

RESEARCH PAPER

Handheld mechanical nociceptive threshold testing in dairy cows – intra-individual variation, inter-observer agreement and variation over time

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Abstract

Objective To examine the use of handheld methodology to assess mechanical nociceptive threshold (MNT) on cows kept loose-housed.

Study design Prospective randomized partial cross-over experimental study. A one-factor (test day) design was used to evaluate MNT over time.

Animals One hundred and fifteen healthy, loose-housed Danish Holstein cattle.

Methods We evaluated intra-individual variation, inter-observer agreement and variation over time of MNT using two handheld devices and two stimulation sites. Mechanical, ramped stimulations were performed with an algometer (6.5 mm diameter steel probe, 0–10.0 kgf) or an electronic von Frey device (plastic tip with diameter 0.8 mm, 0–1000 gf). Each cow received 5–6 consecutive stimulations within a 2 × 5 cm skin area on the dorsal or lateral aspect of the left third metatarsus until an avoidance reaction occurred. We investigated the difference in precision [expressed as coefficient of variation (CV)] between the combinations of devices and stimulation sites. The inter-observer agreement and the difference in MNT

between test day 1, 3, 7, 10 and 24 were investigated for selected combinations. Data were analysed in mixed models and Bland-Altman as relevant.

Results The CVs did not differ [range 0.34–0.52 ($p = 0.1$)]. Difference between observers (95% limits) was 0.2 kgf (2.8) and 4 gf (369) for the algometer and von Frey device, respectively. Mechanical nociceptive threshold increased from 361 on test day one to 495 gf on test day 24 ($p < 0.01$).

Conclusion and clinical relevance All methods showed a high degree of intra-individual variation, and no combination of device and stimulation site showed superior precision. Mean difference between observers was low, and MNT was not consistent over time. Further development of the methods is required before they can be used in research to investigate possible relations between claw lesions and hyperalgesia.

Keywords dairy cows, mechanical nociceptive threshold, pain.

Introduction

Claw disorders and lameness are considered to be among the major welfare problems in intensive milk production (Anonymous 2009). Claw lesions

often are associated with pain (O'Callaghan et al. 2003; Dyer et al. 2007) and persistent pain may lead to hyperalgesic states via peripheral and central sensitisation of the nervous system (Anderson & Muir 2005). Nociceptive threshold testing can be used to investigate hyperalgesia associated with clinical conditions (Love et al. 2011). In previous studies in dairy cattle, mechanical nociceptive thresholds (MNT) have been used to quantify hyperalgesia associated with claw disorders. Mechanical nociceptive stimulation has been applied to the skin of the dorsal part of the metatarsus/metacarpus by use of a blunt pin, driven by a pneumatic actuator and attached to the leg with a cuff (Whay et al. 1997, 1998; Laven et al. 2003). However, this method requires handling and restraint of the cows, potential stressors which might influence the nociceptive thresholds (Rushen et al. 1999; Herskin et al. 2004, 2007). Furthermore, in the modern dairy industry, many dairy cows are kept in loose-housing systems. Handheld devices for MNT testing have been used in other animal species (horses: van Loon et al. 2012; dogs: Pieper et al. 2011; sheep: Stubbsjøen et al. 2010 and pigs: Di Giminiani et al. 2013). Thus, in order to be able to quantify MNT in modern dairy production, handheld methods, which can be used on freely behaving dairy cows kept in their home environment, seem to offer a good alternative but such method have not yet been investigated.

Application of mechanical force on the skin creates a pressure which spreads into the skin and underlying tissue. The pressure causes deformation that may lead to activation of nociceptors in different layers of the tissue depending on the size and shape of the probe (Treede et al. 2002). To reduce the spread of pressure the amount of distensible tissue underlying the stimulation site should be minimized (Love et al. 2011). The dorsal aspect of the metatarsus has been used to investigate hyperalgesia related to bovine claw disorders (Whay et al. 1997, 1998; Laven et al. 2003), but other anatomical locations have not yet been investigated.

A prerequisite for the study of changes in the pain processing system over time or in response to an intervention is that threshold quantification remains stable over time (Potter et al. 2006). This has been evaluated in other species using handheld equipment, e.g. in humans (Jensen et al. 1986; Potter et al. 2006), horses (Haussler & Erb 2006), pigs

(Janczak et al. 2012) and sheep (Stubbsjøen et al. 2010) but has not been reported in cattle.

For a handheld algometer to be used in the clinic or in large scale studies, the dependency of observer must be known. This has been investigated in human subjects, where no bias and a reliable inter observer correlation was found between five observers (Chesterton et al. 2007). In dairy cows, inter-observer dependency has not yet been reported.

Thus, as part of the initial work to be able to assess changes in MNT associated with claw disorders in dairy cows, the aim of the present study was to develop handheld methodology appropriate for this purpose. Firstly, we aimed to investigate intra-individual variability of MNT on dairy cows kept in their home environment and relate this to type of the mechanical pressure device and anatomical site of stimulation. Secondly, we aimed to investigate inter-observer agreement between two observers using both devices and the dorsal stimulation site. As a third aim, we investigated the variation over time using the electronic von Frey and the dorsal stimulation site. Finally, *post hoc*, we evaluated the effect of the experimental cow's behavioural response to the initial presence of the observer on the subsequent MNT.

Material and methods

Ethical statement

The procedures and housing of the animals complied with the criteria given by the Danish Animal Experiments Inspectorate as procedures that do not require specific approval.

Animals and housing

Both experiments were carried out at the Cattle Research Centre, Tjele, Denmark between April and July 2011. The 140 cows in the resident herd were kept in two groups in a loose-housing system with resting areas in cubicles (120 × 225 cm with mattresses and limited sawdust) and slatted floors. The cows had 24 hour access to a Total Mixed Ration in individual computer operated feeding boxes (Roughage Intake Control (RIC); Insentec B.V, The Netherlands) and to one milking robot per group (VMS, De Leval A/S, Denmark). During Experiment 2, all cows were claw trimmed at day 8 or 9 as part of the normal management of the herd.

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