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Mini Review

Heart Rate Variability as a Non-Invasive Method to Assess Welfare in Dairy Cows

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Abstract

Adaptation to environmental changes can be challenging for highly productive dairy cow breeds. Animal welfare associated with husbandry procedures cabe assessed not only by classical descriptive behavioral observations, but with physiological measures as well. Assessment of blood cortisol levels requires handling, what represents additional stress to cows. Measures of cardiovascular parameters including heart rate (HR) and heart rate variability (HRV) have a long tradition as indicators of health and welfare in livestock species since the begging of the 1970s. HRV is a parameter that reflects the balance between sympathetic and parasympathetic nervous activity. Therefore, the power spectral analysis of HRV allows researchers to measure stress levels in cattle without handling or restraining them, thus making it a non-invasive indicator of welfare.

Keywords: Autonomic nervous system; Cattle; ECG; Stress; Sympathetic; Parasympathetic

Abbreviations: ANS: Autonomic Nervous System; ECG: Electrocardiogram; HF: High Frequency; HPA: Hypothalamic-Pituitary-Adrenal Axis; HR: Heart Rate; HRV: Heart Rate Variability; LF: Low Frequency.

Introduction

Adaptation to environmental changes can be challenging for highly productive dairy cow breeds, once intensive dairy farming, housing and milking systems are main factors in determining the welfare of animals [1]. The impact of technological environment on cattle welfare has been examined in many different contexts. Certain welfare studies showed that for intensively farmed dairy cows, the fear due to routine handling [2], milking technology [3,4] and painful situations [5,6] mean a stressfully load [7], which consequently have negative impacts on milk production [3]. Animal welfare associated with husbandry procedures ca be assessed not only by classical descriptive behavioral observations [8,9], but with physiological measures as well [10-12].

Measures of cardiovascular parameters including heart rate (HR) and heart rate variability (HRV) have a long tradition as indicators of health and welfare in livestock species since the begging of the 1970s. In farm animals, the vagal component of the autonomic nervous system (ANS) plays a key role in regulating HR in response to stress [2,12]. Many parameters of HRV give information about cardiac vagal tone and the sympathetic-parasympathetic balance [3]. Consequently, besides traditional ways of assess stress – assay of cortisol in plasma, serum or feces [13] , assessment of HR and HRV has also been investigated in dairy cattle in veterinary, behavioral and applied animal research worldwide [8-15].

Significance of HR and HRV as Non-Invasive Stress Parameters in Dairy Cows

There are two major physiological pathways reported to be involved in stress responses in mammals. [1] Stress increases the activity of the hypothalamic-pituitary-adrenal (HPA) axis, which leads to an elevation in circulating levels of cortisol [16]. Thus, serum cortisol level is one of the parameters to evaluate activity of the HPA axis and therefore, is used to estimate stress intensity in farm animals [7,17]. Assessment of blood cortisol levels requires handling, what represents additional stress to cows. [2] The other physiological response is related to ANS: stress increases sympathetic nervous activity and decreases parasympathetic nervous tonus [16].

HR is defined as the number of heart beats per minute, and interpretations have often been based on the assumption that HR reflects the activity of the sympathetic branch of the ANS, and therefore as an indicator of the stress response [18,19]. However, increases on HR can occur either in a state of pleasure/happiness or in response to a negative/painful stimulus. The complex interplay of the two branches – sympathetic and parasympathetic - of the ANS is not always comprehensible when cardiac activity is measured only by HR [20,21], as arise in HR could be attributable to an increase in sympathetic activity, decrease of vagal tone or the simultaneous changes in both systems [19].

Heart rate variability is a parameter that reflects the balance between sympathetic and parasympathetic nervous activity [1, 22, 23]. In the power spectrum of HRV, the high frequency (HF) power corresponds to the respiratory frequency and is influenced by vagal activity [24] therefore HF power is an index of the parasympathetic nervous activity. The low frequency (LF) power is closely associated with the fluctuations of blood pressure [24], and is related to both sympathetic and parasympathetic nervous activity [25].

Previous studies have suggested that an analysis of HRV with a Holter-type electrocardiograph helps evaluate stress caused by sickness conditions in dairy cows [14, 26]. In calves with external stress caused by environment high temperature and insect harassment, or diarrhea, the HF power decreased and LF/HF ratio increased, indicating a reduction of parasympathetic nervous tone during stress load [25,27]. Analysis of HRV in another study [28] revealed that changes in the sympatho-vagal balance were clearly detected in bull calves following surgical castration with or without local anesthesia. Therefore, the power spectral analysis of HRV allows researchers to measure stress levels in cattle without handling or restraining them, thus making it a non-invasive indicator of welfare.

Methods of Measurement and Analysis of HR and HRV in Dairy Cattle

Measuring HR and HRV is based on electrocardiography (ECG). Different types of Holter recorders, fixed or telemetric systems, as well as portable ECG monitors have been used to assess HR and HRV in dairy cows [1]. The latter ones were originally developed for human athletes and sport medicine research [23], and were found to be a valid and reliable method to HR measurement in animals [29].

In dairy cattle practice, the recording of interbeat intervals is accomplished with two specific transmitter electrodes, and a ECG monitor [1]. It is recommended to place one of the electrodes next to the sternum, on the left side of the chest (cardiac area) and the other one on the right scapula [1,23]. The contacting surface should be cleaned before attaching, and electrode belts can be easily fixed around the thorax with an elastic strap [1]. Signal receivers are usually fixed on the outside of girths. Another method is to fix receivers on the site of the observer, instead of the animals [1].

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