The use of HOBO's in lameness detection in Alberta dairy cows.

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Abstract

Lameness is a major problem in present dairy farming. In order to find whether there are other ways to detect lameness in dairy cows instead of gait scoring, the use of HOBO's, a brand of accelerometers, as a lameness detection method is investigated. The aim of the project is to determine whether HOBO's can be used as a more specific and sensitive test method for lameness detection in dairy cows.
It is thought that lame cows can be detected based on their lying times, because literature describes that lame cows, compared to sound cows, are more likely to lie down for longer periods of time. This is thought to be due to claw lesions or other problems inducing lameness causing pain when weight is placed on the hoofs during rising and lying down in the stalls. For the same reason it is thought that lame cows have a lower number of lying bouts and the duration of lying bouts are longer.
The research was part of a running project named "the lameness and longevity project" and took place in Alberta, Canada. Seventeen farms were visited in this province and beside lying times and lying bout information collected using HOBO's, gait scores were performed using video images made on the farms. This data was used to test the hypotheses.
The analysis showed that cows lying down between 8 and 14 hours a day are not necessarily sound and cows lying down less than 8 hours a day are not necessarily lame cows. Cows lying down over 14 hours a day are more likely to be lame and should be watched closely. Also, corrected for farm, the number of bouts was not lower for lame cows and duration of bouts was not longer for lame cows, as was expected.

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Introduction

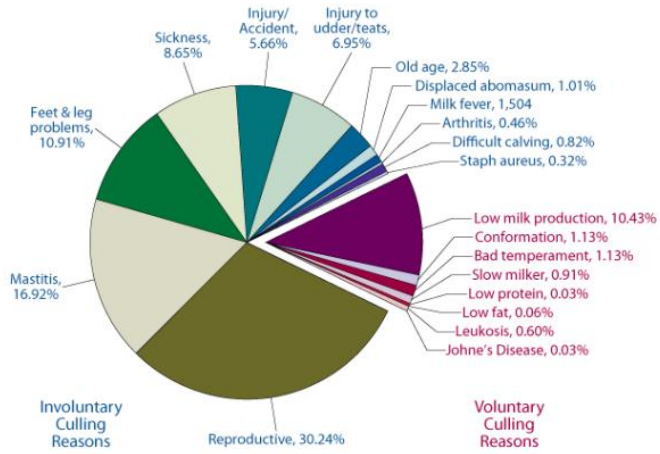


Figure 1 Involuntary Culling Reasons[2]

Lameness in dairy cows is a major issue these days. Estimations of the percentages of cows that suffer from one or multiple claw lesions differ from numbers as low as 0% to 60% in Canada[7] and even up to 80% found in Dutch research.[1] Together with reproductive failure, low milk yield and mastitis, lameness is one of the main reasons for involuntarily culling of a cow. Although mastitis (16,9%) and reproductive failure (30,2%) are thought to be bigger problems, lameness (10,9%) should not be underestimated as an important culling factor as it is still a costly matter with costs estimated at $400,- per lame cow[13]. Lameness may also result in other problems. Fertility performance may be reduced because lame cows are less able to mount other cows, which is an important signal for the farmer that the cow is in heat.[12] It will take a while for the cow to be in heat again and this will bring the fertility performance down. Dry matter intake (DMI) and with that the milk yield might be reduced because the cow is less able to walk to the food alleys and compete with other cows for feeding space[4]. The immune competence of the cows drops, also resulting in suboptimal (reproductive) performance and/or a higher risk for mastitis[2]. Furthermore, lameness has a negative influence on the overall welfare of the cow, because lameness might hurt and it will affect the cows hierarchal position within the herd. Taking this in consideration, lameness detection and early treatment of lameness might prove important to prevent severe lameness and other illnesses, maintain milk yield and improve the cows overall welfare.

Epidemiology

Most cases of lameness are caused by structural damage or infections of claw tissues and are thus located in the foot. In table 1 the prevalence of claw disorders causing lameness in a recent survey of Ontario herds are shown. A similar result was obtained from a study in British Columbia containing 20 free-stall herds.[2] It can be seen that 100% of the free-stalls visited are affected and 46.8% of the cows had one or more claw disorders. For this project and the umbrella project herds in free stall barns were assessed. Numbers in other types of stalls will differ from the numbers shown, because the claws of the cows will be exposed to different environmental factors.
Possible causes for lameness can be divided in claw disorders and other causes.[11]

Lameness in Ontario Dairy Herds, G. Cramer, OLHO Ontario Dairy Symposium p 116 (Mar 2007)

Lesion	Free Stall Herds Prevalence	Free Stall Herds % of herds affected	Tie Stall Herds Prevalence	Tie Stall Herds % of herds affected
Infectious lesion	29.3	94.7	15.8	88.0
Heel Horn Erosion	8.4	68.4	8.3	67.6
Digital Dermatitis	22.9	92.1	9.3	69.7
Foot Rot	0.2	2.6	0.2	7.8
Hoof horn lesions	23.3	100.0	12.2	92.3
Hemorrhage	11.1	81.6	7.1	70.4
Ulcers	9.3	89.5	4.7	70.4
White Line Separations	5.2	68.4	1.0	25.3
White Line Abscess	2.0	50.0	0.6	21.1
Other				
Korn	4.3	73.7	1.0	27.5
Vertical Wall Crack	0.2	13.2	0.1	4.3
Thin Soles	0.5	15.8	0.2	5.6
Deep Sepsis	0.2	2.6	0.0	1.4
Non-Foot Lameness	0.6	18.4	0.2	7.0
Blocked	2.2		0.3	
Wrapped	16.2		6.7	
Lesion	46.8	100.0	25.7	99.3
Number of Cows	4252		7668	

Table 1 Lameness in Ontario Dairy herds[2]

A shortage of lying time can be a factor that causes problems for the cow. When a cow is standing for longer periods, the blood pressure inside the hoofs will rise caused by higher pressure load, which causes reduced perfusion. Not only will this cause inadequate oxygenation and supply of nutrition to the tissues, it will also reduce the removal of toxins. Other negative effects of long standing times are longer exposure to a contaminated environment while standing in manure, leading to a higher risk of infection, and perhaps less movement towards the feeding alley causing a drop in food intake and production.

Diagnosis
An important way to detect clinical lame cows is gait scoring of the cows. Different gait scoring systems have been developed in order to try to detect lameness as early and accurate as possible. The 2 main systems used to gait score cows are the numerical rating scores, using scales to assign a gait score to each cow, and the visual analogue scale, using horizontal lines to detect abnormalities in gait[12]. The last was originally designed to detect pain in humans and was later adapted to lameness assessment in animals. Basically this system detects the same signs of lameness in animals as it does in humans, as the horizontal lines are used to determine whether cows lift their heads or arch their backs more than average.
Since most cases of lameness are caused by claw disorders, it would seem logical to look for these to locate lameness in the herd. Unfortunately, only a small percentage of cows with a claw disorder is diagnosed clinically lame. One reason for this may be that lameness is not detected by the farmer. One study shows that producers missed 1 out of 5 cows that were lame[12]. This could be due to the fact that not all cows with claw disorders show clinical signs[5], in which case the farmer is not able to detect the cow with the claw disorder when checking the herd. Other reasons for missing lame cows could be that cows are not checked regularly for lameness or that conditions are not optimal for detection of lameness. Each farm is different and creates different circumstances, making gait scoring a challenge in one farm due to circumstances as light condition, overcrowding, slippery floors etc. and can be executed perfectly on another farm. What should not be forgotten is that not every claw disorder will cause problems. Some cows will function fine, even with a claw lesion. Making it even more difficult to differentiate between clinical lame cows due to a claw lesion that are undetected or a cow with lesion that will function even though it has a claw lesion.

What can also be a challenge in gait scoring is the specificity of the used lameness detection method. The observer can be of influence on the specificity of the gait scoring. It will always be appealing to interpret results in a way you would like them to be. For example counting a cow sound when doubting, because the farmer is nice and the stalls are well maintained. Cases like this may cause the observer to influence the result due to bias of the observer, but also change in gait scoring over time and inexperience can influence results. A trained observer is 2.5x more likely to detect lameness in an earlier and less obvious stage than an unskilled observer[7]. Agreement between inexperienced observers was 26 to 53%, while this was 94% between experienced observers. All of these factors contribute to the difficulty of detecting lameness in cows. For this reason a different approach is used in this study, in order to obtain more sensitive and specific measurements and cause as little as possible variation between observers.

A possible way to detect lameness in an early stage is the use of accelerometers to measure cow lying time. Research has been conducted with the use of accelerometers to determine the lying time patterns of dairy cows . One study was not promising, but several other studies found that lame cows spent more time laying down for longer periods compared to sound cows. Also lame cows lay down and rose less frequently compared to sound cows.[7, 10,14, 15] *Cook et al. (2004)*[8] attributed this to the fact that lame cows experience discomfort caused by laying down on mats. He compared lame cows housed in stalls where mats were used as bedding compared to stalls with sand bedding and found that lame cows were laying down less in the mat stalls compared to the sand bedded. For the same reason, lame cows might lay down longer, to avoid putting weight on their hoofs when getting up.

Research showed that cows find sufficient lying time important, and they are willing to perform tasks in order to gain more access to lying time. A study by Jensen (2005)[9] shows that heifers that were allowed to lay down for 6 hours would be willing to perform tasks to “earn” extra lying time. They would work for 6 more hours bringing their lying time to 12 hours a day. Younger heifers (10 months) were even willing to work in order to gain 8 extra hours lying time a day to be able to lie down for 14 hours a day. This suggests that normal lying times for cows lie between 12 and 14 hours a day.

It would be interesting to see whether cows lying down less or more than 12 to 14 hours a day will be more prone to develop problems than cows that lie down the preferred 12 to 14 hours. In this research the presence or absence of lameness will be compared to lying times to find out if these factors will influence each other.

Research purpose

In this project the use of accelerometers, so called HOBO's, as a way to detect lameness in dairy cows will be investigated. The accelerometers measure lying time, amount of lying bouts and duration of lying bouts for each cow individually. These results will be compared with outcomes of gait score to assess if the use of HOBO's could be an useful tool in in the detection of lameness in dairy cows. The gait score results will be considered the golden standard.

The hypothesis (H0) is:

1. Lame cows will lay down shorter than 8 hours or longer than 14 hours a day.
2. Lame cows have less lying bouts than the herd average.
3. Lame cows will lay down longer during lying bouts

Materials and methods

Farms

Out of 55 farms visited in 2011, 17 where selected based on the period the first visit took place. In this case between June 7th, 2011 and July 26th, 2011. This was done in an attempt to limit the influence of seasonal factors on the outcome. This way environmental factors like temperature and daylight periods were roughly the same for all animals.
There were a few inclusion criteria that had to be met for the farms to be able to participate in the research. These criteria were chosen to assure that cows were kept in the same way as much as possible in terms of number of cows, milking system, indoor housing and way of milking. The farm needed to have at least 75 milking cows at the moment of visit, of which at least 40 had to be between 10 and 120 days in milk (DIM). Farms with automatic milking systems were excluded from the research. Furthermore only free stall barns that keep their cows inside for the most part of the year were allowed to participate.

Animals

For each farm 40 cows were selected from the farmers herd list. These were called the focal cows. The criteria for these cows was that they had to be between 10 and 120 days in milk (DIM). If too little cows between 10 and 120 DIM were present at the farm at the moment of visiting, cows with DIM times as close as possible to 10 or 120 DIM were selected. This was done in order to select cows that are representive for the cow population in Alberta, Canada.

Experimental design

Each farm was visited twice and each visit was carried out by a team of two to six people. Each team consisted of at least one team leader, who had a 2 week training of how to perform the measurements on the farm, and one or more students. The students had different backgrounds, but were trained by the team leaders to make the measurements on the farms.

HOBO's

Picture 1: Hobo

To record the lying and standing times of the cows so called Hobo® Pendant G Acceleration Data Loggers were used. These HOBO's use an internal three-axis accelerometer to record x-, y-, and z-axis acceleration based on movements made by the cow. This change in direction is converted to voltage, filtered and measured by the logger. In the software these are translated into units of g-force and finally into minutes the cow was standing or lying down.

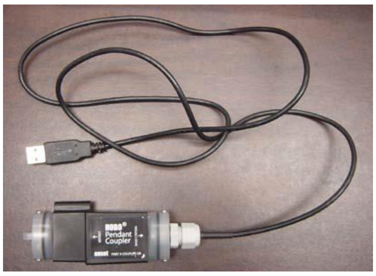
The HOBO's were programmed to start recording at 11:50 pm at the day of attachment with a one minute interval and recorded until moment of detachment at 12:00 pm day 4. Each HOBO was wrapped in three layers of vetwrap. During the first visit to the farm, HOBO's were attached to one of the hind legs, just below the hock during milking.

Picture 2: HOBO wrapping[6]


Picture 3: attaching HOBO[6]

All HOBO's were attached in the same manner, making sure that the HOBO's were placed on the leg in the same way. To attach the HOBO's to the leg of the cow, vetwrap was used. Two layers of vetwrap where first applied to the leg of the cow, making sure the HOBO's would not fall out of the bandage and the cow would not be bothered by the device scratching her skin. Then the HOBO was placed on the vetwrap and 3 more layers of vetwrap were applied. A last check was performed to make sure the vetwrap was not applied to tight.
A preliminary study showed that 4 days measuring were sufficient[15], while leaving the HOBO's on for 10 days gave little different outcomes and caused problems like loss of HOBO's and injuries due to the vetwrap.

At the second visit, at least four days later, the HOBO's were detached either by the farmer or by the students and the collected data was transferred to a laptop using a HOBO coupler (picture 4) and HOBOware® software. The data of all the cows was collected in an excel-sheet. The information per cow would consist of a file with the number of lying bouts, the time of each lying bout, the average lying time per day and the average lying time in 4 days was given. Also the herd average lying time is given.


Picture 4: HOBO coupler[6]

Gait scoring
The focal cows were videotaped with a video camera while they made at least four steps in a straight line. These videos were saved on a computer and evaluated and scored later by one or more of the 3 observers that were trained to gait score cows. For all observers repeatability and consistency are assessed on a regular base during the project. Some cows were gait scored live, when videotaping proved to be difficult and poor videos were expected due to circumstances like poor lighting, overcrowded pens, slippery or uneven floors, unavailability of straight walking lines or cows being scared by the presence of strangers in the pens, showing a disturbed gait pattern.

Lameness was determined by assessment of the gait. Gait scores were made using a modified version of the UBC system[2]. The three aspects that are looked at are:

1. Limping → looking at reluctance to bear weight on one or more legs
2. a head bob → looking at movement of the head during walking
3. asymmetry → looking at rhythm of foot placement

Using these criteria, a cow either given a score of 1 when showing any of the criteria, or a score 0 when showing none of the criteria.

In order to test the hypothesis it was decided to divide the cows in three groups. The cows were divided in the groups lame, slightly lame and sound. Lame meaning the cow showed limping, possibly accompanied by asymmetry or a head bob. Asymmetric meaning no limping was seen but one of the other 2 criteria was present. Sound meaning none of the criteria were seen.
Slightly lame cows could be excluded from the research, investigating only for HOBO's as a test to detect obvious lame cows. But if HOBO's turn out to be only useful to detect obvious lame cows, then their use in the intended way would be redundant. Farmers would notice these cows with gait score more easily. For that reason the asymmetric cows will be included in the group of lame cows to answer the hypothesis question.

Analysis
For analysis a Kappa test, a multiple linear regression test and a student's T-test were used.

The Kappa test was used to determine the agreement of tests between gait scoring as one method and using lying times to determine lameness as another method. To interpret the kappa test the following scale was used.

0,00≤K≤0.20	poor agreement between tests
0,21≤K≤ 0,40	slight agreement between tests
0,41≤K≤0,60	moderate agreement between tests
0,61≤K≤0,80	substantial agreement between tests
0,81≤K≤1,00	almost perfect agreement between tests

To find out whether the farm the cow was staying had too much influence on the test results, a multiple regression equation was performed using SPSS, comparing lying time and lying bout duration of lame and sound cows on all the farms.

The students T-test was used to compare whether differences in lying bouts between lame and sound cows were significantly within farms.
For each cow the average number of lying bouts of four days was taken in all analyses. The same was done for the lying bout duration. Then a student T-test was performed to compare the group of sound cows with the group of lame cows within each farm.

Differences were considered significant if P was ≤ 0,05.

Results

Farms & animals

A total of 679 animals from the 17 selected farms were enrolled in this project. Of these animals, 57 cows were excluded from the project because of absence of gait score or HOBO failure, causing missing data, resulting in a total of 622 animals in our study. Figure 2 shows the variation in lying times of all cows, for each farm. The X-axis shows the amount of cows and the Y-axis shows the lying time of the cows. Each farm is shown in a different color, each dot represents one cow of this farm.

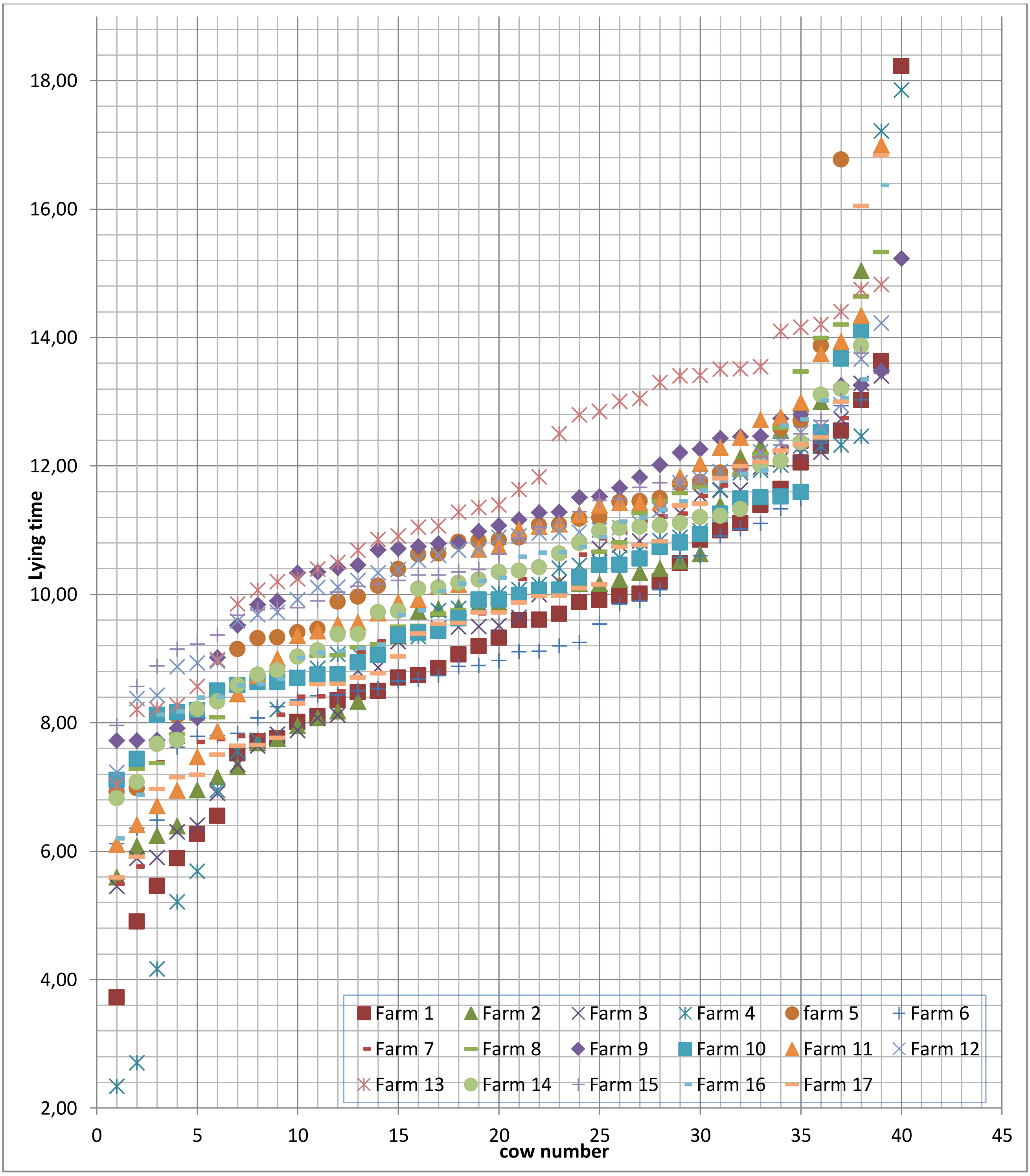


Figure 2: spread cow lying times of all farms

Lying times

Table 2 shows the comparison of the gait score results and the lying times. Lying times are ordered in whole hours. Each column represents one hour of lying time, starting from 2 to 3 hours a day. Comparing the lying times with the gait score, cows were divided in the groups lame, slightly lame and sound. The numbers in the table represent the amount of cows in that specific group.

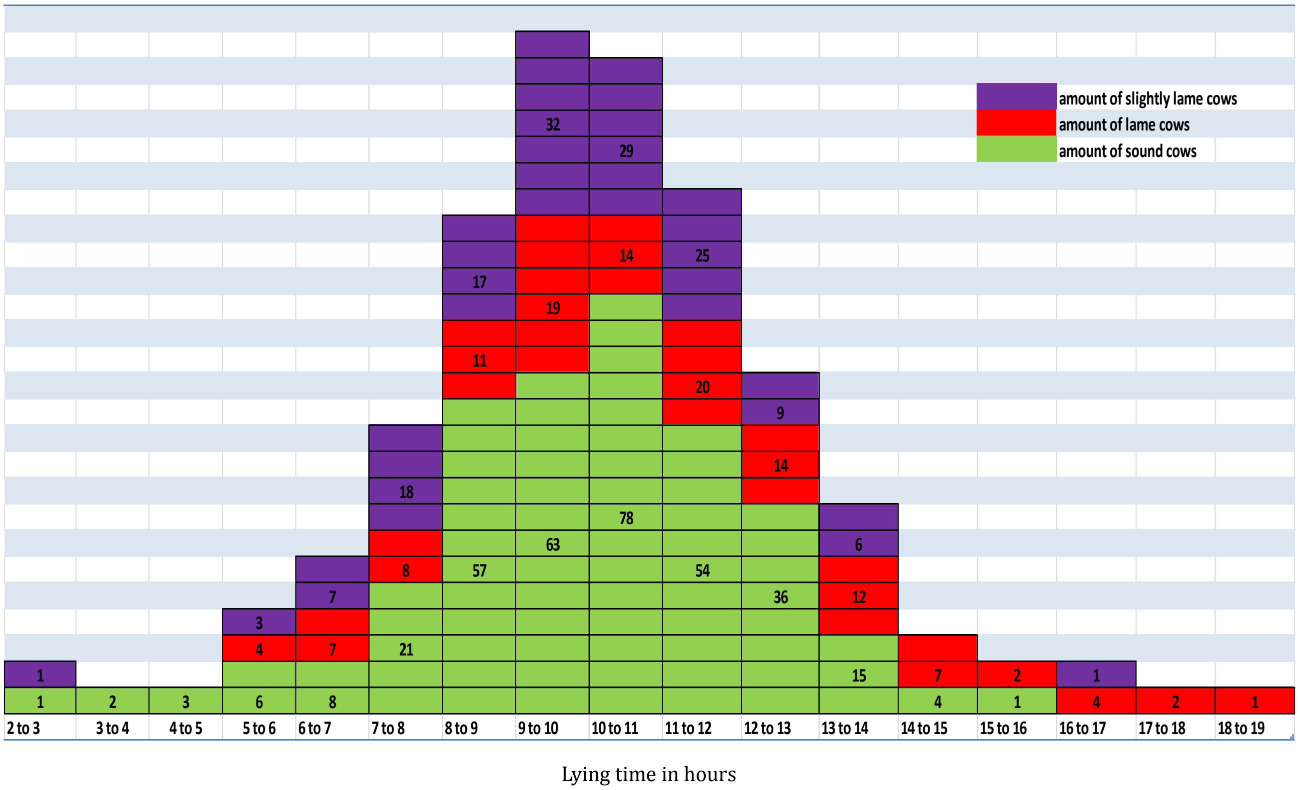


Table 2: Amount of lame, slightly lame or sound cows per lying time category

Table 3 gives an overview of the data shown in figure 2 in number of cows.

Hobo	gait score				
	slightly lame	lame	sound	total	Lameness %
<8 hours	29	19	41	89	54%
>14 hours	1	16	5	22	77%
8-14 hours	118	90	303	511	40%
total	148	125	349	622	

Table 3: overview comparison lying times and gait score

Table 4 shows a comparison of lying time and lameness % per farm.

Average herd lying time	9,3	9,5	9,6	9,6	9,7	9,8	9,8	9,9	10,1	10,2	10,3	10,5	10,5	10,7	10,7	11,1	11,6
Lameness %	3	15	21	62	21	13	8	18	23	25	15	20	16	18	23	5	15

Table 4: comparing lying time to lameness %

Table 5 shows the average lying times per group of cows, with a lower and upper limit, and the median. All lame meaning slightly lame and lame cows together in one group.

	Average (lower limit; upper limit)	median
Slightly lame	9,78 (2,70;16,83)	9,84
lame	10,93 (5,75;18,23)	10,95
all lame	10,31 (2,70;18,23)	10,15
sound	10,06 (2,33;15,23)	10,15

Table 5: averages and median

Lying bouts

Table 6 shows the average amount of lying bouts and the duration of lying bouts for the lame, the sound and all the cows of each farm. Furthermore the results of the student t-test comparing the lame and sound cows on each farm are shown.

Farm	Average # bouts lame cows	Average # bouts sound cows	Average # bouts all cows	T-test # bouts
1	10,89	12,04	11,77	0,5252
2	11,54	11,52	11,53	0,9933
3	8,24	8,22	8,24	0,9807
4	10,82	11,51	11,38	0,6863
5	13,71	12,31	12,84	0,4496
6	10,40	10,95	10,78	0,6727
7	10,30	11,61	11,04	0,4109
8	11,80	10,93	9,95	0,1555
9	9,18	12,57	12,07	0,0032
10	6,38	9,24	9,90	0,8616
11	11,48	10,89	11,14	0,2652
12	14,19	11,73	11,62	0,1554
13	9,21	10,78	11,07	0,8035
14	10,82	11,66	12,17	0,8910
15	9,77	10,36	11,11	0,0160
16	11,19	12,64	11,84	0,3822
17	9,98	9,95	9,86	0,8376
Farm	**Average lying time (min)/bout lame cows**	**Average lying time (min)/bout sound cows**	**Average lying time (min)/bout all cows**	**T-test bout duration**
1	66,29	51,18	54,76	0,0470
2	61,85	56,20	58,39	0,4774
3	77,00	67,77	74,89	0,2306
4	60,54	53,80	55,53	0,2582
5	54,57	55,79	55,33	0,8589
6	59,50	58,72	58,97	0,9614
7	67,24	41,78	58,54	0,0264
8	54,95	51,17	66,44	0,0604
9	56,73	55,36	60,97	0,0403
10	69,44	66,29	66,44	0,5363
11	56,51	56,80	66,49	0,0721
12	25,59	58,58	59,80	0,0975
13	63,92	54,38	73,80	0,1786
14	61,96	53,25	58,77	0,8120
15	68,29	61,03	68,19	0,0104
16	62,21	60,08	56,82	0,4961
17	67,29	62,06	67,25	0,8735

Table 6: data lying bouts

Analysis
When gait score and lying times as a way to detect lameness are compared, a kappa of 0,11± 0,084 was found comparing the gait scoring system and the lying times when all lame cows were placed in one group. When the slightly lame cows were excluded, and the lame cows were compared to sound cows, a kappa of 0,54± 0,034 was found.

The multiple regression test showed that farm effect had an significant impact (P0,042) on the lying bouts, but not on the lying times of cows (P0,065).

Discussion

Comparing tests
In table 3 results of the gait score and the lying times are compared. The specificity of the lying times as a test method was 0,87, which can also be seen in the large amount of sound cows that was correctly considered sound. The 303 sound cows lying down 8-14 hours a day were expected to be sound, showing agreement between tests. Only 46 cows found sound by the gait scoring were not expected to be sound using the HOBO's. This number was even bigger (0,98) when the slightly lame cows were left out of the equation. This suggests that the HOBO's are capable of detecting sound cows quite accurate if gait scoring is considered the golden standard. However, the positive predictive value was only 0,59.
Sensitivity (0,24) was not that high. This was to be expected since a large amount of cows was considered lame using the HOBO's while gait scoring tested them sound. 65 cows lying down <8 or >14 hours a day were expected lame, but the 208 lame cows lying down 8-14 hours a day were not expected to be lame. The negative predictive value was also 0,59. This was higher (0,77) when slightly lame cows were left out of the equation.
The kappa test already showed that there was only poor agreement between the two test methods. It seems that HOBO's and gait scoring do not mark the same cows as lame. The question that remains is whether lying times can be used as a detection method for lameness.

Lying times
Ideally, the HOBO's would be an unbiased method to detect lameness in cows. But for that to happen, it would have meant that all cows lying between 8 and 14 hours a day would be sound and all cows with other lying times would be lame. However, this does not seem to be the case.

When looking at average farm lying times compared to farm lameness percentages in table 4, it can be seen that low average herd lying times do not automatically give low lameness percentages as was thought. Since the average can be influenced by a few cows with extremely low or high lying times, the cows are looked at individually in figure 2.
Here it can be seen that spread patterns seem to differ between farms, suggesting a farm effect on lying time. But as shown in the results, the farm effect was not significant for cow lying times (p=0,065).

Furthermore the figure shows that the majority of the cows lie down between 8 and 13 hours a day. This supports the theory that cows appear to be comfortable lying down 8-13 hours a day and it shows that the choice of 8 to 14 hours as a 'normal lying time' was well considered. For this data set out in a graph it was expected that all the lame cows would be centered either in the left or right columns of table 2 with lying times <8 or >14 hours a day. As can be seen this does not seem to be the case, meaning the first hypothesis is false. Table 3 shows the same conclusion, since the biggest amount of cows would have been divided over the left upper corner and the right lower corner. This seems to be true for the group lying down >14 hours a day, but not for the other groups. This suggests that even though cows lying down between 8 and 14 hours a day are not necessarily sound, there is a connection between lying times of >14 hours a day and lameness.

What can be seen in table 5 is that the average difference between all lame (10,31), lame (10,93), slightly lame (9,78) and sound (10,06) appear to be minimal. To find out whether these group differences are significant, a student T-test was performed. This showed that there was a significant difference between the groups slightly lame and lame (P=0,000) and lame and sound (P=0,000). There was no significant difference between the groups all lame and sound (P=0,169) and slightly lame and sound (P=0,146). This shows that lying times of lame cows are significantly different from slightly lame or sound cows. This can also be seen in the range of lying times. The cow lying times have a range from 2.33 till 18,23 hours lying time per day. The range of lying times is 2,33 – 15,23 hours for the sound group, 2,70 - 16,83 hours for the slightly lame group and 5,75 - 18,23 for the lame group.

Further investigating this, it can be calculated that 77% of the cows lying down >14 hours a day are lame. This percentage is a lot higher than the lameness percentage in the group of cows that lie down 8-14 hours a day (40%) or the group lying down <14 hours a day (43%). This shows that the lameness percentage is clearly higher in cows lying down >14 hours a day. The percentage of lame cows (54%) in the group lying down <8 hours a day is less convincing, but is still significant. This percentage is also bigger than that of the group of sound cows, suggesting that lying down <8 hours a day is somehow connected to lameness.

What is surprising is that slightly lame cows appear to have shorter lying times on average than the sound and the lame cows. This is also shown in table 3, where it can be seen that slightly lame cows are more present in the groups of cows lying down less than 14 hours. Where the group of cows lying down >14 hours a day has a percentage of 4,5% slightly lame cows, this is 30% and 32% for the 8-14 hour group and the <8 hour group respectively.
This might be coincidence, but it would be interesting to find out whether slight lameness is a cause of or a consequence of lower lying times and may lead to more severe lameness and with that higher lying times. To be able to answer this question observation for a longer time period would be needed. Another explanations could be that there are different causes leading to lameness in the group lying down >14 hours a day versus the ones lying down <14 or <8 hours a day. It would be interesting to see whether the cows in the group lying down <8 hours a day stay sound if they are followed for a longer period of time. And if this is the case, to find out why sound cows chose to be standing longer than is considered comfortable for cows. Most likely these cows are in heat or they are lower in the herds hierarchy, being chased from lying spots and feeding areas. And if this is true, does this mean the cows lying down >14 hours a day are the highest productive cows or the ones in the top of the hierarchy? With the data of the umbrella project some of these questions might already be answered, but further research is still necessary.

Lying bouts
Another possible useful tool provided by the HOBO's are the lying bouts. Besides the lying times, the lying bout duration times and the number of bouts per day were collected. The data is shown in table 6. Since the influence of farm ID was significantly big, we look at the data of the lying bouts per farm. It was expected that lame cows would have less lying bouts with a longer duration, because rising or lying down would mean they have to put weight on their legs which would possibly hurt.

# of lying bouts
Comparing the averages of the number of lying bouts within each herd, the numbers do not seem to differ in the expected way. Some farms show an average number of bouts that is higher for the lame cows compared to the sound cows, but others have less lying bouts for the lame cows. It seems that lame cows do not necessarily have less lying bouts compared to sound cows. Also lame cows do not necessarily have less lying bouts than the herds average. When a student T-test was used, only 2 farms had a significant difference when comparing number of lying bouts of lame cows and sound cows.

Duration of lying bouts
For the duration of the lying times, it was expected that the lame cows would have longer lying times than the sound cows. With the exception of 3 farms, lame cows had a longer bout duration on average compared to sound cows. A student T-test showed that the difference was significant only on 4 out of 17 farms.

It seems both the hypotheses about the lying bouts were false. Lame cows do not have less lying bouts or a longer duration of lying bouts.

Other aspects

The biggest problem in this research might be the gait scoring. This was only done once during this research, just before the lying times were measured. This means a cow has to be clinically lame at the moment of gait scoring and for at least 2-3 days after that to be detected as lame using lying times. In this research it cannot be said whether a cow is still lame or sound at the moment of lying time recording. And even though gait score was considered the golden standard in this research, it is not clear how well gait score works as a detection method for lameness. It should not be forgotten that detection of lameness using gait score is still difficult and has to be done by people. The observers where trained before actually scoring cows, but overcrowded barns, differences in floor slipperiness, light conditions, cows being more or less used to strangers in the barn and other causes will still influence the gait scoring. Also Flower notes that an observer becomes more skilled, reaching a PABAK value of 0,88 after scoring 49 farms using a five point system.[12] Since the observers have both scored 4 farms before scoring the farms used in this research, it may be wondered whether the gait scoring results would have been different if done by other, more skilled observers. Slight differences might also occur because different observers did the gait scoring and different students assisted the observers in guiding the cows. The author noticed that cows walked more or less 'naturally' depending on which student 'pushed' them forwards.

What also should be observed is whether cows have a reason to be more active, for example when they are in heat or became ill during the trial, because these animals would walk more or less than usual. N. Blackie showed that cows are significantly more active during their first week of lactation compared to being in their 12th week of lactation (P0,03).[14]

Other factors that should be considered is that the focal cow group consisted of high productive cows between 10 and 120 DIM. Since these cows are high productive, they are more prone to develop problems if conditions are suboptimal and were chosen for this reason. But that does exclude the normal producing cows and young stock from this research. Other results may be found for these groups.

Another important factor that should also be included is the influence of stall design. As said before, lame cows are less willing to put weight on their hoofs. Having deep bedded stalls or concrete stall bases for example might mean a big difference as Cook shows in figure 5. Here it can be seen that lying bouts of cows bedded in sand based stalls have the highest peaks at 60, 75 and 90 minutes. The most cows bedded on mat based stalls seem to lie down between 15 and 60 minutes.

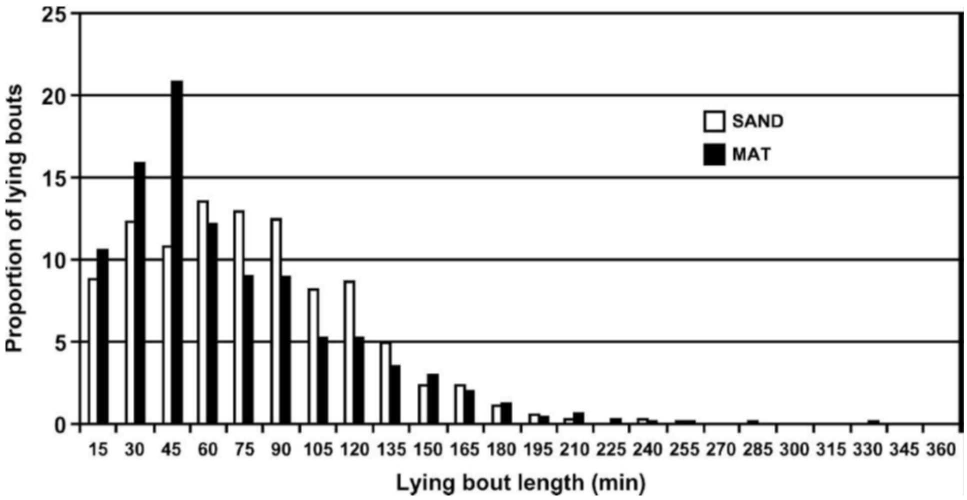


Figure 5: Cook et al.[8] effect of stall base on cow lying bouts.

This is only one factor that already seems to influence the results. Other factors that should be considered are overcrowding, herd structure (meaning looking at how often is the herd structure changed by adding or removing cows, changing herd hierarchy), stall climate, floor slipperiness, presence of possible injury causing objects, lactation stage and many other influencing factors could be thought of that need to be considered when researching the connection of lameness and lying times.

Conclusion

Looking back at the hypotheses formulated at the beginning of this project, it seems that none of the assumptions made were correct for the farms investigated and therefore the hypotheses have to be rejected.

Lame cows were not necessarily the cows lying down less than 8 or more than 14 hours a day. Nor were the sound cows necessarily lying down between 8 and 14 hours a day. However, there seems to be a higher lameness risk for cows lying down >14 hours a day, since 77% of the cows lying down >14 hours a day appeared to be lame. Therefore it may be concluded that cows with lying times over 14 hours a day should be checked by a hoof trimmer or watched closely by the farmer.

The tendency of lame cows lying down 2 hours longer like the results found in N. Blackie's research[14] was not found in this project. In order to get a better understanding of the relationship between lameness and lying time, more research is needed. Cows should be followed for longer periods and stall influences should be added to the research.

When only HOBO's are used to determine lameness, the results are not useful. Lame cows have higher lying times on average, but on herd level this is not usable. Within one herd there are lame cows with various lying times. The few lame cows with high lying times cause the rise in average lying time. Statistical this can be proven, but in practical circumstances this cannot be considered a useful tool for farmers. Possibly lameness detection can be accomplished by combining lying times and one other criteria like claw lesions for example. But for now, lying time cannot be used to detect lameness in a dairy herd.

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