MATERNAL AND NEWBORN NUTRITION STUDIES AT PHILADELPHIA LYING-IN HOSPITAL*

NEWBORN STUDIES. I. SIZE AND GROWTH OF BABIES OF MOTHERS RECEIVING NUTRIENT SUPPLEMENTS

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THE Nutrition Study carried on at the Pennsylvania Hospital from 1947 to 1952 was designed to investigate the effect of the addition of protein and vitamin supplements to the diets of pregnant women upon the outcome of their pregnancy and upon the physical status of their infants. The previous reports from the Study have dealt primarily with the first of these two questions, and it is with the second, the relationship between supplementation of the maternal diet and the physical status of the baby, that this report is concerned.

Under the plan of the study, women coming to the Clinic of the Hospital during the first 16 weeks of pregnancy were referred to the Nutrition Clinic. There they were assigned to one of four groups, on a random basis controlled for race, age, and gravida. One group was designated as the control and was given no nutritional supplement, a second group was given vitamins only, the third group a protein supplement only, and the fourth group was given both vitamins and the protein supplement.[4] Uniform diet instructions were given to the women

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[4] The nutrient supplements used in this study are: Therapeutic polyvitamin concentrate (Upjohn's Zymacaps and E. R. Squibb & Sons' Theragran) three capsules per day; Protein concentrate (Mead Johnson & Company's Protenum), to furnish 50 gms. of protein daily if taken as advised.

in all four groups during their first visit to the Clinic, and were reemphasized at several subsequent visits. At birth, all infants were placed on the same regime in the hospital, and the mothers were given the same diet instructions and vitamin supplements for their babies.

The physical status of the infants of the women in each of these four groups has been evaluated in terms of weight, crown-sole length, and chest circumference at birth and at one, two, and three months. The study groups have been compared on the basis of the mean values of these measurements to estimate the influence of the nutritional supplements taken by the mother upon the physical status of her infant. The measurements were made in a uniform manner, and during much of the study, were done by the same pediatrician (A.R.).[5] The infants were weighed nude on a scale measuring in units of pounds and ounces and the weight was read to the nearest ounce. The crown-sole length was measured with the baby placed flat and straight on a board and the measurement was made from the plane tangent to the top of the head to the bottom of the heels. The measurement of chest circumference was made with a steel tape at the level of the xiphoid, normal to the body axis. Both length and chest circumference were measured in centimeters to the nearest tenth.

In this report twins and premature infants, defined as weighing less than $5\frac{1}{2}$ lbs. at birth, are excluded, as are babies born to mothers who had a serious chronic disease or syphilis.[6] From the interviews with the patients by the nutritionist and examination of the records of the amount of protein supplement provided each patient in the protein groups, it appeared that some had not taken the supplement in the desired quantity. In the present analysis, infants have been excluded if the mother took some of the protein supplement over a period of

[5] Measurements not done by Alexander Randall, IV, M.D. were done by Josephine Perlingiero Randall, M.D., and Thomas R. Boggs, M.D.

[6] Patients with chronic disease or syphilis referred to the Nutrition Research Clinic were carried but have been excluded from tabulations in this report. Chronic diseases excluded are essential hypertension, chronic heart classified II-a or higher, chronic nephritis, and chronic pyelitis.

several months but was given less than a total of 20 lbs. of the supplement compared with the scheduled maximum of 45 to 50 lbs.

The number of infants on whom acceptable measurements were made varied with the measurement and with the age of the infants. Birth weight is available for 1,141 infants divided among the groups as follows: 404 in the controls, 356 in the vitamin group, 185 in the protein group, and 196 in the vitamin and protein group. The number of measurements of length and chest circumference at birth is slightly less and still more attrition occurred in the population measured at one, two, and three months, since the mothers did not always bring their infants to the clinic for the regular monthly examination. The condition of these babies at birth was good as indicated by the appraisal by the pediatrician at the newborn physical examination. Two-thirds were rated as good or excellent and less than 3 per cent as poor.

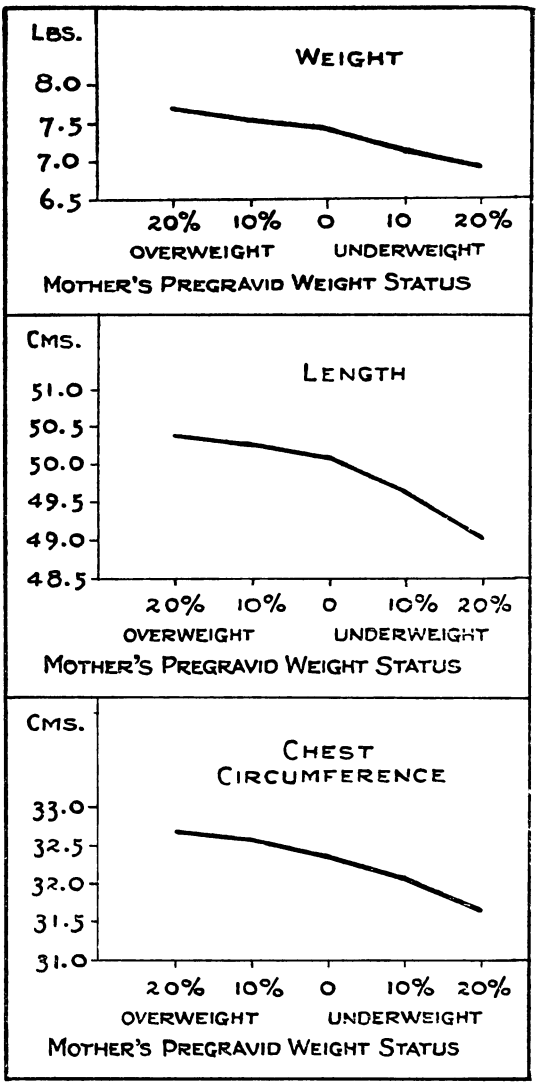

Fig. 1. Mean weight, length, and chest circumference at birth by mother's pregravid weight status.

Mother's Pregravid Weight Status	Weight (Lbs.)			Length (Cms.)			Chest Circumference (Cms.)		
	No.	Mean	Standard Error	No.	Mean	Standard Error	No.	Mean	Standard Error
Overweight 15 Per Cent or More	247	7.69	.07	227	50.36	.14	227	32.69	.12
Overweight 5–14 Per Cent	210	7.52	.07	195	50.24	.14	193	32.56	.13
Within 5 Per Cent of Normal	349	7.42	.05	321	50.06	.12	319	32.32	.09
Underweight 5–14 Per Cent	233	7.12	.06	219	49.61	.13	216	32.08	.11
Underweight 15 Per Cent or More	102	6.90	.07	95	49.01	.17	94	31.62	.16

Table 1. Mean weight, length, and chest circumference at birth by mother's pregravid weight status.

There was no difference among the study groups in the distribution of appraisals.

Previous analysis has demonstrated an association between prematurity and the pregravid weight status of the mothers. There is also a definite relationship, shown in Figure 1 and Table 1, between the birth measurements of non-premature infants and pregravid weight status.[7] The largest means for each measurement are found for infants of mothers 15 per cent or more overweight before pregnancy and the smallest are noted for babies of the most underweight mothers. Over the weight groups between these two extremes, the mean values decrease uniformly. This relationship is independent of the nutritional supplements taken by the mothers, being found for each of the four study groups.

The mean values for weight, length, and chest circumference at birth are shown in Table 2 for each study group. The mean

[7] Patients were carefully questioned in the Clinic as to their immediate pregravid weight and were measured for height without shoes. The standard weight for a specific height and age used is from the Report of the Medico-Actuarial Investigation 1912–1914 up to age 25 years. The average weight at 25 years is extended to older ages and the value used is the mid-point of the weight range for women of medium frame published by the Metropolitan Life Insurance Company.

Table 2. Mean weight, length, and chest circumference at birth by study group.

Study Group	Weight (Lbs.)			Length (Cms.)			Chest Circumference (Cms.)		
	No.	Mean	Standard Error	No.	Mean	Standard Error	No.	Mean	Standard Error
Control	404	7.45	.05	384	50.02	.11	383	32.29	.09
Vitamin	356	7.29	.05	315	49.85	.11	313	32.38	.10
Protein	185	7.40	.07	173	49.96	.15	171	32.17	.13
Vitamin and Protein	196	7.43	.07	186	50.06	.15	182	32.34	.12

Table 3. Mean weight, length, and chest circumference at birth of infants of mothers never transferred from assigned study group.

Study Group	Weight (Lbs.)				Length (Cms.)				Chest Circumference (Cms.)			
	Total	Total Nontransfers			Total	Total Nontransfers			Total	Total Nontransfers		
	Mean	No.	Mean	Standard Error	Mean	No.	Mean	Standard Error	Mean	No.	Mean	Standard Error
Control	7.45	300	7.48	.06	50.02	292	50.19	.12	32.29	290	32.32	.10
Vitamin	7.29	293	7.33	.06	49.85	257	49.90	.13	32.38	255	32.42	.11
Protein	7.40				49.96				32.17			
Vitamin and Protein	7.43				50.06				32.34			

birth weights for babies in the control group, the protein group, and the vitamin and protein group are about equal (7.40 to 7.45 lbs.) with the mean for those in the vitamin group being somewhat lower (7.29 lbs.). The four birth-weight means do not differ significantly[8] when tested by analysis of variance, but the means for the vitamin group is significantly smaller than the combined mean of the other three groups. The means of the crown-sole lengths at birth are in much the same pattern as were the mean birth weights, the control and the protein plus vitamin groups having the largest means, and the vitamin group the lowest. In contrast, the largest value among the means of chest circumference at birth is noted for the vitamin group (32.38 cms.) and the lowest among the protein group (32.17 cms.). However, the differences among the means of neither length nor chest circumference are statistically significant.

These mean measurements for the control and vitamin groups may have been affected by the inclusion of infants of mothers not originally assigned to these groups. Some patients allocated to the protein groups either could not or would not take the protein supplement. Of these women, those who had been assigned to the protein and vitamin group were transferred to the vitamin group, and those assigned to the protein group were transferred to the control group. None of these transfers took more than 10 lbs. of the protein supplement. In addition, a small number in the vitamin group who were unable to take the vitamin capsules were transferred to the control group. In order to evaluate the effect the transfer of these patients may have had upon the results for their study group, the mean measurements for infants in the control and vitamin groups were recomputed with the babies of the transfers eliminated, that is, with only the infants of patients originally assigned to these groups included. These means are shown in Table 3, and suggest that the babies of these transferred patients did tend to depress the mean values for their study group

[8] Statistical significance in this report implies $P \leq .05$.

Table 4. Mean weight, length, and chest circumference at birth by race, sex, and study group.

Study Group	White Males			White Females			Negro Males			Negro Females		
	No.	Mean	Standard Error	No.	Mean	Standard Error	No.	Mean	Standard Error	No.	Mean	Standard Error
	WEIGHT (LBS.)											
Control	160	7.58	.08	140	7.37	.08	47	7.47	.15	57	7.24	.15
Vitamin	145	7.39	.08	120	7.14	.08	48	7.51	.17	43	7.09	.13
Protein	75	7.56	.10	60	7.37	.12	30	7.23	.16	20	7.13	.21
Vitamin and Protein	87	7.62	.11	65	7.22	.11	25	7.30	.19	19	7.41	.25
	LENGTH (CMS.)											
Control	158	50.44	.16	127	49.79	.18	46	50.24	.34	53	49.16	.26
Vitamin	136	50.14	.19	105	49.51	.17	39	50.35	.33	35	49.19	.30
Protein	73	50.35	.20	54	49.76	.31	27	49.80	.40	19	49.24	.46
Vitamin and Protein	84	50.26	.25	60	49.83	.25	24	49.71	.36	18	50.39	.55
	CHEST CIRCUMFERENCE (CMS.)											
Control	156	32.41	.14	128	32.37	.13	46	32.17	.26	53	31.88	.26
Vitamin	135	32.64	.15	104	32.27	.17	39	32.32	.33	35	31.73	.27
Protein	72	32.49	.19	54	32.24	.23	26	31.69	.38	19	31.45	.39
Vitamin and Protein	82	32.68	.18	60	32.12	.15	23	31.63	.37	17	32.38	.35

to a slight extent. However, the overall pattern of means among the study groups is much the same, and the measurements for the infants of the transfers have been included in the tables which follow.

The mean values of weight, length, and chest circumference at birth are shown for each study group by race and sex in Table 4. The variation of the study group means within each race-sex group is not statistically significant except for the means of length for the Negro male babies. The relatively low mean weight in the vitamin group noted for the total population is found for each race-sex group except Negro males among whom this mean was largest. The lowest mean length for white males and females is also found in the vitamin group.

The data presented thus far do not give any substantial indication of a relationship between the nutritional supplement taken by the mother and the size of her infant at birth. The infants in the control group appear to be no different in weight or body dimensions than the offspring of mothers receiving the supplements. In fact, there is some suggestion that the babies in the vitamin group tend to be a little lighter at birth than those in the other groups.

In order to see whether this tendency for the babies in the vitamin group to have a smaller mean weight than those in the other three groups persists when factors which are known to influence the birth weight are allowed for, the means of the birth weight by race and gravida are given in Table 5, by gravida and age of mother in Table 6, and by race and mother's pregravid weight status in Table 7. A lower mean weight is noted for the vitamin group for babies of both white and Negro primagravidae and for white multigravidae. (Table 5.) The mean weight for this group was also lowest for infants of primagravidae in both age categories and of the older multigravidae. (Table 6.) This was also true for white infants of mothers in each pregravid weight-status classification but not for Negro babies. (Table 7.) Thus, it does not appear that the low mean weight in the vitamin group is related to the fac-

Table 5. Mean weight at birth by race, gravida, and study group.

Study Group	Primagravidae						Multigravidae					
	White			Negro			White			Negro		
	No.	Mean	Standard Error	No.	Mean	Standard Error	No.	Mean	Standard Error	No.	Mean	Standard Error
Control	122	7.37	.08	45	7.21	.16	178	7.57	.08	59	7.45	.14
Vitamin	99	7.21	.11	31	7.12	.16	166	7.34	.07	60	7.41	.14
Protein	55	7.34	.12	14	7.53	.25	80	7.55	.10	36	7.06	.15
Vitamin and Protein	62	7.25	.12	14	7.24	.21	90	7.60	.11	30	7.39	.20

Table 6. Mean weight at birth by age of mother, gravida, and study group.

Study Group	Primagravidae						Multigravidae					
	Under 25 Years			25 Years and Above			Under 25 Years			25 Years and Above		
	No.	Mean	Standard Error	No.	Mean	Standard Error	No.	Mean	Standard Error	No.	Mean	Standard Error
Control	123	7.38	.09	44	7.16	.12	76	7.40	.11	161	7.59	.08
Vitamin	88	7.21	.11	42	7.11	.16	66	7.53	.12	160	7.29	.07
Protein	42	7.43	.13	27	7.30	.20	35	7.31	.19	81	7.45	.09
Vitamin and Protein	58	7.26	.11	18	7.22	.26	36	7.76	.18	84	7.46	.12

Table 7. Mean weight at birth by race, mother's pregravid weight status, and study group.

Study Group	Underweight 5 Per Cent or More			Normal			Overweight 5 Per Cent or More		
	No.	Mean	Standard Error	No.	Mean	Standard Error	No.	Mean	Standard Error
	WHITE								
Control	88	7.06	.09	88	7.57	.10	124	7.73	.09
Vitamin	76	6.99	.09	86	7.37	.11	103	7.45	.10
Protein	39	7.17	.15	43	7.46	.10	53	7.68	.13
Vitamin and Protein	58	7.17	.12	50	7.46	.14	44	7.85	.17
	NEGRO								
Control	31	6.95	.16	22	6.91	.19	51	7.77	.16
Vitamin	22	6.91	.16	27	7.37	.21	42	7.48	.16
Protein	7	7.13	.28	19	7.49	.20	24	6.96	.19
Vitamin and Protein	14	6.92	.20	14	7.43	.28	16	7.66	.27

Table 8. Mean weight at birth by case number classes and study group.

Study Group	Case Number					
	1–999			1,000 and Above		
	No.	Mean	Standard Error	No.	Mean	Standard Error
Control	167	7.38	.08	237	7.51	.06
Vitamin	204	7.20	.07	152	7.43	.08
Protein	70	7.47	.11	115	7.36	.08
Vitamin and Protein	74	7.41	.12	122	7.45	.09

Table 9. Mean of the difference, birth weight minus expected weight, by study group, and by case number classes and study group.

Study Group	All Cases			Case Number					
				1–999			1,000 and Over		
	No.	Mean	Standard Error	No.	Mean	Standard Error	No.	Mean	Standard Error
Control	381	−.015	.026	152	−.156	.042	229	.078	.030
Vitamin	313	−.117	.029	168	−.222	.042	145	.003	.036
Protein	171	−.033	.033	61	−.132	.058	110	.024	.039
Vitamin and Protein	182	.009	.038	69	.018	.064	113	.006	.048

tors of gravida, age of mother, or mother's pregravid weight status, since the mean for this group generally remains low when these factors are held constant.

An unpublished analysis of data from the Nutrition Clinic showed that a decrease took place during the six-year period of the study in the occurrence of premature births. This suggested that there may have also been a trend toward higher average birth weights as the study continued. This hypothesis was investigated by classifying the infants of each study group into six classes according to their case number, computing mean birth weights for each class, and fitting trend lines for each study group to these means. It was found that the slopes of these lines do not differ significantly from zero, indicating that no uniform change in weights occurred over the period of the study. It may be seen, however, in Table 8, which shows the means for those with case numbers above and below 1,000, that the lower mean weight in the vitamin group is related to low weights among the early entrants in this group. The shift in mean weight in the vitamin group from 7.20 lbs. among the earlier cases to 7.43 lbs. among the later ones is of statistical significance, while this is not true for the changes in the other three groups.

The nutritional status of infants at birth has been evaluated in a previous report from the Nutrition Clinic (1) by calculating the difference between the birth weight and an expected weight derived from a multiple regression equation of weight, length, and chest circumference.[9] This index may take either positive or negative values, and the lower the value of the index the poorer the nutritional status is presumed to be. The means of this index for each study group are shown in Table 9

[9] These calculations were made from multiple regression formulae as follows:
(L = crown-sole length and Ch. = chest circumference.)
Whites, male and female:
Expected weight = .236 cms. L + .286 cms. Ch. − 13.59
Colored, male and female:
Expected weight = .133 cms. L + .420 cms. Ch. − 12.68
The formulae are based on data for babies born to patients of any pregravid weight status that were rated excellent or good in the first week of life by the pediatricians for the Nutrition Research Clinic.

Table 10. Mean weight, length, and chest circumference at birth, and 1 month, 2 months, and 3 months of age by study group.

Study Group	Birth	1 Month			2 Months			3 Months		
	Mean	No.	Mean	Standard Error	No.	Mean	Standard Error	No.	Mean	Standard Error
	WEIGHT (LBS.)									
Control	7.45	301	9.03	.06	222	11.21	.09	223	13.04	.11
Vitamin	7.29	281	8.84	.06	201	11.05	.09	213	12.88	.11
Protein	7.40	156	8.85	.08	105	11.19	.12	120	13.06	.14
Vitamin and Protein	7.43	148	8.96	.08	117	11.14	.12	117	13.12	.13
	LENGTH (CMS.)									
Control	50.02	303	54.07	.13	223	57.62	.14	223	60.58	.14
Vitamin	49.85	278	53.87	.13	203	57.34	.15	215	60.43	.16
Protein	49.96	156	54.01	.16	105	57.89	.20	122	60.62	.21
Vitamin and Protein	50.06	148	54.16	.18	116	57.69	.21	117	60.64	.22
	CHEST CIRCUMFERENCE (CMS.)									
Control	32.29	301	35.93	.10	223	38.46	.12	223	40.22	.13
Vitamin	32.38	272	35.74	.11	202	38.27	.12	213	40.26	.13
Protein	32.17	156	35.80	.14	105	38.57	.15	122	40.42	.16
Vitamin and Protein	32.34	147	35.87	.13	116	38.57	.15	117	40.53	.17

and that of the vitamin group (−.117) is significantly lower than those for the other three groups, indicating a less favorable nutritional status for the infants in this group. However, when the population is divided according to case numbers above and below 1,000, it may be seen that the poorer nutritional status of babies in the vitamin group is found only during the first part of the study. The mean index is significantly higher during the second part of the study for all infants except those whose mothers received both vitamins and the protein supplement. The nutritional index for infants in this latter group remains about the same over the entire study and is significantly higher than the means for the other three groups during the earlier part of the study.

The growth of the infants during the first three months after birth is indicated in Table 10, giving the means of the three measurements at birth, and one, two, and three months of age

Table 11. Per cent increase in the means of weight, length, and chest circumference from birth to 1 month, 2 months, and 3 months of age, by study group.

Study Group	Per Cent Increase from Birth to:		
	1 Month	2 Months	3 Months
	WEIGHT		
Control	21.2	50.5	75.0
Vitamin	21.5	52.3	76.7
Protein	19.6	51.2	79.1
Vitamin and Protein	20.6	50.6	76.6
	LENGTH		
Control	8.1	15.2	21.1
Vitamin	8.1	15.0	21.2
Protein	8.1	15.9	21.3
Vitamin and Protein	8.2	15.2	21.1
	CHEST CIRCUMFERENCE		
Control	11.3	19.1	24.6
Vitamin	10.4	18.2	24.3
Protein	11.3	19.9	25.6
Vitamin and Protein	10.9	19.3	25.3

for each study group. The per cent increase in the means from birth at each month of age is given in Table 11. The relative magnitude of the means of weight and length remains much the same among the study groups during the first three months after birth. The lowest mean values of these measurements continue to be noted for the vitamin group during this period. The increase in the means of each measurement during the first three months of infancy is much the same for each study group. The percentage change for any one measurement is quite uniform among all study groups with slightly more variation among the increases in weight than for length or chest circumference. There is no evidence in these data that growth of an infant during the three months after birth is affected by the nutritional supplement taken by the mother during pregnancy. Analysis of the same material by race and sex also failed to suggest any consistent difference between nutritional supplements in their effect on infant growth.

The means of the minimum weights following post-natal weight loss are shown in Table 12 for each study group, along with per cent of birth weight lost, and the per cent gain in weight from the minimum to 1 month. Here again there seems to be no apparent differences among the study groups, either in relative amount of weight lost post-natally or in the ability to establish weight gain after this loss.

The conclusions to be drawn from this analysis are mostly

Table 12. Mean minimum weight after birth, per cent decrease from mean birth weight, and per cent increase to mean weight at 1 month of age, by study group.

Study Group	Minimum Weight (lbs.)			Per Cent Decrease from Mean Birth Weight	Per Cent Increase to Mean 1 Month Weight
	No.	Mean	Standard Error		
Control	400	6.97	.05	6.4	29.6
Vitamin	352	6.82	.05	6.4	29.9
Protein	181	6.92	.07	6.5	27.9
Vitamin and Protein	193	6.98	.07	6.1	28.4

negative. No consistent differences were found between babies in the control group, whose mothers received no nutritional supplementation, and those in the two groups whose mothers received the protein supplement with respect to size and nutritional status at birth or growth during the first three months of life. There is some evidence that the babies of mothers who received the vitamins alone tend to be lighter at birth than the infants in the other groups and that their nutritional status at birth as a group was poorer than that of the other babies. However, both of these tentative conclusions apply only to the infants born during the earlier part of the study. Although the mothers' diet histories have not yet been analyzed in sufficient detail to substantiate it, the impression of persons connected with the Clinic is that the general level of diet while good for a large majority of patients may have been lower in the early years of the study than in the later years. This would suggest that the vitamin supplement may have had a slight adverse effect upon infants of women on a relatively poor diet. If there is such an effect it is evidently offset by protein supplementation, since it was not noted among the infants of mothers who took both vitamins and proteins. The combined vitamin and protein supplementation may be effective in inducing a more favorable nutritional status at birth in babies of mothers on a relatively poor diet, since the mean index of nutritional status for infants in this group was significantly higher than the means for the other groups during the earlier part of the program.

In summary, with these reservations concerning the effect of vitamins, and of the combined vitamin and protein supplementation, it seems evident that the dietary supplements given to the mothers in this study had no effect upon the physical status of their infants at birth or upon their growth during the first three months of life.

References

(1) Wiehl, Dorothy G. and Tompkins, Winslow T., M.D.: Size of Babies of Obese Mothers Receiving Nutrient Supplements. The Milbank Memorial Fund *Quarterly,* April, 1954, xxxii, pp. 125–140.