Deliberate Exercise of Pregnant Holstein Heifers Improves Milk Composition During Lactation

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Summary

Exercise has substantial impacts on systemic physiology, but little research has been conducted to assess how it may influence dairy cattle in modern confined production systems. Dairy heifers were walked for up to 45 minutes, 4 days per week for 8 weeks during pregnancy to assess impacts on subsequent health and productivity. Heifers that were exercised had increased milk protein and solids-not-fat concentrations for up to 15 weeks into lactation, and increased milk fat and energy-corrected milk production at some time points during this period, as compared to sedentary contemporaries. No adverse or beneficial effects of exercise were found on locomotion, calving ease, date of parturition, or somatic cell scores. These findings point to potential impacts on lactation productivity following exercise in pregnant heifers.

Introduction

Enormous improvements have been made in the pounds of milk produced by dairy cattle through artificial selection programs as well as through improvements in nutrition. For example, an average dairy cow in the 1950s produced approximately 5,300 pounds of milk per year, while in 2019 the average cow produces approximately 23,000 pounds per year, an increase of 334% in just 70 years. Production efficiency has accounted for many of these improvements, with far more milk produced from fewer nutrients and reduced animal waste per unit of milk. Modern dairy cattle and modern production practices have allowed dairy producers to meet a greater market demand with fewer cows. Importantly, researchers at Cornell University found that the carbon footprint of the modern dairy cow is only about 37% of the dairy cow from 1944 when compared per kg of milk. Thus, improvements in efficiency of milk production have allowed for greater sustainability of dairy products as a source of human food.

Although the majority of the improvements in production efficiency in the past 60 years have involved artificial selection, it is likely that further genetic improvement may be slowed substantially by inbreeding within the Holstein breed. In a recent study, researchers found that all current Holstein bulls used for AI in North America are derived from only 2 ancestors, Hulleman and Neptune H. These investigators also calculated that the effective population size of all Holstein cattle is less than 100 individuals due to lack of genetic diversity; a similar effective population for any species in the wild would be considered an extreme risk for extinction. Thus, it is critical that researchers begin examining alternative means of improving production efficiency in Holstein cattle. One potential strategy for improving production efficiency is intentional exercise. In studies conducted in the late 1970s and early 1980s, exercise of pregnant Holstein heifers was found to improve milk composition in the subsequent lactation. In theory, exercise should improve overall fitness, body composition, and general welfare of cattle as it does in other species. Therefore, our objectives were to examine the impacts of deliberate exercise of pregnant Holstein heifers on calving, milk production, and milk composition.

Experimental Procedures

Pregnant Holstein heifers at the Kansas State University Dairy Teaching and Research Center were chosen at random to either exercise (EX; n = 12) or to remain sedentary (EC; exercise controls; n = 12). Exercised heifers underwent an 8-week endurance exercise program in an 8-panel motorized free walker 4 times per week that involved walking at a slow pace (3.0 - 3.5 mph) for up to 45 minutes (after a 5-minute warmup at 2.5 mph and followed by a 5-minute cool-down at 2 mph). The exercise regimen was initiated approximately 11 weeks prior to parturition such that the exercise activities were stopped 3 weeks before parturition. Exercise-control heifers were taken to the exerciser but not exercised. All heifers received the same ration and access to water throughout the 8-week experimental period and were weighed weekly.

At parturition, calving ease was assessed by using a subjective scale of 1 to 5: 1 = no problems, 2 = minor problem, 3 = needed assistance, 4 = considerable force, and 5 = very difficult (e.g. C-section). In addition, “calving date accuracy” was calculated by subtracting the actual calving date from the estimated calving date based on breeding date. Milk samples were collected once weekly from all heifers beginning on day 3 of lactation (designated as week 0) through week 15 of lactation, for analysis of milk components by the Dairy Herd Improvement Association (DHIA).

All data were analyzed by ANOVA using PROC MIXED with SAS v. 9.2 (SAS Inst., Cary, NC), including body weight, milk components, and milk yield. Fixed variables included treatment, time (day, week), and time × treatment; the random variable was heifer.

Results and Discussion

Effects of Exercise on Growth and Calving Characteristics

Growth rates of heifers (based on weekly body weight) did not differ between the exercised or exercise-control groups, indicating that overall body mass was not changed by consistent exercise (Figure 1). However, body composition was not assessed in this experiment and future studies are planned to determine proportional muscle mass and fat deposition in pregnant heifers that undergo exercise. Although researchers in 1979 found that exercise improved calving ease, we found no differences in calving ease scores between exercised and sedentary heifers (Table 1). The previous researchers exercised pregnant heifers for 4 weeks prior to parturition through the day of parturition for approximately 30 minutes per day, matching our exercise conditions fairly closely except for the fact that we ceased exercise 3 weeks prior to estimated day of parturition.

Thus, the calves in the previous study may have been lighter due to increased nutrient requirements by the heifers, although they did not report calf birth weights. It is also likely that genetic selection of bulls for calving ease has improved calving ease scores for all Holstein heifers since the time of the previous study.

Effects of Exercise on Subsequent Lactation

Exercise was not found to have any adverse impacts on locomotion, metabolic disorders, or observed signs of distress during the first 2 trips to the milking parlor (data not shown), while we did find that exercise had positive effects on the subsequent lactation and milk quality. Following 8 weeks of exercise that ended 3 weeks prior to parturition, both milk protein and solids-not-fat (SNF; which includes protein) content increased. Our finding that milk protein and SNF increased after exercise conflicts with some reports that have found no differences in these parameters between exercised and non-exercised multiparous cows and 2-year-old heifers. However, there does appear to be some relationship between milk protein increases after exercise and the duration of the exercise activities. When investigators increased the distance exercised from approximately 1 mile/day (where there were no differences in milk composition) to approximately 5 miles/day, milk protein was found to increase. In our experiment, heifers exercised up to approximately 3 miles per day for 4 days/week, so perhaps it is important for exercise programs to include greater distances in order to improve muscle growth to the point where greater muscle breakdown can occur during lactation to provide the necessary circulating amino acids for milk protein synthesis. Further research is necessary to determine body composition after different types of exercise programs.

Although we found that milk protein and SNF content were increased by exercise, other parameters appeared to change very slightly or not at all. Milk lactose concentration was greater in the first week of lactation, but there was no accompanying increase in total milk volume from exercised heifers at that same time, which was surprising given that lactose is generally considered to be the primary component that draws water into the mammary gland during lactation. Milk fat and energy-corrected milk appeared to be improved at certain sampling times during lactation, but there was no overall improvement in these parameters. Additionally, no differences were found between exercised and sedentary heifers for somatic cell scores, indicating that exercise had no beneficial or detrimental effect on udder health.

Conclusions

An exercise regimen that involves fairly low-speed walking (approximately 3.5 mph) for up to ~45 minutes per day appears to improve milk composition in the subsequent lactation without causing any detrimental effects on the animals. Future research will be required to examine body composition after exercise, as well as longevity of exercised animals within the milking herd.

Table 1. Averages for calving characteristics between exercised and sedentary heifers

	Treatment[1]	
Item	EX	EC
Calving ease[2]	1.8 ± 0.24	1.3 ± 0.24
Calf birth weight, lb	84 ± 2.80	86 ± 3.38
Gestation length,[3] d	285.8 ± 1.24	285.7 ± 2.02

[1]Treatment: EX = exercised heifers (n = 12); EC = exercise-control (n = 12), brought to exerciser but not exercised.
[2]Scale from 1–5, with 1 denoting no intervention and 5 denoting a cesarean section.
[3]Expected gestation length = 280 days.

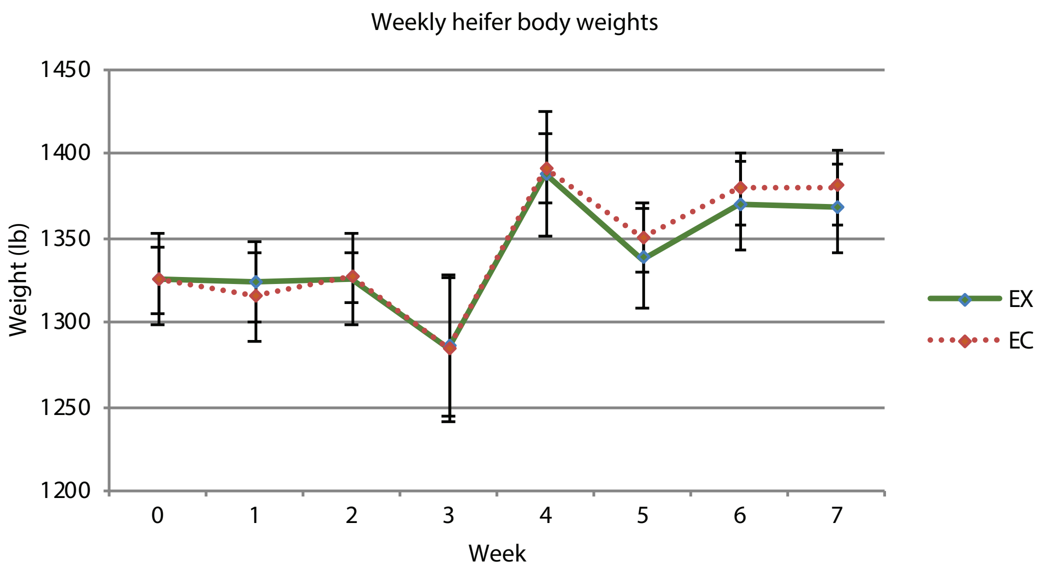

Figure 1. Average heifer weights during the 8-week exercise regimen. The exercised group of heifers (EX; n = 12) were walked at an average pace of 3 mph for an average of 30 minutes per day for 4 days/week for a total of 8 weeks. The exercise-control group of heifers (EC; n = 12) were brought to the exerciser but did not exercise. No apparent differences in growth rate were caused by activity levels during pregnancy.

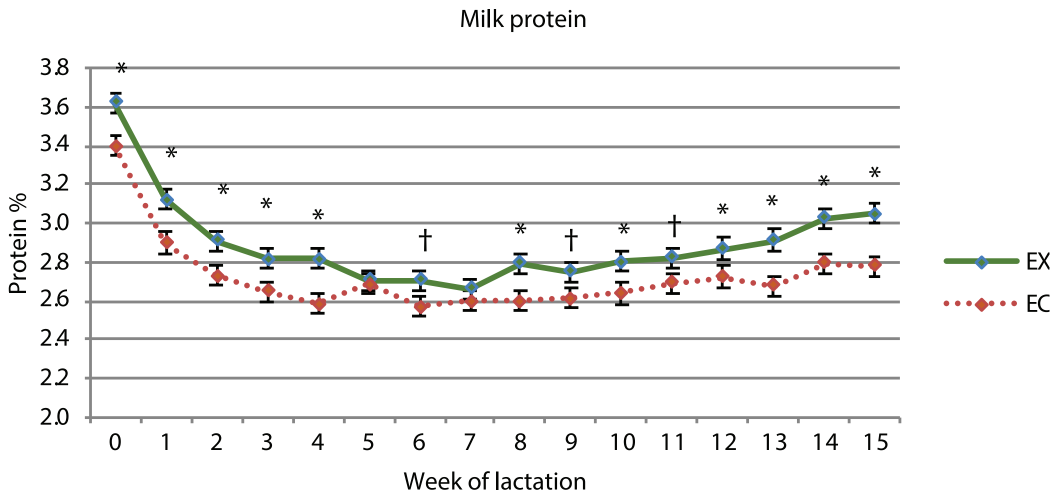

Figure 2. Average percent milk protein through 15 weeks of lactation. The exercised group of heifers (EX; n = 12) were walked at an average pace of 3 mph for an average of 30 minutes per day for 4 days/week for a total of 8 weeks. The exercise-control group of heifers (EC; n = 12) were brought to the exerciser but did not exercise. All exercise activities were stopped by 21 days prior to parturition, so the effects of exercise on improving milk protein persisted even 15 weeks into lactation (18 weeks after exercise was stopped). $^*P < 0.05$; $†P < 0.10$.

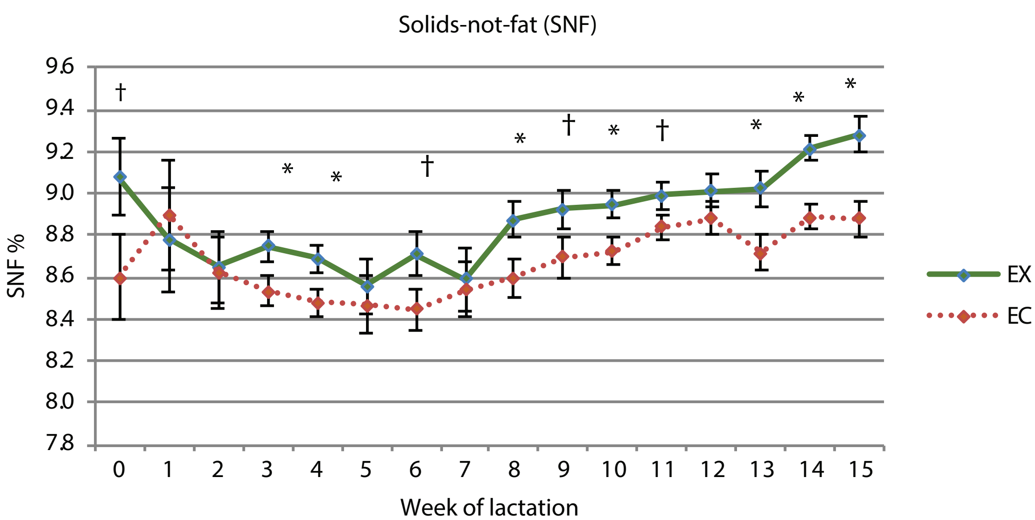

Figure 3. Average percent solids-not-fat through 15 weeks of lactation. The exercised group of heifers (EX; n = 12) were walked at an average pace of 3 mph for an average of 30 minutes per day for 4 days/week for a total of 8 weeks. The exercise-control group of heifers (EC; n = 12) were brought to the exerciser but did not exercise. All exercise activities were stopped by 21 days prior to parturition, so the effects of exercise on improving solids-not-fat persisted even 15 weeks into lactation (18 weeks after exercise was stopped). $^*P < 0.05$; $†P < 0.10$.

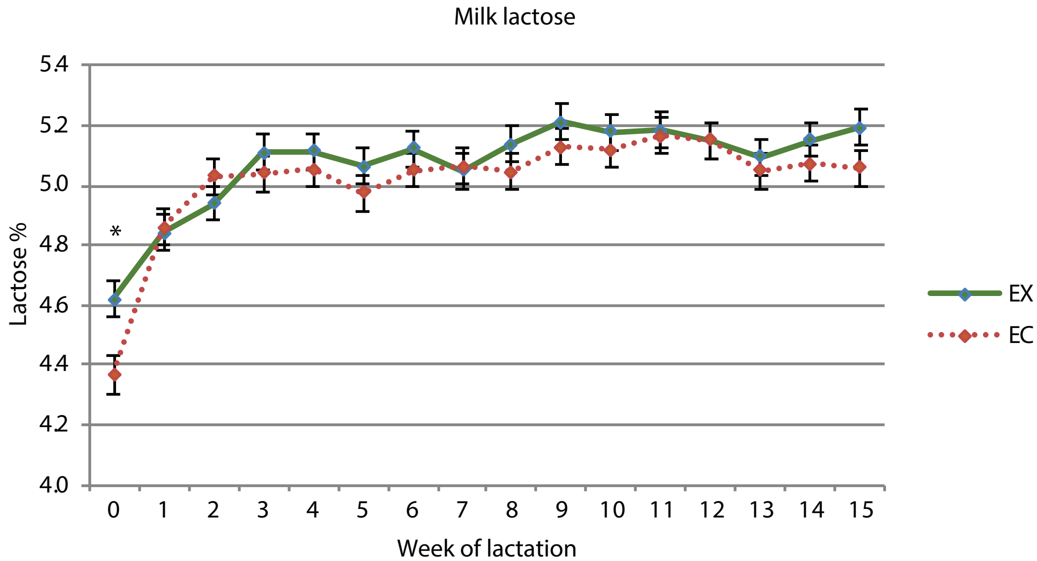

Figure 4. Average percent lactose through 15 weeks of lactation. The exercised group of heifers (EX; n = 12) were walked at an average pace of 3 mph for an average of 30 minutes per day for 4 days/week for a total of 8 weeks. The exercise-control group of heifers (EC; n = 12) were brought to the exerciser but did not exercise. All exercise activities were stopped by 21 days prior to parturition. *$P < 0.05$.

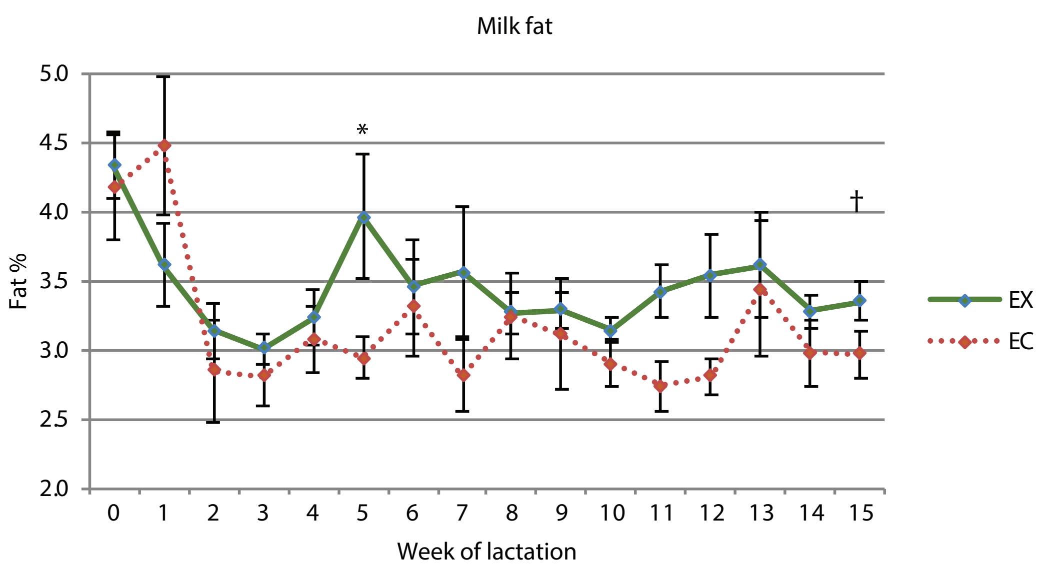

Figure 5. Average percent milk fat through 15 weeks of lactation. The exercised group of heifers (EX; n = 12) were walked at an average pace of 3 mph for an average of 30 minutes per day for 4 days/week for a total of 8 weeks. The exercise-control group of heifers (EC; n = 12) were brought to the exerciser but did not exercise. All exercise activities were stopped by 21 days prior to parturition. *$P < 0.05$; †$P < 0.10$.

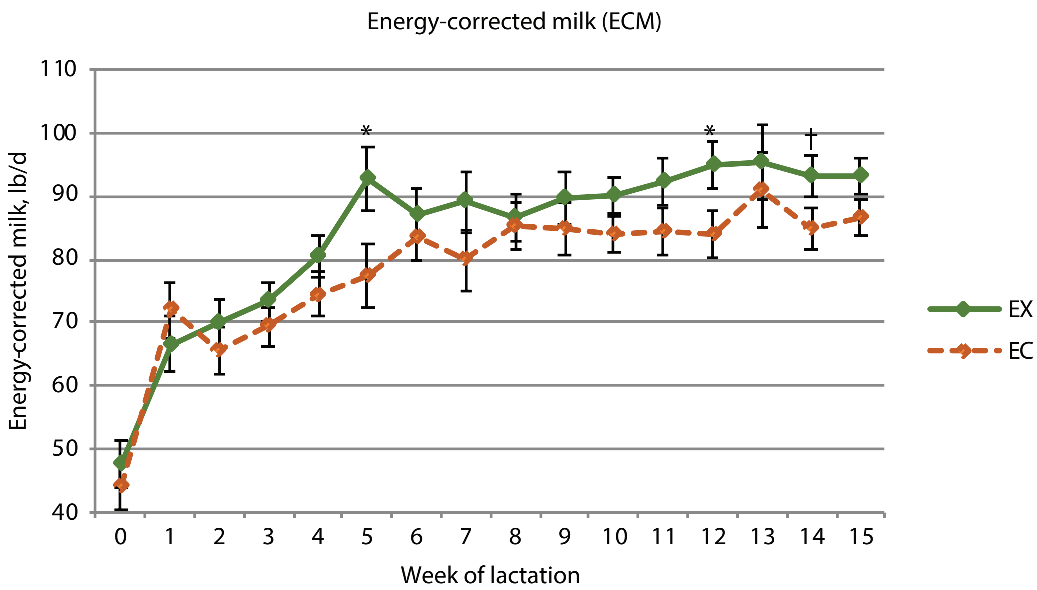

Figure 6. Energy-corrected milk production through 15 weeks of lactation. The exercised group of heifers (EX; n = 12) were walked at an average pace of 3 mph for an average of 30 minutes per day for 4 days/week for a total of 8 weeks. The exercise-control group of heifers (EC; n = 12) were brought to the exerciser but did not exercise. All exercise activities were stopped by 21 days prior to parturition. *$P < 0.05$; †$P < 0.10$.

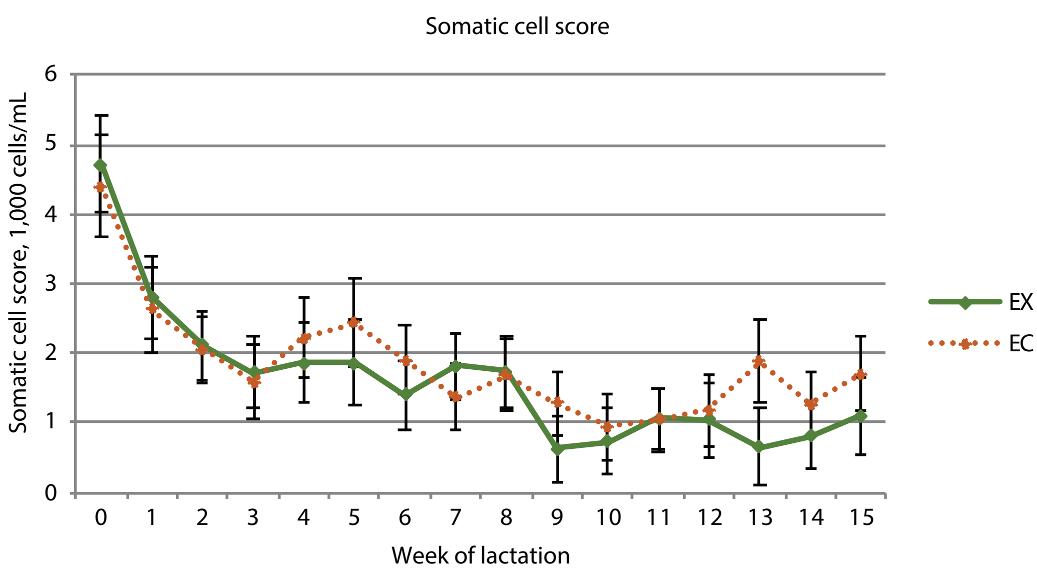

Figure 7. Somatic cell score (SCS) through 15 weeks of lactation. The exercised group of heifers (EX; n = 12) were walked at an average pace of 3 mph for an average of 30 minutes per day for 4 days/week for a total of 8 weeks. The exercise-control group of heifers (EC; n = 12) were brought to the exerciser but did not exercise. All exercise activities were stopped by 21 days prior to parturition. *$P < 0.05$; †$P < 0.10$.