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PROCEEDINGS OF THE NUTRITION SOCIETY

ABSTRACTS OF COMMUNICATIONS

The Four Hundred and Fifty-seventh Meeting of the Nutrition Society (One Hundred and Seventy-ninth of the Scottish Group) was held at Heriot-Watt University, Edinburgh, on Thursday and Friday, 15/16 September 1988, when the following papers were read:

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Assessing the efficacy of a soluble glass bolus as a slow-release source of copper, cobalt and selenium for sheep. By H. G. BALLA, E. HERBERT, C. S. MUNRO and N. F. SUTTLE, *Moredun Research Institute, 408 Gilmerton Road, Edinburgh EH17 7JH*

Many favourable assessments of the soluble glass bolus for preventing copper, cobalt and selenium deficiencies in ruminants have been reported but in one of the few trials to involve a clinical deficiency, swayback in lambs was not prevented by dosing ewes at mating (MacPherson & Gray, 1985). The release and absorption of Cu, Co and Se from an orally administered bolus (COSECURE, Chance Pilkington Ltd) was therefore assessed in four Scottish Blackface ewes, given 0·8 kg/d of a semi-purified diet, low in Cu (18·9 μmol/kg dry matter (DM); Suttle & Field, 1968) and marginal in Co and Se, together with 80 g straw/d to encourage rumination. Faecal and plasma compositions were compared with those of four undosed sheep given the same diet.

The mean (SE) initial plasma Cu, plasma vitamin B_{12} and blood glutathione peroxidase (GSHPx) and faecal Cu concentrations in all sheep were 3·2 (0·3) μmol/l, 950 (688) pmol/l, 135 (17·7) U/g haemoglobin (Hb) and 73 (4·4) μmol/kg DM respectively, and none of the values had changed significantly in the untreated group after 57 d. In the dosed sheep all indices increased significantly within 14 d and were sustained for more than 180 d (see Table). The sustained release of Cu was shown also by the great increase in mean faecal Cu (range 1025–1716 μmol/kg DM between samplings): from the total faecal output between days 35–42 (192 g DM/d), it was estimated that 18 mg Cu/d were released and from the composition of the bolus (g/kg: 134 Cu, 5 Co, 3 Se) the release rates for Co and Se would be 0·6 and 0·35 mg/d, respectively. The provision of Co and Se relative to animal requirements was more generous than that for Cu, which is also more vulnerable to the influence of antagonists. However, the addition of molybdenum (50 μmol/kg DM as sodium molybdate) to the diet of two dosed sheep from days 9 to 100 did not inhibit Cu repletion: their livers contained 614 and 1667 μmol Cu/kg DM after 100 d, similar to the concentrations in the dosed ewes not given Mo (753 and 1594) and greater than those of untreated ewes (133 (21)). After 365 d the livers of the four dosed ewes contained 354–1610 μmol Cu/kg DM and all were normocupraemic. A low rumen pH with the readily fermentable diet may have increased the solubility of the glass, giving a release rate 38% higher than that expected by the manufacturer.

Mean change in trace element status of four sheep dosed with a soluble glass bolus

Period of experiment (d) . . .		7	14	21	28	57	180
Blood GSHPx*	Mean	+13·0	+51·7	+118	+161	+274	+415
(U/g Hb)	SE	13·6	11·2	28·2	30·2	91·3	105·0
Plasma vitamin	Mean	+1510	+1433	+1588	+1457	+1895	+1320
B_{12} (pmol/l)	SE	1059	558	317	106	716	561
Plasma Cu	Mean	+3·8	+5·3	+7·4	+9·1	+9·5	+11·7
(μmol/l)	SE	0·6	1·7	1·6	1·8	3·6	0·9

*Measured at 37°.

MacPherson, A. & Gray, D. (1985). *Veterinary Record* **117**, 290–291.
Suttle, N. F. & Field, A. C. (1968). *Journal of Comparative Pathology* **78**, 351–362.

Towards an optimum oral dose of cobalt in anthelmintics in lambs. By N. F. SUTTLE, J. BREBNER, C. S. MUNRO and E. HERBERT, *Moredun Research Institute, 408 Gilmerton Road, Edinburgh EH17 7JH*

Manufacturers of anthelmintics use cobalt and selenium to supplement their products for sheep on the grounds that the monthly doses given are of nutritional benefit in reducing risks of Co and Se deficiencies. Recent experimental (Field *et al.* 1988) and field evaluations (MacPherson *et al.* 1987) of two supplemented anthelmintics (OVITELMIN SC and PANACUR SC) indicated that while Se gave sustained improvements in Se status, the effects of Co were variable and transient. In view of the wide range in Co doses achieved by different products, an attempt was made to define an optimum dose of Co for lambs.

Twenty-four Scottish Blackface lambs, average live weight 25 kg, were given a low-Co diet until they had subnormal plasma vitamin B_{12} concentrations. The diet was similar to that used by Field *et al.* (1988) except that propionic acid-treated whole barley replaced whole oats as the principal constituent (910 g/kg) and that urea was added to the coated supplement at a rate of 23 rather than 18 g/kg diet. The lambs were randomly allocated to one of six groups of four within strata after ranking them on the basis of plasma vitamin B_{12} concentrations (mean 158 (SD 132) pg/ml) 1 week before oral dosing and given 1, 2, 4, 8, 16 or 32 mg Co as $CoCl_2$ in 10 ml water respectively. The lambs were housed in larger groups and fed *ad lib*. Blood samples were taken at 0, 2, 3, 4, 7, 11 and 14 d after dosing for the measurement of vitamin B_{12} concentrations in plasma (Field *et al.* 1988).

Mean increase in plasma vitamin B_{12} concentrations (pg/ml) from day 0

Period after dosing (d) . . .	2	3	4	7	11	14
Co dose (mg)						
1	425	542	480	457	88	108
2	386	459	436	270	177	211
4	534	706	608	213	206	225
8	519	670	647	448	258	269
16	490	692	744	633	283	205
32	694	1085	1085	739	219	216

Peak concentrations of vitamin B_{12} in plasma for each group were recorded 3–4 d after dosing (Table). The smallest dose (1 mg) produced a relatively large increase in plasma vitamin B_{12}. Plasma vitamin B_{12} concentrations declined after 4 d at rates proportional to the peak attained so that by day 14 there was relatively little difference between groups. The areas (A) under each curve generally increased with Co dose (D, mg) as follows: 4·10, 3·74, 4·59, 5·67, 6·16 and 7·85 ng/ml d giving a linear relation, with $A=4{\cdot}04+0{\cdot}125$ D (r 0·97, 4 df). Thus there was diminishing but continued benefit up to the maximum dose.

The average Co dose provided by the current range of supplemented anthelmintics for a 25 kg lamb, 5·6 (SD 3·1) mg, appears to be well below the optimum for Co in aqueous solution. Furthermore, we suspect that some anthelmintics may inhibit the synthesis of vitamin B_{12} by the rumen microflora. It may therefore be necessary for dose:response trials to be conducted for each drug or group of drugs if the optimum supplement of Co for an anthelmintic is to be found.

Field, A. C., Suttle, N. F., Brebner, J. & Gunn, G. (1988). *Veterinary Record* (In the Press).
MacPherson, A., Rice, D. A. & Patterson, J. (1987). *Veterinary Record* **121**, 560.

Uric acid and allantoin in plasma and saliva of sheep. By X. B. CHEN, D. J. KYLE, C. C. WHYTE, F. D. DEB. HOVELL and E. R. ØRSKOV, *Rowett Research Institute, Bucksburn, Aberdeen AB2 9SB*

Purine end-products in urine could provide an estimate of microbial biomass production in the rumen. Previous studies showed a recovery (corrected for the endogenous excretion) of infused exogenous purines as the urinary end-products xanthine, hypoxanthine, uric acid and allantoin, of 0·70 (Fujihara *et al.* 1987). The unaccounted loss could partly be due to secretion of purine derivatives into the rumen via saliva. This possibility has now been investigated.

Twenty sheep (50–70 kg live weight) were given 1200 g/d of barley and grass nuts (50:50). Plasma and saliva samples were taken once daily for a period of 4 d between 09.00 and 16.00 hours and the sampling was so arranged that each animal was sampled both in the morning and afternoon over this period. Blood and saliva samples were obtained from each animal within 15 min. TCA-soluble supernatant fractions of plasma and saliva samples were analysed for allantoin and uric acid. Results are shown in the Table. There was no significant correlation between the plasma and salivary concentrations. Time of sampling during the day did not affect either plasma or salivary concentrations of uric acid and allantoin. However, day-to-day variations in plasma and particularly salivary concentrations were noticeable.

Uric acid and allantoin concentrations (mg/l) in plasma and saliva of twenty sheep

	Uric acid		Allantoin	
	Mean	SD	Mean	SD
Plasma	1·06	0·18	8·24	0·89
Saliva	2·72	0·76	18·93	2·59

Since concentrations of both allantoin and uric acid were greater in saliva than in plasma, it is possible that secretion of purine derivatives via saliva was through an active transport, rather than simple diffusion.

Provisional results from a separate experiment with a lamb given 1000 g/d of a complete diet (hay:barley:molasses, 50:30:10, w/w) showed a salivary concentration of allantoin plus uric acid of 18·7 (SD 7·1, *n* 22) mg/l and a urinary excretion of allantoin plus uric acid of 2·12 (SD 0·36, *n* 12) g/d. If saliva flow was assumed to be 10 litres/d (Kay, 1966), the salivary secretion of the purine derivatives would be equivalent to about 9% of the urinary excretion. A further experiment with four lambs nourished by intragastric infusion showed that when up to 1·28 g/d of allantoin was infused into the rumen, no additional allantoin was excreted in the urine. This indicated that allantoin recycled to the rumen via the saliva would not be absorbed and subsequently excreted in urine.

Fujihara, T., Chen, X. B., Ørskov, E. R. & Hovell, F. D. (1987). *Proceedings of the 5th International Symposium on Protein Metabolism and Nutrition*. Rostock, GDR.

Kay, R. N. B. (1966). *World Review of Nutrition and Dietetics* **6**, 292–325.

A novel, sustained-release rumen bolus for cattle, containing trace elements and vitamins.

By D. C. LAWSON, N. S. RITCHIE, R. G. HEMINGWAY and J. J. PARKINS, *Department of Veterinary Animal Husbandry, Glasgow University Veterinary School, Bearsden, Glasgow G61 1QH*

Trace-element inadequacies in ruminants are widespread and individual supplementation at grazing is difficult, particularly if more than one element is involved. A bolus supplement has been devised with a constant pattern of nutrient release extending for about 300 d. It is of cylindrical form (62 mm length × 26 mm diameter, specific gravity 2·5 g/cm^3) with one rounded end and is composed of a compressed mixture of cobalt, sulphate, copper oxide, manganese sulphate, potassium iodide, sodium selenite, vitamin A, vitamin D_3, vitamin E, zinc oxide and zinc sulphate. The whole surface, apart from the flat end, is coated with a polymer resin such that as loss of active material takes place in the reticulorumen, the coating progressively breaks off to maintain a constant exposed surface area.

Two boluses are given to assist the uniformity of release, as loss is partly by solution and partly by mutual erosion of the exposed surfaces. Each bolus weighs 85 g and two boluses contain a total of 33·6 g Cu, 182 mg Co, 192 mg Se, 18·6 g Mn, 29·8 g Zn, 552 mg I, 382 mg vitamin A, 6 mg vitamin D_3 and 2448 mg vitamin E.

The release of material from two boluses administered together has been assessed by frequent withdrawal from the reticulorumen of cows each fitted with a rumen fistula. Release rates were substantially linear and were unaffected by change of diet from hay–silage to grazing. Typical release rates over 119 d are given in the Table.

The loss in weight of twelve boluses over 119 d when placed in pairs in the reticulorumen of six fistulated cows

Period after experiment (d) . . .	0	21	42	63	84	105	119
Bolus wt (g): Mean	87·9	80·3	75·3	70·9	66·5	62·2	59·6
SD	1·53	2·50	3·22	4·00	4·72	5·46	5·39
Loss per d (g): Mean	—	0·36	0·24	0·21	0·21	0·21	0·19
SD	—	0·112	0·065	0·053	0·045	0·060	0·049

Other observations indicate that when the bolus weight falls to about 15 g the bolus may pass down and dissolve in the digestive tract. No residue remains in the rumen. The overall mean weight loss for two boluses is 0·48 g/d over the projected life in the rumen of 300 d. This gives an estimated daily provision of 112 mg Cu, 0·6 mg Co, 0·6 mg Se, 62 mg Mn, 99 mg Zn, 1·8 mg I, 1236 μg vitamin A, 20·4 μg vitamin D_3 and 8·2 mg vitamin E.

Secretion in the colon of the pseudo-germ-free rat. By A. YOUNG, HELEN NZEGWU and R. J. LEVIN, *Department of Biomedical Science, The University, Sheffield S10 2TN*

It is known that a large percentage of the energy needs of rat colonocytes comes from short-chain fatty acids produced by luminal bacteria. Little is known concerning secretion in the colon of rats made pseudo-germ-free (PSGF) by allowing healthy male rats to drink an antibiotic cocktail containing 1 mg/ml each of Bacitracin, streptomycin and neomycin for 7 d. Electrogenic secretion was monitored as the short-circuit current (Isc) across sheets of most proximal colon (MPC), mid-colon (MC) and distal colon (DC) removed from control (antibiotic untreated) and PSGF rats. The sheets were stripped of their external muscle layers. Basal Isc and maximal increases in Isc above basal (ΔIsc) induced by secretagogues were measured. The secretagogues used were bethanecol (BCh, 1 mM); dibutyryl cAMP (cAMP, 1 mM); prostaglandin E_2 (PGE_2, 28 μM) and *Escherichia coli* enterotoxin STa (STa, 50 U/ml). BCh, PGE_2 and cAMP were applied to the serosal reservoir, whereas STa was applied to the mucosal reservoir.

Antibiotic treatment caused a marked decrease in the bacterial content of the PSGF colon, there being a reduction of approximately 10^4–10^5 colony forming units/g wet weight ($P<0{\cdot}01$), with a complete absence of *E. coli* as well as a marked enlargement in caecal size compared with fed controls (length +82%, $P<0{\cdot}001$; empty wet weight +77%, $P<0{\cdot}001$; full wet weight +169%, $P<0{\cdot}001$).

The basal Isc of the MPC and MC did not differ in the PSGF and control rats (both $P>0{\cdot}05$), but was significantly elevated in the DC of the PSGF rats (+120%, $P<0{\cdot}001$). BCh caused large elevations in ΔIsc in the MPC, MC and DC of the PSGF rats (MPC +92%, $P<0{\cdot}001$; MC +41%, $P<0{\cdot}01$; DC +110%, $P<0{\cdot}001$). *E. coli* STa caused less secretion in the MPC of the PSGF rats (−38%, $P<0{\cdot}01$) but no significant changes were seen in the MC or DC. Both PGE_2 and cAMP caused greater secretion in the MPC of the PSGF rats (PGE_2 +128%, $P<0{\cdot}01$; cAMP +79%, $P<0{\cdot}01$) but had similar effects in both the MC and DC of the control and PSGF rats (all $P>0{\cdot}05$).

Thus secretion in the PSGF colon showed differences compared with control animals, with the changes occurring primarily in the most proximal colon where an elevated response to BCh, PGE_2 and cAMP existed, but had reduced response to *E. coli* STa. This differential response may be due to the differing mode of action of these secretagogues and is under further investigation.

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Histidine oxidation in folate-deficient chicks. By J. SARAH RENNIE and C. C. WHITEHEAD, *Institute for Grassland and Animal Production, Poultry Department, Roslin, Midlothian EH25 9PS*

The major mammalian and avian pathway for the catabolism of histidine involves the production of formiminoglutamate (FIGLU). Glutamic acid formiminotransferase (*EC* 2.1.2.5) catalyses the conversion of FIGLU to glutamate, tetrahydrofolate (THF) acting as the acceptor of the formimino group. The glutamate is subsequently deaminated and the carbon skeleton is broken down via Kreb's cycle.

In folate deficiency, FIGLU catabolism is inhibited and FIGLU excretion in the urine of man and other mammals is elevated. The nature of avian excreta precludes using measurement of urinary FIGLU to identify folate deficiency in birds.

A study was carried out to determine whether carbon dioxide production derived from histidine breakdown could be used to ascertain folate status. The chicks, in groups of fifteen, were fed for 2 weeks on purified diets containing graded amounts of folic acid at levels of 0, 1, 1·5, 2 and 4 mg/kg. $^{14}CO_2$ production from histidine catabolism was measured by injecting the chicks with a tracer dose of L-[carboxyl-^{14}C]histidine in unlabelled histidine solution. The amount of $^{14}CO_2$ excreted was measured using a metabolism chamber and a CO_2 trapping system.

Supplemental folic acid (mg/kg) . . .	0	1	1·5	2	4	Pooled SD
Body-wt (g)	146*	200	208	181	207	45
Histidine oxidation (% of label released as $^{14}CO_2$ in 1·5 h)	4·67*	8·41	7·13	8·75	8·66	2·62
Glutamic acid formiminotransferase (μmol 5,10-methylene THF/mg protein per min)	4·55	5·70	5·35	5·35	4·95	0·85

*$P<0·05$ compared with other treatments.

Histidine oxidation was greatly impaired in severely deficient birds as shown in the Table and expressed by the equation

$$\text{response (histidine oxidation)} = 8·58-(3·87 \times 0·24^{\text{dose}}) \ (r\ 0·46)$$

A paired feeding comparison confirmed that differences in histidine oxidation were not caused by depressed growth of folate-deficient birds.

Glutamic acid formiminotransferase was assayed in liver samples from chicks fed on the different levels of folic acid. The enzyme showed no significant change in activity between the groups.

It is concluded that the rate of histidine oxidation is reduced when folic acid is deficient in chicks.

The financial support of Hoffman-La Roche, Basle is gratefully acknowledged.

Effects of exercise on lactational performance in cattle. By R. W. MATTHEWMAN, J. MERRITT and A. J. SMITH, *CTVM, University of Edinburgh, Easter Bush, Roslin, Midlothian EH25 9RG* and P. PHILLIPS, *Scottish Agricultural Statistics Service, James Clerk Maxwell Building, Mayfield Road, Edinburgh* and J. D. OLDHAM, *Edinburgh School of Agriculture, West Mains Road, Edinburgh EH9 3JG*

In many tropical countries cows are used as draught animals but work may affect their lactational performance. Leng (1985) has suggested that glucose availability may be a constraint to the maintenance of lactational performance during work.

To investigate the effects of work on lactation, two experiments were carried out, each using twelve mature, pregnant, lactating Hereford × Friesian cows. In Expt 1 a cross-over design with 3-week periods was used, in which groups (*n* 6) either walked 8·8 km with an increase in elevation of 400 m/d (W), or were permanently housed (C). A complete pelleted diet (AA6; 9·1 MJ metabolizable energy and 140 g crude protein (nitrogen × 6·25)/kg dry matter) was rationed at a level determined by body-weight and milk yield at the start of the trial. In Expt 2, the effect of the diet type on response to exercise was measured. Half of the cows received diet AA6 and half a complete pelleted diet of the same calculated specification, but with an increased proportion of starch (HS). In this trial, performance in a 3-week exercise period (W) was compared with preceding and subsequent control (C) periods. The cows were milked twice daily and samples for compositional analysis taken on alternate days. In Expt 2, blood samples were taken from the tail-vein of each animal weekly.

Expt no.		Milk (kg/d)	Milk fat (g/d)	Milk protein (g/d)	Milk lactose (g/d)
1	C	5·89	233	171	348
	W	5·26	228	156	308
	SED	0·19	8·3	4·7	12·5
2	C	7·67	270	277	364
	W	7·02	273	256	330
	SED	0·078	4·0	2·9	4·2

Exercise reduced yields of milk protein and lactose in each experiment but did not reduce the yield of milk fat (Table). Milk yield declined on walking days but recovered on non-walking days and the speed of the response was rapid. In Expt 2 there was no difference between diets in the response to exercise and results in the Table are combined across diets. Blood glucose concentrations fell from 4·04 mM immediately before exercise to 3·07, 3·61 and 4·04 mM in weeks 1, 2 and 3 of exercise, indicating some adaptation which was also apparent in the milk yield results.

We conclude that a major response to exercise is a metabolic adjustment to the use of substrates which are required for milk protein and lactose synthesis but that severe reductions in lactational performance with exercise may be transitory.

Leng, R. A. (1985). In *Draft Animal Power for Production, ACIAR Proceedings*, No. 10, pp. 69–77 [J. W. Copland, editor]. Queensland, Australia: James Cook University.

Fetal glucose metabolism during maternal exercise and undernutrition in pregnant ewes.

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Glucose production rate in sheep is markedly increased by moderate exercise (Judson *et al.* 1976). In pregnant ewes, fetal sensitivity to exercise-induced changes in maternal glucose metabolism may be increased by chronic undernutrition (Chandler *et al.* 1985). The present study sought to define and compare the source(s) of increased fetal glucose supply in well-fed and severely underfed, exercising ewes.

Twelve single-pregnant Merino ewes were studied at 124–136 d gestation, 7–20 d after surgical implantation of catheters in the maternal abdominal aorta, a maternal external jugular vein, the fetal abdominal aorta, the common umbilical vein and the fetal posterior vena cava. Between surgery and the day of study they were fed on lucerne (*Medicago sativa*) chaff (metabolizable energy content ~9 MJ/kg, crude protein (nitrogen × 6·25) content 180 g/kg dry matter) at 1000–1200 g/d ('fed', *n* 6) or 350–400 g/d ('underfed', *n* 6). Then [2-^{3}H]glucose was infused into the maternal jugular vein, and antipyrine and [U-^{14}C]glucose into the fetal vena cava to measure maternal and glucose flux rates (isotope dilution) and umbilical blood flow and net glucose uptake (Fick principle). Measurements were made while the ewe stood at rest for 120–180 min, then during the final 30 min of a 60 min period of treadmill exercise (0·7 m/s, 10° slope). Mean values for maternal and fetal blood glucose concentrations (mmol/l) and glucose flux rates (μmol/min) at rest (R) and changes with exercise (ΔE) are given in the Table.

	Fed		Underfed		Pooled SE		Effect of nutrition	
	R	ΔE	R	ΔE	R	ΔE	R	ΔE
Maternal concentration	2·81	+0·17	1·54	+0·90	0·18	0·32	$P<0·001$	$P<0·05$
Maternal flux rate	505	+297	252	+277	39	93	$P<0·001$	NS
Fetal concentration	0·73	+0·11	0·32	+0·42	0·07	0·07	$P<0·001$	$P<0·01$
Fetal flux rates:								
Total	196	+36	122	+83	8	20	$P<0·001$	$P<0·05$
Utilization	102	+7	84	+18	9	16	$P<0·1$	NS
Umbilical uptake	88	+5	32	+50	11	11	$P<0·001$	$P<0·01$
Endogenous production	14	+3	52	−32	14	16	$P<0·05$	$P<0·1$

NS, not significant.

Exercise caused similar increases in maternal glucose flux rate in well-fed and underfed ewes. In the latter group only, the fetus took advantage of the increase in maternal glucose supply to offset its substantial reliance on endogenous glucose production. The effect was substitutive rather than additive because fetal glucose utilization was unaffected by exercise, irrespective of maternal nutrition and fetal glucose supply. This is consistent with the lack of response in fetal insulin secretion to exercise-induced fetal hyperglycaemia (Bell *et al.* 1983).

Bell, A. W., Bassett, J. M., Chandler, K. D. & Boston, R. C. (1983). *Journal of Developmental Physiology* **5**, 129–141.

Chandler, K. D., Leury, B. J., Bird, A. R. & Bell, A. W. (1985). *British Journal of Nutrition* **53**, 625–635.

Judson, G. J., Filsell, O. H. & Jarrett, I. G. (1976). *Australian Journal of Biological Sciences* **29**, 215–222.

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The validity of a food frequency questionnaire in assessing specific nutrient intakes in a group of females. By AEDIN CASSIDY and CLARE E. CASEY, *Department of Medicine and Therapeutics, University of Aberdeen, Aberdeen AB9 2ZD*

There is considerable interest in developing a method for assessing dietary intake of specific nutrients that can be readily and inexpensively applied to a large number of subjects and still yield accurate information about their habitual intakes. The aim of the present study was to evaluate the validity of a food frequency questionnaire (FFQ) for an investigation of iron status in females, age 18–38 years.

The FFQ was developed from 7 d weighed food records made by four subjects. Twenty-eight food diaries which had been collected from seven other women more than 1 year previously were also available and were used to check that food lists were comprehensive. The FFQ contained all foods which made a significant contribution to intakes of fibre, Fe and vitamin C; foods were included because of their frequency of consumption rather than their individual content of the three nutrients. Appropriate average portion sizes for the group were established, and food models were used to represent the predetermined average amounts. Daily intakes of the three nutrients and the contribution of specific foods to total intake were calculated with a specially written computer program. The FFQ was then administered to the subjects between 3 and 15 months after collection of their weighed intakes.

The Table compares the mean (SD) intakes of the three nutrients from the 7 d weighed method and the FFQ for the two groups. The methods were compared by Pearson's correlation coefficient for the two groups separately.

			Intakes				
			7 d weighed		FFQ		
	n	Time between assessments (months)	Mean	SD	Mean	SD	*r*
Fe (mg/d)	4	3	15·6	5·5	15·6	4·5	0·99**
	7	15	14·1	4·6	15·3	7·1	0·94*
Dietary fibre (g/d)	4	3	34·1	9·3	30·8	5·3	0·71
	7	15	24·2	6·3	25·5	11·5	0·88**
Vitamin C (mg/d)	4	3	122·2	52·2	136·9	53·8	0·92*
	7	15	98·3	40·7	84·1	61·0	0·88**

*$P<0·05$, **$P<0·01$.

The highly significant correlations between FFQ and both current and historic 7 d weighed intakes suggest that a specially composed FFQ can be used in epidemiological studies to provide a reasonably reliable estimate of habitual intake of specific nutrients.

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The energy cost of a menopausal hot flush. By A. S. KINDLEN and R. E. C. MUNRO, *Queen Margaret College, Edinburgh EH12 8TS*

The menopausal hot flush is a common phenomenon, but there is very little information on the effect of flushing on energy metabolism (Collett, 1949). The subject, aged 54 years, engaged in a long-term study of her own basal metabolic rate (BMR), found that she experienced a hot flush during the estimation of BMR on several occasions.

The pneumotachygraphic method employed allowed the measurement of respiratory variables on individual minutes and the differences between flush and non-flush minutes could be identified. The study was carried out under standard BMR conditions with the subject fasted for 8–10 h and rested for 30 min before assessment. Ambient temperature was maintained at about 22°. The pneumotachygraph is calibrated by establishing a calibration factor by the delivery of a known volume of air from a 1 litre syringe. Our extensive calibration studies of this instrument have shown that it is necessary to take into account the performance of the pneumotachygraph at low air flow rates. A small error may be introduced in the selection of a factor for these conditions; however, once the factor has been established, the effect of any error becomes constant for these conditions. For this reason, results have been expressed as percentage change. The oxygen content of expired air was measured by the paramagnetic method and the carbon dioxide by infra-red. Each measurement cycle occupied 16 min, the first 3 min being discarded to allow any air to be flushed out of the analysers.

Nine cycles contained flush episodes, each lasting for about 3 min. The mean O_2 usage of the 27 flush min was compared with the mean O_2 usage of the 90 non-flush min and the difference in means was found to be highly significant (t 4·07, df 115, $P<0·001$) (Kindlen & Munro, 1988). The mean % increase in O_2 consumption was 7·3 (SEM 2·4). As O_2 consumption is directly related to energy consumption, the increase in metabolic rate over flush minutes was therefore approximately 7·3%. This subject's BMR, measured using this technique and the classic Douglas bag technique, was approximately 4830 kJ (1150 kcal)/24 h or 3·35 kJ (0·80 kcal)/min. The extra cost of a flush lasting 3 min was approximately 0·71 kJ (0·17 kcal).

Flushes vary considerably between subjects, within subject and with time. In the case of our subject, whose flushes were mild at this time, the occurrence of a flush within a 15 min BMR estimation would have increased the estimated BMR value by only 1·4%, probably not enough to affect the acceptability of duplicate estimations. These measurements were made 4 years into the climacteric and our subject reported that flushes were much more severe in the earlier stages. At that time, the occurrence of a flush during a BMR estimation might well have invalidated the result.

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The effect of growth hormone on hind-limb muscle protein metabolism in growing lambs.

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Long-term (12 weeks) daily administration of growth hormone (GH) to growing lambs has been shown to stimulate muscle protein turnover, the increase in synthesis exceeding the increase in degradation (Pell & Bates, 1987). The objective of the present study was to examine the short-term effects of GH treatment on hind-limb muscle protein metabolism in growing lambs.

Seven wether lambs, live-weight range 29–39 kg, were fed on a diet of concentrate (Lamlac start-to-finish, Volac Ltd, Herts) and chopped hay (4:1, w/w) at a level of 49 g dry matter/kg live weight per d. Lambs were treated with either saline (9 g sodium chloride/l, S) or ovine GH (0·25 mg/kg per d) for a period of 5–11 d. On the last day of treatment, hind-limb muscle protein synthesis, degradation and gain were measured using a hind-limb model similar to that of Oddy & Lindsay (1986). The model uses arterio-venous (A-V) difference and blood flow rate procedures to examine tyrosine metabolism across the hind-limb muscle of lambs, as reported previously (Crompton & Lomax, 1987). Hind-limb blood flow was measured by an equilibrium diffusion method (Lindsay *et al.* 1978) immediately after the 6 h A-V sampling period.

There was no difference in the mean nitrogen intake of S and GH-treated lambs (28·2 (SEM 1·8) and 27·8 (SEM 1·6) g/d respectively. GH concentrations were elevated 25- to 30-fold in all GH lambs; other results are shown in the Table.

		Plasma flow rate (ml/min per g)		Muscle protein turnover (%/d)					
				Net gain		Synthesis		Degradation	
Treatment	*n*	Mean	SEM	Mean	SEM	Mean	SEM	Mean	SEM
S	6	0·092	0·003	1·1	0·2	3·6	0·4	2·5	0·4
GH	7	0·129*	0·012	2·0**	0·2	4·9*	0·4	2·9	0·4

Significantly different from saline control: $*P<0·05$, $**P<0·01$.

There was a significant decrease ($P<0·05$) in urinary nitrogen output in GH-treated lambs (mean values on day 5 of treatment were S, 14·1 (SEM 0·4) and GH, 9·0 (SEM 1·6) g/d).

GH-treated lambs showed an 88% increase in protein gain due to a significant stimulation of hind-limb plasma flow rate and an increase in tyrosine A-V difference. Muscle protein synthesis was significantly increased by 37% with protein degradation also increasing but only by 15%.

The results of this short-term study agree with those of Pell & Bates (1987) and show that the anabolic effects of GH on muscle protein turnover occur rapidly after the onset of treatment. These results and those of Crompton & Lomax (1987) support the validity of the calculated values for muscle protein turnover and confirm the usefulness of the hind-limb model.

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Absorption of deuterium from an orally ingested isotonic carbohydrate–electrolyte solution and a carbonated, low-alcohol drink. By J. B. LEIPER[1], A. E. FALLICK[2] and R. J. MAUGHAN[1], [1]*Department of Environmental and Occupational Medicine, University Medical School, Foresterhill, Aberdeen AB9 2ZD* and [2]*Scottish Universities Research and Reactor Centre, East Kilbride, Glasgow G75 0QU*

Anecdotal evidence suggests that rehydration following exercise is more rapidly achieved using carbonated drinks with a high-carbohydrate and low-alcohol content (shandy) than with other drinks. The rate of water absorption from an ingested solution is determined mainly by the gastric emptying of the solution and the active transport of solutes which facilitate intestinal water uptake. Measurement of the accumulation in the circulation of deuterium as a tracer molecule for water has been used as an index of water absorption from ingested solutions (Leiper *et al.* 1988). We have measured the rate of accumulation of deuterium in the circulation of subjects following ingestion of a carbohydrate–electrolyte solution ('Isostar', CES) or shandy. Eight fasted, well-hydrated male volunteers took part in a randomized cross-over study, drinking 200 ml isotonic CES formulated to promote water absorption on one occasion and 200 ml shandy on another occasion, separated by 7 d. Each drink contained 71·4 mg/kg body-weight of 99·8% deuterium oxide. Arterialized venous blood samples were collected from the seated subject at timed intervals following ingestion of the drink. The concentration of deuterium in the plasma samples was measured by mass spectrometry. Plasma alcohol levels were measured using an enzymic fluorometric assay.

The mean (SD) rate of deuterium accumulation (ppm/min) was similar from the CES (12·0 (6·5)) and shandy (11·1 (10·6)). Following ingestion of shandy the times to peak deuterium concentration (22 (8) min) and peak alcohol concentration (17 (10) min) in the circulation were the same. Although there was considerable variation in deuterium accumulation rate between subjects, these results suggest that water uptake from shandy is as rapid as that from isotonic drinks which have been formulated to promote water absorption. The absorption of alcohol and water from shandy appear to follow similar patterns.

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Misinterpretation of body image: implications for exercise participation. By P. J. CLOUGH and R. J. MAUGHAN, *Department of Environmental and Occupational Medicine, University Medical School, Aberdeen AB9 2ZD*

Body fat content was estimated by skinfold thickness on 170 men and 177 women taking part in an investigation into exercise and health. Skinfold thickness was measured in triplicate at each of four sites: biceps, triceps, subscapular and supra-iliac (Durnin & Womersley, 1974). All subjects were also asked whether they considered themselves to be underweight, about right or overweight. Few of the males (*n* 10) or females (*n* 9) considered themselves to be underweight, but roughly two-thirds of the volunteers of either sex considered themselves to be overweight.

These subjective classifications were compared with two objective measures of physique, body fat content and body mass index (weight/height^2). The values used for the normal ranges of body fat content were 15–20% for males and 20–30% for females whilst the normal range used for body mass index was 20–25% for both sexes (Garrow, 1988). Within each sex, there were individuals who considered themselves to be overweight who were clearly not, according to both their body fat and body mass index. In this category were seventeen men (16% of the males who felt overweight); a significantly greater proportion of the women (49% of those reporting that they were overweight, $P<0{\cdot}001$) misinterpreted their body image in this way. Several extremely lean women, including three with a body fat content of less than 20%, considered themselves to be overweight, indicating a substantial disparity between their subjective perceptions and reality. It therefore appears that many individuals have an inaccurate body image, and this appears to be a particularly prevalent phenomenon in women. It was found, using the multiple adjective check list (Zuckerman & Lubin, 1965), that the females who misinterpreted their body image were significantly more depressed than those with correct perceptions.

The importance of body image as a motivating factor for exercise was highlighted in a series of extensive semi-structured interviews conducted with 120 of these subjects (sixty-three females, fifty-seven males). Of the females, 91% reported that weight control/weight loss/physical appearance were important motivating factors in their desire to exercise. A smaller, but still substantial, number of males (79%) also reported these as motives for exercise. Body image thus has a central role in exercise participation but it has been demonstrated here that these body image perceptions may be distorted, especially in the case of women. This has a number of implications. Exercising to reduce weight when an 'ideal weight' has already been achieved may lead to frustration, ill health, or both (De Coverley Veale, 1987). In addition an over-concentration on extrinsic motivations, such as weight loss, may reduce the individual's chance of obtaining the intrinsic satisfactions that may be derived from an involvement in exercise (Deci, 1972).

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