Qualitative and Quantitative Analysis on Lactating Holstein Cows (*Bos taurus taurus*), Utilizing a Polar Equine Heart Rate Belt and RFID Tag

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Abstract

The effects of various stressors on first-lactation dairy Holsteins can be viewed through a qualitative and quantitative analysis of heartrate using physical recordings utilizing polar equine belts. For lactating dairy cattle, links between mental and physical harmony are crucial for maintaining adequate performance within the milking parlor and for reproductive purposes. A random selection of first-lactation Holsteins was selected, and each given a four-day acclimation period to ensure no further stimulation was detected from primary discomfort. The direct association between body systems such as the respiratory, circulatory, and nervous correlate with heartrate physiology and allow for further analysis of how environmental and anxiety-induced factors contribute to stimulation. Cows can experience natural stress from specific stimuli throughout their daily routines, consisting of pre-milking (PM) periods, into the parlor holding area (into PHA), while in the parlor holding area (PHA), during milking, and exiting the milking parlor (exit PHA) to the feed bunk. These periods were sampled to be considered as "positive-stress periods." Negative-stress periods were sampled through dairy cattle resting states (Rest). The resting state of dairy cattle is of high significance for monitoring heartrate and overall cow health. The use of five first lactation dairy cattle in correlation over a six-week period of gathering data points allowed for accurate analysis of the overall data from the study. Results show that there were no significant differences between any positive stress periods, but most positive stress periods were significantly higher in heartrate than the rest period (P ≤ 0.05). While the Into PHA period was not significant to rest at P ≤ 0.05, it did have a P-value of 0.06 indicating that it approached significance and thus was still a positive stressor.

Introduction

Dairy cattle are bred to produce offspring with specific characteristics that include showing, milking quality, or milk production. Consumers want to know their product is coming from high quality conditions including animal welfare. For lactating dairy cattle, the reduction of stress while maintaining mental and physical harmony is crucial for maintaining a high milk yield. Common types of stress suffered by dairy cattle can include dystocia, social behavior, milking, feeding, husbandry, and environmental changes or conditions. Cows are likely to experience natural stress during feeding periods due to the nature of fighting over a spot at the feed bunk as well as by interacting with humans during milking. "The term 'temperament' is frequently used to describe the relatively stable differences in the behavioral predisposition of animals, which can be related to psychobiological mechanisms." (Kovacs, Kezer, Tozser, Szenci, Poti, Pajor, 2015). Discomfort in larger animals is sometimes difficult to detect. Testing for increased heart rate is a successful indication of challenging situations cows endure. Monitoring the heart rate in first-lactation Holstein cows at the Delaware Valley University Dairy could lead to navigating a better way to cause less stress under milking conditions before, during, and after the act of milking. With the use of both the polar equine belt and the radio frequency identification tags, we were able to compare the heart rate and bodily functions, such as rumination, over the duration of this experiment. The feeding period was first assumed to be a positive stressor, while the negative stressors would be ruminating and resting.

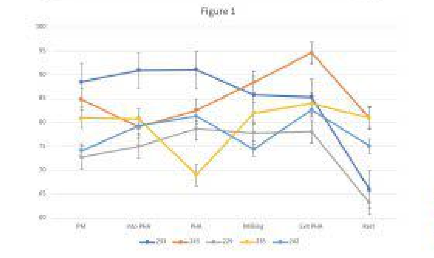

Figure 1: Shows variability between treatment data sets of each individual cow. Individual points represent the average heart rate for each stress period ± standard error.

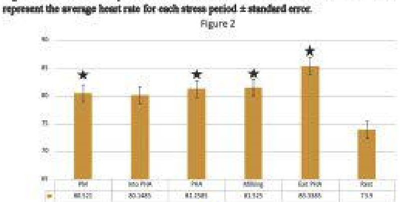

Figure 2: Cow average heartrates for each stress period ± standard error. Stars indicate significant difference (P ≤ 0.05) from Rest period as determined by T-Hypothesis Test. No other significant differences were found.

Methods:

Participants:

All participants were first-lactation dairy Holsteins.
Weeks of 02/15/22 and 03/15/2022
233: Days in Milk- 111
243: DIM- 60
Weeks of 02/22/2022 and 03/22/2022
229: DIM- 71
241 (removed from data due to sickness and euthanasia)
Weeks of 03/01/22 and 03/29/2022 (Both treated for pneumonia during study)
235: DIM- 61
242: DIM- 66

Materials:

- Polar H10 Equine Heart Rate Monitor and Belt (www.polar.com)

Belt contact points were maximized using ultrasound gel and data collection was via Bluetooth connection on smartphone

- Smartphone Application "ECGLogger," (records Electrocardiogram, Pulse, and Respiration)
- Littmann Stethoscopes
- RFID Tags
- CowManager
- StatCrunch

Procedures:

- The initial four-day period used to habituate the cows to wearing the belts and assuring that the data transmitted seems valid compared to measurement of heartrate by auscultation. This period also allowed researchers to learn appropriate placement of the belts, utilization of ultrasound gel to increase contact to allow for better data transmission via Bluetooth as well as working out other Bluetooth transmission issues.
- Heartrate detection was accomplished on two cows per week for 3 weeks, then this process was repeated.
- The six first lactation Holstein cows were split up into three groups of two. One cow was later euthanized for health reasons and was therefore removed from the study.
- Cow groups were tested on Tuesday and Friday during the respected periods for that group.
- Polar Equine Belts were worn from the prior Friday to Tuesday for acclimation, and data was taken on Tuesday. From Tuesday to Friday of that same week, the belts were kept on and data was recorded on that Friday. After all data was collected, the belts were moved from one cow group to the next cow group for acclimation from Friday through the following Tuesday. Data from resting periods was not accurate via the belts so this data was collected by auscultation with stethoscopes during comparable time periods
- Data collection occurred for 5-minute intervals during pre-milking, the transition from pre-milking to the parlor holding area, when all lactating cows were settled in the parlor holding area, during the process of milking, the transition from leaving the milking parlor to the feed bunk, and at rest.
- Data was also compared to the information recorded by the RFID Tags via CowManager.
  - This included rumination, activity levels, resting periods, behavior, feed intake, heat cycles, inseminations, calving, etc.
- Notes were also recorded manually on activities occurring at the dairy that could affect data and included:
  - Heat Cycles
  - Inseminations
  - Copper Sulfate Foot Baths
  - Hoof Trimming
  - Cow Treatments and Injuries
  - University Classes and Activities
- Analysis of variance was performed on the entire data set using Microsoft Excel.
- Individual means were compared with a T Hypothesis-Test on the StatCrunch statistics application.

Results

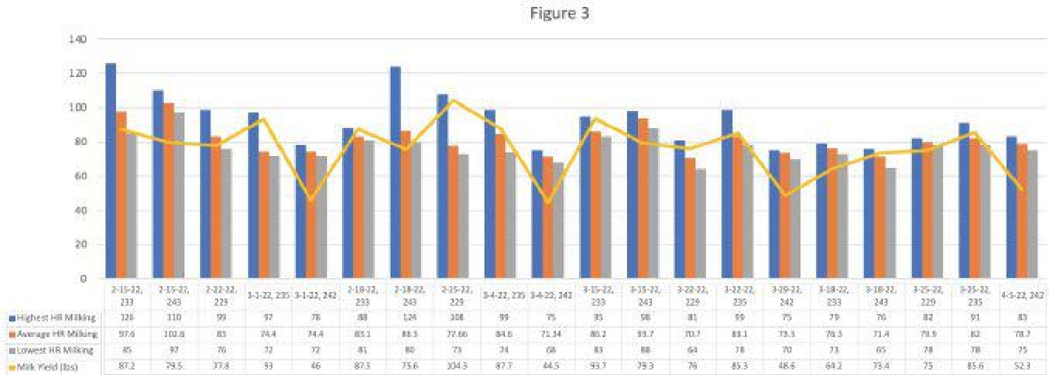

Figure 3: Complete data set of heart rate of each cow on each date during the milking period. This shows variability within an animal and shows milk production on each date.

Discussion and Conclusions:

These results indicate that PM, Into PHA, PHA, Milking, and Exit PHA are all positive stressors that increase heart rate compared to Rest. Analysis of variance as reported in Table 1 indicates that differences between stressor periods (Shown as groups) was highly significant. Statistical analysis between individual stressor periods by T-Hypothesis Test shows that heart rate increased with most recorded stressors as compared to the resting period. The resting period is relatively low stress with a lower heart rate than all other stressor periods (P ≤ 0.05) except into PHA, which neared significance (P = 0.06). This warrants further study where more data points with more subjects over a longer duration could be achieved. While initially it was assumed that the feeding period was a positive stressor, it was easier to obtain data for Exit PHA. Our positive stress indication can be viewed by comparisons of the Exit PHA stress period to all other periods where P ≥ 0.05 except at Rest. There was, however, no significant difference between positive stressor periods. The P-Value at Rest for all compared stressor periods remains 0.0002, indicating this is a low stress heart rate period. Milk production will usually decrease as a result of stress however we did not see a clear pattern relating these two things as shown (figure 3). This study showed the use of the Polar H10 equine heart rate monitor and belt were efficient for monitoring heart rate in dairy cattle. While there was no significant difference between heart rates of positive stressor periods, there was considerable animal variability in heart rate (Figure 1). While factors that could have influenced this were recorded by the RFID tags and notes by the researchers, these factors were not included in the statistical analysis. Further research with larger numbers of animals and data points could reveal more differences in stressor periods.

Groups	Count	Sum	Average	Variance
	5	1182	236.4	35.8
Pre-Milking	5	402.605	80.521	46.76222
Into Parlor Holding Area	5	400.7425	80.1485	40.02413
Parlor Holding Area	5	406.2925	81.2585	45.56819
Milking	5	407.625	81.525	32.62549
Out of Parlor to Eating	5	426.6925	85.3385	36.46734
Resting	5	369.5	73.9	83.52281

Source of Variation	SS	df	MS	F	P-value	F crit
Between Groups	104575.7	6	17429.29	380.3502	1.73E-25	2.445259
Within Groups	1283.081	28	45.82431			
Total	105858.8	34				

Table 1: Analysis of variance of the data using Microsoft Excel.

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