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PROCEEDINGS OF THE NUTRITION SOCIETY

ABSTRACTS OF COMMUNICATIONS

The Four Hundred and Second Meeting of the Nutrition Society was held in the Martin Hall Lecture Theatre, Loughborough University of Technology, Loughborough, on Tuesday and Wednesday, 11/12 *September* 1984, *when the following papers were read:*

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Exercise and obesity in a national birth cohort. By F. E. M. BRADDON, *MRC National Survey of Health and Development, University of Bristol, Department of Epidemiology and Community Medicine, Canynge Hall, Whiteladies Road, Bristol BS8 2PR*

Exercise and obesity has been studied in a nationally representative birth cohort of 5362 men and women born in 1946; the MRC National Survey of Health and Development. Contact has been maintained at 2–5 yearly intervals since birth, thus providing a unique longitudinal data set (Atkins *et al.* 1981).

In 1982, when the survey members were aged 36 years, they were interviewed and physical measurements were carried out by a nurse. Height, weight, upper arm, chest and abdominal circumferences were measured. Leisure activity was measured via a self-completion questionnaire based upon that used by Taylor *et al.* (1978). Intensity and duration of each leisure pursuit was used to calculate an activity metabolic index: a measure of the total amount of leisure-time work done over the 4 week period prior to the interview date. The method used by Shapiro *et al.* (1965) to score 'on-the-job' physical activity has been adapted to include survey members who were unemployed and those not working and not looking for work (e.g. housewives). Thus a score was obtained for all non-leisure daytime activity. Prevalence of obesity has been estimated using the Quetelet body mass index, and this is compared with the work and leisure activity indices.

There is conflicting evidence concerning the extent to which the obese exercise (Royal College of Physicians, 1983). In the National Survey of Health and Development there was significantly less obesity in men who undertook heavy lifting at work ($P<0.05$). Only women in sedentary occupations showed a significantly higher rate of obesity ($P<0.05$). The overall level of leisure time activity was important only in relation to women's body mass, obese women taking significantly less exercise than others ($P<0.01$).

Obesity and leisure activity %

Activity metabolic index		Body mass index ...	Leisure activity (%)					
			Men			Women		
MJ/month	kcals/month		Normal	Moderately obese	Obese	Normal	Moderately obese	Obese
		Range ...	20·1–25·0	25·1–29·9	⩾30	18·7–23·8	23·9–28·5	⩾28·6
0–4·184	0–1000		3·6	4·7	8·0	7·6	11·2	17·4
4·184–41·84	1001–10000		31·7	34·1	34·0	51·8	50·7	51·0
41·84–83·68	10001–20000		34·9	30·2	30·0	28·2	24·6	22·6
>83·68	>20000		29·8	31·0	28·0	12·4	13·6	9·0
		n ...	808	580	100	955	448	155
			$x^2 = 7.852$, 6 df, not significant			$x^2 = 19.344$ 6 df, $P<0.01$		

Atkins, E., Cherry, N., Douglas, J. W. B., Kiernan, K. E. & Wadsworth, M. E. J. (1981). In *Prospective Longitudinal Research: an Empirical Basis for the Primary Prevention of Psychological Disorders* [S. A. Mednick and A. E. Baert, editors]. Oxford: Oxford University Press.

Royal College of Physicians (1983). *Obesity*. London: Royal College of Physicians.

Shapiro, S., Weinblatt, E., Frank, C. W. & Sager, R. V. (1965). *Journal of Chronic Diseases* **18**, 527–558.

Taylor, H. L., Jacobs, D. R., Schuckler, B., Knudsen, J., Leon, A. S. & Debacker, G. (1978). *Journal of Chronic Diseases* **31**, 741–755.

Effects of sodium bicarbonate ingestion on maximal exercise. By D. P. M. MACLAREN and G. D. MORGAN, *Department of Sport and Recreation Studies, Liverpool Polytechnic, Byrom Street, Liverpool L3 3AF* (Introduced by C. WILLIAMS)

The effects of sodium bicarbonate ingestion on exercise has been investigated previously, with varying results (Dennig *et al.* 1931; Johnson & Black, 1953; Margaria *et al.* 1971; Jones *et al.* 1977; Wilkes, 1981; Inbar *et al.* 1983). The present study was concerned with the effects of sodium bicarbonate ingestion on maximal exercise using a bicycle ergometer. Seven male subjects underwent a ride to exhaustion at a work load corresponding to 100% maximum oxygen uptake after a pre-treatment with either 0·25 g/kg body-weight of sodium bicarbonate (HCO_3^-) or placebo (P) 2 h before the test. Measurements of blood pH, plasma lactate and plasma bicarbonate were made before and after the test, while the determination of elevated post-exercise O_2 consumption (EPOC) and time to exhaustion were also recorded. Blood pH was found to be significantly higher for the HCO_3^- treatment than for P at the start of the test ($P<0·001$), at exhaustion ($P<0·01$) and 15 min post-exercise ($P<0·01$). Plasma lactate was significantly higher for the HCO_3^- treatment at the point of exhaustion and 5 min post-exercise ($P<0·001$), but not before the test or 15 min post-exercise. Furthermore, plasma bicarbonate levels were significantly elevated in the HCO_3^- treatment immediately before the start of exercise ($P<0·001$) but not at any other time. The total EPOC was found to be significantly higher for the HCO_3^- treatment ($P<0·05$), which was due mainly to a significantly elevated 'lactacid' portion ($P<0·05$) since the difference between 'alactacid' portions was not significant. Times to exhaustion were found to be 12% longer for the HCO_3^- treatment (326 (SE 43) s) than for the placebo (285 (SE 51) s) and this was determined to be a significant increase ($P<0·05$). This study demonstrates that sodium bicarbonate ingestion will increase time to exhaustion during maximal exercise as a result of increasing the buffering capacity of the body and thus enabling accumulation of greater lactate levels without a concomitant decrease in blood pH.

Dennig, H., Talbot, J. H., Edwards, H. T. & Dill, D. B. (1931). *Journal of Clinical Investigation* **9**, 601–613.

Inbar, O., Rotstein, A., Jacobs, I., Kaiser, P., Olin, R. & Dotan, R. (1983). *Journal of Sports Sciences* 1(2), 95–104.

Johnson, W. & Black, D. (1953) *Journal of Applied Physiology* **5**, 577–578.

Jones, N. L., Sutton, J. R., Taylor, R. & Toews, C. J. (1977). *Journal of Applied Physiology* **43**, 959–964.

Margaria, R., Aghemo, P. & Sassi, G. (1971). *Internationale Zeitschrift für Angwandte Physiologie* **29**, 215–223.

Wilkes, D. (1981). *Medicine and Science in Sports and Exercise* **13**, 85.

Impact of marginal vitamin intake on physical performance in healthy young men. By E. J. VAN DER BEEK, W. VAN DOKKUM, J. SCHRIJVER and R. J. J. HERMUS, *Institute CIVO-Toxicology and Nutrition TNO, PO Box 360, 3700 AJ Zeist, The Netherlands*

The functional significance of indices of vitamin status is still controversial. Therefore an 11-week experiment was carried out to study the effect of a vitamin B_1-, B_2-, B_6- and C-deficient diet, leading to biochemical deficiencies, on physical performance.

Twelve healthy male volunteers (mean age 23 years) were given a diet of normal foodstuffs for 8 weeks. The diet provided a maximum of 30–35% of the Dutch recommended dietary allowances (RDA) for the four vitamins. The 8 weeks were preceded and followed by 1 and 2 weeks respectively when the diets were supplemented with two times the RDA of the four vitamins. A control group of eleven males (mean age 23 years) received the same diet, but was supplemented with all vitamins during the entire period. Physical performance was measured on a bicycle ergometer and quantified by means of the maximum oxygen uptake ($\dot{V}O_2$ max) and the anaerobic threshold (AT). The AT was defined as the workload at which a venous whole blood lactate level of 4 mmol/l was reached.

Within 4 weeks the vitamin-deficient diet had caused the indices of vitamin status to reach borderline levels in the experimental group. A statistically significant decrease of the $\dot{V}O_2$ max and AT was observed during the period when the vitamin-deficient diet was given ($P<0{\cdot}01$) (see Fig. 1). During the 2-week repletion period virtually all indices of vitamin status reached values comparable to those measured at the start of the experiment. The same was true for values of $\dot{V}O_2$ max and AT (see Fig. 1). During the whole experiment the control group remained in normal condition.

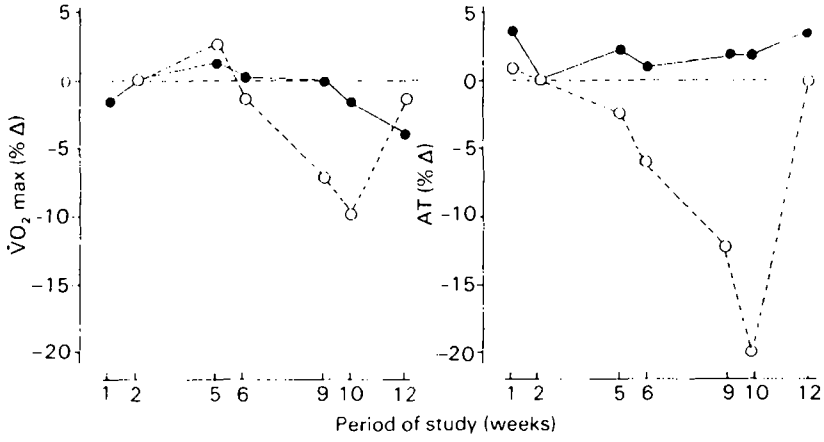

Fig. 1. Maximum oxygen consumption ($\dot{V}O_2$ max) and anaerobic threshold (AT) (percentage change from values at 2nd week of study) of men given a vitamin-deficient diet (○— — —○) or a control diet (●——●).

It is concluded that a vitamin B_1-, B_2-, B_6- and C-deficient diet providing a maximum of 30–35% of the RDA, induces a decrease in the vitamin status of volunteers within 4 weeks. This situation clearly influences $\dot{V}O_2$ max and has a large impact on AT.

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Influence of diet on recovery from prolonged exercise. By C. WILLIAMS, A. PATTON and J. BREWER, *Department of Physical Education and Sports Science, Loughborough University of Technology, Loughborough, Leics LE11 3TU*

Fatigue during prolonged heavy exercise is associated with the depletion of muscle glycogen (Hermansen *et al.* 1967). Repletion of muscle glycogen and recovery from prolonged exercise appears to be most rapid when a high carbohydrate (CHO) diet is consumed (Costill & Miller, 1980). The purpose of the present study was to assess the influence of high CHO diets on the recovery process following exercise to exhaustion. Two methods of increasing the CHO contents of normal diets were used, the first involved supplementation with pasta and the second involved supplementation with confectionery. Confectionery was used because it is a convenient form of high-carbohydrate food for athletes.

The fifteen recreational runners who volunteered for this study (nine males and six females) recorded their weighed food intakes for 7 d and then again for 3 d immediately before the first trial. During Trial 1 each subject was required to run to exhaustion, on a treadmill, at a running speed equivalent to 70% maximum oxygen uptake. Thereafter the subjects were assigned to either a control, pasta or confectionery group. The individuals in the latter two groups attempted to double their normal CHO intake using either pasta or confectionery during the 3 d for recovery following Trial 1. During Trial 2 each subject again ran to exhaustion and attempted to match or improve on the running times achieved during Trial 1.

The pasta and the confectionery groups achieved a significant ($P<0.01$) increase in their daily CHO intakes (294 (SD 97) g *v.* 564 (SD 86) g and 271 (SD 55) g *v.* 522 (SD 113) g respectively), whereas the control group did not (305 (SD 106) g *v.* 339 (SD 98) g). These increases in CHO consumption were accompanied by a significant increase in energy intake which was not achieved by the control group. All three groups improved their performance during Trial 2, however, the improvements of 26% in the pasta group (21·9 (SD 5·8) km *v.* 27·5 (SD 8·7) km) and of 27% in the confectionery group (24·6 (SD 3·5) km *v.* 31·2 (SD 6·8) km) were both significantly greater ($P<0.05$) than the 6% improvement in the control group (25·0 (SD 2·4) km *v.* 26·5 (SD 2·7) km).

The results of this study suggest that recovery from prolonged exercise is enhanced by an increase in dietary CHO, which can be accomplished by supplementing the normal diet with either pasta or confectionery.

This study was supported by Mars Confectionery Ltd.

Costill, D. L. & Miller, J. M. (1980). *International Journal of Sports Medicine* **1**, 2–14.
Hermansen, L., Hultman, E. & Saltin, B. (1967). *Acta Physiologica Scandinavica* **71**, 129–139.

DL-Carnitine supplementation during exercise training in the rat. By J. DECOMBAZ, D. SARTORI and N. FOURNIER, *Nestlé Research Department, CH-1814 La Tour-de-Peilz, Switzerland*

Increasing the rate of fat oxidation in muscle results in glycogen sparing during exercise, thereby improving endurance. However, the maximal rate of fat oxidation during exercise is controlled in part by unknown factors (Newsholme, 1979).

Carnitine, an essential carrier for fatty acid (FA) oxidation, can be obtained from the diet and from endogenous biosynthesis. The effect of dietary supplements of DL-carnitine was investigated in the exercising rat.

Rats were trained on a treadmill for 5 weeks with or without 10 g DL-carnitine/kg diet (groups CARN and CONT respectively). On the last day, they were killed either before or after a 1 h exercise period. A third group of rats (SED) was kept sedentary without treatment.

The utilization of muscle glycogen during exercise was not significantly less in the CARN group than in the CONT group ($0.10 < P < 0.20$).

Some of the links in the intracellular transport chain of FA were examined in the soleus muscle. No change was observed in acyl-CoA synthetase (*EC* 6.2.1.3) or carnitine acetyltransferase (*EC* 2.3.1.7) activities. The concentration of the FA-binding protein (FABP), a cytoplasmic FA carrier (Fournier *et al.* 1978), was unaltered by training as well as by DL-carnitine supplementation.

Group ...			CONT				CARN			
	SED		Pre-exercise		Post-exercise		Pre-exercise		Post-exercise	
	Mean	SE	Mean	SE	Mean	SE	Mean	SE	Mean	SE
n ...	7		6		6		6		7	
Blood:										
Glycerol (μmol/l)	184	68	94	12	212	26	117	11	278	62
Plasma free-FA (μmol/l)	405	68	364	56	746	66	454	38	762	117
Soleus muscle:										
Glycogen (mg/g)	3·3	0·3	3·2	0·3	0·6***	0·2	3·3	0·5	0·9***	0·2
Triglycerides (mg/g)	10·2	0·8	9·3	1·0	7·3	1·7	8·3	0·9	7·0	1·0
Total L-carnitine (μmol/g)	0·46	0·05	0·36	0·03	0·35	0·02	0·39	0·05	0·53	0·05
Long-chain acyl-L-carnitine (μmol/g)	0·38	0·06	0·17	0·03	0·09	0·04	0·15	0·05	0·08	0·04
FABP (*n* 1 or 3) (mg/g)	1·60	0·05	1·50	0·03	1·61	0·03	1·50	—	1·54	0·02

Significantly different from pre-exercise value: ***$P < 0.001$.

The exercise caused expected changes in blood and muscle substrates. Chronic administration of DL-carnitine did not modify drastically the carnitine status in the exercised muscle and seemed to have little influence on the endogenous fuels used. It is possible that the unphysiological D-isomer exerted a negative effect on the disposal of L-carnitine.

Fournier, N., Geoffroy, M. & Deshusses, J. (1978). *Biochimica et Biophysica Acta* **533**, 457–464.

Newsholme, E. A. (1979). *Diabetes* **28** (Suppl. 1), 1–7.

The effect of prolonged cooking on the digestibility of legume protein.

By SANOJA S. SANDARADURA and A. E. BENDER, *Department of Nutrition, Queen Elizabeth College, Campden Hill, London W8 7AH*

The low digestibility of legume protein, 70–80% in both experimental animals and man, has been well documented. There are reports that prolonged cooking (a) can increase (Elias *et al.* 1976; Bressani & Elias, 1977), (b) can decrease (Hellendoorn *et al.* 1969), and (c) has no effect on digestibility of nitrogen.

In the present study, whole and dehusked white kidney beans (*Phaseolus vulgaris*) were cooked at 103 kPa (15 p.s.i.) at 121° for (a) 20 min normal cooking, or (b) 60 min prolonged cooking. The cooked beans were dried at 55° in an air oven and incorporated into experimental diets at levels of 400 g/kg diet which is approximately 100 g protein/kg diet. The four diets, and casein as control, were fed *ad lib.* to groups of six weanling rats for 10 d.

Mean values with their standard errors for six rats per treatment

				Faeces							
		Food intake (g/d)		Dry wt (g)/kg diet		N (g)/kg diet		TND (%)		DNA (g)/kg diet	
Diet	Cooking time (min)	Mean	SEM	Mean	SEM	Mean	SEM	Mean	SEM	Mean	SEM
Whole bean	20	77	4	203**[a]	8	5·0**	0·4	79**	2	0·84**	0·04
Whole bean	60	72	6	201**[a]	3	6·3	0·1	76**	1	0·83**	0·04
Dehusked bean	20	73	5	167**[b]	4	6·1**	0·2	78**	1	0·86**	0·05
Dehusked bean	60	74	4	180**[b]	4	5·8**	0·2	80**	1	0·85**	0·05
Casein diet	- --	90	8	94	1	2·6	0·2	97	1	0·39	0·03

TND, true nitrogen digestibility.

[a, b]Values within a column not sharing a common superscript letter differ significantly ($P<0·01$). Significantly different from casein diet: **$P<0·01$.

Results show that (a) twice as much N and twice as much DNA were excreted on the legume diets compared with the casein diet and (b) that true digestibility was unchanged on prolonged cooking, both for the whole and dehusked beans. These results agree with earlier findings from this laboratory that prolonged cooking had no effect on true digestibility. Reports of decreased digestibility with prolonged cooking would appear to be due to severe Maillard reaction. Reports that digestibility is increased are not acceptable since the differences reported are within the range of experimental error. For example, an increase from 73·0% to 74·2% (Elias *et al.* 1976).

Bressani, R. & Elias, L. G. (1977). In *Nutritional Standards and Methods of Evaluation for Food Legume Breeders*, Report no. IDRC TS7e, pp. 61–72 [J. H. Hulse, K. O. Rachie and L. W. Billingsley, editors]. Ottawa, Canada: International Development Research Centre.

Elias, L. G., Hernandez, M. & Bressani, R. (1976). *Nutrition Reports International* **14**, 385–403.

Hellendoorn, E. W., de Groot, A. P. & Slump, P. (1969). *Voeding* **30**, 44–69.

Soluble and available iron from raw and cooked pigeon meat. By Y. LATUNDE-DADA and R. J. NEALE, *Department of Applied Biochemistry and Food Science, University of Nottingham School of Agriculture, Sutton Bonington, Nr Loughborough, Leics LE12 5RD*

The importance of meat on iron availability from the diet is now widely recognized (Cook *et al.* 1982). The relative importance of various meat types, however, and the effects of processing have received little attention. Using ^{59}Fe-labelled chicken meat, which is relatively low in haemoproteins, Bogunjoko *et al.* (1983) showed that cooking markedly reduced Fe availability, and this was attributed to the denaturation and polymerization of some haemoproteins. The present work describes Fe availability studies in pigeon meat, which is high in haemoproteins. ^{59}Fe-labelled pigeon meat was prepared according to the method of Bogunjoko *et al.* (1983) using 6-month-old pigeons. Meat was obtained at slaughter, 1 month after injecting $^{59}FeCl_3$. Meat samples were frozen immediately or cooked at 90° for 30 min before frozen for subsequent use.

Samples of raw and cooked meat were then used for in vitro digestion studies and in vivo absorption studies in rats, and the results are shown in the table.

	Percentage soluble ^{59}Fe			
	Raw meat		Cooked meat	
Digestion conditions	Mean	SE	Mean	SE
1. Pepsin (*EC* 3.4.23.1)/hydrochloric acid, pH 1·5, 90 min digestion at 37°	88·8	0·5	56·1	2·3
2. Pepsin/HCl (as 1) followed by neutralization with sodium bicarbonate	37·4	2·0	21·1	1·6
3. Pepsin/HCl (as 2) + pancreatin–bile extract, 2 h digestion at 37°	60·4	1·1	26·6	1·2
In vivo ^{59}Fe absorption (% dose)	21·9	2·98	10·9	2·0

Fe solubility was highest in pepsin/HCl, fell on neutralization but increased again with digestion. Under all conditions, Fe solubility from cooked meat was significantly lower than that for raw meat ($P<0·001$). In vivo Fe absorption was also significantly lower for cooked as opposed to raw meat ($P<0·001$).

Bogunjoko, F. E., Neale, R. J. & Ledward, D. A. (1983). *British Journal of Nutrition* **50**, 511–520.

Cook, J. D., Morck, T. A., Skikne, B. S. & Lynch, S. R. (1982). In *Animal Products in Human Nutrition*, pp. 322–337 [D. C. Beitz and R. G. Hansen, editors]. New York: Academic Press.

Effect of ambient temperature on the energy costs of activity by tropical cattle. By J. C. MATHERS* and JENNIFER C. SNEDDON, *Centre for Tropical Veterinary Medicine, University of Edinburgh, Easter Bush, Roslin, Midlothian EH25 9RG*

Although 250 million cattle are used for draught in tropical countries, little is known of the effects of ambient temperature on rates of energy expenditure by working animals. The present study is part of a long-term investigation of the nutrition of such animals.

Two pure-bred Brahman (*Bos indicus*; weighing 278 kg) and two Friesian × Brahman crossbred cattle (346 kg) were adapted to environmental temperatures of 20° or 30° before undergoing a defined series of treadmill exercises which included standing, walking unloaded at about 1 m/s, walking whilst carrying a load (20 kg for the Brahmans, 26 kg for the crossbreds) and standing loaded. On each occasion, these activities were carried out both on a horizontally placed treadmill and on one mounted at +6° in a controlled-environment room at the appropriate temperature. Two estimates of the animals' energy expenditure were made by open circuit indirect calorimetry during each activity on each of 2 d at each environmental temperature for each animal, and mean results are given in the table.

Activity . . .	Standing (J/s per kg body-wt $^{0.75}$)		Horizontal transport* (J/kg per m travelled)		Raising mass against gravity† (J/kg per m ascended)	
Ambient temperature	Horizontal	+6° Slope	Body mass	Applied load	Body mass	Applied load
20°	7·8	8·6	1·6	3·5	38	71
30°	8·4	9·0	1·6	3·1	38	75
SEM	0·12	0·20	0·05	0·49	0·5	10·4

*In addition to costs of standing still.
†Vertical component of costs only.

The animals expended significantly ($P<0.01$) more energy whilst standing on the horizontal treadmill in the hotter environment than at the more comfortable temperature but ambient temperature had no effect on the energy costs of the other activities. Rates of energy expenditure were increased when the animals stood on a slope but no effect of applied load on the energy expenditure of standing animals was detected. Transporting applied loads horizontally was about twice as expensive as transporting the same mass of body tissue and a similar relation was observed when comparing the energy costs of raising mass against gravity. Although the loads were firmly secured to the animal in a pack mounted on the shoulders across its hump, it may be that movements of the load disturbed the animal's gait and that energy had to be expended in compensatory activities.

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Prediction of energy expenditure from heart rate measurements in exercising cattle. By JENNIFER C. SNEDDON, J. C. MATHERS*† and CLAIRE J. THOMSON, *Centre for Tropical Veterinary Medicine, University of Edinburgh, Easter Bush, Roslin, Midlothian EH25 9RG*

Whilst there have been some reports of reasonably good relations between heart rate (HR) and energy expenditure (EE) for individual cattle and sheep, there was, until recently, no general relation which might be of use for predicting EE. In a study in which adult Brahman cattle (*Bos indicus*) and swamp buffaloes (*Bubalus bubalis*) pulled loads whilst walking on treadmills, Richards & Lawrence (1984) found that for all animals the rate of EE (EE^W; watts/kg body-weight$^{0.75}$) was related to relative HR (RHR; heart rate of working animal/heart rate at rest) by the equation $EE^W = 24.94 \times RHR - 16.25$.

Two young Brahman and two Friesian × Brahman crossbred cattle carried loads whilst walking on treadmills with slopes of 0 and +6°. Continuous measurements were made of EE (Mathers & Sneddon, 1984) and concurrent recordings of HR made over 30-s periods every 5 min. Mean HR (SE) for animals standing on the 0° slope was 91 (2·1), standing on the +6° slope 92 (1·5), walking on the 0° slope 111 (1·7) and walking on the +6° slope 160 (2·6), with significant ($P<0.01$) between-animal differences for all activities. Carrying a load increased significantly ($P<0.05$) HR of animals walking on the +6° slope. Using the HR whilst standing on the horizontal as baseline, RHR were calculated and regressed against EE^W using the model $EE^W = A \times RHR + B$. Regression coefficients are given in the table.

Animal . . .	Brahman 1	Brahman 2	Crossbred 1	Crossbred 2	All calves
A (SE)	28·5 (2·17)	25·4 (1·15)	34·3 (1·68)	27·7 (1·39)	28·2 (0·85)
B (SE)	−18·0 (2·78)	−17·7 (1·60)	−26·7 (2·28)	−18·0 (1·86)	−19·2 (1·14)
Correlation coefficient (*n*)	0·91 (38)	0·95 (54)	0·94 (56)	0·95 (47)	0·92 (195)

Individual relations were very similar for three of the calves whilst the relation for all calves was close to that of Richards & Lawrence (1984).

Mathers, J. C. & Sneddon, J. C. (1984). *Proceedings of the Nutrition Society* (this meeting).
Richards, J. I. & Lawrence, P. R. (1984). *Journal of Agricultural Science, Cambridge* **102**, 711–717.

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The energy cost of some behaviour patterns in laying domestic fowl: simultaneous calorimetric, Doppler-radar and visual observations.

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The combination of Doppler-radar activity measurement and chamber calorimetry can be used to estimate the heat production (H) attributable to spontaneous activity (A) (MacLeod *et al.* 1982). Such a system cannot, however, distinguish between types of behaviour. Measurements of H and A were made for 2 d, including four 1 h periods of visual behavioural observation, on each of four White Leghorn hens. Only those behaviour patterns which occurred in discrete episodes of at least 60 s were recorded by the observer (feeding, drinking and preening). Walking failed to satisfy these criteria and can be more reproducibly studied by a treadmill technique (van Kampen, 1976).

Correlation and regression analysis showed that A accounted for 50% (r 0·70) of within-bird variation in photoperiod H and that a single A unit cost 0·2–0·4 J/kg body-weight$^{0.75}$ depending on the individual. The A/H relation was linear, indicating that an A unit had the same H cost whatever the type or intensity of behaviour; the A/min count was therefore multiplied by the mean cost of one A unit to give H/min. The results are given in the table.

Activity ...	Resting		Feeding		Drinking		Preening	
	Mean	SEM	Mean	SEM	Mean	SEM	Mean	SEM
Activity count (units/min)	0	0	320	64·9	243	48·5	313	50·7
Activity cost (J/kg body-wt$^{0.75}$ per min)	0	0	89	9·4	67	7·2	94	23·6
Total H (J/kg body-wt$^{0.75}$ per min)	340	14·8	430	8·3	407	12·1	434	21·1
Activity cost/resting H	0	0	0·27	0·039	0·20	0·026	0·28	0·075

Pre-oviposition behaviour and sleep each occurred once in one bird during visual observation. The former gave an A count of 610 units/min and an increase in H to 575 J/kg body-weight$^{0.75}$ per min (+58%). The latter gave negligible A and a decrease in H to 255 J/kg body-weight$^{0.75}$ per min (−30%), which was identical to the scotoperiod zero-A H and significantly lower than mean photoperiod zero-A H. Identifiable behaviour therefore produced a two-fold variation in the photoperiod H of the fowl, even when caged and socially isolated, although behaviour such as feeding, drinking and preening increased H by only 20–30% above the resting level.

MacLeod, M. G., Jewitt, T. R., White, J., Verbrugge, M. & Mitchell, M. A. (1982). *Proceedings of the 9th EAAP Symposium on the Energy Metabolism of Farm Animals* [A. Ekern and F. Sundstøl, editors]. Aas: Agricultural University of Norway.

van Kampen, M. (1976). *Journal of Agricultural Science, Cambridge* **87**, 81–84.

The usefulness of a questionnaire in predicting the types of food consumed in the subsequent period of 7 d. By L. STOCKLEY, F. A. JONES and E. HOGG, *AFRC Food Research Institute, Colney Lane, Norwich NR4 7UA*

One approach to improving the quality of food intake information is to use a microprocessor-based system. This has a number of advantages, which are described elsewhere (Stockley, 1984). However, if this system is to be used in the estimation of energy, protein, fat and carbohydrate intake, it is necessary to condense McCance and Widdowson's composition tables (Paul & Southgate, 1978) into food groups. Eighty-five food groups have been identified, and nutrient values obtained using these are currently being compared with values derived from analysis of duplicate diet collections (L. Stockley, F. A. Jones, R. M. Faulks, unpublished results). This study was undertaken to determine whether a questionnaire listing the eighty-five groups could be used to select those which an individual would consume over a 1-week period.

Eighty-five subjects were recruited from a random sample of households in an electoral ward in Norwich. They were interviewed in their homes and asked whether or not they would be likely to consume foods from each of the food groups in the following 3 weeks. At the end of the interview they were asked to keep a 7-d qualitative record of all food and drink ingested, with a note of items eaten outside the home. The record commenced within 2 weeks of the interview. After completion the diaries were collected, and coded by categorizing the items into the food groups in the questionnaire.

Consumption of commonly eaten foods, e.g. bread and milk, was well predicted by the questionnaire. Foods which were underestimated included plain biscuits, cakes, chips and cream. Foods which were overestimated included double crust fruit pie, jelly and shepherd's pie.

The mean number of meals eaten outside the home was 4·7 (SD 5·2)/week. The items most often eaten out were alcoholic and soft drinks and high-fat snack items, e.g. rich biscuits, cakes, cheese, cream, chips and chocolate. This observation is of relevance in the interpretation of dietary surveys which are confined to the home, e.g. the national food survey (Ministry of Agriculture, Fisheries and Food).

Using the information gained from this study the questionnaire should be of use in personalizing the microprocessor-based system. For example, if consumption of a commonly overestimated food is predicted, more detailed questions about usual frequency of consumption of the item will be asked. Foods which are likely to be underestimated will form a standard addition to a basic food group list obtained using the questionnaire.

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Calculation of nutrient intake by microcomputer. By S. BASSHAM and L. R. FLETCHER, *Department of Mathematics and Computer Science, University of Salford, Salford M5 4WT* (Introduced by C. WILLIAMS)

In order to assess the nutrient intake of an individual, or a group of people, it is necessary to know what has been eaten and the composition of the foods; then the total intake of the different nutrients and vitamins can be calculated. There are several methods of doing dietary surveys (Graham, 1982) and a standard UK data-base is available with about 100 nutrient values for nearly 1000 basic foods (Paul & Southgate, 1978; Paul *et al.* 1980). This paper concentrates on the computational problem involved in assessing nutrient intake.

Although complex mathematics is not needed, the calculations are laborious, time-consuming and subject to computational errors if done by hand. However, the problem is ideally suited for solution by computer and appropriate main-frame programs have been available for some years (Brereton *et al.* 1973; McConnell & Wilson, 1976). The University of Salford's dietetic software, 'Microdiet', was written for microcomputer, and one solution to the problem of storing 92 000 data items on a 130 mm (5″) floppy disc has recently been described (Bassham, 1984). Making such software available to those without access to main-frame computers, and the associated computing skills, means that programs must be as 'user-friendly' as possible and need a minimum amount of explanation and instruction.

'Microdiet' was written in response to the needs and suggestions of professional dietitians to include as many as possible of the facilities they request and enable them to spend more time on nutrition education and principles and less time on tedious arithmetic. It includes various ways of doing nutrient analysis and allows nutrient data to be inspected and, if necessary, updated. The data-base may be enlarged by the addition of extra foods and extra nutrient values for any food.

Co-operation between the University of Salford and qualified, working dietitians has ensured the professional usefulness of the 'Microdiet' software and it is clear that there are opportunities for further valuable work to be done as the sciences of nutrition and computing develop.

The software is available for purchase for use on a number of different types of microcomputer. Further details may be obtained from the authors.

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Metabolic balance studies in the very low birth weight infant. By M. REEVES[1], J. B. MORGAN[2]* and M. HALL[1], *Departments of* [1]*Child Health and* [2]*Nutrition, Faculty of Medicine, The University, Southampton, Hants SO9 5NH*

A previous report on the energy and nitrogen utilization of the low birth weight infant (<2·5 kg) suggested that a standard milk formula was unable to support the potential for gain in lean body tissue (Persaud *et al.* 1983).

The present study examined the growth and energy and N retentions in the very low birth weight infant (<1·5 kg) given (a) specialized milk formulae: SMA Plus (Wyeth Laboratories, Maidenhead, Berks) or Preaptamil (Milupa Ltd, Hillingdon, Middx), or (b) expressed breast milk (EBM) from the infant's mother.

Seven infants (one infant was studied on two separate occasions) were included in the study. They weighed (mean (SD)) 1089 (320) g and were 29 (4) weeks at birth. At the onset of the study they weighed 1280 (230) g and were 28 (20) d old. Eight double metabolic balances were performed using techniques described previously (Persaud *et al.* 1983). Pooled 24 h EBM samples were used for analysis of energy and N contents.

Details of metabolic balance trials for seven infants

	Milk formulae		EBM	
	Mean	SD	Mean	SD
Incremental weight (g/kg body-wt per d)	23	4	16	9
Incremental head circumference (mm/3 d)	2	1	2	2
Energy intake (kJ/kg per d)	605	40	550	60
Energy digestibility (%)	81	7	73	5
N intake (mg/kg per d)	639	56	635	129
Urinary N (mg/kg per d)	94	38	144	39
N retention (%)	60	11	53	9
Serum calcium (mmol/l)	2·3	0·1	2·3	0·1
Serum phosphate (mmol/l)	2·1	0·3	1·1	0·6

The mean gross energy content for EBM was lower than that for SMA Plus and Preaptamil (2820, 3360 and 3310 kJ/l respectively). The mean N contents of the milk were similar.

Oedema occurred in some infants given milk formulae but was not present in EBM-fed infants. A positive correlation was found between weight gain and mean digestible energy (r 0·587, $P<0·05$) and weight gain and N retention (r 0·587, $P<0·05$). N retention in five EBM balances and one formula balance did not reach intrauterine accretion rates (340 mg/kg per d) reported for the fetus in the third trimester (American Academy of Pediatrics, 1977). As the protein intake of the infants given EBM was adequate but their energy intakes were not, energy requirements may have been met through gluconeogenesis.

The addition of an energy supplement to EBM should be considered as part of the routine clinical management of these infants.

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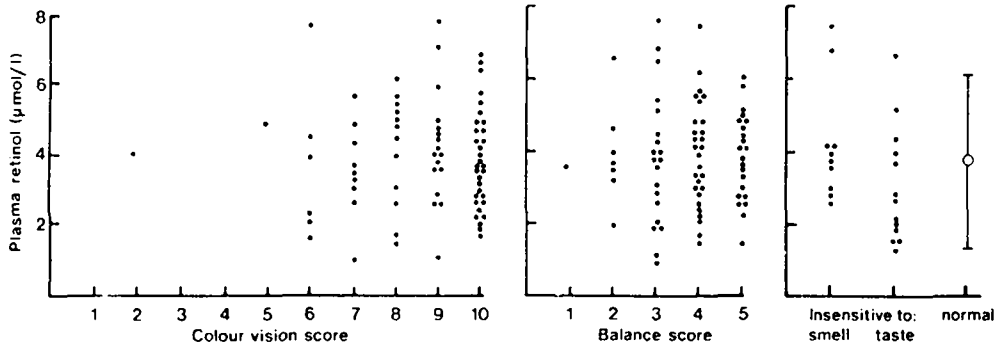
Colour vision, balance and impairment of the senses of taste and smell do not predict children at risk of vitamin A deficiency. By JUSTIN A. VALE, ATUL KAPILA and DAVID A. BENDER, *Courtauld Institute of Biochemistry, The Middlesex Hospital Medical School, London W1P 7PN*

Studies in Iowa during the 1960s suggested that early signs of vitamin A deficiency include impairment of colour vision, balance and the senses of taste and smell (R. E. Hodges, unpublished results, personal communication). This study was undertaken in rural western Java (Indonesia) in order to determine whether similar impairment might provide a means of screening for children at risk of vitamin A deficiency.

Children (106) aged between 4 and 7 years were studied. Plasma from 100–200 μl capillary blood was separated and frozen in sealed capillary tubes until it was returned to London for measurement of retinol, using trifluoroacetic acid (International Vitamin A Consultative Group, 1983). Colour vision was assessed using standard paediatric charts (10 = unimpaired) and the ability to balance was assessed by asking each child to walk along a 10 m straight line (5 = no deviations). The ability to discriminate smells (peppermint and pineapple essences) and taste (salt and sugar solutions placed on the tongue) was assessed.



As can be seen from the figure, few of the children had low plasma concentrations of retinol. A significant number showed impairment of colour vision, balance or the senses of taste and smell. These did not correlate with the plasma concentration of retinol.

It is concluded that such simple assessments are unlikely to be useful to detect children at risk of vitamin A deficiency.

J.A.V. and A.K. thank ISFE, the International Foundation for Nutrition Education and Research, Zurich, and the Middlesex Hospital Club for travel grants.

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A survey of the nutrient status of the elderly. By J. R. KEMM, *Department of Social Medicine, University of Birmingham* and J. L. SKINNER and P. A. WESTON-SMITH, *Littlewick Health Centre, Ilkeston*

A survey of biochemical indicators of nutritional status of elderly people living in the town of Ilkeston, Derbyshire was carried out from November 1982 to July 1983. The age/sex register of a group practice of general practitioners was used as a sampling frame and a sample was drawn consisting of all patients aged 85 or more, one-third of those aged 75–84 and any patient living in the same house as one of these patients.

The patients were visited at home by a research health visitor who completed a health and social status questionnaire, took a blood sample and made anthropometric measurements. The blood was analysed for haemoglobin, albumin, plasma vitamin C, retinol, retinol-binding protein, erythrocyte glutathione reductase (NAD(P)H) (*EC* 1.6.4.2; EGR) and transketolase (*EC* 2.2.1.1; TK) by methods specified by Kemm & Allcock (1984), except for albumin which was done by the Brom Cresol Purple method. Significance between groups was tested by Mann Whitney U test.

The mean values of each measurement for each age/sex group are shown in the table. 'Abnormal' values were frequently found. Thirty-one out of 136 had plasma vitamin C levels <2·0 mg/l, forty-five out of 124 had EGR activation coefficients (EGRAC) >1·35 and thirteen out of 132 had TK activation coefficients (TKAC) >1·25. The values found for vitamin C were similar to those reported by Burr *et al.* (1974) but lower than those found in the Department of Health and Social Security (DHSS) (1979) survey. The TKAC were similar to those found in other surveys (DHSS, 1979; Vir & Love, 1979).

	Male						Female					
Age (years) . . .	75–84			⩾85			75–84			⩾85		
	Mean	SD	*n*	Mean	SD	*n*	Mean	SD	*n*	Mean	SD	*n*
Albumin (g/l)	34·5	3·3	51	32·1	2·8	17	33·8	3·3	84	32·4	3·6	45
Vitamin C (mg/l)	2·8	1·6	31	3·6	2·5	13	3·4	1·8	53	3·5	2·4	34
Retinol (μg/l)	625	179	33	716	224	14	732	209	61	695	219	36
EGRAC	1·37	0·24	29	1·29	0·21	11	1·31	0·31	47	1·35	0·24	32
TKAC	1·11	0·19	31	1·17	0·20	13	1·05	0·10	51	1·05	0·15	32

Males tended to have lower vitamin C levels ($P = 0·11$) and higher TKAC ($P = 0·02$) than females. Those who were confused (mental score <6/10) tended to have lower vitamin C ($P = 0·003$) and higher EGRAC ($P = 0·09$) than those who were not confused. Those who reported a poor appetite and those who reported eating small meals did not have values significantly different from those who reported a good appetite or eating large meals.

The support of BENCARD for this investigation is gratefully acknowledged.

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Digestible and metabolizable energy values of lactitol and lactulose for the rat and miniature pig. By SUSAN P. BIRD, DAVID HEWITT and MICHAEL I. GURR, *National Institute for Research in Dairying, Shinfield, Reading RG2 9AT*

Lactitol (4-O-β-D-galactopyranosyl-D-sorbitol) has many potential applications in the food industry because of its chemical and physical properties. It is prepared by the catalytic hydrogenation of lactose with Raney nickel, the lactose being in plentiful supply as a by-product of the dairy industry. Mammalian enzymes hydrolyse lactitol little, if at all, hence its nutritional contribution in terms of energy has been assumed to be small, but there are no published figures. Lactulose (4-O-β-D-galactopyranosyl-D-fructofuranose) is another lactose derivative. It has found medical applications as a laxative and in the treatment of portal systemic encephalopathy. The quantities prescribed can be considerable, up to 120 g/d, but the contribution of this sugar to the energy metabolism of the patient is not considered and no energy values are available. Digestible and metabolizable energy values have been determined by balance experiments in young, female hooded rats and young, female Gottingen miniature pigs, and are shown in the table. Lactitol was included in the test diet at a level of 100 g/kg for both the rats and mini-pigs. Lactulose was given to the mini-pigs at a level which depended on their individual tolerance and ranged from 190 g/kg to 310 g/kg diet. The rats received the lactulose in the diet at a level of 75 g/kg.

Digestible energy (DE) and metabolizable energy (ME) values (kJ/g)

	Lactitol					Lactulose				
		DE		ME			DE		ME	
	n	Mean	SEM	Mean	SEM	*n*	Mean	SEM	Mean	SEM
Rat	12	12·33	0·44	11·85	0·77	6	9·94	0·81	8·42	1·05
Mini-pig	6	9·20	1·28	9·78	1·54	6	9·30	0·84	9·00	0·79

There was considerable variation between individuals, although the low levels of sugars tested may have contributed to this. Energy values of the diets were quite precise (coefficients of variation were 0·007 and 0·013 respectively for DE and ME in the rat and corresponding values for the pig were 0·025 and 0·027).

The results indicate that for both sugars considerable digestion occurred and digested energy was almost completely metabolized. For both dietetic and medical use the energy values of these sugars should be considered.

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The analysis of bile acids in rat faeces with reference to colonic cancer.

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Bile acids and neutral steroids have been implicated in the pathogenesis of colonic cancer on the basis of high concentrations of faecal bile acids found in some high-risk populations (Hill, 1977). It has also been suggested that certain steroids may be converted by colonic bacteria to cocarcinogens in human large bowel cancer (Reddy *et al.* 1975).

Several studies have shown that the rat is a good animal to use for the induction of intestinal tumours by chemical carcinogens such as azoxymethane and 1,2-dimethylhydrazine (Nigro *et al.* 1973). The detailed analysis of faecal bile acids is important in these studies but the methods are complex and unsuitable for routine work. In the present study we have applied the method which we have been using for human faeces (Sian & Rains, 1979) with suitable alterations for the analysis of faecal bile acids in the rat.

Nineteen male Wistar rats, weighing approximately 220–250 g and housed in four cages (5, 4, 5, 5), were given a standard diet and water *ad lib.* Faecal pellets from each cage were collected for 3 d and stored at −20° until analysed. For analysis, the sample was freeze-dried and powdered. Duplicate samples of the dry powder (0·5 g) were taken through extraction, hydrolysis and methylation followed by gas chromatography of bile acid methyl esters. For individual bile acids, the methyl esters were analysed on a QF-1 column. For quantification, methyl ester derivatives were analysed using 23-*nor*-deoxycholic as an internal standard.

From preliminary results of duplicate analysis, the bile acid excretion per animal from each cage was 1·99, 2·20, 3·22 and 1·81 mg/d (mean 2·3 (SD 0·59), *n* 8). The main bile acids included lithocholic, deoxycholic, chenodeoxycholic, hyodeoxycholic and cholic acids. Several small peaks were not identified.

The method was found to be suitable for both the individual and total bile acids in rat faeces and has a number of advantages such as technical simplicity, processing of multiple samples, speed of analysis and safe method for methylation.

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