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Pulsation cycles - a welfare concern?

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Abstract

Configurations of milking machine installations need to comply with International Standards as a minimum requirement. Thus, milking machine constructors are free to adjust milking installations to optimise milking processes. Particularly liner movements, which are controlled by pulsators, have the potential to improve milk removal and animal welfare.

The aim of this study was to evaluate the effect of two pulsation cycle types differing in closing (c-phase) and closed phase (d-phase) with specific regard to hind leg activity and milk removal in dairy cows.

Forty-two dairy cows were confronted randomly with two different pulsation cycle types (treatment A and B) for 12 milkings in an auto tandem milking parlour (2×3). Treatment A and B differed in c- and d-phases. The c-phase of the pulsation chamber vacuum in treatment B was prolonged to 130 ms and the d-phase was shortened to 270 ms in contrast to the respective phases in treatment A (reference; c-phase: 70 ms; d-phase: 330 ms).

Cows tended to produce a higher total milk yield in treatment B than in treatment A. Further, the peak flow rate was significantly higher in treatment B than in treatment A. However, the treatments did not differ significantly in mean hind leg activity.

Concerning milk removal, the prolonged c-phase showed to be beneficial. Restlessness during milking, regardless of the treatment, occurred only seldom, likely because of the cows` disposition and the good conditions in the milking palour. As udder quarter emptying is known to be time delayed, overmilking may cause stress. Thus, we expected that hind leg activity would increase towards the end of the milking procedure as it causes discomfort on teats. However, the results of the current research could not confirm this hypothesis.

Keywords: milking machine, pulsator, pulsation cycle type, milk physiology, behaviour

1 Introduction

To ensure functionality of milking machines, configurations of milking machine installations need to comply with International Standards ISO/DIN 5707 (2007) as a minimum requirement. Thus, variable constructions of single elements are possible and occur on dairy farms. To optimise milking machine configurations, the interpretation and understanding of processes during milking are required.

Several studies show that liner movements controlled by pulsators can cause discomfort on teats and have negative effects on udder health (Albers, 2011; Billon and Gaudin, 2001; Hamann and Mein, 1996; Reitsma et al., 1981; Worstorff et al., 1985).
Therefore, the durations of pulsation cycle phases are defined as follows: the b-phase should take up at least 30 % of a pulsation cycle, and the d-phase should last at least 150 ms (ISO/DIN 5707, 2007). Billon and Gaudin (2001) noticed that the a-and c-phases are not mentioned in the International Organization for Standardization due to lack of scientific results on their influence on milking and udder health of dairy cows. They found lower milk flow rates when cows were milked with a short c-phase compared with a long c-phase.

Previous studies examined different durations of b- and d-phases and the associated consequences on total milk yield (TMY) and peak flow rate (PFR). Ambord and Bruckmaier (2009) observed an elevated PFR caused by a prolonged b-phase, but found no effects on TMY. Contrary, Bade et al. (2009) and Hamann and Mein (1996) extended the b-phase and achieved increased TMY and PFR. Gygax et al. (2008), Rushen et al. (2001), and Wenzel et al. (2003) further found that stepping, kicking, and constant movement during milking are indicative of stressful situations.

The aim of this study was to evaluate the effect of two pulsation cycle types differing in their closing phase (c-phase) and closed phase (d-phase) with specific regard to hind leg activity and milk removal in dairy cows.

We hypothesised that a slower closure of the liner induced by a prolonged c-phase could be more gentle and comfortable than a closure at regular speed and as a result lead to optimised milk removal and calmer dairy cows in the milking parlour.

2 Materials and Methods

The current study was conducted in July 2013 at the Agroscope Taenikon ISS Federal Research Station in Switzerland.
Forty-two experimental dairy cows (16 Red Holstein × Fleckvieh and 26 Brown Swiss) were housed in a loose-housing system and milked twice per day at equal intervals in a low line 2×3 auto tandem milking parlour (GEA Farm Technologies GmbH, Bönen, Germany). Lactation stages ranged from 3 to 596 DIM and were classified in three categories: early = < 100 DIM (15 animals), mid = 101-200 DIM (9 animals) and late = > 201 DIM (18 animals). Lactation numbers ranged from 1 to 9 and were summed up in first lactation (11 animals) and second and further lactations (31 animals). Average TMY per milking was 16.4 kg and ranged from 6.2 kg to 25.2 kg.

Milk flow meters (LactoCorder, WMB AG, Balgach, Switzerland) and pulsator devices (RotoPuls integral, BITEC Engineering, Romanshorn, Switzerland) were installed at each milking stall during test-period milkings. After a two-week visual adaption period for the cows to pulsators, measuring devices, and observer, cows were confronted randomly with treatment A and B for 12 milkings. Treatments were applied during morning milkings due to warm weather conditions and high density of flies at the afternoon milkings, which could have had an influence on cows behaviour.

Treatment A and B differed in closing phases (c-phases) and closed phases (d-phases). The c-phase of the pulsation chamber vacuum in treatment B was prolonged to 130 ms and the d-phase shortened to 270 ms in contrast to the settings in treatment A (reference, c-phase: 70 ms, d-phase: 330 ms).

Pulsation cycle phase durations were verified with a dry test of pulsation before each treatment to ensure durations settings. The pulsation rate was 60:40 with a pulsation rate set to 60 cycles per minute. Automatic stripping and automatic cluster removers were adjusted to a flow threshold of 0.8 kg/min and 0.3 kg/min, respectively. Milking clusters GEA “Classic 300” with commercial nitrile rubber liners, renewed six weeks before experiment start, were used (GEA Farm Technologies GmbH, Bönen, Germany).

Milk flow characteristics were evaluated by LactoCorders and included TMY and PFR. Milking characteristics were processed by the program pack LactoPro Software (LactoCorder Software, version 6.0.28; WMB AG, Balgach, Switzerland, 2013).

The two milking parlour operators used consistent preparation procedures that consisted of pre-milking, cleaning, and unit attachment. In total, milkers had a task time of 45 s for the preparation procedures. The automatic stimulation lasted for approximately 30 s for dairy cows in the first lactation stage. Dairy cows in the second lactation stage were stimulated automatically for approximately 40 s and dairy cows in the third lactation stage for approximately 50 s.

Additionally, 18 out of 42 experimental dairy cows (7 Red Holstein × Fleckvieh and 11 Brown Swiss) were observed with hind leg activity measurements by 3D accelerometer sensors which functioned as pedometers (RumiWatch, Itin + Hoch, Liestal, Switzerland). Cows were equipped with these pedometers on each hind leg for one treatment each. Two positions were distinguished: hind leg turned towards milking pit and hind leg turned away from milking pit. The RumiWatch Converter (RumiWatch, Itin + Hoch, Liestal, Switzerland) listed data in form of activity indices (activity index = g × 1/56) with a sampling rate of 10 Hz for the three axes x, y, and z in a spreadsheet. For calculating mean activity, activity indices values were converted to absolute values, axes x, y, and z were summed up, and mean values were calculated for each milk flow curve phase: phase 1 = plateau phase (PLP), phase 2 = decreasing phase (DP), phase 3 = overmilking phase (OP), and phase 4 = post-milking phase (PMP).

The statistical analysis was performed in the statistic program system R 1.9.1 (R Development Core Team, 2011). The linear mixed-effects model (Bates et al., 2011) was used to evaluate differences in the milk flow characteristics TMY and PFR and the mean hind leg activity. Through stepwise backwards elimination, upper interactions that did not reach significance were excluded. To satisfy assumptions of the statistical models, responses were log-transformed for PFR. In the model calculation for milking characteristics, target variables were TMY and PFR. The model contained the treatments A and B as explanatory variables and lactation stage (DIM: early, mid, late) and lactation number (early, second and further) as co-variables. Animals and measuring days were regarded as random effects (nested). The model calculation for hind-leg activity contained the target variable mean activity, the explanatory variables treatments A and B, and the following co-variables: phases of the milk flow curve (PLP, DP, OP, and PMP) and position of pedometer (turned towards milking pit, turned away from milking pit). Animals and measuring days were regarded as random effects (nested).

3 Results

The TMY decreased significantly with increasing lactation stage ($P < 0.001$) and increased significantly with increasing number of lactations ($P < 0.001$; figure 1). A tendency could be detected between treatments A and B ($P = 0.06$). Regarding the model calculation, when cows were confronted with treatment B, their TMY was on average 0.21 kg higher than when they were milked with treatment A.

Lactation stage had no significant influence on PFR ($P > 0.1$), whereas lactation number had a significant influence ($P < 0.05$). The model calculation showed that the PFR at the second and further lactation was at least 1.24 kg/min higher than that at the first lactation. Furthermore, the PFR was significantly higher with 1.04 kg/min in treatment B than in treatment A ($P < 0.001$).

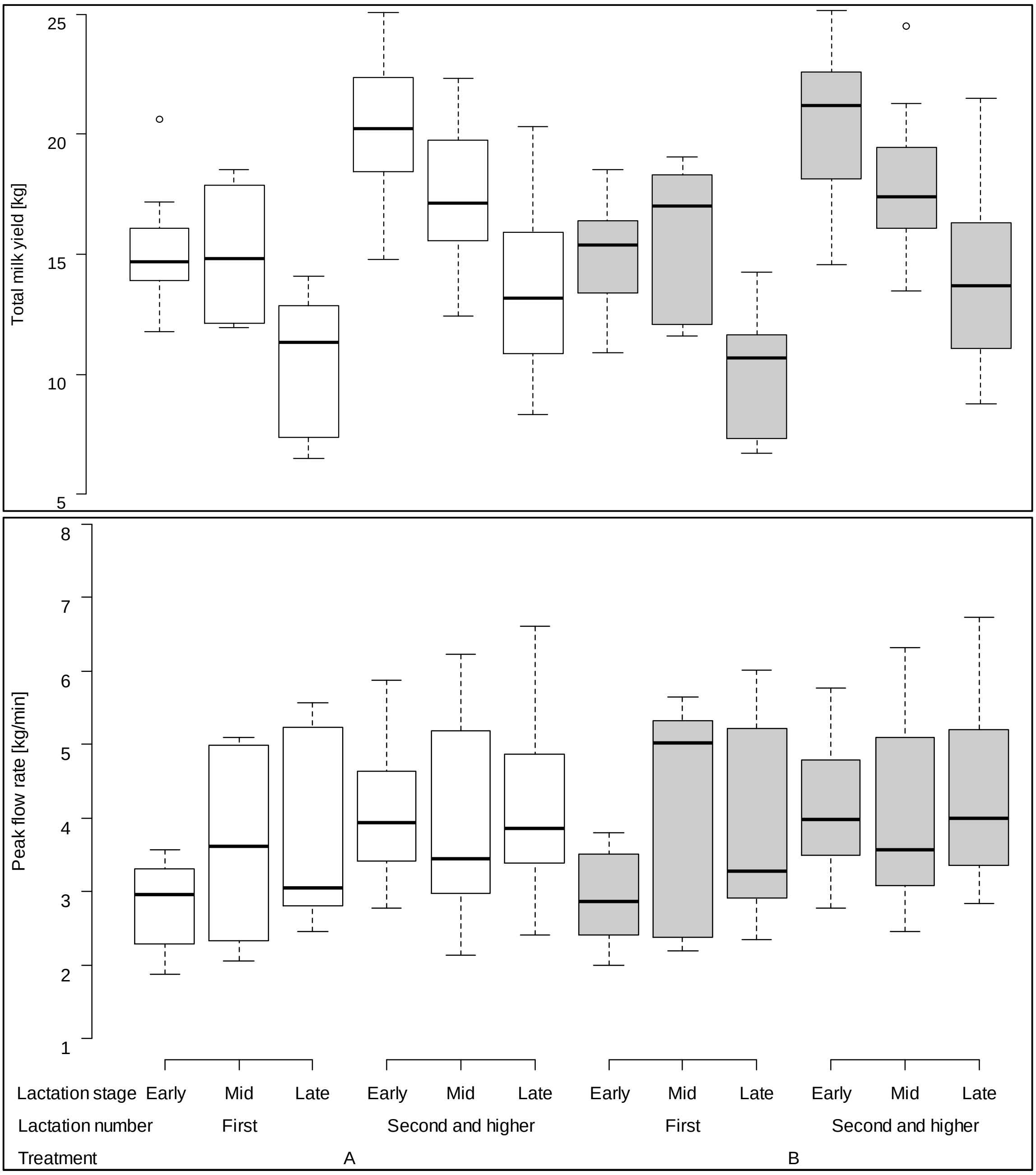

Figure 1: Total milk yield per milking and peak flow rate per minute achieved with treatment A (white boxplots) and B (grey boxplots), categorised in lactation numbers and subdivided in lactation stages.

No significant differences in mean values of hind leg activity could be found between the different milk flow phases ($P > 0.1$; figure 2). Nevertheless, a tendency of significant interaction could be detected between treatments and positions of pedometers ($P = 0.06$). In treatment B, animals showed higher activity in the hind leg turned away from the milking pit than in the hind leg turned towards the milking pit (figure 2). In treatment A, no difference in activity could be detected between the two positions of the pedometers.

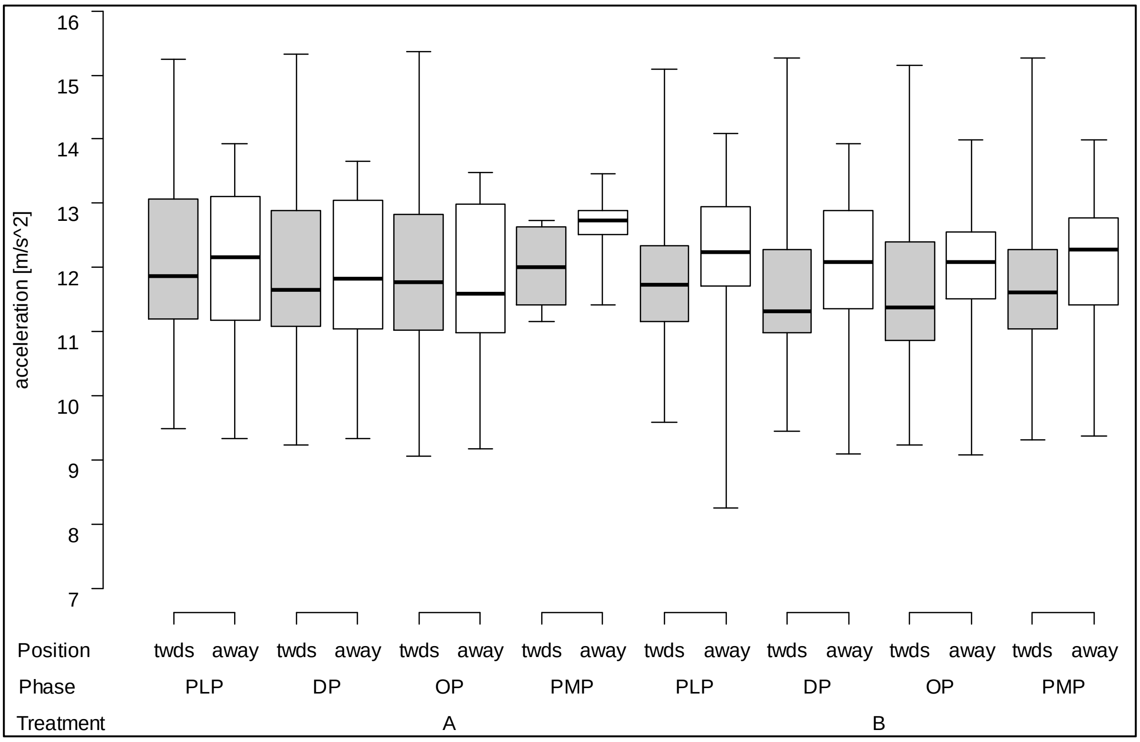

Figure 2: Mean hind leg activity of cows milked with treatments A and B, categorised in plateau phase (PLP), decreasing phase (DP), overmilking phase (OP), and post-milking phase (PMP) and subdivided in hind leg turned towards milking pit (twds, grey box plots) and hind leg turned away from milking pit (away, white box plots).

4 Discussion

The current study reported the TMY to decrease with increasing lactation stage and increase with increasing lactation number. These findings were in line with former studies that reported similar results (Antalik and Strapak, 2010; Dodenhoff et al., 1999; Strapak et al., 2011). Rushen et al. (2001) detected that dairy cows milked in stressful situations had reduced milk yields and increased residual milk, thus total milk yields were not affected. In the present study, the TMY tended to be 0.21 kg higher in treatment B than in treatment A. However, these small differences indicate neither reduced well-being in treatment A nor improved comfort in treatment B. Rosca et al. (2010) described that milk flow starts about 25-50 % into the a-phase, continues through the b-phase and ceases during the first part of the c-phase. The extended c-phase in treatment B caused a less rapid closure of the liner after the b-phase and thus prolonged the duration of milk removal. Consequently, we can assume that treatment B could improve the milk-out grade. Complete and fast milk removal is obligatory to sustain high milk yield and animal health (Bruckmaier et al. 1998; Worstorff et al., 1980).

The PFR was found to be positively correlated with lactation number in this study, which was in accordance with studies by Antalik and Strapak (2010) and Strapak et al. (2011). Billon and Gaudin (2001) and Kochman et al. (2008) observed lowest flow rates when the c-phase was short, and their result was confirmed in this study. The prolonged c-phase in our study was combined with a shortened d-phase. Therefore, our results were contrary to those of Albers (2011), who marked a reduced flow rate as a negative consequence of a short d-phase, as a short massage phase is insufficient and thus has a negative effect on teat condition.

Further, Albers (2011) and Kochman et al. (2008) reported that a short c-phase caused pain and/or discomfort on dairy cows` teats, as the liner closes relatively fast, and thus, leads to restlessness, kicking, and milk-ejection disturbances. This could not be confirmed in the current study as hind leg activity did not differ significantly between the treatments. Prolonging the c-phase had no positive effects on experimental cows. However, as Albers (2011) and Kochman et al. (2008) mentioned, a short d-phase had a negative effect on teat condition and increased the risk for mastitis. Hence, the effects of a lengthened c-phase in combination with a shortened d-phase should be investigated further in a long-term study.

Finally, we observed a tendency towards a statistically significant interaction of treatments and position of pedometer. Dairy cows showed the highest mean activity in the hind leg turned towards the milking pit when they were milked with treatment A. Nevertheless, this activity was not significantly higher than that recorded in treatment B The lack of significant differences in hind leg activity between the two treatments may be due to the cows' long habituation to treatment A (the reference treatment). Therefore, the cows did not experience an acute stress situation in treatment A, so that treatment B, contrary to our expectations, did not improve the cows' comfort. Furthermore, the hind leg activity in either treatment did not increase towards the end of the milking procedure.

5 Conclusions

The prolonged c-phase caused an increased TMY and a significantly higher PFR, compared with the reference c-phase and thus appeared to be beneficial. Progressions of TMY and PFR according to lactation stage and lactation number confirmed the findings of previous studies. However, the hypothesis of an increased hind leg activity in treatment A and towards the end of the milking process could not be confirmed and might be explained by the calm disposition of the tested cows. Further research with activity measurements during the milking process would be recommended.

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