concrete corral with access to individual stalls where the heifers could rest. The total area per heifer averaged 10 square meters in this experimental unit. The milking barn was connected to this corral by a concrete alleyway 120 meters long.

These heifers were grouped by threes by sire, body weight, and expected calving date. The three heifers in each group were each placed at random on one of three treatments. Treatment 1 served as a control (no exercise). Treatment 2 was exercise 5.5 kilometers per hour for 1.6 kilometers per day, five days per week beginning 4 weeks before expected calving date and continuing until calving. Treatment 3 was exercise the same as treatment 2, but continued for

ten days after calving. Two heifers in treatment 3 were removed from the trial. One did not calve near her expected due date and the other was a show heifer managed under a different environment than the other heifers.

A mechanical exerciser was constructed using lengths of steel pipe 2.5 centimeters in diameter. These lengths of pipe were curved and welded together into two fences 1.8 meters high and 0.9 meters apart, making a circular lane 9.8 meters in diameter and 30.7 meters in circumference. A variable speed motor propelled four gates in a clockwise direction following the heifers around the lane. An electric fence battery attached to the gates delivered a mild electric shock to keep the heifers moving.

Severity of udder edema was estimated on day of calving by the author and the herdsman and rated according to a simple scale of 1 to 5 in which 1 represented slight edema, 2 moderate edema, 3 heavy edema, 4 severe edema, and 5 represented very severe edema. The number of days with measurable udder edema preceding calving were recorded. Duration of edema was the number of days past calving until edema was no longer evident.

Parturition ease was rated by the author and the herdsman the day of calving. The rating was on a scale of 1 through 5 in which 1 represented an easy delivery requiring less than 2 hours; 2 represented a delivery ranging from 2 to 4 hours; 3 represented a delivery of over 4 hours labor and of greater difficulty than a number 2; 4 represented a dystocia delivery where assistance was given; and 5 represented a dystocia birth of such difficulty that veterinary assistance was needed to save the cow.

Placenta release was recorded as the time from calving to actual release of the placenta. In some cases it was necessary to approximate the time of placenta release to the nearest hour.

Uterine horn involutions were determined by rectal palpation by the veterinarian in charge of her health at 3-10 days after parturition, and at approximately 14, 21, 42, 63 and 84 days postpartum. The diameter and length of the uterine horns were recorded at these intervals.

The date of first observed estrus following calving, date of first breeding, number of breedings and subsequent calving date were also recorded for each heifer.

Daily milk production was recorded and averaged for the first 50 days following calving on the basis of two milkings per day.

Feed intake data was not collected during the prepartum period. Following parturition each heifer was housed in an experimental unit where individual daily feed consumption of alfalfa hay and grain was recorded for 50 days postpartum, at which time these heifers were committed to another research project. Prior to calving, all heifers were fed alfalfa hay, salt, and mineral free choice. They also received 2.3 kg of grain per animal per day for two months prior to calving. Following calving the alfalfa hay, salt, and mineral were continued free choice.

Grain feeding was started at 4.5 kg per day, then was raised 0.9 kg every other day until reaching 10.9 kg per day. Each heifer was then fed according to NRC requirements for maintenance, growth, and milk production.

Comparisons

Udder edema, parturition ease, placenta release time, uterine horn involution, reproductive performance, milk production, feed consumption, and percent of requirements consumed for heifers on the three treatments were compared.

Statistical procedure

Means for each of the variables being compared were determined for each treatment. A least squares analysis of variance was performed to test for significant differences between treatment means.

Significant differences in number of days before calving that edema was first noticeable, severity of udder edema at day of calving, parturition ease, and placenta release time were also tested by least squares analysis of variance by combining treatments 2 and 3 as one prepartum exercise treatment versus the controls.

RESULTS AND DISCUSSIONS

Effects of exercise

Udder edema. Actual mean measurements, standard deviations, and coefficients of variation for udder edema are listed in Table 1. Statistical analysis did not indicate any significant differences between the three treatments in duration or severity of edema due to exercise, but there was a tendency for edema to be first noticeable in control heifers. Analysis of variance on two treatments only (control versus treatments 2 and 3 combined), showed that exercise significantly ($P < .10$) shortened the number of days prepartum that edema was first evident. However, prepartum exercise had no significant influence on severity of udder edema on day of calving or on duration of edema following calving. Coefficients of variation was fairly high for all three edema traits, indicating that edema is a highly variable trait in first lactation heifers.

Table 1. Means, standard deviations, and coefficients of variation for udder edema

Trait	Means			C.V.
	Treatment 1	Treatment 2	Treatment 3	
Edema evident ^{1/}	18.9 ± 8.6	15.2 ± 6.1	14.6 ± 4.7	.41
Edema at calving ^{2/}	2.1 ± 0.8	1.9 ± 0.7	2.2 ± 0.7	.35
Duration of edema ^{3/}	23.4 ± 1.9	25.0 ± 1.4	21.2 ± 0.8	.38

1/ Number of days prepartum that edema was first evident

2/ Severity of udder edema on day of calving: 1 = minimum edema to 5 = maximum edema

3/ Number of days postpartum that edema was still evident

Parturition ease and placenta release time. Table 2 lists the mean measurements and coefficients of variation of parturition ease and placenta release time. Prepartum exercise significantly increased ease of calving ($P < .10$) and significantly ($P < .05$) reduced the time from calving to release of the placenta. Placenta release time for the 40 heifers ranged from 1 hour to just over 8 hours. The single case of dystocia was a control heifer which took just over 8 hours to calve. The high coefficient of variation for parturition ease (.71) indicates that there was a high degree of variability for ease of calving. There was also a fairly high variability for placenta release time.

Table 2. Means and coefficients of variation of parturition ease and placenta release time

Trait	Means			C.V.
	Treatment 1	Treatment 2	Treatment 3	
Parturition ease ^{1,2/}	2.1 ^a	1.5 ^b	1.4 ^b	.71
Placenta release time ^{3,4/}	4.2 ^a	2.8 ^b	2.2 ^b	.46

^{1/} Means with different superscripts differ at $P < .10$.

^{2/} 1 = easy calving to 5 = dystocia.

^{3/} Means with different superscripts differ at $P < .05$.

^{4/} Number of hours from calving to placenta release.

Involution of uterine horns. At 3-10 days postpartum there were 7, 8, and 8 heifers on treatments 1, 2, and 3, respectively, with uterine horns that were too large to measure. By 14 days postpartum there were 3, 2, and 2 heifers respectively with uterine horns still too large for accurate measurement. Because there were so many heifers with uterine horns that were too large to measure accurately at approximately 3-10, and 14 days postpartum, analysis of these measurements were deleted from this study. Exercise did not appear to affect uterine horn involution by 14 days postpartum. By 21 days accurate measurements could be made on all heifers.

As shown in Table 3, the only statistically significant difference in uterine horn involution as determined by rectal palpation was smaller uterine diameter at 42 days post calving in exercised heifers; however, there was a tendency for faster uterine horn involution for exercised heifers for the first 63 days postpartum.

By 84 days postpartum the uterine horns were completely involuted in all heifers. Diameter of uterine horns regressed in size more than did uterine horn length. The coefficients of variation show that uterine horn diameter was more variable than uterine horn length, especially at 21 days postpartum. Variation in uterine horn length and uterine horn diameter did not change much after 42 days postpartum.

Table 3. Means and coefficients of variation of uterine horn involutions at 21, 42, 63 and 84 days postpartum ^{1/}

Trait	Means ^{2/}			C.V.
	Treatment 1	Treatment 2	Treatment 3	
Diameter - 21 d.	3.9	3.0	2.9	.76
Length - 21 d.	24.5	23.4	22.8	.24
Diameter - 42 d.	2.4 ^a	1.8 ^b	1.9 ^b	.36
Length - 42 d.	22.0	20.0	21.2	.14
Diameter - 63 d.	2.4	1.8	2.1	.37
Length - 63 d.	20.6	20.0	19.6	.14
Diameter - 84 d.	1.8	1.9	1.8	.28
Length - 84 d.	19.7	18.4	18.9	.15

^{1/} Means in same row with different superscripts differ at $P < .05$.

^{2/} Diameter or length of uterine horns (cm).

Fertility. The means and coefficients of variation for fertility are given in Table 4. Statistical analysis did not indicate any significant differences between the three treatments; however, the number of services and days open tended to be less for exercised heifers. Days to first observed estrus following calving may not indicate actual function of these heifers because estrus prior to 60 days postpartum may not have been recorded accurately. Number of services per conception and days open are higher for all three treatments than should be. These heifers were all bred by the same technician. The high number of services per conception was the cause of the high number of days open and may indicate needed management improvement.

Table 4. Means and coefficients of variation for fertility

Trait	Means			C.V.
	Treatment 1	Treatment 2	Treatment 3	
Days to first observed estrus following calving	53.6	58.5	48.7	.60
Days to first service	63.5	79.6	70.9	.35
Number of services per conception	3.1	2.1	2.7	.76
Days open	158.7	109.6	113.2	.52

Milk production and feed consumption. Table 5 gives the means and coefficients of variation for average daily milk production and feed consumption for 50 days postpartum. Milk production showed no effect from prepartum exercise, but continuing exercise after calving reduced milk production 2.4 kg per day ($P < .05$). Grain was fed according to production, hence grain consumption was also significantly lower for the group that continued exercise for 10 days postpartum.

Hay consumption for the prepartum exercise group was significantly ($P < .05$) lower than for controls. This agrees with the work of Morrison (40) and Kaczmarczyk (33) who reported decreased feed intake when pigs were exercised. As seen from percent requirements consumed prepartum exercise significantly ($P < .05$) increased feed utilization efficiency as compared to postpartum exercise. This is in agreement with the work of Ellenberger and Schneider (20) who reported higher coefficients of digestibility when dairy cows were moderately exercised and with the findings of Clapperton (14) who reported a slight increase in the digestibility of the dry matter of the ration when sheep were exercised. These results disagree with the findings of Mitchell and Hamilton (10) who reported a decreased feed efficiency when beef cattle were exercised.

Table 5. Means and coefficients of variation for milk production and feed consumption ^{1/}

Trait	Means			C.V.
	Treatment 1	Treatment 2	Treatment 3	
Milk per day (kg)	23.6 ^a	23.6 ^a	21.2 ^b	.13
Grain per day (kg)	9.4 ^a	9.3 ^a	8.8 ^b	.06
Hay per day (kg)	7.6 ^a	6.5 ^b	7.2 ^{ab}	.15
Percent of requirements consumed ^{2/}	94.7 ^{ab}	88.2 ^a	98.7 ^b	.10

^{1/} Means in same row with different superscripts differ at $P < .05$.

^{2/} Percent of NRC requirements for production and maintenance actually consumed.

These results indicate a benefit from prepartum exercise of dairy heifers and imply that heifers in better physical condition prior to calving are more efficient in converting feed into milk after calving than heifers which receive no prepartum exercise. Management could motivate exercise by feeding at one end of the corral or paddock and have water available at the other end.

SUMMARY AND CONCLUSIONS

The objective of this research was to use two-year old dairy heifers to study the effects of pre and postpartum exercise on parturition, edema, fertility, feed consumption, and milk production. Exercise occurred in a circular lane with a motor driven gate.

Exercise did not affect the severity or duration of udder edema, but there was a tendency for edema to be noticeable earlier in control heifers. Prepartum exercise increased ease of parturition and significantly reduced the time from calving to release of the placenta. Uterine horn involution was determined by rectal palpation at 21, 42, 63, and 84 days post calving. Although not statistically significant, there was a tendency for faster uterine horn involution for exercised heifers for the first 63 days postpartum. However, by 84 days postpartum the uterine horns had completely involuted in all heifers. Although exercise did not significantly influence fertility, non-exercised cows did tend to have fewer days to first service, but required more services per conception and had more days open.

Milk production for the first 50 days after calving was no different for prepartum exercise and control treatments, but continuing exercise after calving reduced milk production 2.4 kg per day ($P < .05$). Grain was fed according to production, hence grain consumption was also significantly lower for the postpartum exercise group. Hay consumption for the postpartum exercise group was significantly

lower than for controls. Prepartum exercise significantly increased feed utilization efficiency as compared to postpartum exercise.

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