Artykuł przeglądowy *Review*

Risk factors influencing lameness and key areas in reduction of lameness in dairy cows

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Summary

Lameness in dairy cows is a clinical sign with multifactorial aetiology and has been classified as one of the three most common health problems, after infertility and mastitis, which present an increased risk of culling in dairy cows. Clinical lameness of cows (≥ 3 lameness score) results in a decrease of milk yield and fertility. Factors influencing lameness in dairy cows can be considered in two groups: intrinsic factors, or unavoidable risks, and extrinsic risk factors. The most important intrinsic unavoidable risk factors are the following: season of calving, gestation and stage of lactation, breed and milk yield level, previous disease, parity and season of claw trimming. These factors increase the risk with age and milk yield level of cows. The risk of lameness is also genetically determined for the development of claw lesions. Extrinsic risk factors influencing lameness of cows are claw disorders and the housing system (with exercise vs. without exercise), including different floor surfaces. Claw disorders cause approximately 90% cases of lameness in dairy cows. Claw lesions are more frequent and their prevalence reaches 80%. The housing system (tie-stall barns with exercise and without exercise versus loose housing with exercise and without exercise) cannot be considered as a single factor. Maintenance of cows is associated with numerous co-active environmental and management factors, including different floor surfaces. There are six key areas that we can consider when attempting to reduce lameness in dairy cows. These risk areas include cow comfort, cow hygiene, social and physical integration for heifers and dry cows, cow flow on the farm, diet and correct routine professional functional preventive hoof trimming.

Keywords: cow, lameness, claw diseases, intrinsic and extrinsic risk factors, prevention, cow comfort

Locomotion score (LOCO) of cows is generally evaluated using a 5-point scale suggested by Sprecher et at. (44). Normal gait of cows was defined as 1, mildly lame as 2, moderately lame, lame and severely lame as 3, 4 and 5, respectively. Clinical lameness (CL) was identified by these authors as a ≥ 3 lameness score. Lameness in dairy cows is a clinical sign with multifactorial aetiology and it has been classified as one of the three most common health problems, after infertility and mastitis, which present an increased risk of culling in dairy cows (6, 41). However, the effect of lameness on culling is not clear, since the decision to cull varies across lactation and is associated with parity, calving season and milk yield (6). CL has a negative effect on milk yield (17, 49) and within the first 30 days postpartum it was associated with a higher incidence of ovarian cysts, a lower likelihood of pregnancy, and lower fertility when compared with non-lame cows (15, 29). Lame cows are characterized by a longer interval from calving to conception and a higher number of services required per conception when compared with healthy cows (19).

In Swedish dairy cows (101 dairy farms and 4899 heifers and cows) the prevalence of lameness was 5.1%, but most hoof lesions did not cause lameness (27). According to those authors the prevalence of hoof lesions varied greatly between herds. Sole haemorrhages (SH) were found in all herds. In Norwegian dairy cows claw health was relatively good when compared with most other countries; however, the cows kept in free stall barns were characterized by a higher prevalence of claw lesions than cows kept in tie stall barns (39). In Danish Holstein heifers abnormal gait, including CL, was associated with digital dermatitis (DD) and white line lesions (WLL) (7). Heifers were lame up to 4 months before calving. Similar results for heifers in Austria were reported by Hulek et al. (21). Data from 37 dairy farms in four regions of England and Wales showed that there were 8 991 lesions in 4 837 cows, and 8 645 lesions were associated with

lameness (31). The high incidence and prevalence of lameness in cows in the United Kingdom was also observed by Clarkson et al. (9). In cows in 383 herds in the Netherlands, sole ulcers (SU) were present in 85% herds and in 5.6% of the study population (22 454 cows) (20). The within-herd prevalence varied from 0% (14.6% of herds) to 26% (0.3% of herds). In the United States 24.6% of cows housed in free stall barns were clinically lame (14). Lameness of cows was associated with lactation rank, body condition score (BCS) and stall surface. In Polish Holstein Friesian dairy cows (1330 cows were examined at claw trimming on 11 Polish Holstein Friesian dairy farms) parity and housing systems of cows (tie vs. free stalls) had no effect on the total percentage of healthy claws (35). The percentage of affected animals in terms of main disorders was 32.1% for sole ulcers, 18.4% for sole haemorrhage, 17.8% for digital dermatitis, 9.4% for the white line disease, 8.1% for thick hock and 4.5% for interdigital dermatitis of the total number of claw lesions observed.

The objectives of this study were to present risk factors influencing lameness and to identify key areas for external risks in dairy cows. Factors influencing lameness of dairy cows can be considered in two groups: intrinsic unavoidable risk factors and external risk factors.

Intrinsic unavoidable risk factors

There are intrinsic risks for lameness that cannot be changed. These include season, gestation and stage of lactation, previous disease and parity (1, 40). Risk of lameness is also genetically determined for development of claws lesion (5, 47, 48). Older cows are more likely to become lame when compared with younger cows. It is, however, possible to moderate the intrinsic risk through better environment and herd management. The following are considered as factors influencing claw disorders: housing system (tie stall barn with exercise and without exercise and loose housing with exercise), lactation rank (1, 2 + 3, > 3) combined with milk yield class of previous lactation (heifer, < 6000, 6000-7000, > 7000 kg), lactation stage (0-100, 100--200, > 200 days in milk), breed (Brown Swiss, Simmental, Holstein, others), and season of claw trimming (autumn: September-November, winter: December--February, spring: March-June) (3). In a study by those authors the lactation number and milk yield class of previous lactation had a significant effect on all disorders. These factors result in an increased risk with the age of cows. Incidence of claw disorders (sole disorder, white line disorder, heel erosion and interdigital disorders) showed a tendency to increase with milk yield level. The season of claw trimming had a significant effect on all observed traits. Differences between individual herds of cows were a major source of variance in the prevalence of claw disorders. They are probably caused by differences in the environment, feeding and management (1). According to this author a higher frequency of lameness was recorded in the following breeds: Red Danish, Danish Black and White and Danish Red and White rather than Danish Jersey. Cows in parities 1 or 4 had a higher frequency of lameness than cows in parities 2 or 3. A higher frequency of lameness was found in cows from large herds than cows in small herds. According to Sogstad et al. (40) risk factors for lameness include parity three and above and narrow cubicles; for heel horn erosions it is lactation stage around 5-7 months after calving and solid concrete alleys; for haemorrhages of the white line: lactation stage around 3-5 months after calving and solid concrete alleys; for haemorrhages of the sole: parity one, lactation stage around 5-7 months after calving and short cubicles; for white line fissures: slatted concrete alleys; for asymmetric claws: parities two and above, and for corkscrewed claws it is solid concrete alleys, respectively.

LOCO of cows is a good indicator for the development of claw disorders at a later stage of life (48). This indicator was genetically correlated with feet and legs (L&F), foot angle (FA) and rear legs (side-view) (5, 47, 52). According to those authors a high genetic correlation of these traits with locomotion suggested that selection for a low LOCO might improve walking ability of cows when integrated into an index of L&F. A majority of heifers had abnormal leg and claw conformation before calving. Abnormal hind leg conformation and asymmetry of claws were associated with SH, WLL and lameness (7). Cow-hocked conformation may increase the risk of claw lesions and lameness. The level floor surface was associated with fewer locomotion disorders and better L&F index scores (36). Locomotion had a high genetic correlation with L&F and a moderate genetic association with FA and mammary composite (MAMM). It is suggested that cows with higher scores for L&F and MAMM and with steeper FA had genetically better locomotion. Similar, genetic associations between bone quality (BONEQ) and LOCO and L&F suggested that selection for these traits would improve locomotion.

Extrinsic risk factors

Claw disorders caused approximately 90% cases of lameness in dairy cows (31), but the most-prevalent lesions were not associated with lameness, for example sole ulcers had the strongest association with lameness (27). Lesions of claws are more frequent (80% prevalence) and will be used to identify risks for lameness (27).

The housing system cannot be considered as a single factor. Maintenance of cows is associated with numerous co-active environmental and management factors contributing to the „housing system" factor. Such factors as the material of the walking surface and the moisture, space and design of the resting area were not documented in detail and were distributed very

unevenly and were confounded. Therefore, when results of many studies are discussed, the general term „housing system" is used (tie-stall barns with exercise and without exercise versus loose housing with exercise and without exercise). The best claw health in cows was observed in the loose housing system with regular outdoor exercise (3). According to the authors of this study only WLL were identified as more prevalent in loose housing systems, and exercise in tie-stall barns was beneficial with respect to lameness and sole disorders. The prevalence of heel erosion was by far higher in tie-stall systems (with and without exercise) as compared to loose housing. No differences were found in claw shape between cows kept on several concrete flooring types and in straw yards, except for claw angle (43). In this study horn growth and wear were unaffected by floor type. Therefore, no differences were found in terms of claw health between cows kept on concrete and soft flooring. Under commercial production conditions, the loose housing system of cows is associated with the time which the cows spend away from their pen during milking, the comfort of stalls, hoof trimming frequency, height of the brisket board, and the presence of an area behind the brisket board filled with concrete were associated with the prevalence of lameness in high producing cows (13). The flooring system had no effect on asymmetry between lateral and medial claws in rear limbs (45).

Reduction of lameness in dairy cows

There are six key areas that we can consider when attempting to reduce lameness in dairy cows (30). These risk area include the following: cow comfort, cow hygiene, social and physical integration for heifers and dry cows, cow flow on the farm, diet and correct routine professional functional preventive hoof trimming.

Cow comfort. Substantial differences were found in the behavior of non-lame cows, slightly lame cows, and moderately lame cows in free stall barns with sand bedding (SAND) vs. those in free stall barns with mattress bedding (MAT) (10). Lame cows kept in sand stalls do not modify their daily time budgets; in contrast, lame cows in mattressed stalls spend up to 4.31 h/d longer standing in the stall. The prevalence of CL (locomotion scores = 3 and 4) was 11.1% in contrast to 24.0% for herds using SAND vs. MAT surfaces, respectively. Prolonged time spent standing in the stall has been associated with the presence of sole ulcers and increased the severity of claw lesions (10, 11). Free stall barns with mat or mattress surfaces provide good rest for non-lame cows, but between resting sessions the cows are exposed to hard concrete (11). Poor stall designs with obstructions to normal stall use and a long period of waiting for milking on hard concrete surfaces as well as prolonged milking times are factors associated with an increased risk of lameness. Daily lying times of only 5 to 7 h/d appear to be a significant risk factor (12). According to those authors, in cases when cows have lying times around 10 h/d or more, stall standing behavior, including perching (with 2 feet on the stall platform and 2 feet in the alley, is also an important risk factor. Longer lying times were observed when cows lie on mattresses as compared with mats (8) and when cows lie on deep sand as compared with mats and sawdust (10). A significantly higher incidence of leg injuries over the tarsus (hock) were observed in cows kept in cubicles with mats in comparison with cubicles bedded with straw (50). Cows preferred stalls with sawdust or sand over stalls with mattresses (46). Cows lie down more when cubicles and the lying area are comfortable (30).

Cow hygiene. Hygiene of cows is a second area determining the risk of lameness. Cleanliness of cows is a good general indicator of hygiene status (30). A dry environment of cow maintenance reduces chances of bacteria invading the tissue. In contrast, under wet conditions, slurry and water soften the horn and destroy the skin barrier and cause horn corrosion in claws. In cows housed on solid concrete floors an increased risk of digital dermatitis (DD) is observed as compared with those kept on slatted floors without scrapers (42). It was also suggested in that study that an improved cleanliness of cows is an important factor resulting in the reduction of DD. An important factor in the management of a cow herd is biosecurity (30, 51). Mülling et al. (30) reported that maintaining a closed herd at a high level of hygiene prevents the introduction of infections, lameness or other infectious diseases. It was also recommended that whenever it is impossible to observe a two-week quarantine when introducing new cows into a herd, a careful examination of lifted and cleaned feet of such animals should be conducted. Similarly, other authors suggested the introduction of biosecurity programs and „cow hoof" environment inspection while assessing digital dermatitis control plans (51).

Social and physical integration for heifers and dry cows. A very important factor in herd management is a social and physical integration between heifers and dry cows after calving (16). This integration should begin several weeks before calving. Good integration between these groups of cows not only reduces the incidence of lameness and other diseases, but it may prevent loss of body condition (25). A significant part of this integration is a gradual adaptation of heifers and dry cows to hard floor surfaces instead of a violent change of maintenance conditions. A sudden change in the environment of animals may create challenges in the social hierarchy of cows (4, 22).

Cow flow on the farm. Poor cow flow may arise in the case of a poor physical layout of the farm. Cows kept under such conditions have problems with good rest and changing the position of the body when lying. Poor cow flow can also occur when there is restricted access to feed or water, or when areas of the feed face are blocked by other cows (4, 22). Frequent turning

and twisting of cows on hard and abrasive surfaces can cause damage to the living dermis and horn, producing epidermis inside the claw capsule (11). A poor physical design of the housing system may lead to prolonged standing times. Periods when cows may have to stand are frequently prolonged, including waiting time for the milking and milking time, as well as eating and drinking time. It is particularly important for cows producing 30-40 kg of milk per day, which require a long time to ruminate, that the time of lying should be longer than the time of standing. It shows that good management can reduce the risk of sole ulcer and other horn disorders.

Nutrition of cows. The nutrition of cows may result in a build-up of organic acids in the rumen and reduced rumen buffering (23). The combination of these changes can lead to a depression of the rumen pH. Subacute ruminal acidosis (SARA) occurs when the rumen pH is depressed for prolonged periods each day, e.g. < 5.6 for > 3 h/day (23, 37, 38). The connection between SARA and laminitis has been described by several authors (23, 32, 37, 38). Vasoactive substances secreted during the process of acidosis alter the vascular microcirculation at the corium of the claws, affecting the nutrition of the keratin-producing cells, leading to a poor condition of corneal tissue and hoof lesions, such as WLL, wall abscesses, SH and SU (32). Feeding cows with wet silage in early pregnancy as compared to hay was found to be associated with a greater prevalence of poor locomotion and claw-horn disruption (CHD) in mid-lactation (33). According to those authors, the mechanisms remain unclear, but nutrition is one of many risk factors for lameness and claw horn lesions. In another study no effect of concentrate composition on lameness and hoof health was found in cows examined in the pre-calving period and then re-examined within the week of calving and at 8, 14 and 20 weeks after calving (34). Biotin supplementation at 20 mg/cow/day (heifers started supplementation up to 3 months before calving and dry cows in their dry period) may improve white line structure and strength and also reduce the incidence of lameness (18). The role of biotin supplementation in preventing lameness is biologically plausible because enzymes requiring biotin are responsible for lipogenesis, which is required for the synthesis of the intercellular cementum establishing horn cell adhesion in the claw horn (24). The effect of biotin supplementation in terms of an improved health status of hooves takes 4-6 months to develop. Feeding cows with maize silage is associated with increased lameness, particularly „laminitis", and SU (2).

Functional hoof trimming. Presently, there is still much discussion on the correct approach to trimming cow's feet. It is not clear which approach is preferable. Generally, a lower incidence of non-infectious foot lameness is observed in herds in which hoof trimming is performed (28). Hoof trimming in the autumn, on average 4.5 months before the spring trimming, reduced the prevalence of lameness and hoof lesions associated with laminitis, particularly SU (26). Similarly, a decreased risk of DD was observed when hoof trimming equipment was washed between treating individual cows (51).

In conclusions, intrinsic risk factors for lameness in cows are the following: season of year, gestation and stage of lactation, previous disease and parity. Older cows are more likely to become lame as compared with younger cows. The risk of lameness is also genetically determined for the development of claw lesions. Major extrinsic risk factors influencing lameness include claw disorders, causing approximately 90% of lameness in dairy cows, and the housing system (with exercise vs. without exercise), including different floor surfaces. The key areas leading to reduced lameness in dairy cows are the following: cow comfort and quality floor surfaces, hygiene of cows including their biosecurity, social and physical integration, cow flow, nutrition and functional hoof trimming.

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