pISSN 1598-298X
J Vet Clin 30(3) : 178-185 (2013)

Journal of Veterinary Clinics
www.ksvc.or.kr

Effects of Milk Yield on the Postpartum Health and Reproductive Performance of Dairy Cows

Sang-Gon Kim, Jae-Kwan Jeong, Tae-Young Hur*, Hyun-Gu Kang and Ill-Hwa Kim[1]

College of Veterinary Medicine, Chungbuk National University, Cheongju 361-763, Korea
**National Institute of Animal Science, RDA, Cheonan 330-801, Korea*

(Accepted: June 10, 2013)

Abstract : This study evaluated the effects of milk yield on the postpartum health and reproductive performance of dairy cows. In total, data were collected from 1,060 cows on six dairy farms, including their milk production, body condition score (BCS), postpartum disorders, and reproductive performance. The lactation data were grouped based on the 305-day milk yield into control (< 10,000 kg, n = 445) and high milk yield (≥ 10,000 kg, n = 615) groups. The milk fat and protein, and BCS were lower during the first 5 months postpartum in the high milk yield group compared with the control group ($p < 0.01$). Ovarian cysts were more frequent ($p < 0.0001$) in the high milk yield group (28.6%) than in the control group (15.3%), whereas endometritis tended to be less frequent in the high milk yield group (29.6%) than in the control group (35.1%, $p = 0.06$). A higher proportion of cows tended to receive reproductive hormones ($p = 0.06$) in the high milk yield group (62.4%) than in the control group (56.6%). The probability of a pregnancy after first insemination tended to be lower (odds ratio = 0.78, $p = 0.07$) in the high milk yield group (30.2%) than in the control group (35.2%). Furthermore, the hazard of pregnancy by 210 days in milk was lower in the high milk yield group (hazard ratio = 0.84, $p = 0.04$) than in the control group, which resulted in a 20-day increase in the median interval to pregnancy. In conclusion, high milk yield was related to lower milk fat and protein, lower BCS, an increased incidence of ovarian cysts, and increased use of reproductive hormones, which resulted in decreased reproductive performance of dairy cows.

***Key words* :** dairy cows, milk yield, postpartum health, reproductive performance.

Introduction

Breeding and advanced nutritional management have increased the milk yield greatly throughout the world. However, there is a great debate on the relationship between milk yield and reproductive performance in dairy cows. The adverse effects of high milk yield on the reproductive performance have been reported extensively (2,4,28,30), although other reports found no relationship between the milk yield and reproductive performance (8,33). These contradictory reports of the relationship between milk production and reproductive performance may be related to various confounding variables, e.g., feeding, housing, and reproductive management, and the environments in the regions and farms investigated.

The energy balance during early lactation is critically important for dairy cows because a severe negative energy balance (NEB) can increase reproductive and metabolic disorders and decrease subsequent fertility (3,15,23,33,39,41). High milk yield cows require more energy to produce more milk compared with low milk yield cows, so an insufficient intake of feed may increase the energy deficit and NEB, thereby resulting in reduced fertility. However, appropriate nutritional provision that meets the needs of high milk yield cows will maintain their capacity to produce milk, thereby reducing the NEB and facilitating normal reproduction (1,34).

In Korea, the milk production per cow per year reached 9,672 kg in 2011 (7), which ranked fourth among the 49 International Committee for Animal Recording (ICAR) country members according to the Yearly Milk Enquiry Online Database. In addition to a major increase in milk yield, estimates of other parameters might be needed to achieve the goals of good production and good reproduction, e.g., milk contents, changes in the body condition score (BCS), postpartum health, and reproductive performance, depending on the increase in the milk yield. Therefore, the present study aimed to determine the effects of the milk yield on the milk contents (fat and protein), BCS, occurrence of postpartum disorders, and reproductive performance of dairy cows.

Materials and Methods

Animals

This study was conducted in six Holstein dairy farms (A-F) in Chungcheong. In total, 1060 Holstein dairy cows (331 primiparous and 729 multiparous; mean parity = 2.6 ± 0.1)

[1]Corresponding author.
E-mail : illhwa@cbu.ac.kr

were enrolled in this study. The cows were maintained in free-stall facilities, fed a total mixed ration, and milked twice daily. The mean milk yield was 10,525 (± 2,006) kg per cow per year.

Case definitions and treatments

The definitions and treatments of postpartum disorders used in the present study were similar to those found in previous publications (6,10,14,18,21,27,28,40). Retained placenta was defined as the retention of the fetal membrane for longer than 24 h. Uncomplicated cases of the retained placenta were not treated, but cows subsequently diagnosed with metritis representing fever and/ or fetid vaginal discharge were treated with antibiotics (ceftiofur) and antipyretic. Metabolic disorders, e.g., milk fever, ketosis, and abomasal displacement, were diagnosed based on clinical signs in field conditions. Milk fever was diagnosed when cows exhibited weakness and recumbence after calving. Cows with milk fever were treated intravenously with 500 mL of a 25% calcium borogluconate solution. Ketosis was diagnosed when cows had the following clinical signs: anorexia, depression, and the odor of acetone on the breath. Cows with ketosis were treated with intravenously with 1 L of a 50% glucose solution. Abomasal displacement was diagnosed by a ping sound during abdominal auscultation and all cases were corrected by surgery. Endometritis was diagnosed based on the presence of a visible mucopurulent vaginal discharge and/or rectal palpation of the enlarged uterus at four weeks postpartum. Cows with endometritis were treated with an intrauterine infusion of cephapirin or 2% povidone-iodine solution, or treated with $PGF_{2\alpha}$. Ovarian cysts were diagnosed based on the identification of follicles > 25 mm in diameter on the ovaries using ultrasonography. They were differentiated based on the thickness of the follicle wall as follicular cysts (<3 mm) or luteal cysts (> 3 mm), and treated with GnRH and $PGF_{2\alpha}$, respectively.

Reproductive management

The voluntary waiting period from calving to first artificial insemination (AI) was 45 days in each farm. In addition to estrous detection, a herd reproductive management program was employed for cows that failed to receive AI within the 80 day postpartum interval. This included estrus synchronization using 25 mg $PGF_{2\alpha}$ (Lutalyse®, Pharmacia & Upjohn, Belgium). Ovsynch was used, which combined the GnRH analogue gonadorelin (Fertagyl, MSD AH Korea, Seoul, Korea) on day 0 (initiation of the Ovsynch), $PGF_{2\alpha}$ on day 7, and the GnRH analogue on day 9, with or without the insertion of an internal drug-release device containing 1.9 g of progesterone (CIDR™, InterAg, Hamilton, New Zealand) between days 0 and 7. Cows were inseminated according to the am-pm rule if they exhibited natural estrus or after estrus synchronization using $PGF_{2\alpha}$, whereas cows treated with Ovsynch received timed AI 16 h after the second GnRH injection. Pregnancy was diagnosed rectally 40-50 days after AI using ultrasonography and manual palpation.

Data collection and analysis

Data were collected from 1,060 lactating cows on six dairy farms. These data included detailed information on milk production and composition, health, and reproduction. The data on milk yield and contents (fat and protein) were collected monthly from the Korean Animal Improvement Association. Body condition was scored monthly after calving, which was based on the procedures described by (12). Postpartum disorders (retained placenta; metabolic disorders, i.e., milk fever, ketosis, and abomasal displacement; endometritis; and ovarian cysts), records of the cows that received reproductive hormones (e.g., $PGF_{2\alpha}$ and GnRH), and culling due to reproductive failure were also included. Cow parity and the dates of previous calving, insemination, and conception were also obtained.

Initially, this study determined the effects of the milk yield (305-day milk yield; ≥ 10,000 kg vs < 10,000 kg) on the milk contents (fat and protein), BCS, and the occurrence of postpartum disorders. The proportions of cows that received reproductive hormones, the mean hormonal treatment per cow, and culling due to reproductive failure were also compared. The reproductive performance, e.g., hazard of first postpartum insemination by 150 days in milk (DIM), the probability of the first insemination conception, and the hazard of pregnancy by 210 DIM, were also compared.

Statistical analysis

For the statistical analysis, the cow parity was separated into primiparous or multiparous groups, while the calving seasons were grouped into spring (March to May), summer (June to August), autumn (September to November), and winter (December to February).

The milk contents (fat and protein) and BCS during 5 months postpartum were compared using a repeated measures ANOVA in SAS (SAS version 9.1; SAS Inst. Inc., Cary, NC, USA). The occurrence of postpartum disorders (retained placenta, metabolic disorders, endometritis, and ovarian cysts), the percentage of cows that received reproductive hormones, and the culling rate were compared using a Chi-squared test. The mean number of hormonal treatments per cow was compared using an ANOVA test. Cox's proportional hazard model with the PHREG procedure in SAS was used to analyze the hazard of first insemination by 150 DIM and the hazard of pregnancy by 210 DIM for cows in the ≥ 10,000 kg and < 10,000 kg classes. This method estimated the hazard of a cow being inseminated or pregnant at a given time. The time variables used in the model were the interval in days between calving and first insemination, and the interval in days between calving and pregnancy. Cows that were sold, died, or remained noninseminated by 150 DIM or that remained nonpregnant at 210 DIM were censored. The Cox models included farm, group, cow parity, calving season, and postpartum disorders (retained placenta, metabolic disorders, endometritis, and ovarian cysts). The proportional hazard rate was evaluated based on the interactions between the explanatory variables and time, and by evaluating the Kaplan-Meier curves. The median and mean days to first insemination or pregnancy were determined by a survival analysis based on the Kaplan-Meier model using the LIFETEST procedure in SAS. A survival plot was generated using the survival option in MedCalc version 11.1 for Windows (MedCalc Software, Mariakerke, Belgium).

The probability of the first insemination conception was analyzed by logistic regression using the LOGISTIC procedure in SAS. The logistic regression model for the initial insemination pregnancy rate included farm, group, cow parity, calving season, and postpartum disorders. Backward stepwise regression was used in all models and elimination was performed based on the Wald statistic criterion when $p > 0.11$. The odds ratio (OR) and 95% confidence interval (CI) were determined by logistic regression. The results were expressed as proportions and ORs with their respective 95% CIs. Differences where $p < 0.05$ were considered significant and $0.05 < p < 0.1$ was regarded as a trend toward a difference.

Results

Fig 1 shows a comparison of the milk yield for the 10 months postpartum in the high milk yield and control groups. Fig 2 and 3 show the comparisons of the milk fat and protein for the 5 months postpartum in the high milk yield and control groups. The milk fat and protein were lower during the 5 months postpartum ($p < 0.0001$) in the high milk yield group compared with the control group. Furthermore, BCS was also lower during the 5 months postpartum ($p < 0.0001$) in the high milk yield group compared with the control group (Fig 4).

Table 1 shows a comparison of the occurrence of postpar-

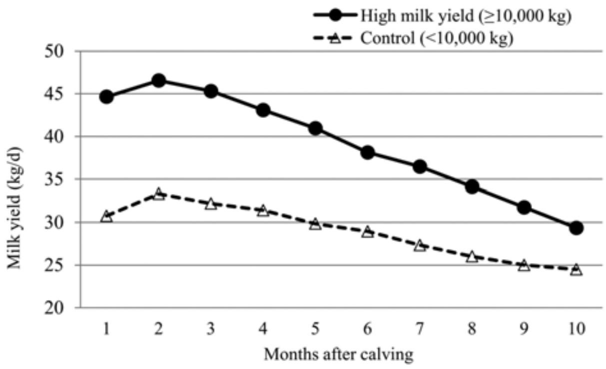

Fig 1. Lactation curves during 10 months after calving for the high milk yield and control groups.

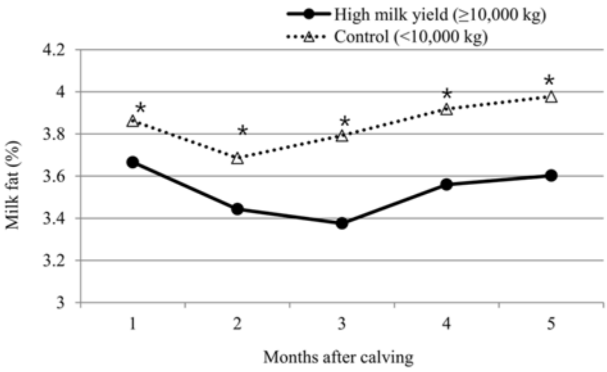

Fig 2. Comparison of milk fat (%) during the 5 months after calving for the high milk yield and control groups. $*p < 0.01$.

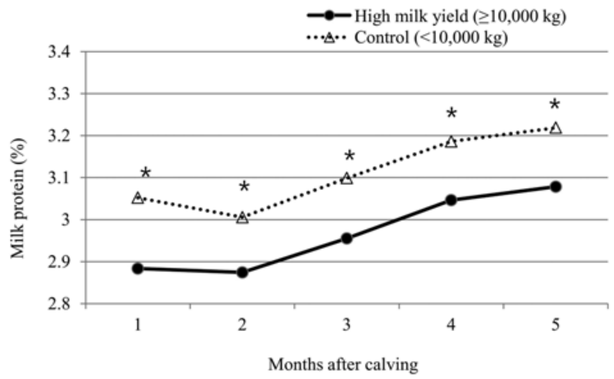

Fig 3. Comparison of milk protein (%) during the 5 months after calving for the high milk yield and control groups. $*p < 0.01$.

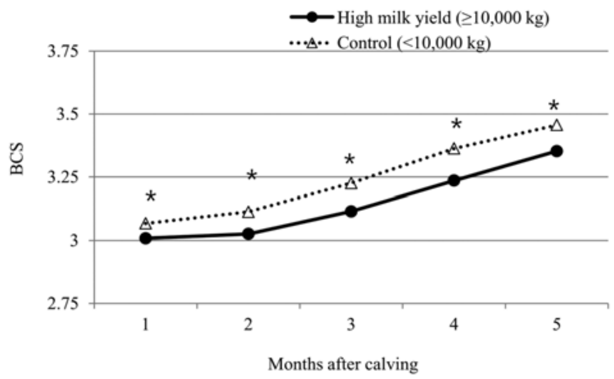

Fig 4. Comparison of BCS during the 5 months after calving for the high milk yield and control groups. $*p < 0.01$.

Table 1. Comparisons of postpartum disorders in the high milk yield and control groups

Group	Retained placenta (%)	Metabolic disorders* (%)	Endo-metritis (%)	Ovarian cysts (%)
Control (n = 445)	51 (11.5)	18 (4.0)	156 (35.1)	68 (15.3)
High milk yield (n = 615)	71 (11.5)	16 (2.6)	182 (29.6)	176 (28.6)
p-value	0.97	0.18	0.06	< 0.0001

*The metabolic disorders were milk fever, ketosis, and abomasal displacement.

Table 2. Comparisons of the use of reproductive hormone treatments and culling in the high milk yield and control groups

Group	Percentage of cows that received reproductive hormones (%)	Mean number of hormonal treatments per cow	Culling* (%)
Control (n = 445)	252 (56.6)	1.90 ± 1.20	32 (7.2)
High milk yield (n = 615)	384 (62.4)	1.96 ± 1.11	53 (8.6)
p-value	0.06	0.5	0.4

*Culling due to reproductive failure.

tum disorders in the high milk yield and control groups. The occurrence of retained placenta and metabolic disorders, i.e., ketosis, milk fever, and abomasal displacement, did not differ between the groups ($p > 0.05$). Ovarian cysts were significantly more frequent in the high milk yield group (28.6%) than the control group (15.3%, $p < 0.0001$), whereas endometritis tended to be less frequent in the high milk yield group (29.6%) than the control group (35.1%, $p = 0.06$).

Table 2 shows comparisons of the proportion of cows that received reproductive hormones, the mean number of hormonal treatments per cow, and the culling rate in the high milk yield and control groups. The proportion of cows that received reproductive hormones tended to be higher ($p = 0.06$) in the high milk yield group (62.4%) than the control group (56.6%). However, the mean number of hormonal treatments per cow and the culling rate did not differ between the two groups ($p > 0.05$).

Table 3 shows the factors that affected the hazard of first insemination by 150 days postpartum. The hazard of first postpartum insemination by 150 DIM tended to be lower in the high milk yield group compared with the control group (hazard ratio [HR] = 0.88, $p = 0.07$). The farm, calving season, and postpartum disorders were associated with the hazard of first postpartum insemination by 150 DIM ($p < 0.05$), while the cow parity tended to affect the hazard ($p = 0.08$). The hazard of first postpartum insemination by 150 DIM was 0.58-fold lower at farm B compared with farm A, whereas cows that calved during autumn (HR = 1.37, $p < 0.001$) were more likely to be inseminated by 150 DIM compared with those that calved during spring. However, cows that had postpartum disorders were less likely to be inseminated

Table 3. Factors affecting the hazard of first insemination by 150 days postpartum analyzed by PHREG procedure

Variable	HR	95% CI	*p*-value
Farm			
A	Reference		
B	0.58	0.440-0.766	0.0001
C			> 0.05
D			> 0.05
E			> 0.05
F			> 0.05
Group			
Control	Reference		
High milk yield	0.88	0.760-1.011	0.07
Cow parity			0.08
Calving season			
Spring	Reference		
Summer			> 0.05
Autumn	1.37	1.133-1.644	0.001
Winter			> 0.05
Postpartum disorders*			
No	Reference		
Yes	0.74	0.651-0.840	< 0.0001

*The postpartum disorders were as follows: retained placenta; metabolic disorders, i.e., milk fever, ketosis, and abomasal displacement; endometritis; and ovarian cysts.

Table 4. Adjusted odds ratios (OR) for variables included in the logistic regression model of the probability of the first insemination conception

Variable	First service conception rate (no. of cows)	Adjusted OR	95% CI	*p*-value
Farm				0.1
Group				
Control	35.2% (154/437)	Reference		
High milk yield	30.2% (184/610)	0.78	0.597-1.025	0.07
Cow parity				0.3
Calving season				0.6
Postpartum disorders*				
No	38.4% (196/510)	Reference		
Yes	26.4% (142/537)	0.58	0.445-0.759	< 0.0001

*The postpartum disorders were as follows: retained placenta; metabolic disorders, i.e., milk fever, ketosis, and abomasal displacement; endometritis; and ovarian cysts.

Table 5. Factors affecting the hazard of pregnancy by 210 days postpartum analyzed by PHREG procedure

Variable	HR	95% CI	*p*-value
Farm			
A	Reference		
B	0.43	0.318-0.575	< 0.0001
C	0.55	0.418-0.730	< 0.0001
D	0.65	0.482-0.867	0.004
E			> 0.05
F	0.54	0.381-0.770	0.0006
Group			
Control	Reference		
High milk yield	0.84	0.716-0.988	0.04
Cow parity			> 0.05
Calving season			
Spring	Reference		
Summer			> 0.05
Autumn	1.28	1.033-1.579	0.02
Winter			> 0.05
Postpartum disorders*			
No	Reference		
Yes	0.58	0.503-0.674	< 0.0001

*The postpartum disorders were as follows: retained placenta; metabolic disorder, i.e., milk fever, ketosis, and abomasal displacement; endometritis; and ovarian cysts.

(HR = 0.74, $p < 0.0001$) by 150 DIM compared with those that had no postpartum disorders.

Table 4 shows the adjusted OR for the variables included in the logistic regression model of the probability of the first insemination conception. The probability tended to be lower (OR = 0.78, $p = 0.07$) in the high milk yield group compared with the control group. In addition, the probability was lower (OR = 0.58, $p < 0.0001$) in the cows that had postpartum disorders compared with the cows that had no postpartum disorders. However, the farm, cow parity, and calving season did not affect the probability of pregnancy after the first insemination ($p > 0.05$).

Table 5 shows the factors that affected the hazard of pregnancy by 210 days postpartum. The hazard of pregnancy by 210 DIM was lower in the high milk yield group (HR = 0.84, $p = 0.04$) than the control group, which resulted in a 20-day increase in the median interval to pregnancy (Fig 5). The farm, calving season, and postpartum disorders also affected the hazard. The hazards of pregnancy by 210 DIM were 0.43- to 0.65-fold lower at four farms (B, C, D, and F) compared with farm A, while cows that calved during autumn were more likely to be pregnant by 210 DIM (HR = 1.28, $p = 0.02$) compared with those that calved during spring. The hazard of pregnancy by 210 DIM was lower in cows with postpartum disorders (HR = 0.58, $p < 0.0001$) compared with cows without postpartum disorders, which resulted in a 50-day increase in the mean interval to pregnancy (Fig 6). However, the cow

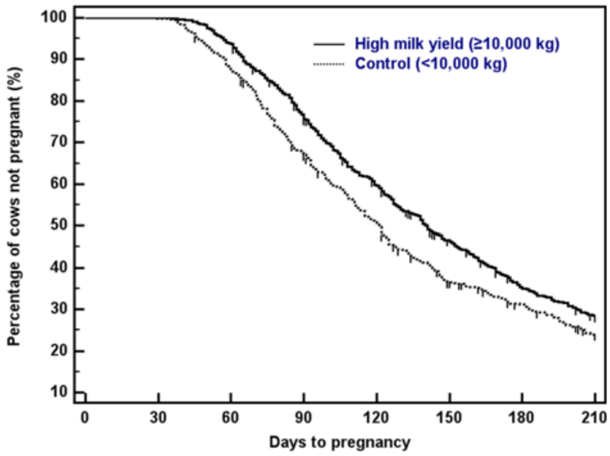

Fig 5. Survival curves for the interval to pregnancy in the high milk yield group and control group. The hazard of pregnancy by 210 DIM was lower (HR = 0.82; CI = 0.709-0.949; $p = 0.0007$) in the high milk yield group (n = 615; solid line) compared with the control group (n = 445; dashed line). The median and mean (± SEM) days to pregnancy were 141 and 142.7 ± 0.1 in the high milk yield group and 121 and 130.4 ± 0.1 in the control group, respectively. The tick marks on the curves indicate censored cows. The proportions censored were 30.2% in the high milk yield group and 26.1% in the control group.

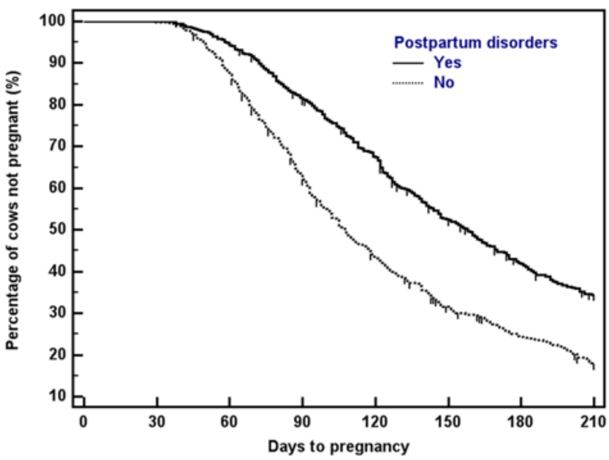

Fig 6. Survival curves for the interval to pregnancy for cows with postpartum disorders and cows without postpartum disorders. The hazard of pregnancy by 210 DIM was lower (HR = 0.58; CI = 0.498-0.665; $p < 0.0001$) for cows with postpartum disorders (n = 546; solid line) compared with those without postpartum disorders (n = 514; dashed line). The median and mean (± SEM) days to pregnancy were 158 and 151.1 ± 0.1 for cows with postpartum disorders and 108 and 123.0 ± 0.1 for cows without postpartum disorders, respectively. The tick marks on the curves indicate censored cows. The proportions censored were 36.1% for cows with postpartum disorders and 20.4% for cows without postpartum disorders, respectively.

parity did not affect the hazard ($p > 0.05$).

Discussion

The present study showed that an increased milk yield was associated with lower milk fat and protein, lower BCS, an increase in ovarian cysts, and the increased use of reproductive hormones, which resulted in the lower reproductive performance of dairy cows.

The lower milk fat and protein contents in the high milk yield group compared with the control group in the present study are consistent with a previous report (1). The lower milk fat in this study may have been associated with an increased intake of concentrate, which might have led to the occurrence of acidosis, as reported by (1). The lower milk protein during lactation in the high milk yield group indicates a more prolonged and severe energy deficit (17), which may have been related to lower BCS in the high milk yield group in the present study. Similarly, an increased milk yield may be associated with a more severe loss of BCS and delayed recovery during lactation (36), which increases the occurrence of postpartum disorders and reduces reproductive performance (3,23,33). Thus, increasing the dietary intake to maintain the correct energy balance during lactation by high milk yield cows may be a crucial factor in the reproductive management of dairy cows. However, there is great variation in the energy intake capacity among cows (42), which may indicate the importance of appropriate nutritional management during calf rearing to develop their rumen capacity and digestive function.

The occurrence of retained placenta and metabolic disorders did not differ between the two groups in the present study, which agreed with previous studies (1,19), although some other studies reported a higher incidence of metabolic disorders in high milk yield cows (16,22), which was possibly due to severe energy deficiencies after calving. The present study detected a lower likelihood of endometritis in the high milk yield group compared with the control group, which was not unexpected because it is assumed that high milk yield cows may suffer a more severe NEB and this might suppress the immune response to postpartum bacterial infections (20,25). However, several previous studies reported no relationships between the milk yield and the incidence of endometritis (16,22,32,35). The increase in ovarian cysts in the high milk yield group compared with the control group was consistent with many previous studies (16,22,29), although another study detected a similar incidence of ovarian cysts in high milk yield and control cows (1). The peripartum nutritional status, i.e., an increased BCS in the prepartum period (29) and severe BCS loss between dry and early lactation (24), were risk factors for ovarian cysts, which suggests that an inadequate nutritional status during lactation might trigger cyst formation via hormonal imbalance.

The higher proportion of cows that received reproductive hormones in the high milk yield group may have been due to increased treatments for ovarian cysts and greater use of herd reproductive management programs, e.g., the synchronization of estrus or ovulation. The greater application of herd reproductive management programs to the high milk yield cows in the present study may have been related to the difficulty of estrus detection with a weak estrus and/or a shorter duration of estrus. The greater feed consumption by the high milk yield cows increased the blood flow to the liver, steroid catabolism, and the progesterone and estrogen clearance rates, thereby leading to lower circulating concentrations (38), which may support our finding that a higher proportion of high milk yield cows received reproductive hormone treatments. The culling rate due to reproductive failure did not differ between the groups in this study, whereas high milk yield reduced the risk of culling in other studies (22,37). The decision to cull depends on the farm's policy, and the milk yield is often a significant factor that determines whether a cow is culled or kept in a dairy herd (11).

High milk yields had negative effects on the reproductive performance in the present study (a lower hazard of the first insemination by 150 DIM, a lower probability of first insemination conception, and a lower hazard of pregnancy by 210 DIM), which agrees with previous studies (13,22,28). However, other studies reported that the milk yield did not affect the reproductive performance (1,31,33,34). The adverse effects of high milk yield on the reproductive performance may be due to inadequate nutrition causing a more severe and prolonged NEB, which leads to lower milk protein and an inferior BCS during lactation (5,33). The adverse effects of high milk yield on reproductive performance could also be responsible for the increased number of treatments of ovarian cysts (13,24) and the increased application of herd reproductive management programs to high milk yield cows in the present study.

The analyses using logistic regression and Cox's proportional hazard model also demonstrated that the reproductive performance was related to the farm, calving season, and reproductive disorders, as well as milk yield. The nutrition management systems and environments including cow population and/or barn conditions (e.g., dimensions) of farms are different, which could have affected the reproductive performance. The present study showed that cows that calved during autumn had increased reproductive performance compared with those during spring, which was consistent with previous studies (9,13). The effect of calving season on the reproductive performance may be in part due to the field conditions that cows calved during spring would have been exposed to unfavorable high temperature and humidity than those calved during autumn, which would have resulted in a decrease in the amount of dry matter intake. More importantly, reproductive disorders (retained placenta; metabolic disorders, i.e., milk fever, ketosis, and abomasal displacement; endometritis; and ovarian cysts) also had detrimental effects on reproductive performance in the present study, which agreed with previous studies (13,26,28).

In conclusion, high milk yield was related to reduced reproductive performance in the present study, which was linked to an inadequate nutritional balance that was reflected by the lower milk content (fat and protein) and BCS during lactation, and the increased occurrence of ovarian cysts and increased application of reproductive hormone treatments. Therefore, to achieve the goals of good production and good reproduction, appropriate management may be needed to meet the nutritional requirements of cows and to prevent ovarian cysts, thereby maintaining the herd health.

Acknowledgments

This work was carried out with the support of the "Cooperative Research Program for Agriculture Science & Technology Development (Project no. PJ008464)", Rural Development Administration, Republic of Korea.

References

1. Aeberhard K, Bruckmaier RM, Kuepfer U, Blum JW. Milk yield and composition, nutrition, body conformation traits, body condition scores, fertility and diseases in high-yielding dairy cows - Part 1. J Vet Med A 2001; 48: 97-110.
2. Bagnato A, Oltenacu PA. Phenotypic evaluation of fertility traits and their association with milk production of Italian Friesian Cattle. J Dairy Sci 1994; 77:874-882.
3. Buckley F, O'Sullivan K, Mee JF, Evans RD, Dillon P. Relationships among milk yield, body condition, cow weight, and reproduction in spring-calved Holstein-Friesians. J Dairy Sci 2003; 86: 2308-2319.
4. Butler WR. Energy balance relationships with follicular development, ovulation and fertility in postpartum dairy cows. Livest Prod Sci 2003; 83: 211-218.
5. Buttchereit N, Stamer E, Junge W, Thaller G. Genetic relationships among daily energy balance, feed intake, body condition score, and fat to protein ratio of milk in dairy cows. J Dairy Sci 2011; 94: 1586-1591.
6. Correa MT, Erb H, Scarlett J. Path analysis for seven postpartum disorders of Holstein cows. J Dairy Sci 1993; 76: 1305-1312.
7. Dairy Cattle Improvement Center, National Agricultural Federation. 2011 DHI Annual Report in Korea.
8. Darwash AO, Lamming GE, Wooliams JA. The phenotypic association between the interval to post-partum ovulation and traditional measures of fertility in dairy cattle. Anim Sci 1997; 65: 9-16.
9. de Vries A, Risco CA. Trends and seasonality of reproductive performance in Florida and Georgia dairy herds from 1976 to 2002. J Dairy Sci 2005; 88: 3155-3165.
10. Domecq JJ, Skidmore AL, Lloyd JW, Kaneene JB. Relationship between body condition scores and conception at first artificial insemination in a large dairy herd of high yielding Holstein cows. J Dairy Sci 1997; 80: 113-120.
11. Ducrocq V, Quaas RL, Pollak EJ, Casella G. Length of productive life of dairy cows. 1. Justification of a Weibull model. J Dairy Sci 1988; 71: 3061-3070.
12. Edmonson AJ, Lean IJ, Weaver LD, Farver T, Webster G. A body condition scoring chart for Holstein dairy cows. J Dairy Sci 1989; 72: 68-78.
13. Eicker SW, Gröhn YT, Hertl JA. The association between cumulative milk yield, days open, and days to first breeding in New York Holstein cows. J Dairy Sci 1996; 79: 235-241.
14. Farin PW, Youngquist RS, Parfet JR, Garverick HA. Diagnosis of luteal and follicular ovarian cysts in dairy cows by sector scan ultrasonography. Theriogenology 1990; 34: 633-642.
15. Ferguson JD. Yield and reproduction in dairy cows. Bovine Pract 1994; 28: 79-82.
16. Fleischer P, Metzner M, Beyerbach M, Hoedemaker M, Klee W. The relationship between milk yield and the incidence of some diseases in dairy cows. J Dairy Sci 2001; 84: 2025-2035.
17. Fulkerson WJ, Wilkins J, Dobos RC, Hough GM, Goddard ME, Davidson T. Reproductive performance in Holstein-Friesian cows in relation to genetic merit and level of feeding when grazing pasture. Animal 2001; 73: 397-406.
18. Garcia-Ispierto I, López-Helguera I, Martino A, López-Gatius F. Reproductive performance of anoestrous high-producing dairy cows improved by adding equine chorionic gonadotrophin to a progesterone-based oestrous synchronizing protocol. Reprod Dom Anim 2012; 47: 752-758.
19. Gröhn YT, Eicker SW, Hertl JA. The association between previous 305-day milk yield and disease in New York State dairy cows. J Dairy Sci 1995; 78: 1693-1702.
20. Hammon DS, Evjen IM, Dhiman TR, Goff JP, Walters JL. Neutrophil function and energy status in Holstein cows with uterine health disorders. Vet Immunol Immunopathol 2006; 113: 21-29.
21. Hostens M, Ehrlich J, Van Ranst B, Opsomer G. On-farm evaluation of the effect of metabolic diseases on the shape of the lactation curve in dairy cows through the MilkBot lactation model. J Dairy Sci 2012; 95: 2988-3007.
22. Heuer C, Schukken YH, Dobbelaar P. Postpartum body condition score and results from the first test day milk as predictors of disease, fertility, yield, and culling in commercial dairy herds. J Dairy Sci 1999; 82: 295-304.
23. Kim IH, Suh GH. Effect of the amount of body condition loss from dry to near calving periods on the subsequent body condition change, occurrence of postpartum diseases, metabolic parameters and reproductive performance in Holstein dairy cows. Theriogenology 2003; 60: 1445-1456.
24. Kim KD, Ki KS, Kang HG, Kim IH. Risk factors and the economic impact of ovarian cyst on reproductive performance of dairy cows in Korea. J Reprod Dev 2005; 51: 491-498.
25. Kim IH, Na KJ, Yang MP. Immune responses during the peripartum period in dairy cows with postpartum endometritis. J Reprod Dev 2005; 51: 757-764.
26. Kim IH, Kang HG. Risk factors for delayed conception in Korean dairy herds. J Vet Sci 2006; 7: 381-385.
27. LeBlanc SJ, Duffield TF, Lesile KE, Bateman KG, Keefe GP, Walton JS, Johnson WH. Defining and diagnosing postpartum clinical endometritis and its impact on reproductive performance in dairy cows. J Dairy Sci 2002; 85: 2223-2236.
28. Loeffler SH, de Vries MJ, Schukken YH. The effects of time of disease occurrence, milk yield, and body condition on fertility of dairy cows. J Dairy Sci 1999; 82: 2589-2604.
29. López-Gaitus F, Santolaria P, Yániz J, Fenech M, López-

Béjar M. Risk factors for postpartum ovarian cysts and their spontaneous recovery or persistence in lactating dairy cows. Theriogenology 2002;58:1623-1632.
30. Mackey DR, Gordon AW, McCoy MA, Verner M, Mayne CS. Associations between genetic merit for milk production and animal parameters and the fertility performance of dairy cows. Animal 2007; 1: 29-43.
31. Morton JM. High genetic merit and high-producing dairy cows in commercial Australian herds don't have substantially worse reproductive performance. Br Soc Anim Sci 2001; 26: 305-311.
32. Nakao T, Moriyoshi M, Kawata K. The effect of postpartum ovarian dysfunction and endometritis on subsequent reproductive performance in high and medium producing dairy cows. Theriogenology 1992; 37: 341-349.
33. Patton J, Kenny DA, McNamara S, Mee JF, O'Mara FP, Diskin MG, Murphy JJ. Relationships among milk production, energy balance, plasma analytes, and reproduction in Holstein-Freisian cows. J Dairy Sci 2007; 90: 649-658.
34. Pedernera M, García SC, Horagadoga A, Barchia I, Fulkerson WJ. Energy balance and reproduction on dairy cows fed to achieve low or high milk production on a pasture-based system. J Dairy Sci 2008; 91: 3896-3907.
35. Potter TJ, Guitian J, Fishwick J, Gordon PJ, Sheldon IM. Risk factors for clinical endometritis in postpartum dairy cattle. Theriogenology 2010; 74: 127-134.
36. Pryce JE, Coffey MP, Simm G. The relationship between body condition score and reproductive performance. J Dairy Sci 2001; 84: 1508-1515.
37. Rajala-Schultz PJ, Gröhn YT. Culling of dairy cows. Part III. Effects of diseases, pregnancy states and milk yield on culling in Finnish Ayrshire cows. Prev Vet Med 1999; 41: 295-309.
38. Sangsritavong S, Combs DK, Sartori R, Armentano LE, Wiltbank MC. High feed intake increases liver blood flow and metabolism of progesterone and estradiol-17β in dairy cattle. J Dairy Sci 2002; 85: 2831-2842.
39. Spicer LJ, Tucker WB, Adams GD. Insulin-like growth factor-1 in dairy cows: relationships among energy balance, body condition, ovarian activity, and estrous behavior. J Dairy Sci 1990; 73: 929-937.
40. Tebble JE, O'Donnell MJ, Dobson H. Ultrasound diagnosis and treatment outcome of cystic ovaries in cattle. Vet Rec 2001; 148: 411-413.
41. Veerkamp RF, Beerda B, van der Lende T. Effects of genetic selection for milk yield on energy balance, levels of hormones, and metabolites in lactating cattle, and possible links to reduced fertility. Livest Prod Sci 2003; 83: 257-275.
42. Villa-Godoy A, Hughes TL, Emery RS, Chapin LT, Fogwell RL. Association between energy balance and luteal function in lactating dairy cows. J Dairy Sci 1988; 71: 1063-1072.

젖소에서 산유량이 분만 후 건강과 번식 능력에 미치는 영향

김상곤 · 정재관 · 허태영* · 강현구 · 김일화[1]

충북대학교 수의과대학, *국립축산과학원

요 약 : 본 연구는 젖소에서 산유량이 분만 후 건강과 번식 능력에 미치는 영향에 대하여 조사하였다. 젖소 목장 6개소의 총 1,060두로부터 산유 성적, 신체충실지수(BCS), 분만 후 질병 및 번식 능력에 대한 자료를 수집하였으며, 모든 자료는 305일 산유량에 기준으로 대조군(< 10,000 kg, n = 445)과 고산유량군(≥ 10,000 kg, n = 615)으로 구분하였다. 유지방, 유단백 및 BCS는 분만 후 5개월 동안 대조군에 비해 고산유량군에서 낮았다($p < 0.01$). 자궁내막염 발생은 대조군(35.1%)에 비해 고산유량군(29.6%)에서 낮은 경향이 있었으나($p = 0.06$), 난소낭종의 발생은 대조군(15.3%)에 비해 고산유량군(28.6%)에서 증가되었다($p < 0.0001$). 번식 호르몬 처리를 받은 소의 비율은 대조군(56.6%)에 비해 고산유량군(62.4%)이 높은 경향을 보였으나($p = 0.06$), 첫 수정 수태율은 대조군(35.2%)에 비해 고산유량군(30.2%)에서 낮은 경향을 나타내었다(odds ratio = 0.78, $p = 0.07$). 분만 후 210일까지 임신율은 대조군에 비해 고산유량군에서 낮았으며 (hazard ratio = 0.84, $p = 0.04$), 이것이 분만 후 평균 임신 간격의 연장(20일)을 초래하였다. 결론적으로, 젖소에서 고산유량은 유지방, 유단백질 및 BCS의 저하, 난소낭종의 발생 증가 및 번식 호르몬의 사용 증가로 번식 능력의 감소를 초래하였다.

주요어 : 젖소, 산유량, 분만 후 건강, 번식 능력