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Unravelling the temporal association between lameness and body condition score in dairy cattle using a multistate modelling approach

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ABSTRACT

Recent studies have reported associations between lameness and body condition score (BCS) in dairy cattle, however the impact of change in the dynamics of BCS on both lameness occurrence and recovery is currently unknown. The aim of this longitudinal study was to investigate the effect of change in BCS on the transitions from the non-lame to lame, and lame to non-lame states. A total of 731 cows with 6889 observations from 4 UK herds were included in the study. Mobility score (MS) and body condition score (BCS) were recorded every 13–15 days from July 2010 until December 2011. A multilevel multistate discrete time event history model was built to investigate the transition of lameness over time. There were 1042 non-lame episodes and 593 lame episodes of which 50% (519/1042) of the non-lame episodes transitioned to the lame state and 81% (483/593) of the lame episodes ended with a transition to the non-lame state. Cows with a lower BCS at calving (BCS Group 1 (1.00–1.75) and Group 2 (2.00–2.25)) had a higher probability of transition from non-lame to lame and a lower probability of transition from lame to non-lame compared to cows with BCS 2.50–2.75, i.e. they were more likely to become lame and if lame, they were less likely to recover. Similarly, cows who suffered a greater decrease in BCS (compared to their BCS at calving) had a higher probability of becoming lame and a lower probability of recovering in the next 15 days. An increase in BCS from calving was associated with the converse effect, i.e. a lower probability of cows moving from the non-lame to the lame state and higher probability of transition from lame to non-lame. Days in lactation, quarters of calving and parity were associated with both lame and non-lame transitions and there was evidence of heterogeneity among cows in lameness occurrence and recovery. This study suggests loss of BCS and increase of BCS could influence the risk of becoming lame and the chance of recovery from lameness. Regular monitoring and maintenance of BCS on farms could be a key tool for reducing lameness. Further work is urgently needed in this area to allow a better understanding of the underlying mechanisms behind these relationships.

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1. Introduction

Lameness is one of the most challenging diseases for the dairy industry due to its serious welfare impact and associated economic losses (Kossaibati and Esslemont, 1997; Cha et al., 2010). There is a significant impact of lameness on milk production, reproductive performances and it results in a higher culling rate (Rajala-Schultz and Grohn, 1999; Green et al., 2002; Bicalho et al., 2007; Peake et al., 2011; Huxley, 2013). In the UK, the estimated average herd prevalence of lameness is 36% (range: 0–79%) (Barker et al., 2010; Leach et al., 2010); similar prevalence estimates have been reported from other locations around the world (Hernandez et al., 2005; Dippel et al., 2009; Tadich et al., 2010).

Over the last decade a small number of studies have reported an association between lameness and poor body condition score (BCS) (Espejo et al., 2006; Dippel et al., 2009; Hoedemaker et al., 2009). The area has recently been reviewed (Huxley, 2013); historically it has been assumed that lameness led to cows having a lower BCS because disease meant that cows were more likely to have lower dry matter intakes, decreased feeding time and longer lying time (Bach et al., 2007; Kilic et al., 2007). However, in a cross-sectional study, Bicalho et al. (2009) reported that lame cows were more likely to have thinner digital cushions compared with non-lame cows and reported a significant positive association between BCS and thickness of the digital cushion, i.e. cows with low BCS had thinner digital cushions compared with cows with higher BCS. The authors hypothesized that losing BCS could influence the cows to change from non-lame to lame due to thinning of the digital cushion but could not test this due to the cross-sectional nature of the data. In a longitudinal study conducted on one farm, Green et al. (2013) reported that cows with low BCS (BCS < 2.5) in the previous 0–2 months and >2–4 months had a higher risk of treatment for lameness in a 30 day period. However, exploration of the dynamics of change of BCS on both the occurrence and recovery from lameness was not investigated and the study was conducted on a single farm, which limited the generalizability of the findings.

Multilevel multistate discrete time event history models can be used to investigate the effects of factors on the likelihood of transitions between states among animals (e.g. disease/healthy) in longitudinal data. Their use is becoming more common in exploring the complex dynamics of diseases on farms (Kaler et al., 2010; Reader et al., 2011; Nielsen et al., 2012) and understanding the interplay of animal level factors. Moreover, they avoid the limitation of fitting a separate model for each state transition (Steele et al., 2004) accounting for the correlation that may exist between the transitions due to heterogeneity. The aim of this longitudinal study was to investigate the temporal effect of changes in BCS in a cow, and other cow level factors, on the transitions from non-lame to lame and lame to non-lame states in a 15-day risk period.

2. Material and methods

2.1. Dataset and study methodology

The data was collected from a convenience sample of four dairy herds in the South West region of the UK. Herds were selected based on their proximity and previous working relationship with the observer (JAW), the quality of their records and their willingness to participate. Animals on the study farms were predominantly Holstein Friesians. The number of animals in milk, average yield and herd calving to conception intervals are outlined in Table 1. On three farms cows were housed through the winter period and had access to pasture during the summer, cows in one herd (Farm 3) were continuously housed throughout the year. All four herds, when housed, used cubicles (freestalls); herd 4 bedded cows on deep sand, herd 3 bedded cows on mats with straw and the remaining two farms bedded animals on mats with sawdust. In all herds dry cows were loose housed on straw and all farms had loose straw areas available for freshly calved and sick cows.

Animals calving between July 2010 and June 2011 were selected from each herd. One trained observer (JAW) visited all the herds every 13–15 days from July 2010 until December 2011. At every visit, the body condition score (BCS) and mobility score (MS) of selected cows were recorded. No treatment interventions were instigated by the observer, consequently no temporal information on the cause of the lameness association with the elevation in mobility score was collected. Cows identified as lame were treated by the herdsmen according to the standard farm protocols. Body condition score (BCS) was scored according to Edmonson et al. (1989) using a scale of 1–5 with increments of 0.25. Mobility score (MS) was scored according to Whay et al. (2003) on a four point scale (0 to3). Other information such as parity, age, days in lactation and month of latest calving of selected cows were recorded.

2.2. Statistical analysis

Cows with no information for parity, age, days in lactation, month of latest calving or BCS at calving (0-15days post-partum) were excluded from the dataset. Any missing observation at the start of the study and end of the study was excluded and if cows had missing visits in the middle of the observation period, the remaining observations following the missing visit were excluded. Only cows with at least 5 observations were used in the analysis. The BCS was grouped into four categories based on distribution of the data ensuring meaningful range of scores: group 1 (BCS G1 1.00–1.75), group 2 (BCS G2 2.00–2.25), group 3 (BCS G3 2.50–2.75) and group 4 (BCS G4 3.00–5.00), while MS was categorized into two groups: non-lame (MS 0 and 1) and lame (MS 2 and 3). Descriptive analyses were conducted in Stata version 12 (StataCorp, USA).

2.3. Multilevel multistate discrete time event history model

A multilevel multistate discrete time event history model (Steele et al., 2004) was set up to investigate