The effect of dietary protein intake on calcium metabolism of the pregnant ewe

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1. The effect of protein intake on calcium metabolism has been studied in the pregnant ewe.

2. Results suggest that decreased Ca retention in protein-deficient animals was a result of a decreased rate of Ca absorption and not a decreased rate of bone accretion as suggested by other workers.

The considerable losses in skeletal calcium content of hill sheep that frequently occur during pregnancy (Field, Suttle & Gunn, 1968) are probably a result of an inadequate protein intake rather than an inadequate Ca intake (Sykes & Field, 1972). Sykes & Field (1972) suggested that the deficiency of dietary protein may have resulted in impaired formation of bone matrix with a consequent decrease in the rate of accretion of Ca into bone and hence a decreased Ca retention.

Ca kinetic studies with pregnant ewes now show that this decrease in Ca retention occurs as a result of a decreased rate of Ca absorption and that the rate of bone accretion remains unchanged.

EXPERIMENTAL

Eight 4-year-old Suffolk × Clun Forest ewes weighing 60–65 kg were used. At 1 month after mating they were placed in individual metabolism cages designed for the separate collection of urine and faeces and were randomly divided into two equal groups. One group was given a protein-deficient diet and the other a diet adequate in protein (Agricultural Research Council, 1965). The composition of the diets is shown in Table 1. Uneaten food was collected daily and the total amount eaten determined.

Ca kinetic studies were done at 135–140 d gestation and the various processes of Ca metabolism calculated by the method of Aubert & Milhaud (1960) modified for use with sheep (Braithwaite, Glascock & Riazuddin, 1969; Braithwaite & Riazuddin, 1971; Braithwaite & Glascock, 1976). The methods used for the determination of Ca and radioactivity in samples of blood, urine, faeces, food and foetal tissues have been described previously (Braithwaite *et al.* 1969).

RESULTS AND DISCUSSION

The results of these studies are summarized in Table 2. Considerable losses of body-weight (15–17%) occurred during pregnancy in both groups of ewes but no significant effect attributable to the reduced protein intake was observed. In previous studies with a large number of ewes, however, Sykes & Field (1972) did find a slight but significant increase in body-weight loss in protein-deficient animals.

Neither group of ewes absorbed enough dietary Ca to meet the high demands of late pregnancy and retention was negative. This is not unexpected, however, as it has previously been shown that an unavoidable negative retention occurs in late pregnancy irrespective of the dietary supply of Ca (Braithwaite, Glascock & Riazuddin, 1969, 1970). Although the rates of Ca ingestion and Ca loss into urine, intestine and foetuses were approximately

Table 1. *Daily intake (/kg body-weight) of dietary ingredients by control and protein-deficient ewes*

	Intake (g)		Total calcium (mg)		Total phosphorus (mg)		Total protein (mg)	
Ingredient	Control	Protein-deficient	Control	Protein-deficient	Control	Protein-deficient	Control	Protein-deficient
Straw	8	8	30·8	30·8	3·7	3·7	364·3	364·3
Barley	6	6	3·2	3·2	20·3	20·3	333·8	333·8
Casein	0·7	—	1·3	—	1·0	—	501·9	—
Mineral mixture*	0·4	0·4	59·2	59·2	46·3	46·3	—	—
Total	—	—	94·5	93·2	71·3	70·3	1200·0	698·1

* Super Mindif (Boots Pure Drug Co., Nottingham). Diets also contained Beta vitamin no. 3a (Cooper Nutrition Products Ltd, Witham, Essex) to supply (/kg body-wt) 37·5 μg cholecalciferol.

Table 2. *A comparison of the calcium metabolism in late pregnancy of control and protein-deficient ewes which had received respectively an adequate and a deficient protein intake*† *throughout pregnancy*

(Mean values with their standard errors for four animals/group; tests of statistical significance determined using the *t* test)

	Control		Protein-deficient		Statistical significance of difference between means
	Mean	SE	Mean	SE	
Rate of ingestion of Ca (mg/d per kg body-wt)	90·5	0·7	90·0	0·9	NS
Rate of loss of Ca in faeces (mg/d per kg body-wt)	80·3	2·4	93·1	1·3	**
Rate of excretion of Ca in urine (mg/d per kg body-wt)	3·2	1·3	2·0	0·1	NS
Rate of transfer of Ca to foetus (mg/d per kg body-wt)	17·3	3·4	20·1	1·0	NS
Rate of retention of Ca (mg/d per kg body-wt)	−10·3	3·8	−25·2	1·6	**
Rate of secretion of Ca into intestine (faecal endogenous Ca) (mg/d per kg body-wt)	11·3	0·4	11·3	0·9	NS
Rate of absorption of Ca from intestine (mg/d per kg body-wt)	21·5	1·3	8·3	0·5	***
Ca absorbed (% Ca ingested)	23·8	1·7	9·2	0·5	***
Rapidly exchangeable pool of Ca (mg/kg body-wt)	40·5	1·5	45·0	1·2	NS
Slowly exchangeable pool of Ca in bone (mg/kg body-wt)	39·0	2·1	41·5	2·1	NS
Rate of accretion of Ca into bone (mg/d per kg body-wt)	13·1	0·8	14·5	1·0	NS
Rate of resorption of Ca from bone (mg/d per kg body-wt)	23·4	3·7	39·7	2·5	**
Loss in body-wt of ewes during pregnancy (% initial wt)	14·8	1·9	16·9	2·2	NS

NS, Not significant.
** 0·01 > *P* > 0·001, *** 0·001 > *P*.
† For details, see Table 1.

the same in each group, the rate of absorption of Ca was considerably lower in the ewes given the protein-deficient diet. As a consequence, the rate of Ca retention was lower in these ewes and they had to mobilize greater amounts of their skeletal stores of Ca in order to meet demands. This was achieved by an increase in the rate of bone resorption relative to that of bone accretion which remained unchanged.

Although the present measurements refer only to changes in late pregnancy whereas those of Sykes & Field (1972) are the sum total of changes throughout the whole of pregnancy, this study does appear to show that the decreased retention of Ca associated with protein-deficient diets occurs as a result of a decreased rate of Ca absorption and not, as suggested by Sykes & Field (1972), a decreased rate of bone accretion. Furthermore, this study suggests that losses of bone ash and bone matrix previously observed in protein-deficient pregnant ewes (Sykes, Nesbit & Field, 1973) are due to an increased rate of bone resorption. Certainly, similar changes in bone structure do occur as a result of increased bone resorption in Ca-deficient rats (Harrison & Fraser, 1960).

The reason for the decreased rate of Ca absorption, which has also been observed in protein-deficient rats (LeRoith & Pimstone, 1973) is at present uncertain. It might, however, be explained by the recent observation that the concentration of intestinal Ca-binding protein, thought to be essential for the vitamin D mediated active absorption of Ca, is reduced during protein deficiency (Kalk & Pimstone, 1974).

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