THE EFFECT OF FOOD SUPPLEMENTS ON POORLY FED WORKERS IN BRUSSELS IN JANUARY, 1945

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In a previous paper (Bastenie, Macrae, Smart, and Yudkin, 1945) the diet of the families of a group of employees at a works in Brussels was described in detail. In order to determine whether the theoretical deficiencies which were found to exist had caused any marked deterioration the effects of the addition of a known supplement to the diet of these men have been investigated. This paper gives an account of the work.

Methods

Experimental Plan

The men, 18 in number, were divided into Groups A and B, containing 10 and 8 subjects respectively. During a preliminary control period of one week two 24-hour samples of urine were collected four and two days before the beginning of the experiment; throughout this period the men were given practice on the use of a dynamometer, and on the last day each man was weighed, the strength of his grip was measured, and an estimate was made of the degree of irritability of his biceps muscle to mechanical stimulation.

A highly nutritious food supplement (Table I) was given to Group A for ten days—designated the first experimental period. During this time Group B received no supplementary food and acted as a control. Four 24-hour samples of urine were collected from each member of both groups on the first, fourth, seventh, and tenth days, and at the end

of the period the weight, grip strength, and muscle irritability were again determined. At each examination care was taken that the subjects arrived in random order so that the observer did not know to which group they belonged.

For three weeks after the first experimental period none of the men in either group received any supplement. During this time, however, one man in Group B became ill and retired from the experiment, and two new men were allocated to this group. A second experimental period of ten days began at the end of the three-weeks interval. Measurements were made of weight, grip strength, and muscle irritability at the beginning and end of the second experimental period, but no samples of urine were collected. During these ten days the men in Group B received a supplement of food similar to but not identical with that given in the first experimental period (Table II), whereas those in Group A received no supplement and acted as controls. During both periods the supplement was consumed under supervision, and emphatic instructions were given to all the subjects that they must continue to eat the usual amount of food at home. Unfortunately supervision could not be exercised over their intake at home.

Measurement of Weight.—The men were weighed at approximately 10.30 a.m. on each occasion. Trousers, trunks, and stockings were worn, but the rest of the clothes were removed before weighing.

Estimation of Grip Strength.—The strength of the grip of the right hand (all subjects were right-handed) was determined on a grip dynamometer, with the right arm close to but not touching the side of the body, the elbow flexed to a right-angle, and the forearm fully supinated and parallel with the ground. Practice was allowed for several days, and when this appeared to be sufficient the estimations were made. Five readings were taken at intervals of 30 seconds. There was no evidence of tiring.

Estimation of Muscle Irritability.—In order to estimate the irritability of the biceps muscle to mechanical stimulation the elbow was flexed to approximately a right-angle, the forearm supported, and the subject told to relax his arm muscles as fully as possible. The centre of the biceps muscle belly was then gripped transversely and quickly nipped and rolled between the observer's thumb and forefinger, the operation being somewhat painful to the subject.

TABLE I.—Daily Intake of Nutrients by Subjects Receiving Food Supplement During Period 1

	Kilo-calories	Protein	Fat	Carbo-hydrate	Calcium	Iron	Vitamin A	Aneurin	Nicotinic Acid	Ribo-flavin
		(g.)	(g.)	(g.)	(mg.)	(mg.)	(i.u.)	(μg.)	(mg.)	(μg.)
Sweet egg block (58 g.)	334	17.1	22.3	15.5	203	3.5	1,055	37	0.4	627
Dehydrated cheese block (58 g.)	394	20.0	33.3	0	626	0.5	1,045	22	0.2	346
Milk block (25 g.)	136	4.9	8.0	11.0	180	0.1	298	48	0.2	250
Egg custard block (44 g.)	255	9.3	16.5	16.4	248	0.8	440	62	0.1	377
Cocoa block (25 g.)	129	5.0	7.0	11.5	3	0.8	205	39	0.2	196
Total from supplement	1,248	56.3	87.1	54.4	1,260	5.7	3,043	208	1.1	1,796
Estimated nutrition value of normal ration*	2,460	74.2	50.0	428.3	488	17.3	6,900	1,887	14.1	1,280
Estimated total intake	3,708	130.5	137.1	482.7	1,748	23.0	9,943	2,095	15.2	3,076

* Calculated from data given in previous publication (Bastenie *et al.*, 1945).

TABLE II.—Daily Intake of Nutrients by Subjects Receiving Food Supplement During Period 2

	Kilo-calories	Protein	Fat	Carbo-hydrate	Calcium	Iron	Vitamin A	Aneurin	Nicotinic Acid	Ribo-flavin
		(g.)	(g.)	(g.)	(mg.)	(mg.)	(i.u.)	(μg.)	(mg.)	(μg.)
Sweet egg block (58 g.)	334	17.1	22.3	15.5	203	3.5	1,055	37	0.4	627
Dehydrated cheese block (58 g.)	394	20.0	33.3	0	626	0.5	1,045	22	0.2	346
Milk block (50 g.)	272	9.8	16.0	22.0	360	0.2	596	96	0.3	501
Dehydrated beef (50 g.)	280	25.0	20.0	0	8	6.0	75	15	7.0	700
Total from supplement	1,280	71.9	91.6	37.5	1,197	10.2	2,771	170	7.9	2,174
Estimated nutrition value of normal ration*	2,460	74.2	50.0	428.3	488	17.3	6,900	1,887	14.1	1,280
Estimated total intake	3,740	146.1	141.6	465.8	1,685	27.5	9,671	2,057	22.0	3,454

* Calculated from data given in previous publication (Bastenie *et al.*, 1945).

In all subjects a raised ridge appeared in the region stimulated (see illustration). The time during which this ridge persisted was taken as an index of the irritability of the muscle. Five estimations, all on the right biceps muscle, were made on each occasion.

Photograph showing response of biceps muscle to mechanical stimulation.

Urinary Analysis.—The total volume of each of the 24-hour samples of urine was measured, and after acidification with 4 ml. of 2N. H_2SO_4 , per 100 ml., was kept for analysis. The total nitrogen was estimated by the Kjeldahl method.

Food Supplements.—All subjects normally had a small midday meal at the works. During the periods of supplementation the experimental groups received highly nutritious dehydrated foods at midday in addition to their normal factory meal. The food supplements consisted almost entirely of milk, cheese, butter, and eggs; in the second experimental period beef was added. The nutritive value of the supplements given during the two periods is shown in Tables I and II, respectively. The dehydrated food, apart from the beef, was specially prepared by the Low Temperature Research Station, Cambridge. After dehydration the food was moulded into blocks each weighing about 50 g. and suitable for one helping (see de Rousset-Hall and Ingram, 1945). The advantages of this arrangement are many: there is no need to weigh the food before each meal, since it is only necessary to count a suitable number of blocks for reconstitution; there is an assured uniformity in the food given on different days, since the whole of the amount required for the experiment can be prepared in advance; the keeping qualities are excellent: the low weight and small bulk facilitate transport; and the uniformity of the experimental diet enables a great saving to be made in the analysis of foodstuffs.

Results

The average values of weight, grip, and muscle irritability of subjects are shown with the appropriate standard errors in Table III. It will be seen that, whereas there were no significant changes during the experimental periods in the control group, the group which received a supplement in

both experimental periods did change, there being an increase in weight and grip and a decrease in the length of time for which local contraction of the biceps muscle persisted after mechanical stimulation.

The results obtained from these measurements may be expressed in a different way. Seventeen of the subjects were on different occasions in both the experimental and the control group. The different changes in these individuals when they acted in each capacity may therefore be com-

TABLE IV.—Average Difference in Change in Weight, Grip, and Muscle Irritability of 17 Subjects When Acting as Control and When Receiving Supplementary Food

Observation	I. Average Change While Acting as Controls	II. Average Change While Receiving Food Supplement	Difference in Changes (II-I)	S.E.	t	P
Weight (kg.) ..	+0.159	+1.271	+1.112	0.30	3.71	0.001
Grip (kg.) ..	+0.71	+3.18	+2.47	0.72	2.91	0.01
Muscle irritability (secs.)	-0.43	-1.76	-1.33	0.46	2.84	0.012

pared. Table IV presents the results expressed in this way. It will be seen that the differences are not likely to be due to chance.

The average urinary nitrogen values for the first experimental period are shown in Table V. Two subjects have

TABLE V.—Average Urinary Nitrogen Excretion on Certain Days During the Preliminary Period and Period I

Group	No. of Subjects	Before Experimental Period		Experimental Period			
		4th Day	2nd Day	1st Day	4th Day	7th Day	10th Day
A (experimental) ..	8	(g.) 9.05	(g.) 7.98	(g.) 9.92	(g.) 12.67	(g.) 10.86	(g.) 10.15
B (control) ..	7	(g.) 8.23	(g.) 10.74	(g.) 10.97	(g.) 10.97	(g.) 10.87	(g.) 10.57

Significance of differences of changes in Groups A and B: $P = 0.053$

been excluded from Group A and one from Group B in calculating these averages, since the 24-hour specimens of urine presented by them were obviously false. Both the experimental and the control group showed a significant increase in urinary nitrogen excretion during the experimental period; although the increase was somewhat greater in the experimental group than in the control group, this might possibly have been due to chance.

Discussion

The workers under investigation obtained from their ordinary diet about 12 g. of nitrogen a day (Bastenie *et al.*, 1945). They excreted 9 g. in the urine, and, assuming the faecal excretion to be about 1.5 daily and that the same amount was lost in sweat (Cuthbertson, McCutcheon, and Munro, 1937), it would seem that they were in nitrogen equilibrium.

TABLE III.—Effect of Food Supplements on Weight, Grip, and Muscle Irritability

	Group	Period 1 (Group A: Food Supplement) (Group B: Control)				Period 2 (Group A: Control) (Group B: Food Supplement)			
		Mean at Beginning of Period	Mean at End of Period	Mean Change During Period	S.E. of Change	Mean at Beginning of Period	Mean at End of Period	Mean Change During Period	S.E. of Change
Weight (kg.) ..	A	63.1	64.4	1.3	0.33	64.1	64.3	0.2	0.25
	B	60.6	60.6	0.0	0.27	59.2*	60.5*	1.3	0.29
Grip (kg.) ..	A	44.8	47.8	3.0	1.11	47.3	48.1	0.8	0.70
	B	42.0	42.1	0.1	0.89	40.6*	44.0*	3.4	0.58
Muscle irritability (secs.)	A	4.65	2.67	-1.98	0.59	2.83	2.75	-0.08	0.25
	B	4.43	3.62	-0.81	0.51	3.87*	1.97*	-1.90	0.40

* One subject is not included in these figures, as he became ill during the second experimental period. Two new subjects are included in Group B for the same period.

While the men were acting as experimental subjects both the protein and the calorie intakes were increased to a theoretical level of about 130–145 g. of protein and 3,700 calories daily. It was of course impossible to guarantee that they ate as much at home as they did when not receiving the supplement, although they were asked to do so: the above values are maxima, and it is probable that the actual total intakes were somewhat lower.

Under the dietary conditions resulting from the consumption of the highly nutritious food supplement the daily urinary output of nitrogen rose from an average of 8.5 g. to 10.9 g., an increase of only 2.4 g.; the control Group B showed an increase from 9.5 g. to 10.8 g. In Group A, allowing for sweat and faecal loss, there must have been a total daily elimination of nitrogen per man of about 14 g. Since, provided the experimental subjects continued to eat the same foods at home when they were receiving the supplement, they had a daily nitrogen intake of about 21 g. per man, they must have retained about 7 g. of nitrogen per man daily. According to Rubner (1898), 1 g. of retained nitrogen gives 33 g. of tissue, mostly muscle. Thus in ten days the experimental subjects (Group A) should have gained 2.3 kg. In fact, they gained on the average 1.3 kg. This difference between the theoretical gain in weight and that which was actually found was not likely to be due to a loss in body fluids, since the 24-hour urinary volumes of subjects in Group A were never significantly different from those of the control subjects or from the volumes obtained during the preliminary period. It is improbable that either the experimental error or inaccuracies in Rubner's factor could account for all the discrepancy, and it seems most likely that the men did not in fact continue to eat the same amount as usual in their homes while receiving the experimental supplement. If we assume that Rubner's factor is reasonably accurate, they should have been receiving 100 g. of protein per man daily; in other words they must have consumed about 60% of the protein in their normal daily ration at home while receiving the food supplement. Cuthbertson *et al.* (1937) and Cuthbertson and Munro (1937) showed that subjects who were adequately fed retained over a period of eight days about 40% of the nitrogen of a milk or similarly constituted food supplement to their normal diet. In the present experiment the food supplement had a calorie-protein ratio similar to that of the supplement fed by Cuthbertson *et al.* The subjects in Group A excreted on the average an extra 2.4 g. of nitrogen per man daily while receiving the supplement and those in Group B (control) 1.3 g. during the same period. Thus it can be considered that the extra food received by Group A resulted in an increase in the daily urinary nitrogen excretion of about 1 g. per man, which on the basis of Cuthbertson's findings would have resulted from an extra intake of about 1.7 g. of nitrogen or about 10 g. of protein. They were, however, supposed to be receiving an extra 56 g. of protein per man daily, and, calculated theoretically on their gain in weight, using Rubner's factor, they received at least 25 g. extra per man daily. The nitrogen retention from the food supplement was thus more than twice as great as that found by Cuthbertson *et al.* (1937) and Cuthbertson and Munro (1937) for normally fed individuals. On these grounds it seems reasonable to conclude that the experimental subjects were in equilibrium on a plane of nitrogen metabolism lower than that encountered in subjects who are considered to be well fed.

There was a gain in grip strength and a decrease in muscle irritability to mechanical stimuli during the experimental period, and it is of interest to consider whether these factors can be related to the gain in weight or to the nitrogen retention. Consideration of the variations in weight, grip,

and muscular irritability of each of the subjects in the present investigation revealed no significant correlation between change in weight and change in muscle irritability or change in grip strength, between nitrogen retention and change in muscle irritability or change in grip strength, or between change in muscle irritability and change in grip strength.

The abnormal irritability of muscles to mechanical stimuli was first described by Schiff (1858–9) and later investigated in greater detail by Curschmann (1905), Langley and Hashimoto (1918–19), and Denny-Brown and Pennybacker (1938). There is no very definite evidence that would indicate which biochemical lesion produces the hyperirritability; the most that can be said is that the phenomenon is increased by the conditions which interfere with normal muscle metabolism. There seems to be little doubt that the duration of the ridge in the Belgian workers (about 4.5 seconds) was abnormally long before they received the supplement (the mean duration in healthy R.A.F. subjects has been found to be 2.1 seconds), and that the supplementation did result in a decrease in the duration of the phenomenon. Initially also there was a strikingly significant inverse correlation between the strength of grip and the duration of the ridge of localized contraction following mechanical stimulation ($r = -0.77 \pm 0.092$).

The gain in grip strength which occurred during supplementation is also statistically significant, but unfortunately it is impossible to eliminate the psychological factor. There is likely to be a greater urge to try hard in a subject who is receiving extra food than in one who is living on short rations, and it is impossible to provide a "dummy" substitute for food in control subjects.

In conclusion it has been shown that the addition of supplementary foodstuffs to the defective diet of Belgian workers produced a considerable retention of nitrogen, a gain in weight, an increase in muscle strength, and a decrease in the irritability of muscle to mechanical stimuli. None of these changes, however, could be correlated when consideration was given to the changes occurring in each individual, nor was it possible to correlate any of the changes with the intake of any particular nutrient.

Summary

A group of workers in Brussels in 1945 who were receiving inadequate food were given a supplement to correct the deficiency, and the effects of this supplement on the weight, the grip, the urinary nitrogen excretion, and the irritability of muscle to nipping were measured; their values were compared with those given by a control group receiving no supplement.

The average weight increased significantly in the experimental groups during the ten days of supplementation, as did the strength of the grip; the duration of the local contraction of the biceps muscle which followed mechanical stimulation decreased significantly.

There was a marked retention of nitrogen during the period of supplementation; the large increase in protein nitrogen intake resulting from consumption of the supplement caused no pronounced increase in urinary nitrogen output.

The significance of myotatic irritability has been discussed and an inverse correlation was shown to exist between it and strength of grip.

No relationship could be demonstrated between individual changes in weight, nitrogen retention, grip, or muscle irritability.

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willingly submitting to the experimental procedures. The determinations of urinary nitrogen were carried out by Flight-Sergeant G. A. Childs under very great difficulties, and we accord him our thanks and appreciation.

An essential for the carrying out of this experiment was the provision of food blocks, and we thank Dr. F. Kidd, the then Director of the Low Temperature Research Station, Cambridge, and Dr. M. Ingram and Mr. O. de Rousset-Hall of his staff, who supervised the manufacture of the blocks.

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VIABILITY OF STRANGULATED BOWEL

INTERIM REPORT OF SURGICAL SUBCOMMITTEE OF THE CLINICAL RESEARCH COMMITTEE OF THE PUBLIC HEALTH DEPARTMENT OF THE LONDON COUNTY COUNCIL*

This committee is at present organizing a study of the condition and fate of strangulated bowel, with the object of determining the correct operative procedure to be undertaken when confronted with recently strangulated bowel of doubtful viability, and the following preliminary conclusions have been drawn from an initial series of 336 operations.

The main statistical tables form appendices to this report. Where statements in the report require more detailed statistical illustrations reference is given (by a letter in parentheses) to the appropriate paragraph of the notes which follow the main tables.

Causes of Strangulation

In the whole series of cases—68 (20.2%) of which were fatal—the percentage distribution of causes of strangulation, which excluded intussusception, was as follows:

Hernia	Inguinal	31.8	91.9
	Femoral	46.9	
	Umbilical	4.5	
	Incisional	4.8	
	Obturator	1.2	
	Internal	2.7	
By band or adhesions		6.0	2.1
By volvulus		2.1	

Ultimate Condition of Strangulated Bowel

The main object of the research—namely, the discovery of the features which give a clue to the ultimate fate of the strangulated bowel—may be approached in several ways. These may be briefly enumerated and commented on as follows:

1. If a patient dies of bowel gangrene after the strangulated bowel has merely been replaced in the abdomen when dealing

*The members of the surgical subcommittee are: Mr. J. E. Piercy, New End Hospital; the late Mr. G. F. Stebbing, Lambeth Hospital; Mr. N. C. Tanner, St. James Hospital; Mr. J. R. M. Whigham, St. Andrew's Hospital; †Mr. C. R. Boland, Mile End Hospital; †Mr. F. D. Murphy, Fulham Hospital. The convener of the subcommittee was Mr. Tanner, who with Mr. Stebbing was mainly responsible for the report. The statistical analysis was made by the staff of the statistical section of the Public Health Department under the direction of Mr. B. Benjamin.

† Left the Council's service before the completion of the report.

with the strangulating agent, and this has been confirmed at necropsy, then the state of the bowel as noted at operation will give valuable information. The following three cases were reported in which this had occurred.

(i) Case A. B., aged 53. Necrotic purulent ulceration of the mucosa was noted at necropsy. Death occurred eight days after operative relief of strangulation. At the operation it was recorded that 400 cm. of the whole circumference of small bowel was involved, partly by strangulation, partly by secondary mesenteric thrombosis, and that it was plum-coloured with white constriction rings. After release of the strangulation it remained plum-coloured. The bowel was flabby but the surface was shiny, and muscular contractions of the wall were seen. Oxygenation of the patient caused no change in the colour of the bowel. Pulsation was present in the mesenteric vessels.

(ii) Case C. D., aged 34. Gangrene of bowel was discovered at necropsy. Death occurred seven days after operative release of the strangulation. At the operation 50 cm. of the whole circumference of small bowel was found to be plum-coloured but shiny, with normal tonus in the wall. Muscular contractions were seen. Pulsation was present in the mesenteric vessels.

(iii) Case E. F., aged 83. Gangrene of bowel was discovered at necropsy. Death occurred 13 days after operative release of the strangulation. At the operation 60 cm. of the whole circumference of small bowel was found to be plum-coloured but shiny, with oedema of the wall. Muscular contractions were seen. Pulsation was present in the mesenteric vessels.

In each of these cases 50 cm. or more of bowel was involved, but the state of the bowel as noted at operation was no worse than that in many cases which recovered. It seems a reasonable conclusion that risk of subsequent gangrene is greater where a long length of bowel is strangulated than where a short length is involved [Appendix II, (a)].

2. If a patient has a secondary operation for gangrene or damage of bowel after having had a simple "replacement," "untwist volvulus," or "divide constricting band," then the state of the bowel as noted at the original operation would give important data. No case was reported in which total gangrene of a segment of bowel occurred after replacing it in the peritoneal cavity, but in two cases stenosis of the bowel, with peritoneal adhesions, supervened, suggesting that some degree of mucosal and perhaps peritoneal damage had occurred and that the replaced bowel was on the borderline of viability:

(i) Case G. H., aged 51. Had replacement of bowel 30 hours after the onset of hernial strangulation. State at original operation: 12.5 cm. of small intestine was strangulated, black in colour, with grey constriction rings, improving in colour after release of strangulation. Surface of bowel was shiny, and wall flabby; muscular contractions in bowel wall were absent, and pulsation in mesenteric vessels was present. Thirty-six days later a second operation was necessary and 20 cm. of ileum was resected for adhesion and stenosis.

(ii) Case J. K., aged 44. Had replacement of 7 cm. of small intestine 9½ hours after onset of strangulation. At the operation the bowel was plum-coloured and oedematous, with a shiny surface which became mottled after release of strangulation. There were muscular contractions in the bowel wall and pulsation in the mesenteric vessels. Gripping abdominal pains followed after discharge from hospital, and 28 days after the first operation a second operation was necessary and the previously strangulated bowel was seen to be stenosed, with peritoneal adhesions.

3. An examination was made for cases where bowel, coloured before or after release of strangulation black, grey, green, or yellow, was replaced. There were 20 patients with bowel of one of these colours, of whom 14 survived, giving a mortality of 30%. Among 216 "replacement" cases in which the bowel colour was normal the mortality was only 9.7% ($\chi^2=7.42$; $P=0.006$).