CUBICLE DIMENSIONS AFFECT RESTING-RELATED BEHAVIOUR, INJURIES AND DIRTINESS OF LOOSE-HOUSED DAIRY COWS

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SUMMARY

Increasing cubicle dimensions reduced the estimates of prevalence of prolonged movement sequences and general dirtiness of cubicle loose-housed dairy cows in predictive regression models. Neck rail height, distance of neck rail from the curb and availability of head lunging space were the statistically significant predictors. Despite the relatively low R-squared values in the predictive regression models, the results of our pilot study encourage further research on the subject.

Keywords: cubicle housing, lying-down behaviour, standing-up behaviour, skin lesions, cleanliness, animal welfare

INTRODUCTION

Loose-housed dairy cows are most often kept in cubicle (free stall) systems. A dairy cow spends 40–60% of time lying down (Tucker et al., 2005), and lies down and stands up 10–17 times each day (Wechsler et al., 2000). Consequently, cubicle properties, such as dimensions and surface material, have high potential to affect welfare of the cows through hindering normal behaviour (Veissier et al. 2005) and causing injuries (Livesey et al., 2002) or dirtying (Chaplin et al., 2000). In our pilot study we concentrated on examining the influence of different cubicle dimensions on the lying-down and standing-up duration, as well as some health variables in loose-housed dairy cows on Finnish commercial dairy farms.

MATERIAL AND METHODS

The study was carried out on 27 commercial dairy farms located mainly in the North Savo region of Finland during the winter feeding period of 2005 (January-April). The farms housed 28–92 (mean 52 ± S.D. 17) milking cows in insulated cubicle barns. In total, there were 1192 cows in the herds (68% Finnish Ayrshire and 32% Finnish Holstein-Friesian). All farms had cubicles with mats, and used either a small amount of wood shavings (n = 22), peat (n = 2) or straw (n = 1) or nothing (n = 2) as litter.

Lying-down and standing-up behaviour of cows was observed for a total of three hours on each farm. Observations were made directly for 1.5 hours after morning milking and 1.5 hours before evening milking. During the observation periods, the duration (seconds) of all observed lying-down (n = 23–75 / farm) and standing-up (n = 21–75 / farm) sequences (individual cows could not be identified) were measured with a stopwatch. Timekeeping was started for a lying-down sequence when a cow bent her foreleg and stopped when she settled down to a lying position. For standing-up sequence, the timekeeping began when a cow started to pull her feet under herself and made a forward swinging motion with her head, and stopped when she was standing in balance on all four feet. Winckler et al. (2003) have suggested that movement sequences lasting over seven seconds in cattle can be considered prolonged or abnormal. Using this criterion, prevalence of both prolonged lying-down and standing-up sequences in each herd was calculated. Observations of movement sequences longer than 100 seconds (n = 10) were then excluded from the data in order to prevent the few extremely large values from skewing the average, and average duration (seconds) of movement sequences in each herd were calculated.

A random sample of cows (n = 10 / farm) was pre-selected for clinical examination of cleanliness and injuries. Cleanliness of feet, udder (posterior view), underbelly and udder (lateral view) and thighs of each cow were scored as 1 = "clean", 2 = "under 50% of the area soiled" or 3 = "over 50% of the area soiled" on both the left and right side of the cow, where applicable. The separate scores for each location were summed up to form an "overall" dirtiness score (theoretical minimum 7 = perfectly clean, and maximum 21 = extremely dirty) for a cow. Based on the individual cow scores a herd average dirtiness score was calculated. Injuries in the knees (carpal joint), hocks (tarsal joint) and neck were scored as 0 = "no hairless patches, scabs or wounds", 1 = "hairless patches", 2 = "scabs and/or wounds" or 3 = "swelling in the joint / area". All joints were examined but only the cow's highest score for a given location (knee or hock) was taken into account. Prevalence of severe injuries in hocks and knees on a farm was calculated as a percentage of cows observed to have scabs, wounds or swelling. For prevalence of neck injuries also cows with hairless patches were included in the calculation.

The behaviour, cleanliness and injury variables (Table 1.) were used as dependent variables in multiple linear regression analysis (SPSS for Windows 14.0). Cubicle dimensions (Table 2.) were always included as independent variables in the analyses. Table 2 lists also the additional independent variables used in the analyses of injury and dirtiness variables: the age and milk yield of the injury- and cleanliness-sampled cows (all variables), feeding barrier type (neck injuries) or pen floor type (dirtiness score). Backward regression selection was used with the least significant predictor at each step being removed from the model, until the remaining predictors were all significant. The significance threshold for removal from the model was P = 0.1.

Table 1. Descriptive statistics of the behaviour, injury and dirtiness variables used as dependent variables in the regression analyses. Figures are averages of the 27 farms.

Variable	Mean ± S.D.	Min	Max
Average lying-down duration (sec)	6.1 ± 0.7	4.6	7.6
Prevalence of prolonged lying-down sequences (%)	17 ± 7.9	4	35
Average standing-up duration (sec)	7.0 ± 1.8	4.6	11.6
Prevalence of prolonged standing-up sequences (%)	24 ± 14	3	57
Prevalence of severe hock injuries (%)	51 ± 20	0	80
Prevalence of severe knee injuries (%)	42 ± 22	0	80
Prevalence of neck injuries (%)	30 ± 30	0	80
Dirtiness score [1)]	10.2 ± 0.9	8.8	12.8

[1)] High score denotes dirtier animals.

Table 2. Descriptive statistics of the cubicle dimensions and other variables (cow age and yield, feeding barrier and floor type) used as independent variables in the regression analyses. Figures are averages of the 27 farms.

Variable	Mean ± S.D.	Min	Max
Cubicle width (cm) (CW)	112.8 ± 2.1	108	118
Cubicle length (cm) (CL)	225.8 ± 10.0	205	250
Neck rail height (cm) (NRH)	106.1 ± 7.2	85	114
Distance of neck rail from the curb (cm) (NRD)	159.0 ± 13.1	118	190
Median age of cows (years) (AGE) 1) 2) 3)	4.2 ± 0.7	2.8	5.8
Median of yearly yield of cows in 2004 (kg milk) (YIELD) 1) 2) 3)	8031 ± 1239	5044	11041
	Variable coding in regression analysis		
	1		**2**
Availability of head lunging space in front of the cubicle (LS)	No, n = 21		Yes, n = 6
Feeding barrier type (FB) 2)	Gates, n = 18		Neck rail, n = 9
Floor type (FLOOR) 3)	Slatted, no rubber, n = 17		Solid, no rubber, n = 10

1) Median age and yield of the injury- and cleanliness-sampled cows (n = 10) on each farm. 2) Variable used in the analysis of injury. 3) Variable used in the analysis of dirtiness.

RESULTS

Predictive regression models for examined behaviour, injury and dirtiness variables are presented in Table 3. According to the model, increasing neck rail distance from the curb decreased the prediction for the average duration of lying-down sequence, as well as prevalence of prolonged lying-down sequences. Average duration of standing-up sequences was not accounted for by any of the cubicle dimension variables. Prediction for the prevalence of prolonged standing-up sequences decreased by increasing neck rail height and distance of neck rail from the curb, and by providing the animals with lunging space in front of the cubicle.

Prediction for the prevalence of severe hock injuries was increased by lunging space in front of the cubicle and the age of the cows. Prevalence of severe knee injuries could not be predicted by any of the cubicle dimension variables, but it increased with increasing milk yield. Prevalence of injuries in the neck was predicted by the height of the neck rail and the type of feeding barrier (R^2 = 81%), but these two variables had a significant mutual correlation (r_s = –0.43, $P < 0.01$), and could not be used in a common model. Separate regression analyses with these two independent variables revealed that feeding barrier type was a better predictor for neck injuries (R^2 = 79%, $P < 0.001$) than neck rail height (R^2 = 27%, $P = 0.005$). Therefore, we compared the difference in neck injury prevalence only between the feeding barrier types. Farms with head gates (n = 18) had significantly ($P < 0.001$, Mann-Whitney test) lower prevalence of neck injuries (11 ± 13%, mean ± S.D.) than farms with neck rail (n = 9, 66 ± 16%). Increase in the cubicle width and the age of the cows lowered and solid floor increased the prediction for the herd average dirtiness score.

Regression models accounted for between 0 and 44% of variability (R-squared values) in the investigated variables (Table 3.).

Table 3. Predictive models obtained from multiple linear regression analyses for behaviour, injury and dirtiness variables used in the study.

Variable	Model 1)	S.E. 2)	R^2 (%)
Lying-down duration	12.5–0.04×NRD***	0.7	40
Prevalence of prolonged lying-down sequences	68.7–0.33×NRD**	6.77	29
Standing-up duration	7.39	2.0	0
Prevalence of prolonged standing-up sequences	202–11.4×LS º – 0.73×NRH* – 0.55×NRD*	12.5	32
Prevalence of severe hock injuries	–15.7 + 26.1×LS** + 8.24×AGE º	16.8	35
Prevalence of severe knee injuries	–15.5 + 0.01×YIELD*	20.0	17
Dirtiness score	25.2–0.12×CWº –0.58×AGE** + 0.83×FLOOR**	0.72	44

1) Model including the constant. Significance of a variable in the model: º $P < 0.1$, * $P < 0.05$, ** $P < 0.01$, *** $P < 0.001$. See Table 2 for abbreviation keys. 2) Standard error of the model estimate.

DISCUSSION

In our study, the placement and height of the neck rail were the most important cubicle dimensions predicting the lying-down and standing-up behaviour of dairy cows. Tucker et al. (2005) did not find clear preference for cubicles with less restrictive placement of neck rails in non-lactating Holstein cows. Nor did the neck rail placement affect the cows' lying time in the cubicles. When the neck rail was placed low or close to the curb, however, cows spent less time standing with all four feet in the cubicles (Tucker et al., 2005). Thus it is likely that the neck rail placement affects unfavourably mainly behaviours that involve having to stand in the cubicles: i.e. lying-down and standing-up behaviour in the current study.

Interestingly, both average duration of lying-down sequence and prevalence of prolonged movement sequences were predicted by the distance of neck rail from the curb, but duration of standing-up could not be predicted by any of the variables used in the models. To our knowledge, the effect cubicle dimensions on the duration of lying-down and standing-up movements has not been subject to research. Especially the prolonged movement sequences would merit further investigation as possible welfare indicators in cubicle housed cattle.

Providing lunging space in front of the cubicle and the rising age of the cows increased prediction for prevalence of severe hock injuries. The size of a cow usually increases with age, and large cows have more severe hock injuries than smaller cows (Haskell et al., 2006). However, proper lunging space is associated with ease of movement (McFarland, 2003) and reduced rate of injury (Anderson, 2003, Haskell et al. 2006) in dairy cows. Therefore, the influence of lunging space on the prediction of hock injuries in the current study is confusing, but it may be due to some variable that was not accounted for in our study. In addition, high milk yield increased the prediction for prevalence of severe knee injuries. In contrast with our result, Haskell et al. (2006) found that low level of milk production was associated with more knee swellings in cows in cubicle housing on commercial dairy farms. It cannot be determined if this could be due to differences in e.g. farm management between the two studies.

Farms with neck rails at the feed bunk had a higher prevalence of neck injuries than farms using head gates. Therefore, the placement and design of the feeding barrier is important, and should be taken into consideration while designing cow facilities to prevent undue injuries to the animals. The height of neck rail in cubicles could not be used as a predictor in multiple regression analysis due to multicollinearity with the feed barrier type (farms with neck rails at the feed bunk had lower neck rails in cubicles), but it is likely that also the height of the neck rail in cubicles can affect the formation neck injuries in dairy cows.

Wider cubicles are more likely to become soiled with manure than narrow cubicles (Tucker et al., 2004), and thus influence animal cleanliness. However, in our study, cubicle width had a tendency to lower the prediction of the overall dirtiness score of a farm. Cow age was also a lowering factor. The reason for these effects is not clear, but they could be caused by differences in the farm management. Solid floor in the barn alleys increased the estimate of the dirtiness score compared to slatted floor. Slurry accumulates more easily on solid than slatted floors, affecting cleanliness of the cows' legs. Indeed, in our study the solid floor farms had a slightly worse leg cleanliness (data not shown).

Cubicle length was not a predictive variable in any of the models. Neither did cubicle width turn out a significant predictor. The variation in these cubicle dimensions on the farms might have been too low to bring out any significant effects.

Overall, increasing cubicle dimensions reduced the dirtiness score and the prevalence of prolonged movement sequences in the predictive models. The neck rail height, the distance of the neck rail from the curb and the availability of head lunging space were the statistically significant predictors. The regression models explained a rather low proportion of the variability in the data, and produced some unexpected results, which means further research with additional explanatory variables is needed. Cubicle surface material has an important effect on the investigated behaviour, injury and dirtiness variables, as has been shown in previous studies (e.g. Herlin, 1997, Chaplin et al., 2000, Wechsler et al., 2000, Livesey et al., 2002, Haskell et al., 2006). Although the effect of cubicle surface material was excluded to some extent from our study by having farms with mats only, differences in the surface management (e.g. regularity of cleaning and adding new bedding) may still contribute to the formation of lesions or dirtiness (Veissier et al., 2004).

In conclusion, our results indicate that cubicle dimensions affect especially resting-related behaviour, but also injuries and dirtiness of loose-housed dairy cows. Despite the relatively low R-squared values in the predictive models, the results of our pilot study encourage further research.

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