Acta vet. scand. 1978, *19*, 30—38.

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BONE MINERAL CHANGES IN DAIRY COWS

THE EFFECT OF LOW AND HIGH CALCIUM FEEDING DURING LATE PREGNANCY AND AT PARTURITION*

By

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ZETTERHOLM, R.: *Bone mineral changes in dairy cows. The effect of low and high calcium feeding during late pregnancy and at parturition.* Acta vet. scand. 1978, *19*, 30—38. — The bone mineral content in two coccygeal vertebrae of 16 cows of Swedish Red and White Breed was measured with dichromatic photon absorptiometry during the period nine weeks prepartum to one week postpartum. For eight weeks before calving eight cows received 37 g Ca and 50 g P/day and the other eight, 76 g Ca and 50 g P/day. The mean bone mineral changes of the cows on the low Ca ration did not change. The cows on the high Ca ration had a slight increase (4 %) in bone mineral content to some days before calving. The postpartum bone mineral changes were, however, lower than the one prepartum. There was no significant difference between the mean bone mineral changes of the two groups.

absorptiometry; bone mineral measurement; calcium metabolism; cattle; gamma ray source; phosphorus.

Calcium is essential for the maintenance of many body functions, and only small changes in the plasma Ca level can have deleterious effects. The body's main reservoir of Ca is the skeleton. The strength and function of the skeleton is highly dependent on its content of normal bone tissue, properly mineralized. If Ca intake or intestinal resorption is lower than excretion,

* This investigation was supported by the John M. Olin Foundation, the Swedish Medical Research Council, the Swedish Council for Forestry and Agricultural Research, and the Knut and Alice Wallenberg Foundation.

the Ca balance is negative and Ca is removed from the skeleton. If resorption exceeds excretion, an increased amount of Ca is stored in the skeleton and hyperostosis and osteopetrosis may occur. It is generally considered that an ionic exchange of Ca can take place between bone which is not fully mineralized and the extracellular fluid, from where it can be rapidly transported to plasma. By this mechanism the plasma Ca level can be maintained, even if there is e. g. a sudden drain of Ca in early lactation. Ca in hydroxyapatite of the fully mineralized bone is believed not to be available unless bone is resorbed by cellular activity. This is of course a much slower process than the ionic exchange (*McLean & Urist* 1968).

In young animals there is a high turnover of bone, and thus the skeleton to a great extent consists of young, not fully mineralized bone. In mature animals, the turnover rate is lower (*Hansard et al.* 1954, *Braithwaite & Riazuddin* 1971). If the animal is on a high Ca diet, it is considered that bone resorption is decreased, leading to an increase of the skeletal mass (*Krook et al.* 1971). In the bovine species, this increase in skeletal mass with increasing age has been well documented (*Zetterholm* 1972, 1978). In parturient paresis, the plasma Ca level is lowered. It has been theorized that one reason for this is that the skeleton has only a low percentage of young, not fully mineralized bone tissue. It was suggested that one should try to increase the turnover rate in cows during the last few months of pregnancy (*Boda & Cole* 1954) by lowering the amount of Ca in the feed. Thereby it should be possible to increase the amount of resorption in the skeleton with subsequent formation of new, low mineralized bone. The value of this feeding regimen has been disputed, using the argument that an adult animal on a Ca deficient diet can increase resorption and decrease excretion of Ca to such a degree that only a diet extremely low in Ca will have the desired effect. Whether or not low Ca feeding has an influence on the incidence of parturient paresis is still obscure, as contradictory results have been obtained in various investigations (*Gardner* 1970, *Kendall et al.* 1970). It has therefore been seriously questioned if the amount of Ca in the feed or the Ca/P ratio are of any importance in aetiology of parturient paresis. A study of cows in a dairy heard indicated that bone mineral content (BMC) is lowered during early lactation and increased during the dry period (*Zetterholm* 1978).

The aim of the present study was to find out whether or not there was a difference in BMC during late pregnancy and at parturition in cows fed a low respectively high Ca diet.

MATERIAL AND METHODS

The material comprised 16 cows. They were of the Swedish Red and White Breed, their age ranged from five to nine years and they had previously had parturient paresis. They were all in an investigation including 36 animals at the experiment station of Skara of the College of Veterinary Medicine. The purpose of that investigation was to determine whether or not frequency of parturient paresis could be decreased by feeding the animals a low Ca diet. It was shown that the incidence of parturient paresis was not lowered by a moderate decrease of the Ca content in the feed (*Jönsson & Pehrsson* 1974).

The cows in the present investigation were put on the experimental feed eight weeks before the expected day of calving. They all received the same basic ration, consisting of 8 kg of hay during the entire experimental period. During the first six weeks of the experiment they were given 2 kg of a concentrate daily. During the seventh and eighth week their intake of concentrate was 3 respectively 4 kg daily. The animals were put in two groups (L and H), each including eight animals. The two groups were selected in such a way that they were as equal as possible in milk yield and age distribution. The feed given to the cows in group L was supplemented by 100 g monosodium phosphate (19 % P) and for those in group H by 200 g mineral supplement, containing 19 % Ca and 10 % P. Fodder samples were continuously taken and analysed once every second week. On an average, the ration in both groups included a P intake of 50 g/day. The Ca intake averaged 37 g/day in group L and 76 g/day in group H. The animals of group L were put on the diet during the period September 10—November 16, and those in group H during the period September 19—December 29. The mean age of the animals in group L was six years and five months, and in group H six years and three months. The average milk yield during the lactation period following parturition in the present experiment was for the animals in group L 6,429 kg and for those of group H 6,297 kg.

The bone mineral content in two coccygeal vertebrae (V and

VI or VI and VII) was determined by dichromatic photon absorptiometry, using the technique described by *Zetterholm & Dalén* (1978). Five to seven measurements were made of each animal at about nine, six, four, two and one week prior to expected day of calving and three—seven days after calving. The BMC of two of the cows in group H could not be measured after parturition as both animals became paretic and had to be slaughtered.

The measurements were made in a time sequence, which was predetermined using the expected day of calving as the point of reference. Hence, in relation to the actual day of calving the pattern was slightly irregular. E. g. the first measurement was done during the period nine—seven weeks before calving. The second was done during the period seven—five weeks, the third during the period five—three weeks and the fourth during the period three—one and a half weeks before calving. The fifth measurement done one week prior to expected day of calving actually was done from 10 days to one day before calving. The measurement which should have been done three days after calving was actually done from three—seven days after calving. In order to facilitate comparison between the result of the measurements of the BMC of the animals of the two groups, the result of the first measurement was used as the zero point. The mean BMC of the two groups L and H were compared. The difference between the result obtained at zero point and the following was expressed in percentage. The two prepartum mean values and the two postpartum mean values were compared by t-test.

RESULTS

The result of the actual measurement of each individual cow is seen in Figs. 1 and 2. The mean result for the two groups is seen in Fig. 3.

The mean BMC of group L varied very little with time and was about the same at parturition as at beginning of the experiment. The mean BMC of group H showed a slight continuous increase from zero point to the last measurement before parturition, when it was 4.1 % higher. However, BMC fell after parturition and at the last measurement it was only 2.5 % higher than at zero point.

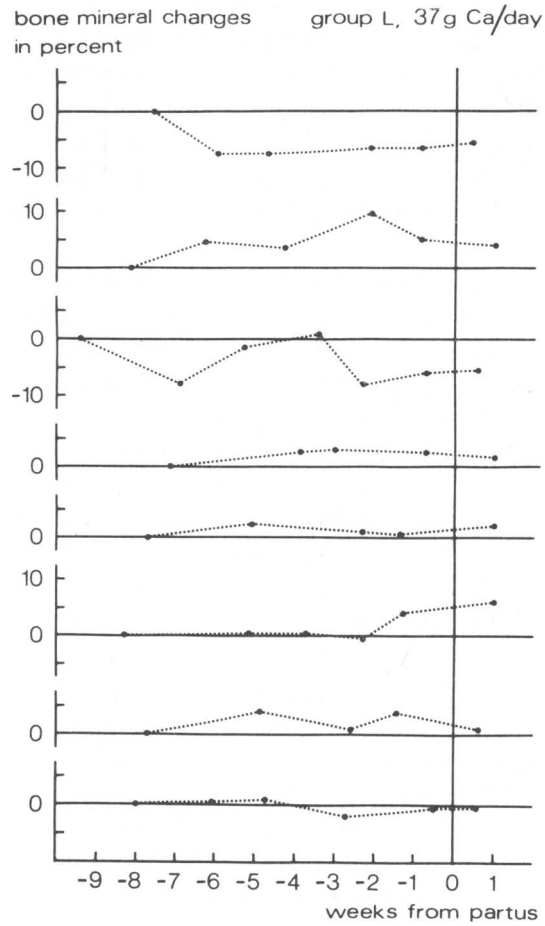

Figure 1. Bone mineral changes in the individual animals of group L. The indicated values are the percentage deviation from the value of BMC obtained at the first measurement.

There were obvious individual variations. In group L the BMC decreased in two cows, increased in two, and remained rather stable in four. In group H the BMC increased in five cows and remained stable in two. In one cow there was first an increase in BMC and then an obvious decrease.

Because of the marked individual variations in BMC, there was no significant difference ($P > 0.05$, t-test) between the mean BMC of the two groups.

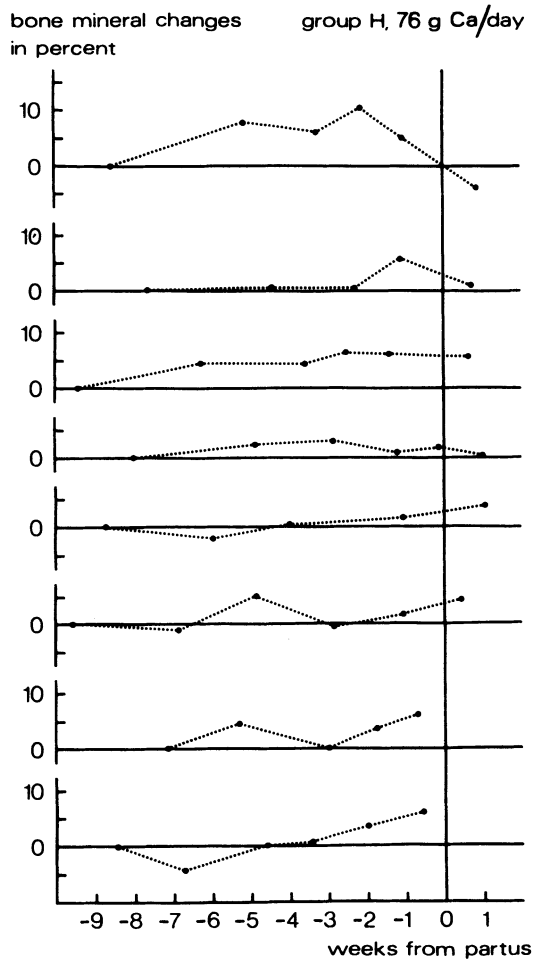

Figure 2. Bone mineral changes in the individual animals of group H. The indicated values are the percentage deviation from the value of BMC obtained at the first measurement.

DISCUSSION

On the basis of the present investigation one can draw the following conclusions. It is not possible to lower BMC during the last eight weeks of pregnancy by giving cows a fodder, which provides them with a daily amount of about 37 g of Ca. One would probably have to give a fodder with this low Ca content for an extended period of time to get the animals in a negative Ca balance. On the other hand, BMC is increased in cows which

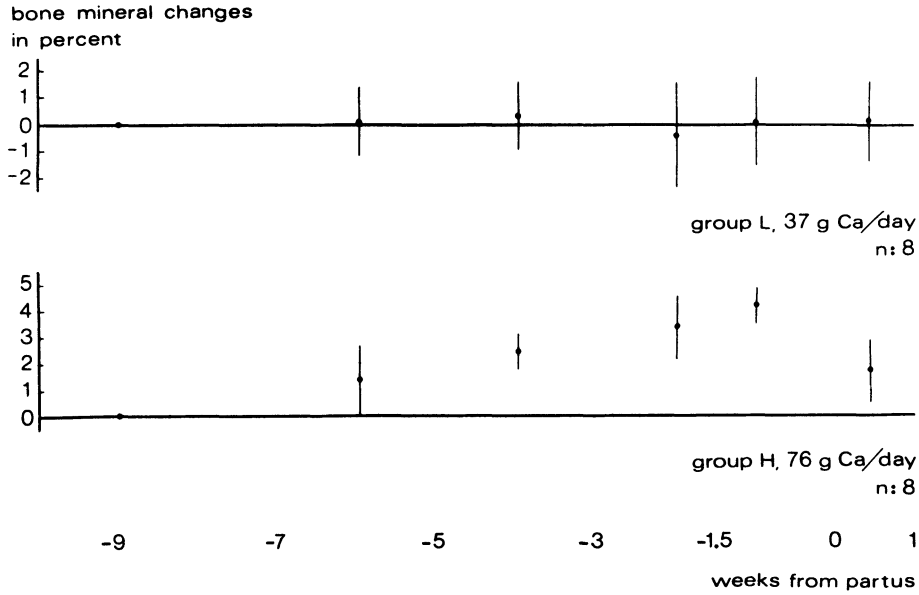

Figure 3. Groups L and H. The indicated values are the percentage deviations (mean ± 1 s.e.m.) from the value of bone mineral content obtained at the first measurement. The indicated values are from the periods nine—seven, seven—five, five—three, three—one and a half weeks before partus, within 10 days before and three—seven days after calving.

are given about 76 g Ca daily during the last eight weeks of pregnancy.

Because of individual variation in the changes of BMC with time, there was no significant difference in the BMC changes between the two groups in the present study.

It is known from balance studies in cows that there are great individual variations in Ca metabolism. It is conceivable that the cows were not conditioned to their new environment long enough when they were put in the experiment. For this reason, their BMC did not change uniformly, even when they were given the same amount of feed with the same composition.

There were sudden changes in the BMC within one and the same individual. The explanation for this is not easy at hand, but in spite of earlier findings (*Zetterholm & Dalén* 1978), one can not fully exclude the possibility that the coccygeal vertebrae in some of the animals were not completely representative

for the skeleton during the whole period. It is possible that the handling of the tail, the epidural anaesthesia, and the application of the measuring device with wing screws can have caused changes in vascularization. In this way localized changes in the BMC can have been induced.

The present study provides no evidence that it is possible to induce a decrease in BMC using a regular fodder to pregnant, non lactating cows.

According to the Swedish standard, 50 g Ca is considered to be the daily requirement for a pregnant, non lactating cow. According to the Agricultural Research Council (ARC) standard, only 30 g is required. It would seem from the present investigation that the ARC requirement is the most adequate.

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SAMMANFATTNING

Benmineralförändringar hos mjölkkor.
Effekten av låg och hög kalciumutfodring under senare delen av dräktigheten och vid kalvningen.

Benmineralinnehållet i två svanskotor hos 16 mjölkkor av SRB-ras mättes med dikromatisk foton absorptionsteknik under perioden 9 veckor pre partum — 1 vecka post partum.

Under 8 veckor före kalvningen erhöll 8 kor 37 g Ca och 50 g P och de andra 8, 76 g Ca och 50 g P/dag.

Hos korna med låg Ca-utfodring förändrades ej benmineralinnehållet. De med hög Ca-utfodring ökade däremot sitt benmineralinnehåll fram till dagarna före kalvningen med 4 %, därefter skedde en minskning. Skillnaden mellan de två grupperna var dock ej signifikant.

Undersökningen visade att benmineralinnehållet ej går att minska under senare delen av dräktigheten (sinperioden) om utfodringen av Ca är 37 g/dag. För att ernå en sänkning av benmineralinnehållet måste Ca-givan ytterligare sänkas vilket torde vara svårt under praktiska utfodringsbetingelser i Sverige.

(Received April 28, 1977).

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