



A systematic review of tests for the detection and diagnosis of foot lesions causing lameness in dairy cows



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ABSTRACT

Foot lesions causing lameness in dairy cows are important economic and welfare issues. Prompt and correct detection and diagnosis are critical for improving economic and welfare outcomes. Few tests are currently available to aid the dairy farmer in the detection and diagnosis of foot lesions. The objectives of this systematic review were to identify those tests that have been investigated for the detection and diagnosis of foot lesions causing lameness in dairy cows, evaluate the methodological quality of the studies investigating the identified tests, compare the accuracy of the identified test, and determine which tests can be recommended for implementation on the farm based on accuracy and practicality for use by dairy farmers. A comprehensive literature search resulted in 2137 papers. After removing duplicates and performing relevance screening, 12 papers with 20 studies met the inclusion criteria. Pertinent data from each study were extracted using a standardised form. Eligible studies were grouped based on the objective of the test under investigation, resulting in the following groups of disorders: lameness, foot lesions, sole ulcer, and digital dermatitis. Methodological quality was assessed using the Quality Assessment of Diagnostic Accuracy Studies (QUADAS-2) tool which includes four domains: animal selection, index test, reference test and flow and timing. Incomplete reporting in the studies limited the assessment of methodological quality. The animal selection domain was particularly poorly reported. No single study could be classified as being at low risk of bias across all domains of the QUADAS-2 tool. One automated test was identified, while all others were manually operated. No studies reported the cost of the test in question and only two studies reported the time taken to carry out the procedures involved with using the test in question. It was not possible to compare the accuracy of these tests or recommend which tests are suitable for implementation on the farm. This was due to incomplete reporting of information and significant risk of bias in all studies.

1. Introduction

Dairy cows frequently succumb to foot lesions as a consequence of animal, agent, environment and management factors and their interactions. Foot lesions are often painful, typically manifesting in lameness, impacting a dairy cow's ability to perform normal behaviours (Callaghan et al., 2003; Whay et al., 2003) and therefore compromise welfare. In addition, the economic impacts are also substantial as lame dairy cows produce less milk (Green et al., 2002), have poor reproductive performance (Reader et al., 2011) and are often culled prematurely (Booth et al., 2004; Bicalho et al., 2009). In addition to these productivity losses, treatment of individual cases can be costly, ranging from \$USD120 to £519 (Kossaibati and Esslemont, 1997; Willshire and Bell, 2009; Cha et al., 2010) depending on the type of

lesion. Therefore, the prompt detection and correct diagnosis of foot lesions are important to minimise the associated welfare and economic implications.

The process of diagnosing the type of lesion, from initial detection through to final diagnosis, is an important task and often begins with observation of a lame cow by the dairy farmer. The literature suggests that a dairy farmers' ability to detect lameness is relatively poor (Wells et al., 1993; Leach et al., 2010; Šárová et al., 2011). However, there is little evidence available to determine a dairy farmers' ability to correctly diagnose the type of foot lesion. To aid dairy farmers in the detection and diagnosis of foot lesions, a number of tests have been investigated in the literature. There is a need to assess the efficacy of these tests to be able to recommend those with high level of accuracy that can be implemented on the farm. The objectives of this systematic

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Table 1The major types of bias that can occur in studies of diagnostic test accuracy, adapted and modified from [White et al. \(2011\)](#).

Type of bias	When does it occur?	How does it impact test performance
Animals		
Selection bias	When eligible animals are not selected randomly.	Typically results in an over estimation of test accuracy.
Spectrum bias	When included animals do not represent a wide spectrum of severity for the target condition.	The sensitivity of a test will often vary according to the severity of disease; thus the accuracy of a test would be expected to be superior in a study population where the majority of animals are in the advanced stage of the disease.
Index test		
Test review bias	When the index test results are interpreted with knowledge of the reference test results.	Typically results in an overestimation of test accuracy.
Threshold bias	When the threshold is not pre-determined.	The selection of a threshold value that maximises the sensitivity and specificity of the test may lead to over optimistic measures of test accuracy.
Reference test		
Diagnostic review bias	When the reference test results are interpreted with knowledge of index test results.	Typically results in an overestimation of test accuracy.
Threshold bias	When the threshold is not pre-determined.	The selection of a threshold value that maximises the sensitivity and specificity of the test may lead to overoptimistic measures of test accuracy.
Misclassification or reference test bias	When the reference test does not correctly classify animals with the target disease/condition.	Underestimation (when different aspects are measured) or overestimation (when similar aspects are measured).
Partial verification	When a number of animals who have received the index test do not receive the reference test.	Typically results in an overestimation of sensitivity.
Differential verification	When a number of animals receive an alternate reference test, especially when this selection depends on the index test result.	Typically results in an overestimation of test accuracy.
Incorporation bias	When the index test forms part of the reference test.	Typically results in an overestimation of test accuracy.
Recovery or disease progression bias	When there is a delay between the performance of index and reference tests or the animal has been treated between tests.	Under or overestimation of test accuracy, depending on the change in the animal's condition.

review were to identify those tests that have been investigated for the detection and diagnosis of foot lesions causing lameness in dairy cows, evaluate the methodological quality of the studies investigating the identified tests, compare the accuracy of the tests, and determine which tests can be recommended for implementation on the farm based on accuracy and practicality for use by dairy farmers.

2. Materials and methods

2.1. Protocol

This systematic review was conducted using the guidelines of the Cochrane Collaborations handbook for systematic reviews of diagnostic test accuracy (DTA) ([The Cochrane Collaboration, 2016](#)) and the PRISMA statement ([Moher et al., 2009](#)). A pre-defined protocol was established using these guidelines before conducting the systematic review.

2.2. Definitions

2.2.1. Index and reference tests

In a systematic review of DTA the test under investigation is referred to as an ‘index test’. For the purpose of this systematic review the term “test” will be used for “index test” throughout this document and will be defined as any method or procedure that has facilitated the diagnostic process, resulting in a different post-test probability of a particular diagnosis from the pre-test probability ([Greiner and Gardner, 2000](#)). A test may be used for one of four major functions: screening, monitoring, diagnosis or staging (a classification system describing how severe or advanced a disease or condition is). All technologies and observational methods that were used for screening, monitoring, diagnosis or staging of lameness or foot lesions in dairy cows were considered in this systematic review.

To determine the accuracy of a test, it is typically measured against a reference test that reflects the ‘truth’ (i.e. whether or not the patient or animal really has the disease or condition being assessed) ([Deeks,](#)

[2001](#)). Ideally the reference test is the best available method for establishing the presence or absence of the target condition ([Whiting et al., 2003](#)). The reference tests used in each of the included studies will be critically appraised to judge their quality as ‘the best available’ method.

2.2.2. Detection and diagnosis

The terms detection and diagnosis are commonly used in human and veterinary medicine. While these are distinct terms, they are often used interchangeably in the literature. For the purpose of this systematic review the following definitions will be used: detection, the act of discovering clinical signs of a disorder or disease (i.e. initial discovery of signs of disease in animals that have previously been considered healthy); and, diagnosis, the distinguishing of one disease or condition from another ([US National Library of Medicine, 2017](#)).

2.3. Inclusion criteria

The inclusion criteria were peer-reviewed papers written in the English language, a description of a test used for the detection of lameness or the detection or diagnosis of foot lesions in dairy cows was provided, a reference test was used, primiparous and/or multiparous lactating dairy cows were used, and sensitivity and specificity data were provided.

2.4. Literature search

The search engines used to identify papers were PubMed, using medical subject headings (MeSH) (1951–February 2015); Web of Science, Core Collection, advanced search (1990–February 2015); and Agricola, advanced search in both the Article Citation Database and National Agricultural Library (NAL) catalogue (1970–February 2015). Database specific search terms were created to ensure the database search contained literature relevant to the topic (Supplementary Table S1). In addition, the references of the included papers were checked for relevant papers.

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