

Relationship Between Daily Rumination Time, Physical Activity, Estrus and Metabolic Changes in Dairy Cows

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Abstract

The present study attempted to ascertain whether there is any connection between reduced daily rumination time and increased physical activity of the animals, on the one hand, and the presence of estrus or metabolic disorders in dairy cows, on the other hand. It has been observed that of the total of 168 cows, 55 (32.73%) showed decreased daily rumination time, 57 cows (33.92%) had specific manifestations for estrous period, while 25 cows (14.88%) showed both decreased daily rumination time and the presence of estrus. Statistical assessment of the data demonstrated a highly significant correlation between these two factors, with a p-value <0.05 ($p = 0.0369$). Regarding the correlation between increased physical activity, found in 40 cows (23.80%) and the presence of estrus, observed in 57 cows (33.92%) this one is extremely statistically significant with a p-value <0.001 ($p = 0.0005$), the combination of increased physical activity and estrus being detected in a total of 23 cows (13.69%). Thus, of 168 dairy cows taken into the study, 37 (22.02%) showed an association between decreased daily rumination time and increased physical activity, resulting in an extremely statistically significant correlation between the combination of the two events and the presence of estrus in cows, with a p-value <0.001 ($p = 0.0003$). Metabolic disorders were found in a total of 12 dairy cows (7.14 %), the association between decreased daily rumination time and increased physical activity being not statistically correlated with the development of metabolic disorders, $p = 0.4676$. It remains to be observed if a correlation between the association of decreased daily rumination time and increased physical activity with the presence of metabolic disorders exists.

Keywords: *dairy cows, estrus, physical activity, rumination.*

INTRODUCTION

Rumination is a cyclical process characterized by regurgitation, remastication, and reswallowing. An important function of rumination is to facilitate digestion, particle size reduction, and subsequent passage from the reticulorumen, maintaining high levels of feed intake. Furthermore, rumination increases saliva secretion and improves rumen functionality because saliva aids in buffering

the volatile fatty acids produced by microbial digestion (Beauchemin, 1991).

Rumination time (RT) is an appropriate parameter for early identification of metabolic disorders such as ruminal acidosis. Saliva secretion and rumen health are closely associated with daily RT (Maekawa *et al.*, 2002). While some measurements of RT implemented by technical methods like pressure transducers (Kaske *et al.*,

2002) or piezo disks integrated within a cow's halter (Yang and Beauchemin, 2006), are mostly invented for research purposes, the microphone-based system (HR-Tag, SCR Engineers Ltd., Netanya, Israel) became commercially available for automatic recording of RT data (Reith *et al.*, 2014). Rejection of feed boluses and mastication produce sounds that are registered by the acoustic sensor (Burfeind *et al.*, 2011) and can be separated from sounds related to eating (Adin *et al.*, 2009). Schirmann *et al.* (2009) and Burfeind *et al.* (2011) found a high correlation ($r = 0.88$ and $r = 0.93$, respectively) between RT obtained from the HR-Tag and visual observation.

Rumination time is mainly used in dairy farms to predict impending metabolic disorders and calving (Soriani *et al.*, 2012, 2013), and provides useful information to control feeding strategies and rations concerning its structure and components. Today, there are commercial systems available to record both RT and activity behavior every 2 h for the individual cow in the herd (Soriani *et al.*, 2013). In validation studies, researchers who compared data for RT generated by these systems with those obtained by visual observation confirmed the suitability of these systems to accurately monitor daily RT in a practical setting on farms (Burfeind *et al.*, 2011).

Although RT can be used for monitoring the metabolic health of dairy cows, it is not known whether RT is influenced by fertility and reproductive management routines. A change that seems to be clearly associated with estrus behavior and that is pronounced in many cows is the increase in physical activity.

The present study attempted to ascertain whether there is any connection between reduced daily rumination time and increased physical activity of the animals, on the one hand, and the presence of estrus or metabolic disorders in dairy cows, on the other hand.

The present study was considered necessary to assess the correlation between the presence of estrus in cows and the association of the following factors: decreased daily rumination time and increased physical activity, all the variables being recorded using a device equipped with sensors or microphone for recording the rumination sounds, the data being transferred to a specialized program.

Also, the study tried to observe if there is a correlation between decreased daily rumination time and increased physical activity with the presence of metabolic disorders, or the two variables correlate strictly with the presence of estrus in cows.

MATERIALS AND METHODS

The study was conducted at a farm near Liverpool, UK on a herd of 168 Holstein Friesian dairy cows over a period of one month. The dairy cows were housed in free stall shelters; the feeding of the cows was made *ad libitum*, while the milking system was automated.

Monitoring rumination and physical activity was performed using HR neck collar (SCR), a rumination monitoring system combined with a unique motion sensor that uses sounds picked up by a microphone that is in tight contact to the cow's neck to measure the rumination time (RT). This system is integrated in commercial activity tags (Hi-Tag) and is named HR-Tag. The collar also permits storing data regarding physical raw activity or weighted activity through its sensors. The recorded data is downloaded to and stored in the herd computer after each milking or any time a cow passes under a tag reader, and is available as individual or group reports, produced by the herd management software (Data Flow). Rumination is recognized by analyzing the chewing sounds, and excluding the sounds related to eating. Data is stored in "2 hours cells", in 2 minutes resolution (Doron and Ran, 2010).

The presence of estrus in dairy cows has been assessed by cyclic activity evaluation generated by Data Flow software and confirmed by physical examination of the animals.

Metabolic evaluation was done by biochemical examination conducted by IDEXX VetTest® Chemistry Analyzer which detects key biochemical parameters for 18 species. The principle of the method is based on dry-slide technology which uses layers and washes to remove impurities for the most reliable results and spectrophotometry. In this study, the following parameters were evaluated: alanine aminotransferase, aspartate aminotransferase, gamma glutamyl transferase, alkaline phosphatase, alkaline reserve, albumins and total proteins.

Data regarding the daily rumination times, physical activity and the presence of estrus in

dairy cows were recorded in contingency tables by entering values reduced to 0 and 1. Thus, decreased daily rumination times (<500 min / day) has been noted as 1 and normal or increased daily rumination time has been noted as 0. Increased physical activity (> 45 minutes / 2 hours period) in dairy cows has been noted as 1 and decreased or normal physical activity as 0. Regarding the presence or the absence of estrus, these have been noted as 1, respectively 0. In a similar manner has been proceeded for the metabolic disorders, their presence being noted as 1 and their absence as 0.

Since the study aimed to observe whether there is a correlation between the presence of estrus and the exact combination of the factors represented by decreased daily rumination time and increased physical activity in dairy cows or the latter can also be seen in various metabolic disorders, the exact combination represented by decreased daily rumination time and increased physical activity has been marked as 1 and the remaining possible combinations as 0.

The recorded data has been statistically interpreted using Fisher's exact and PAWS 18 software which generated the cross tables.

RESULTS AND DISCUSSION

The data obtained using the Hi Tag neck collar have been recorded both individually and from the whole herd. One hundred sixty-eight dairy cows providing relevant data, without breaks in recording, were taken into research.

Rumination is a cyclical process characterized by regurgitation, remastication, and reswallowing. Since visual observation to measure RT is labor intensive, indirect methods of monitoring rumination were proposed. Some were based on jaw-motion-detecting devices in a halter (Luginbuhl *et al.*, 1987). These devices were effective at measuring rumination, differentiating jaw movements associated with chewing or ruminating behavior (Beauchemin *et al.*, 1989) but may be uncomfortable for the animals. In our study a new system was adopted to measure the RT in dairy cows (HR-Tag rumination monitoring system, SCR Engineers Ltd.). This device was described and validated by Schirmann *et al.* (2009), indicating its accuracy for monitoring rumination behavior in dairy cows and its usefulness in research and commercial applications (Soriani *et al.*, 2012).

The system was used in previous research (Adin *et al.*, 2009; Burfeind *et al.*, 2011; Schirmann *et al.*, 2011). Detection of estrus has been identified as one of the primary causes of reduced reproductive performance in dairy cows. Technological progress has led to the development and application of sensor-based monitoring systems that continuously monitor and record detailed information, and use these data to diagnose the status of the cow (sick or healthy, in estrus, etc.). Although measuring activity by pedometers is thoroughly investigated as an indicator of estrus (Ranasinghe *et al.*, 2010; Yániz *et al.*, 2006), only few data on activity measurement by means of acceleration systems attached to the neck collar are available in the literature.

Previous studies have revealed that decreased daily rumination time is related to the presence of estrus (Reith and Hoy, 2012) and also that an increase in physical activity correlates with the presence of estrus in dairy cows (Berka *et al.*, 2004; Reith *et al.*, 2014), but the specific combination of these factors has not been demonstrated.

Validation of the previous obtained results by other authors has been done by assessing the correlations between decreased daily rumination time and the presence of estrus, or increased physical activity and the presence of heat in dairy cows.

It has been observed that of the total of 168 cows, 55 (32.73%) showed decreased daily rumination time, 57 cows (33.92%) had specific manifestations for estrous period, while 25 cows (14.88%) showed both decreased daily rumination time and the presence of estrus. Statistical assessment of the data demonstrated a highly significant correlation between these two factors, with a p-value <0.05 ($p = 0.0369$) (Tab. 1).

Tab. 1. The association between decreased daily rumination time (DRT) and the presence of estrus (E)

		Count		
		DRT		Total
		0	1	
E	0	81	32	113
	1	30	25	55
Total		111	57	168

Regarding the correlation between increased physical activity, which was observed in 40 cows (23.80%) and the presence of estrus, observed in 57 cows (33.92%) there is an extremely significant statistical association, with a p -value <0.001 ($p = 0.0005$). Both increased physical activity and estrus was detected in 23 cows (13.69%) (Tab. 2).

Tab. 2. Association between increased physical activity in dairy cows (PA) and the presence of estrus (E)

		Count		Total
		PA		
		0	1	
E	0	94	34	128
	1	17	23	40
Total		111	57	168

The most probable reason for increased activity during estrus might be the release of estrogens starting in the pre-estrus period. Lopez *et al.* (2004) found a significant correlation between estradiol concentration, duration of estrus, and estrous behavior. Maximum circulating hormone concentrations were recorded one day before estrus (Lopez *et al.*, 2004; Reith *et al.*, 2014) or between 16 h before and 9 h after estrus (Mondal *et al.*, 2006).

The opposite temporal pattern was found for RT. Relating to earlier observations (Reith and Hoy, 2012), we were able to confirm that estrual cows spent significantly less time chewing.

The current study showed that RT was influenced by the onset of estrus in cows. Daily RT quantifies behavioral changes manifested by increased activity and restlessness and also reduced lying time (Brehme *et al.*, 2006), and decreased milk yield and feed intake associated with a decrease in body weight (Maltz *et al.*, 1997; Reith *et al.*, 2014).

Validating the results of previous studies make a thorough assessment of decreased rumination time and increased physical activity association, in the presence of estrus in dairy cows (Lindgren, 2009).

Thus, of 168 dairy cows taken into the study, in 37 (22.02%) we observed an association between decreased daily rumination time and increased

physical activity, resulting in an extremely statistically significant correlation between the combination of these two events and the presence of estrus in cows, with a p -value <0.001 ($p = 0.0003$) (Tab. 3).

Tab. 3. Association between decreased daily rumination time and increased physical activity (DRT/PA) with the presence of estrus in dairy cows (E)

		Count		
		E		Total
		0	1	
DRT/PA	0	96	35	131
	1	15	22	37
Total		111	57	168

But the purpose of the study was to observe if the specific combination of increased physical activity and decreased daily rumination time is strictly associated with the presence of estrus in dairy cows or may be also associated with the presence of metabolic disorders, which have been diagnosed by investigating blood biochemical parameters.

One of the factors that reduces RT is inflammation. There are several models frequently used to induce inflammation, one of those being represented by the lipopolysaccharides (LPS) challenge, which may mimic reduced concentrations of circulating bacterial endotoxin during the beginning of acute gram-negative infections. In accordance with this model, Borderas *et al.* (2008) observed a reduction of the RT in calves after a treatment with a low dose of LPS. In the current study, we assessed metabolic disorders by evaluating biochemical changes. As formulated in different studies (Soriani *et al.*, 2012), the results with an increase or decrease of more than 10% than the upper or lower limit of the reference values were taken into consideration.

Confirmed metabolic disorders were found in a total of 12 dairy cows (7.14 %), the association between decreased daily rumination time and increased physical activity not being statistically correlated with the development of metabolic disorders, $p = 0.4676$ (Tab. 4).

Tab. 4. The association between specific combination of decreased daily rumination time and increased physical activity (DRT/PA) and the presence of metabolic disorders (MT)

	Count		
	MD		Total
	0	1	
DRT/PA	0	120	131
	1	36	37
Total	156	12	168

The study shows an extremely significant correlation between the presence of estrus and the increased physical activity and decreased daily rumination time, the implications of this study being important to differentiate between various pathologies. The research does not rule out the association of the two-specific combinations of decrease daily rumination time and increased physical activity with the development of some early stage disorders that do not cause significant changes of biochemical parameters.

CONCLUSIONS

The conducted study revealed the following conclusions:

1. The statistical assessment between the presence of estrus and decreased daily rumination time demonstrated that a very significant correlation exists, with a p -value <0.05 ($p = 0.0369$).

2. Regarding the correlation between increased physical activity, found in 40 cows and the presence estrus observed in 57 cows it can be stated that there is an extremely significant statistical correlation with a p -value <0.001 ($p = 0.0005$).

3. The correlation between the specific association of decreased daily rumination time and increased physical activity with the presence of estrus in dairy cows is considered to be extremely significant, with a p -value <0.005 ($p = 0.0003$).

4. The combination between decreased daily rumination time and increased physical activity is not statistically correlated with the development of metabolic disorders, $p = 0.4676$.

5. It remains to be shown if a specific correlation between the association of decreased daily rumination time and increasing physical

activity occurs in the early stages of metabolic disorders.

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