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Early detection of lameness in heifers with hairy heel warts using a pressure plate

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Abstract

Lameness is an indicator of pain and suffering, which has substantial animal welfare and economic impact on the dairy industry. Subjective locomotion scoring is unreliable for detecting mild cases of lameness in dairy herds. Undetected lameness can progress to a more serious and painful state with unfavourable prognosis. The aim of this study was to conduct an investigation on the use of a pressure plate for early detection of lameness in dairy heifers compared to a subjective visual scoring system. Seven heifers deemed sound, on the basis of a visual scoring system, were walked through a chute where a pressure plate was disguised on the floor. Claws were then inspected during trimming and revealed no lesions (n = 3) and hairy heel warts on at least one hind claw (n = 4). Peak vertical force (PVF) and right-left hind limb PVF symmetry were calculated. Sound heifers demonstrated significantly higher PVF and better right-left hind limb symmetry than those with hairy heel warts. Using a pressure plate, gait abnormalities from foot lesions that were undiagnosed using a subjective lameness scoring system, were detected. Early detection of lameness is vital to reduce dairy industry losses and to improve animal welfare.

Keywords: *animal welfare, biomechanics, cattle, lameness, pain assessment, pressure plate*

Introduction

Lameness refers to an abnormal gait caused by painful lesions of the limbs or back as the cow attempts to alleviate or avoid pain in the affected area (Scott 1989) by reducing propulsion, reducing her speed of walking, arching her back and lowering her head. The annual lameness incidence rate in adult dairy animals, depending on farm, location and year of study, ranges from 4 to 56% (Booth *et al* 2004), and costs on average US$350 per incident (Greenough & Weaver 1997). The most common lesions associated with lameness are white line disease, sole and toe ulcers, heel erosion, double sole, sole haemorrhage and papillomatous digital dermatitis (hairy heel warts) (Murray *et al* 1996).

The main strategy used for lameness detection in dairy cattle consists of subjective visual scoring that is based on qualitative assessments of kinematic measures. Kinematic measures are descriptions of motion, during standing and walking, ranging from a few measures of back posture and stride length (Sprecher *et al* 1997) to a combination of back posture, leg abduction, limb weight bearing, joint flexion, relative front to hind foot placement, head carriage and 'smoothness' of gait (Welsh *et al* 1993). Unfortunately, the subjective nature of visual scoring often results in high inter-observer variability (Engel *et al* 2003), especially in detecting subtle changes in posture and weight bearing characteristic of mild cases of lameness (O'Callaghan *et al* 2003). This issue results in a large number of lame cows going undiagnosed and therefore treatment is neglected, particularly in the early stages of the condition when the prognosis may be more favourable (Logue *et al* 1998). Therefore, methods of locomotion analysis that offer greater accuracy without the biases that are inherent in a subjective analysis ought to be investigated as a means of improving lameness assessments in dairy cattle. Changes in the vertical component of ground reaction forces have been successfully used as indicators of lameness in horses (Clayton *et al* 2000) and cattle (Scott 1989). Vertical ground reaction force can be measured using a pressure plate, which offers better portability and lower cost compared to force plates. However, to date, limited attempts have been made to objectify lameness assessments in dairy cattle (eg Herlin & Drevemo 1997; Rajkondawar *et al* 2002; Tasch & Rajkondawar 2004) and information regarding the potential use of pressure plates for diagnosis is lacking. The objective of this study was to perform a preliminary investigation on the potential of a pressure plate as a tool for early detection

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Table 1 Mean peak vertical force (PVF), right-left hind limb PVF symmetry of heifers (645 ± 60 kg) with (n = 4) and without (n = 3) hairy heel wart lesions.

Group	PVF RH ($N.kg^{-1}$)		PVF LH ($N.kg^{-1}$)	PVF symmetry
Lesions	3.08 (0.29)[a]		4.19 (0.82)[a]	
Mean PVF		3.64 (0.82)[b]		0.77 (0.16)[c]
No lesions	5.36 (0.60)		5.28 (0.76)	
Mean PVF		5.32 (0.62)[b]		1.04 (0.02)[c]

Significant differences: [a] $P = 0.04$; [b] $P = 0.01$; [c] $P = 0.04$. Comparison 'a' = a significant difference in peak vertical force (PVF) between the right (RH) and left (LH) hindlimbs within the group of animals with lesions; 'b' = a significant difference of mean PVF between animals with and without lesions; and 'c' = a significant difference between PVF symmetry between animals with and without lesions.

of lameness in heifers suffering from hairy heel warts and to determine the sensitivity of this device compared to a subjective lameness scoring system (Sprecher *et al* 1997).

Materials and methods

All procedures of the experiment were approved by the All-University Committee on Animal Use and Care at Michigan State University. Seven Holstein heifers (1.8 ± 0.6 years; 645 ± 60 kg), deemed sound by an experienced veterinarian on the basis of a visual lameness scoring system (Sprecher *et al* 1997) were used in this study performed in early spring (May 2005) at a commercial dairy farm in Michigan, USA. A pressure plate (Footscan Scientific version, RSscan International, Olen, Belgium) able to measure vertical ground reaction force at a sample frequency of 250 Hz was used for data collection. The pressure plate measured 100 × 40 cm with 8192 conductive pressure-sensitive polymer sensors, each 0.39 cm^2. The plate, and a surrounding board of the same thickness, measuring approximately 250 × 100 cm, were placed level in a concrete pathway. This pathway was located in a barn adjacent to the heifers' home pen, which was used to guide heifers to a trimming chute. The pressure measuring device was covered and disguised with a non-slip carpet. Heifers were walked down the pathway where measurements started at initial contact of the fore foot touching the plate. Measurements from both fore and hind limbs of one side of an animal were collected in a single trial. Trials had a duration of approximately 5 seconds. Data collection continued until three good trials from each hind limb were obtained from each heifer. A trial was considered good when the hind limb being analysed was completely on the pressure plate throughout its stance phase and the animal was walking at a constant speed (ie no obvious visual signs of slowing down or speeding up) with no unusual body movements (eg no stumbling or abnormal head placement).

On the following day, trimming was performed according to the farm's standard operating procedure and the claws were inspected. Lesion type and severity were recorded. Heifers were then divided into a group with no foot lesions (n = 3) and, a second group with hairy heel wart lesions on at least one hind foot (n = 4). Trials from heifers from these two groups were then subjected to analysis. Only one trial per hind limb from each heifer had acceptable quality to be included in the analysis. A trial was considered acceptable when vertical ground reaction force exhibited a bimodal pattern on a force-time graphical display (eg Scott 1988; Rajkondawar *et al* 2002). Insufficient trials were recorded from fore limbs from each heifer to analyse the data, hence the fore limbs were omitted from the analysis.

Peak vertical force (PVF) was normalised by body mass (kg) and presented for each hind limb and as an average of both hind limbs ($N.kg^{-1}$), and right-left hind limb PVF symmetry were calculated. Differences in these variables between groups were analysed using SPSS statistical software (SPSS Inc, Chicago, Illinois, USA) at an alpha level of 0.05. As data were normally distributed (Kolmogorov-Smirnov $P > 0.05$), independent Student *t*-tests for unequal (Levene's $P < 0.05$) and equal (Levene's $P > 0.05$) variance were used as necessary.

Results

Heifers with no foot lesions demonstrated significantly better right-left hind limb peak vertical force symmetry than heifers with foot lesions (1.04 ± 0.02 vs 0.77 ± 0.16; $P = 0.04$). In addition, the presence of hairy heel wart lesions significantly reduced the PVF (averaged over right and left) compared to no lesions (3.64 ± 0.82 $N.kg^{-1}$ vs 5.32 ± 0.62 $N.kg^{-1}$; $P = 0.01$) (Table 1). The subjective visual scoring system used in this study was unable to detect lameness in heifers with hairy heel wart lesions.

Discussion

A search for tools that can provide accuracy and account for biases inherent of subjective analysis is timely. In this study, gait abnormalities associated with hairy heel wart lesions undetected by Sprecher's *et al* (1997) lameness scoring system were successfully revealed using a pressure plate. A lame animal reduces the load in the affected limb as means of reducing pain. This study shows that the animal's efforts at load-reducing, which are often subjectively and unreliably assessed using visual scoring systems, can be assessed objectively by measuring the peak vertical force using a pressure plate. The demonstration of reduction in PVF in heifers with hairy heel wart lesions supports the assertion that quantitatively measurable changes occur with lameness, as previously demonstrated in cows (Scott 1989; Rajkondawar *et al* 2002) and horses (eg Merkens & Schamhardt 1988) at the walk. Similarly, right-left limb PVF symmetry changes were revealed to be a promising measure to detect lameness associated with hairy heel wart

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lesions in heifers, which agrees with findings in horses with experimentally induced lameness (Merkens *et al* 1988).

To be considered an auxiliary diagnostic tool, data collection must be practical, reliable, suit operating procedures in dairy farm settings and provide measures that can be easily understood by people who are not necessarily knowledgeable in biomechanics. Although the changes in the peak vertical force observed in this study characterised the presence of hairy heel warts, further studies should be carried out to assess the sensitivity of PVF to detect other important lameness conditions such as white line disease and sole ulcers. Furthermore, the analysis of a single trial per limb might not be a sensitive enough data capture method to detect lameness due to the impacts of locomotion variability. The variation observed between the three trials per limb within an animal suggests that the magnitude of locomotion variation in heifers might be high and methods to minimise it should be implemented. Overall, locomotion variability can be minimised by using an average of multiple trials as a representative of the gait pattern, reducing inter-trial walking velocity variation, and/or collecting data from both right and left limbs simultaneously with a larger pressure plate. In horses, force variables are considered to be quite stable, and analysis of three to five trials is accepted to provide a representative gait pattern (Schamhardt 1996). However in cattle such information is not known. If several trials are deemed necessary to provide representative gait pattern at walk, the practicality of using pressure plates for lameness assessment in dairy settings must be re-assessed and technology would have to evolve to improve reliability of pressure plate measures. Owing to the importance of maintaining a constant walking velocity to achieve reliable pressure plate analysis (Khumsap *et al* 2002), especially when data from right and left limbs are collected in different trials, alternative ways to control cattle walking velocity should be developed to improve detection of lameness in dairy systems.

Conclusion and animal welfare implications

This study has shown that a pressure plate offers opportunities to objectively detect lameness-related gait abnormalities in heifers suffering from hairy heel warts. Further validation of the vertical ground reaction forces and an approach for pressure plate data collection is an important next step to develop this technique further as an objective tool for the early detection of lameness in dairy cattle. Moreover, technology will evolve to enable sources of variability during pressure plate data capture to be minimised; for instance, the use of larger plates that would allow data collection from right and left body sides simultaneously. Quantitative analysis of gait offers a means for early and reliable detection of lameness that contributes to improvements in lameness prognosis, reduction in dairy industry losses, and ultimately, to enhanced animal welfare.

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