FEED BUNK HEIGHT IMPACT ON DAIRY COW'S FRONT CLAWS.

IMPACTO DA ALTURA DO COMEDOURO NAS PATAS DIANTEIRAS DE VACAS LEITEIRAS.

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ABSTRACT

Claw horn lesions are believed to develop from increased pedal bone mobility induced by changes in the corium tissue. During the planning of barns herd owners are faced with choices of materials and dimensions, as well as feed bunk heights. Among the causes that may lead to front claw injuries there is the height of the feed bunk, as the cow changes its postural behavior in order to reach the food. This research aimed to study the dairy cows' front claws force exerted during eating for determining the lesion risk factor of the feed bunk height. Eight dairy cows were placed in front of the feed bunk, their front claws stepped on the pressure assessment system, and the forces exerted on front claws due to the eating postural change were recorded. The mean pressure, the maximum pressure, the floor contact area, and the mean force per region were calculated. While the cow was eating, the highest mean pressure shifted slightly towards the sole. In the lateral claw the maximum pressure was also shifted slightly towards the toe. No difference was found in the variables analyzed for both lateral and medial sides, as well for the force distribution in the left and right claws. Results of this experiment were not conclusive, not allowing explaining either laminitis or the corkscrew deformity as a result of the force exerted in the claws by means of height of the feed bunk being a risk factor.

Keywords: lameness, animal welfare, feed bunk design.

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RESUMO

Acredita-se que lesões de casco se desenvolvem pelo acréscimo da mobilidade podal induzida pelas alterações no casco, durante a produção. Durante o planejamento das instalações, donos de rebanhos encontram distintas escolhas de materiais e dimensões, assim como altura do comedouro. Dentre as causas que podem levar a lesão nos cascos dianteiros está a altura do comedouro, pois a vaca modifica seu comportamento postural para alcançar o alimento. Esta pesquisa objetivou estudar as forças exercidas nos cascos frontais durante alimentação, para determinar o fator de risco da altura do comedouro no aparecimento de lesões. Oito vacas leiteiras foram colocadas em frente do comedouro com as patas dianteiras sobre um sistema de medida de pressão e as forças exercidas pelos cascos frontais, devidas à mudança da postura enquanto comiam, foram registradas. As pressões média e máxima, a área de contato com o piso e a força média por região foram calculadas. Enquanto a vaca se alimentava, a pressão máxima se moveu ligeiramente para a sola. Na parte lateral do casco a pressão máxima também se deslocou na direção anterior (ponta do dedo). Não foi encontrada diferença nas variáveis analisadas para os lados laterais ou centrais, assim como na distribuição de forças do casco direito e esquerdo. Os resultados desse experimento não foram conclusivos, não permitindo que a presença de laminite ou a deformidade de casco “corkscrew claw”, seja entendida como um resultado da força exercida pelos cascos, por causa da altura do comedouro, sendo este um fator de risco.

Palavras-Chaves: laminite, bem-estar animal, dimensionamento de comedouro.

INTRODUCTION

It is widely accepted that lameness is a significant health problem in today’s dairy industry (BLOWEY, 1993; ENTING et al., 1997; JUAREZ et al., 2003) as well as it represents a major impact on behavior, health, reproduction and welfare of dairy cows (GALINDO et al., 2002). In Brazil claw pathologies are the third most important factor of economical losses and affect from 11 to 25% of dairy cows (SILVA et al., 2004).

Much has been done to assess the risk factors involved in the prevalence of claw disorders causing lameness (WELLS et al., 1993, WARNICK et al., 2001), and it seems that the prevalence causes includes feeding, housing, management, behavior and genetics (GREENOUGH, 1997). Claw disorders (infectious or non-infectious) have their own risk factors as well as their own treatment and prevention protocol. Laminitis is non-infectious, but can be the primary disease leading to several other claw disorders, including infectious foot skin diseases (GREENOUGH, 1997, VAN AMSTEL et al., 2004). In general laminitis is only identified in its acute form. In its subclinical and chronic form. In its subclinical and chronic form however, clinical signs are less obvious and observed coincidentally during routine trimming.

In front legs the main claw problem is frequently seen in the medial claws of the front legs, and it is found predominantly in free-stall housing, and it is called corkscrew claw (SHEARER, 2003; VAN AMSTEL et al., 2004), which is an abnormality that results in twisted claws throughout its length in a configuration that displaces the abaxial wall 360°. It is also regarded as a hereditary condition, affecting all claws, but mainly the lateral claws of the hind legs (VAN AMSTEL et al., 2006). The exact pathogenesis is not clear, but it is hypothesized to be pressure-induced abnormal horn growth, due to excessive friction towards hard surface. Feed-bunk design may play an important role in the etiology of this disorder, since the condition has not been observed as a herd problem in tie-stalls (RAVEN, 1989). In free-stalls cows adopt an unnatural position while eating at the feed bunk. Because of the design of the post and bar feed barrier, a cow often stands with her feet and legs side-by-side leaning forward to eat. This position is markedly different from the position adopted in pasture while grazing, whereby one foot will always be in front of the other.

This experiment aimed to study the dairy cows' front claws force exerted during eating from an elevated feed bunk position.

MATERIALS AND METHODS

The experiment took place at a commercial dairy farm located at São Paulo, Brasil, on latitude de 22º 32' 55" South, longitude 47º 54' 50" West, and altitude of 580m.The herd was reared in a free stall house Est-West solar oriented 80.0 m long , 28.0 m wide and 3,5 m higt , with the capability of housing 200 adult cows divided in two lots. The house had the side opened , with wood pillars and concrete floor. The central corridor was 2.92m wide and the rubber bedding had the dimensions of 2.12 m long by 1.10 m wide. During hot the ventilation system over the resting area (1/2 HP fans with a flow of 300 m^3 h $-^1$) was turned on. When ambient temperature was above 25°C during meal time, another cooling system over the feeders (½ HP fans with a flow of 300 m^3 h-^{1} associated with water dripping) was turned on .

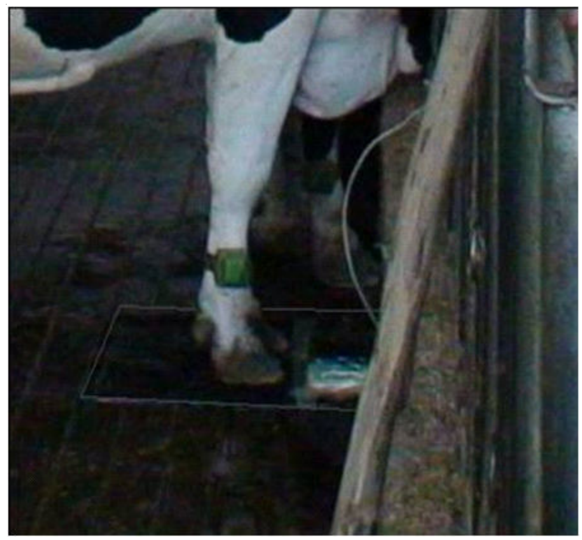
Eight dairy Holstein-Fresian cows with average weights of 650kg were randomly selected from a group in production and they had clinically healthy claws, and no visual evidence of lameness.

Sensor and calibration

The forces exerted in the front claws were measured using the pressure assessment system Tekscan®, Inc.: Matscan System. The sensor contains 2288 sensing elements (sensels) with a spatial resolution of 1.4 sensors cm-^{2} in a mat sized 432mm x 368mm. An addition to the sensor the Matscan-software and associated hardware (Parallel Interface Box & Parallel Data Acquisition Handle) was used. The sensor was calibrated for each evaluated animal, according to CARVALHO et al., (2005). Calibration was performed by placing a single foot of the cow on the surface of the sensor. For this purpose, a thin transparent plastic cover was placed on top of the sensor mat for protecting the device from cow's droppings. When the cow was square standing with one foot on top of the sensor, calibration was performed. This calibration was used for all pressure measurements, and then transformed in force readings using the software output.

Experimental design

The plastic cover and sensor were placed on the rough floor inside the free-stall. The apparatus was placed as close as possible to the feeding barrier (Figure1 a and b).



A

B

FIGURE 1. The cow stepping on the system pressure measurement (a), and the laptop with the installed software for recording data (b).

A small amount of silage was given to the cows as soon as they placed the forefeet correctly on top of the sensor. Subsequent data recording started at the moment the cow the head down in the feed bunk to eat, and then continued at a rate of 40 Hz until 2000 frames were recorded. Then the cow was induced to step with the remaining front claw in the pressure measurement system, and the other front foot pressure was measured in the same way. All data were stored in a laptop for further analysis.

Analysis and statistics

An excel-spreadsheet was used for analysis, as suggested by CARVALHO et al. (2005). This spreadsheet was designed to divert the pressure-frame from the MatScan software into pressure-values (N cm-^{2}). A pressure quantified digital image of the claw was formed and enable to visualize the force distribution on the claws. The area of the claw (in cm^2) that actually made contact with the floor was also assessed.

The claw was divided into two regions, toe and sole/heel, for determining the shifting of pressures over the claw. The claws pressure quantified digital image were aligned horizontally, in order to allow the comparison of all claws in the same position and maintain the interdigital cleft parallel to the X-axis. The division between toe-sole/heel was around 30%-70%. The lateral and medial pressures were also analyzed for determining where the strength was more intense.

The mean pressure, the maximum pressure, the floor contact area, and the mean force per region from all cows were calculated. This data was used to build up diagrams of the claw and the average values of resultant forces were calculated within a confidence interval of 95%. The model assesses the relation between each variable cow-leg-claw, and region. Animal was regarded a non-dependent variable.

RESULTS AND DISCUSSION

Lateral *versus* Medial claw pressure

It was determined in which claw the highest mean pressures occurred. No difference was found in the pressures analyzed for both lateral and medial sides; even though the lateral of the claw was subject to the highest nominal force, mean and maximum pressures (Table 1). It can be seen that the lateral claw is subject to most of the force, about 54%, remaining 46% for the medial claw. It indicates that when the cow bends the head down to eat both pressure and force shift from the medial claw towards the lateral claw.

TABLE 1. Average force balance, area, mean and maximum pressures exerted on the lateral and medial claw in the level of the feed bunk.

Side of claw	Force balance	Area	Mean Pressure	Max. Pressure
	% BW	cm^2	N cm-^{2}	N cm-^{2}
Lateral	54%	34.21	26.32 N/cm^2	73.4
Medial	46%	33.02	21.72 N/cm^2	70.5

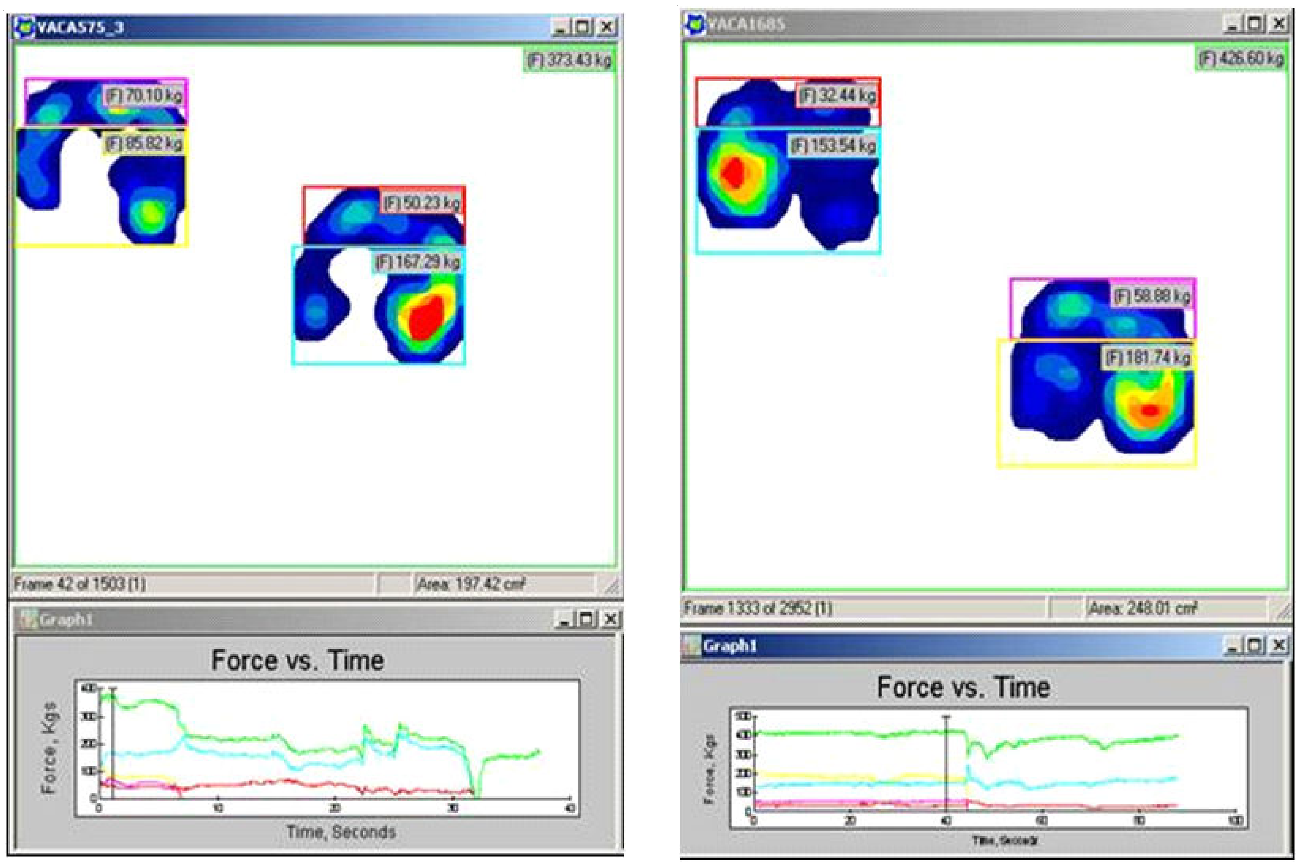
These results are consistent with earlier findings by RAVEN (1973) and VAN DER TOL (2002). Eating from a level lower than the one used in this feed bunk both pressure and force shifted towards the lateral claw. This implies that it is not likely the height of the feed bunk predisposes the claws to the development of deformities such as the corkscrew claw. The hypothesis that eating from the low level leads to increased pressure and force in the medial toe was hereby, rejected. Although when the cow tries to reach the feed in the floor level it lead to increased pressure and force in the lateral toe, not much problems in the lateral front claws of dairy cattle were reported in literature.

Progress in research on laminitis and weight bearing has been limited in the past. Much already is known about equine laminitis and over the years this knowledge has been projected onto cattle as well. Although the suspensor apparatus has the same function, morphology and anatomy are different to a certain extent (LISCHER et al., 2002; HIRSCHBERG & PLENDL, 2005). This difference mainly concerns the laminae and the digital cushion or supporting tissue of the claw. As opposed to horses,cattle does not have the secondary set of lamellae, which increases the suspensor area. On hard concrete surfaces, therefore, the cushion contributes in the weight bearing in bovines. In cows the cushion is soft, containing a large amount of fat, consisting of mono-unsaturated fatty acids, providing a soft cushion and good shock absorbing features. Both these weight bearing structures will be affected in case of overloading, causing alterations in the dermal-epidermal junction and the fatty cushions (HIRSCHBERG et al., 1999).

Claw region pressure

The region of the claw in which the maximum pressure and force where located were assessed and it was found that while the cow was eating, the highest mean pressure shifted slightly towards the sole. In the lateral claw the maximum pressure was also shifted slightly towards the toe. In general a mean pressure shift from the medial heel towards the lateral toe was shown when the cow reaches down to eat from the lower level. Figure 2 a and b shows the digital image output of two cows' claws selected for showing the force exerted in the claws regions while eating. Color scale goes from dark blue (low force) to dark red (high force).

The maximum force was always applied to the sole/heel, as this is a bigger area than the toe. It was also observed that the force shifts away from the medial heel towards the lateral toe.



A B

FIGURE 2. Digital image output of two cows' claws use in the experiment and the uneven force distribution (a), and a more balanced resultant force on claws (b).

Probably due to the unsuitable nature of concrete floors the weight bearing structures evolve differently in an effort to adapt to these housing conditions. These and other findings (OSSENT et al., 1987; VAN DER TOL et al., 2002; CARVALHO et al., 2005, VAN DER TOL et al., 2004) indicate that weight bearing in cattle might not be as similar as to that in horses, as believed before. Cattle are exposed to several concrete areas in free-stall housing systems, such as slatted flooring, milking parlor, holding areas, walkways and free-stalls. This has a major impact on weight-bearing capacities and wear of the claw. External trauma or trauma due to excessive weight bearing on a claw or region of the claw may result in bruising of those parts, which should be protected by the claw capsule. RAVEN (1989) already showed that the weight bearing dynamics in the hind feet of cows is affected by housing conditions of concrete (slatted) floors. SOMERS et al. (2003) showed that over 80 % of cows exposed to concrete flooring had at least one claw disorder, and among them there is incidence of corkscrew deformity.

In the hind feet, the lateral claw carries the most available weight. It is also the claws that show the most known disorders. VAN DER TOL et al. (2002) already suggested a relation between the location of the highest pressures and the location of claw diseases. In analogy of this thought it was expected that in the front feet higher pressures were located in the medial claw, known to be more susceptible for injuries (GREENOUGH et al. 1997; BLOWEY, 1993).

The front feet in cows are known to carry the majority of the weight of the animal (55%) as opposed to the hind feet (45%) (SCOTT, 1986; RAVEN, 1989). Taking into consideration that the contact-area in a standing animal under the front claws is bigger than under the hind claws, this extra weigth shoud not lead to problems. I fact, the front legs carry the animal, whilst the rear legs are for propulsion. So not the weight bearing, but rather forces applied to the claw may result in a higher incidence of claw disorders.

Table 2 shows the results in strength and force exert as percentage of body weight at the level of the feed bunk during eating. No difference was found between the resultant force distribution in the left and right claws. From the results of this experiment it was not possible to explain either laminitis or the corkscrew deformity as a result of overburdening in the medial claw by means of height of the feed bunk being a risk factor.

TABLE 2. Mean force distribution exerted on the left and right claw at the level of the feed bunk.

	Mean force		Mean force	
	N	%BW	N	%BW
	left		right	
Toe	580.91 ± 28.80	15.36 ± 7.04	600.06 ± 13.30	15.83 ± 4.03
sole / heel	1,250.16 ± 37.07	32.51 ± 8.60	1,380.41 ± 36.79	36.30 ± 9.45

A possibility is that not the height of the feed bunk but rather the distance a cow has to reach is the cause of overburdening of certain parts of the claw. A distance of 90-100cm is considered to be the maximum for cows to reach for their food (ZAPPAVIGNA 1982). This could be the case when the food is not pushed up frequently enough for close to the feeding area. When the easy accessible food is all eaten the cow will reach for the food that's further away, possibly straining her front claws.

CONCLUSION

Front claws laminitis and corkscrew deformity in dairy cows are not likely to be an effect of the height of the feed bunk in combination with a concrete feeding alley. Further research is needed to bring some light on the problem of front claws laminitis as well as corkscrew deformity.

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