A Novel Method of Monitoring Mobility of Dairy Cows

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Abstract

A pilot study of 20 cows measured the accelerations on the neck of cows as they walked along a passage from a milking parlour. Neck accelerations were negatively correlated to high mobility scores but with a low R^2. A method of automating measurement of mobility could be developed with this method which shows promise for longitudinal studies.

Introduction

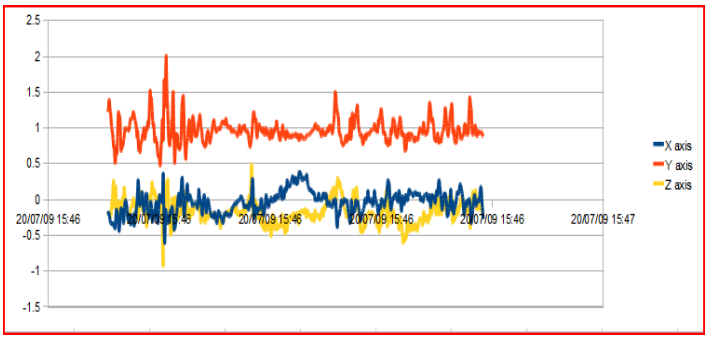
Lameness of cows is a major concern in the dairy industry in the UK with some milk buyers now expecting farmers to measure lameness on their farms as part of their contract. This is being encouraged through visual (subjective) lameness scoring methods with independent auditing by trained auditors. This has some major limitations in terms of ensuring farmers are adequately trained and that auditors are sufficient confident to identify when lameness scoring has not been performed. The introduction of low cost accelerometers has made it possible to propose dynamic logging as a method capable of yielding an objective measure of lameness based on the observation that cows that are lame have a jerky motion of the head. The purpose of this pilot study was to identify whether measurements with an accelerometer can be correlated to mobility score.

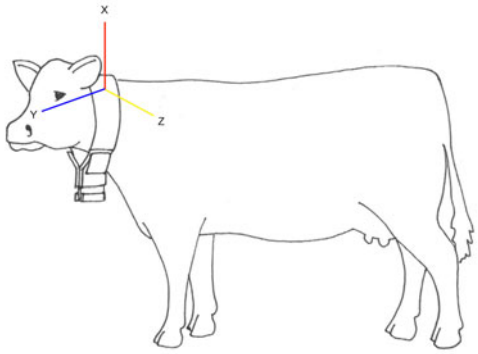
Materials and Methods

A collar was constructed to hold an miniature acceleration data logging device (MSR145 20mm x 15 x 52 mm) in a position on a cows neck such that when the animal was standing the X,Y, Z axes were approximately aligned to the plane of the earth. The X axis aligned parallel to the ground to capture forward and reverse accelerations; the Y axis was vertical motion and the Z axis the sideways movement.

The rate of data capture was set at 50Hz, range up to ±10g. The collar was placed on 20 cows leaving a milking parlour in series and then removed after a couple of minutes. The time stamp was synchronized. Events such as stopping or jumping were recorded. The time stamps in the data were used to extract 15 seconds for analysis on the period when each cow walked alone under their own volition in a straight line for a distance of 20 m as they moved to a holding area where other cows and food was available.

In the Figure the vertical axis shows the values in g and the abscissa the time with a point for each 0.02 s. The Y axis of movement oscillates about a value of approximately 1 indicating the constant acceleration due to gravity and shows the vertical motions of the head. The forward motion is shown by the X axis. The values confirmed observations, for example this cow accelerated in the mid point of the walk and this is confirmed by rising gradient in mid graph.





The X,Y, Z data were analyzed to characterize each curve by time to travel 20 m, maximum values, number of times the forward acceleration exceeded one standard deviation above the mean, and curtosis (kurtosis). These were then correlated to mobility scores.

Results

The 20 cows ranged in mobility score from 0 to 3. As might be expected the least mobile cows took longer to walk the 20 m whilst surprisingly the curtosis which measures jerkiness of a curve diminished.

	Time	Max_X	Max_Y	Peaks_X	curtosis X	curtosis Y
Correlation		0.56	-0.22	-0.56	0.44	-0.28	-0.46
coefficient of determination, R2		0.31	0.05	0.31	0.19	0.08	0.21

A walking cow normally has three feet on the ground at any one instant in time. The feet move in a sequence with the rear foot pushing forward followed by the front on the same side. Accelerations in the x or forward direction are associated with the hind leg movement. A peak in acceleration will occur as the cow begins to thrust forward and will always be matched by later deceleration but probably not at the same rate. The vertical accelerations seem less linked to mobility. When a cow is driven from pasture we have observed cows with jerky motion presumably responding to pain in the feet giving high curtosis values. When not driven as in this study the lame cows walked slowly presumably to minimize pain and this is shown in the lower maximum. There is considerably more potential for analysis and data need to be mapped to a biomechanical analysis as the next step in a longitudinal study.

Conclusions

This pilot study shows that meaningful data can be detected on the neck of the cow and it is possible to relate mobility score to neck movements in an objective manner. The least lame cows move their heads more and the most lame the least. When left to walk at their own speed cows minimize the sharp movements caused by pain. There is inevitably a high degree of variability between cows and almost certainly within cows from day to day. Every effort was made not to excite the cows although some sensed the presence of the observer outside the parlour and the very act of attaching the collar will have caused some disturbance. Behaviour on any single day is variable due to uncontrolled factors but repeatability will be improved by longitudinal studies using wireless collars which also remove the interference of the human presence.