DEPARTMENT OF HEALTH FOR SCOTLAND

Milk Consumption

AND THE

Growth of School Children

REPORT ON AN INVESTIGATION IN LANARKSHIRE SCHOOLS

BY

GERALD LEIGHTON, O.B.E., M.D., F.R.S.E.
Medical Officer (Foods)

AND

PETER L. McKINLAY, M.D., D.P.H.
Medical Officer (Statistics)

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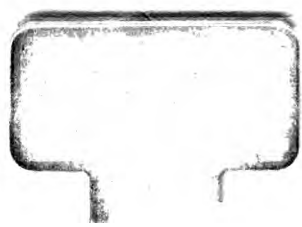

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PREFATORY NOTE

THE investigation which is the subject of this Report followed on a series of tests in America (1), (5), (6), and this country (2), (3), which demonstrated the high nutritive value of milk as a supplementary ration for children.

A previous Scottish test was conducted by the Scottish Board of Health in the years 1927–28 with 1282 elementary school children in 1927 and 1157 in 1928. The results, as published (4), (7), and as summarised in the Annual Report of the Scottish Board of Health for 1928, gave strong support to the conclusion that the addition of milk to the diet produces a marked improvement in children of all school ages, the improvement being shown by greater increase in weight and height and by better general condition. The results also showed that separated milk is of great value in promoting growth, the implication being that while the diet of the ordinary household may have a sufficiency of the constituents contained in the fat of milk, it is deficient in those contained in the residue.

This previous test was open to the criticism that the striking improvement in the nutrition of the children who received the additional ration of milk was due not to the milk alone but in some measure to improved home conditions—food, sleep, and regulation of life—which might follow from the close surveillance which was kept over the children under test.

The present test, the subject of this Report by Drs. Leighton and McKinlay, was conducted under conditions that eliminate this criticism and on a larger scale than any previous test. The investigation was made possible by a grant of £5000 from the Empire Marketing Board, who approved its purpose and scope and the selection of Lanarkshire as a suitable area and as designed to secure results authoritative for the whole country. A contribution of £2000 towards the cost was received from the Central Advisory Committee of the Distress in Mining Areas (Scotland) Fund, and interested firms and individuals in the dairying industry contributed sums amounting to £477, 4s.

The arrangements were made by the Department of Health for Scotland and were carried out by the Education Authority of the County of Lanark.

Some 20,000 school children were included in the investigation, 10,000 of the children receiving daily a supplementary ration of milk over a period of four months, the remaining 10,000 serving as controls. Bulked Grade A (T.T.) milk was used throughout the test, and in order to investigate the relative values of raw and pasteurised milk, one half of the milk was pasteurised.

The results, read along with the results of the previous Scottish

test, are conclusive on the main issue. They demonstrate that the addition of milk to the diet of children has a striking effect in improving physique and general health and increasing mental alertness. They suggest also that, apart from its own food value, milk enables the other constituents of the ordinary diet to be fully utilised as growth factors. The question of the relative merits of pasteurised and raw milk remains open ; but it would appear that pasteurised milk, like separated milk, as a supplementary ration to the usual mixed and variable diet of the household, is a potent growth-producing factor.

The results give a special significance to the new powers conferred on local authorities by the Education (Scotland) Act, 1930. Under that Act, local authorities may make an additional ration of graded milk available to school children. In view of the results of these Scottish tests, it would be difficult to exaggerate the importance of the new powers. Their universal exercise by all the local authorities would affect about 800,000 children (the total school population in Scotland), and by improving their physical and mental well-being, would have a powerful influence in improving the quality of the Scottish race. Indirectly, by greatly increasing the national consumption of graded milk, it would have another important result. It would lead to the rapid elimination of tuberculosis from the dairy herds of Scotland and so to the prevention of many of the crippling disabilities from which the population suffer at present.

J. PARLANE KINLOCH,
Chief Medical Officer.

DEPARTMENT OF HEALTH FOR SCOTLAND.
December, 1930.

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Milk Consumption and the Growth of School Children

1. Introductory

The Milk Investigation in Lanarkshire, which was carried out in the first half of 1930, differed in several important respects from any similar investigations.

In the first place, it was conceived and conducted on a very much larger scale than any which had preceded it. The number of children under observation was no less than 20,000; half of whom were given the milk and the other half used as "controls." This in itself placed the investigation in a category of its own so far as we are aware. Secondly, for the first time in any investigation of this character a special official grade of milk alone was used. All the milk supplied was Grade A (Tuberculin Tested) Milk.*

Thirdly, of the 10,000 children who received the milk daily for the period of investigation, 5,000 of them consumed it raw while the other 5,000 consumed it pasteurised, also in the sense of the official designation of Pasteurised Milk.*

Thus for the first time, as far as we are aware, there was conducted a test on a very large scale of the nutritional value of raw tubercle-free milk as opposed to that same milk when pasteurised.

Fourthly, for the first time a Government Department, in this case the Department of Health for Scotland, made itself responsible for a daily milk supply to 10,000 children for a period of over four months (February to June).

It will readily be understood that the carrying out of such a field investigation required team work of a high order. The success of the investigation depended primarily on the active participation of the teachers in the work. Dr. John Macintyre, Chief Medical Officer of the Education Authority of Lanarkshire, was in executive charge of the investigation. He was responsible for the organisation of the medical and nursing staff of the Education Authority that permitted the weighing and measuring of 20,000 school children.

The collection and distribution of the milk was organised and carried out by the Scottish Milk Agency, Ltd., and the Certified and Grade A (T.T.) Producers, Ltd.

* Under the Milk (Special Designations) Order (Scotland) 1930, Grade A (Tuberculin Tested) Milk must contain (*a*) not less than 3·5 per cent. butter fat, (*b*) not more than 200,000 bacteria per c.c., and (*c*) no coliform bacillus in $\frac{1}{100}$ c.c. Pasteurised milk under the Order must have been retained at a temperature of not less than 145° and not more than 150° Fahr., for at least half an hour and must not contain more than 100,000 bacteria per c.c.

2. The Milk Supplied

The bulking of the total milk supply and its tubercle-free state eliminated from the conditions of the experiment differences in chemical composition of the milk and any individual response to the ingestion of tubercle bacilli or their toxins.

The extent of the investigation was conditioned by the amount of tubercle-free milk available. It was ascertained that sufficient milk of this kind could be obtained to supply 10,000 children each with ¾ pint per day.

The milk came from 26 different herds. These were situated in the counties of Lanark, Ayr, Dumfries, Aberdeen, Renfrew and Kirkcudbright.

The quantities supplied by each producer varied considerably, the smallest being 20 gallons per day and the largest 125 gallons per day. The milk was sent by rail to Glasgow to the depôt of the Certified and Grade A (T.T.) Milk Producers, Limited, where it arrived at varying hours in the evening. At the depôt the milk was bulked, and half in the raw condition was put into churns containing the various amounts required for the different schools and thence immediately transferred to cold store until the early hours of the following morning, when the milk was sent out to the schools. The other half was pasteurised by heating to 145° Fahr. for half-an-hour and immediately cooled; then put into churns as before and likewise stored in cold storage till the early morning. Then from 6 a.m. onwards the churns with their allotted quantities of milk for the various schools were despatched by motor lorry to the 67 schools in Lanarkshire concerned, the milk being delivered in time for its distribution between 10.30 and 11 a.m.

No school received both kinds of milk, that is to say, in any given school a certain number of children got raw milk and there were the same number of "controls" in that school. In another school a certain number of children got the same kind of milk pasteurised and there were the same number of controls. Each scholar on the "Feeders" list received ¾ pint of milk daily.

3. Supervision at the Milk Depot

The treatment of the milk at the central depôt in Glasgow was the subject of careful supervision by the Department. One of us visited the depôt several times weekly and saw the various processes being carried out and checked the charts which showed the times and temperatures of the process of pasteurisation. As soon as the arrangements for delivery of the milk to the schools were completed, and the scheme was in operation, a system of sampling was initiated and carried out throughout the whole period. Under this system samples of the bulked milk, and the individual milks of the different herds, were taken weekly and the closest observation kept upon them. Every attention

was paid to the thorough cleaning and sterilisation of all the apparatus and utensils which were used. Samples of the milk were also taken on delivery at the schools and the result of these will be described later.

4. Selection of Children

The selection of the 20,000 children for the purposes of the investigation was a matter of importance. The question was fully discussed with the school medical officers of the Education Authority of the County of Lanark, who were ultimately responsible for the selection made. The schools were all situated in industrial and densely populated parts of the county, but not specially selected on account of the distress prevalent in any special area. It should be said, however, that at the period of this investigation, unemployment was rife throughout the district, and it was estimated that approximately one-third of the children came from homes where the parents were entirely unemployed or only partially employed. In all, 67 schools came into the scope of the investigation. The numbers selected in these schools varied from a minimum in any one school of 200 (100 feeders and 100 controls) to a maximum of 400 (200 feeders and 200 controls).

It will, of course, be understood that before the actual feeding of these children began, each of the schools was visited by the school medical officers of the Education Authority, who explained to the head teachers all the details of what was proposed to be done, and this constituted a very important part of the preliminary work.

Both the milk-fed children or " feeder " group and the " control " group were drawn from children from 5 to 12 years of age (both years inclusive). The selection of the actual children, however, was left to the head teacher in each school, to whom it was explained that the selected children should be a representative group of all, and not the most ill-nourished or of any other outstanding character. In the same way it was explained to the teachers that the "controls " should also be representative of the average child. Likewise it was laid down that the sexes should be, as far as possible, balanced in each age group.

As a matter of fact, the teachers selected the two classes of pupils, those getting milk and those acting as " controls," in two different ways. In certain cases they selected them by ballot and in others on an alphabetical system. In any particular school where there was any group to which these methods had given an undue proportion of well-fed or ill-nourished children, others were substituted in order to attain a more level selection. The school medical officers were definitely of opinion that each school had furnished a very fair average of its ordinary scholars, both as regards the children receiving the milk and also as regards the " controls."

5. Record Cards

For the purpose of keeping the nutritional record of every child concerned in the investigation, cards were printed having distinctive colours. The children who were getting the raw milk had yellow cards, those getting the pasteurised milk had pink cards, while those for the " controls " were white. On each of these cards was entered up the full name of the child, the home address, and the date of birth. As each child was weighed and measured at the beginning of the investigation the results were added. At the conclusion of the investigation the final weights and heights were also entered. All the cards were then sent to the Department of Health for Scotland for classification and statistical analysis.

6. Taking the Measurements

The measuring of the height and the taking of the weight of 20,000 children in 67 schools was a task of great magnitude. It required the whole time of 5 doctors and 17 nurses, over a period of ten school days, for the initial weighing and measuring, and nine and a half school days for the final weighing and measuring.

Dr. Macintyre, School Medical Officer, thus describes the procedure adopted in the recording of the heights and weights :—

" For the ascertaining of the height of the children, measuring rods, graduated to show feet, inches and an $\frac{1}{8}$ of an inch, were employed and each child was measured, without boots or shoes, to the nearest $\frac{1}{8}$ of an inch. For the weighing of the children, machines were employed which recorded the weight in stones, lbs. and ozs. The machines, which were all of the same pattern, had not before been in use, and as each was fitted with an arrangement for fine adjustment, careful and accurate weighing to the nearest ounce was secured. All of the children were weighed without their boots or shoes and wearing only their ordinary indoor clothing. The boys were made to turn out the miscellaneous collection of articles which is normally found in their pockets, and overcoats, mufflers, etc., were also discarded. Where a child was found to be wearing three or four jerseys—a not uncommon experience—all in excess of one were removed.

" To obviate any slight variation that might exist in the various weighing machines, the same machine was employed at each school both for the initial and final weighing.

" The whole procedure was under the direct control of the principal school medical officer, and the entire weighing and measuring of the children — both ' feeders ' and ' controls '— were actually conducted by the assistant school medical officers (five in number), assisted by members of the school nursing staff (17 in number). A medical officer and a nurse, or two nurses, formed a ' team,' and each team was allocated its group of schools, which were visited in rotation. The same rotation

was observed when the final measurements came to be taken at the close of the investigation."

7. The Milk at the Schools

Having been despatched from the central depôt in the early morning the milk arrived at the various schools in time for distribution amongst the scholars, between 10 and 11 a.m. The head teachers in each school were allowed to fix the exact hour for giving the milk, provided it was not later than 12 noon. As a matter of fact, in most cases it was given about 10.30 a.m. Before being distributed in the mugs or tins the milk in each churn was carefully mixed by a " plunger," one of which was supplied for use in each school, in order to secure, as far as possible, the uniform distribution of the milk constituents. In nearly every case the actual distribution of the ration was carried out extremely well. It was supervised by various members of the teaching staffs, sometimes with the assistance of senior scholars, and worked very smoothly on the whole. Head masters frequently expressed the opinion that very little interference with the work of the school resulted.

After the milk had been consumed there followed a very thorough washing and cleansing and sterilising of all the utensils which were in use. Great care was taken by the janitors in the different schools in this matter, which was one of very great importance considering the number of children involved.

8. Sampling of Milk

A very thorough system of sampling and analysing the milk was carried out throughout the whole investigation. Since the milk was all of a definite grade it was necessary to see that it conformed to, and kept up to, the conditions and standard laid down for that grade. The sampling was done in two distinct processes ; one carried out at the central depôt in Glasgow on arrival of the milk from the various herds, and the other carried out by the County Medical Officer of Health and his staff in Lanarkshire, when the milk arrived at the various schools for distribution. The sampling at the schools, therefore, was that of milk which would be perhaps 12 hours older than on its arrival at the central depôt. This accounts for differences in the bacterial counts.

The sampling done at the central depôt was also carried out in two ways. First of all, samples were taken of the bulked milk, and secondly, the milk of each single herd was sampled individually. This latter procedure was found to be most useful, for in the event of any deviation from the standard it was possible to check that at the source at once, and even to exclude, if necessary, that particular milk from the mass which was bulked.

The actual results of the sampling at the depôt and the sampling at the schools were as follows :—

The number of samples taken at the depôt was 205. The average fat content of these samples was 3·7 per cent. The average bacterial count was 18,304 per c.c. The number of samples taken at the schools was 110. The average butter fat content of these was 3·86 per cent. The average bacterial count during February, March and April was 23,968, while during three or four very hot weeks towards the end of the investigation it was rather higher.

9. The Attitude of Parents and Children

Doubtless owing to the inaugural meeting at Hamilton when the Under Secretary of State for Scotland explained the scheme to the public, very widespread interest was aroused at the beginning in the whole district. Some of the parents of the children, however, did not at first grasp what was actually going to be done, or the objects in view.

Dr. Macintyre says :—

" Some resented what they chose to regard as a charity, others that their children had been singled out as ill-nourished and in need of additional sustenance. There were others, again, who objected to their children being ' experimented upon,' but, on the whole, the scheme was received with an enthusiasm which was quite surprising. Even in the case of objectors a visit to the school, where they received enlightenment as to the nature of the investigation, generally cleared up any misunderstanding and permission for their children to take part in the test was usually forthcoming. As a general rule, not only was the scheme warmly welcomed by the great majority of the parents, but keen disappointment was frequently expressed that more of the children were not included in the category of ' feeders.' "

As one head teacher remarked :—

" Some of the parents were disappointed but none were dissatisfied with the result of the ballot."

While it may be difficult to sum up very accurately the parental attitude, it was not at all difficult for the teachers, and others who were in constant touch with the children, to know what the latter thought of it. On this point Dr. Macintyre says:—

" At the commencement of the test, when the selection of the ' feeders ' and ' controls ' had to be made, there was almost universal regret that all could not be included in the former category.

" When, however, the scheme was fully explained to the children, the ' drys ' took the decision in a sporting spirit and concealed their chagrin very successfully. On the other hand, the ' wets ' did not show any marked desire to exult over their successes in the ballot ; but rather seemed to evince a sincere sympathy for those who had been unsuccessful. The great

majority of the children genuinely liked the milk and were truly sorry when the test was completed. It was observed in most schools that the keenest appreciation of the ration came from the younger children and especially those children who were rather poorly nourished."

10. Teachers' Opinions

During the last week or two of the investigation the various head teachers of the schools concerned were asked if they would be good enough to submit to us in writing their general impressions of the effects upon the children which had impressed themselves upon their teachers. A number of the teachers were good enough to send in a short statement on these lines. These documents varied very considerably, but from the general opinions expressed certain interesting facts emerge.

The teachers, of course, had no figures regarding either heights or weights to influence their opinions, which were formed merely upon observation of the scholars in their schools; and so it is not surprising to find that they could not observe any appreciable increase in height or weight amongst those receiving the milk, as compared with those who were not. At the same time there was a very general and definite opinion that the appearance of the milk feeders showed quite an obvious improvement after the scheme had been in operation for six or eight weeks. Especially did they think so in the case of the younger children and those who were least well-off. In these cases the teachers speak of an increase in the bloom of their cheeks and the sleekness of their skins. Many of them say that the physical energy and animal spirits of those receiving the milk were stimulated to the extent of the children becoming more boisterous and more difficult to control. One teacher went so far as to write, " in the playground buoyancy and pugnacity are developing to an alarming extent." Another head teacher states that one girl increased so much in vitality that she told her teacher " she could now fight her brother," a feat which before was impossible. Another " feeder " emphasises the fact that he could use certain dumb-bells quite easily which formerly he had been unable to do. A parent told the head master that a boy of hers, for the first time for years had been free from illness during the Spring period.

Such individual instances could be given in considerable numbers, but they all point to the general impression received by the teachers, apart from any figures to substantiate it, that the general improvement in the physique of the children was very obvious in a great many directions.

It is not so easy to gather any general conclusion as to the change in their capacity as scholars; but many teachers are quite emphatic in stating that mental lassitude gave place to alertness, especially among the younger children; while others were of opinion that the effect of the milk feeding was to produce

some drowsiness for a period. One or two striking instances of mental improvement were recorded by teachers, such as that of a boy who had great difficulty in reading and who rapidly improved in a remarkable way, not only in this but in memory and arithmetic. Another records a case of a child who, previously morose and hardly ever spoke, became lively and talkative.

We record these instances as matters of interest, without laying undue stress upon them; but there was an almost general experience that the regularity of the pupils attending the schools, amongst those receiving milk, was definitely increased. This was not a temporary matter but was continued.

11. Comparison of the Growth in the "Feeders" and "Controls"

In the present report we deal only with the initial weights and heights and growth in weight and height in the several groups of children concerned. Examination of the original records made it doubtful whether the labour involved in a detailed analysis of the sickness or absence rates among the three groups of children would be justified by the results.

The whole series of cards were, in the first instance, scrutinised and from these were excluded :—

(1) all cases in which no final measurements were recorded—these absentees form the great proportion of the records which have not been dealt with, and are due chiefly to the large scale of the inquiry which made impracticable any revisiting of individual schools to weigh and measure those children absent on the final visitation of any particular school;

(2) those in which the date of birth was not stated;

(3) a few cases in which, from the children's names, the sex was a matter of doubt;

(4) those cases in which there was an obvious error in the record of the heights and weights; and, later in the inquiry,

(5) several cases of children over 12 years of age, almost entirely confined to the control groups, and for which there were insufficient observations on feeders of the same age and sex to make analysis of these data worth while.

The remaining utilisable records relating to 17,159 children were thereafter sub-divided into the three groups of control, raw milk-fed and pasteurised milk-fed children and each of these in turn into age and sex groups. The changes in height and weight within the period of observation were then recorded on the card. Tables were thereafter prepared in such a form that not only the average increase in height or weight for the whole group, but also the average increase in height or weight for children of a given initial weight or height were able to be calculated. The reason for this provision will emerge later.

In assessing the value to the children of this addition of milk

to the diet it seemed to us necessary to inquire, first of all, whether or not the groups are really initially comparable one with another. For this purpose the average initial weights and heights for each group by age and sex were computed and are given in Tables 1 and 2, and the differences with their respective probable errors in Tables 3 and 4. It will be seen that the control groups compared with the two milk-fed groups were, at the beginning of the experiment, slightly, though in many instances, significantly heavier and taller.

TABLE 1

AVERAGE INITIAL WEIGHTS OF BOYS AND GIRLS IN EACH GROUP.*

Age.	Boys.			Girls.		
	Control.	Raw Milk.	Pasteurised Milk.	Control.	Raw Milk.	Pasteurised Milk.
5 —	42·68(42)	42·89(26)	41·66(27)	41·16(51)	38·09(16)	40·58(26)
6 —	45·35(672)	44·08(325)	43·72(359)	43·03(686)	42·53(332)	41·57(353)
7 —	49·65(733)	48·83(372)	49·14(334)	46·93(716)	46·24(335)	46·25(352)
8 —	54·00(850)	53·05(419)	52·93(369)	51·84(802)	51·31(414)	50·19(410)
9 —	59·36(803)	58·83(466)	58·29(402)	57·00(820)	56·27(408)	56·07(406)
10 —	64·49(749)	62·95(363)	63·34(338)	62·01(729)	60·64(373)	59·77(340)
11 —	69·35(471)	68·51(265)	67·66(259)	67·85(494)	65·51(261)	66·78(246)

* The figures in brackets represent the number of children in each group.

TABLE 2

AVERAGE INITIAL HEIGHTS OF BOYS AND GIRLS IN EACH GROUP.

Age.	Boys.			Girls.		
	Control.	Raw Milk.	Pasteurised Milk.	Control.	Raw Milk.	Pasteurised Milk.
5 —	43·25	42·65	42·15	42·56	41·28	41·30
6 —	44·01	43·43	43·15	43·54	43·08	42·69
7 —	45·94	45·45	46·02	45·37	44·93	44·89
8 —	47·88	47·31	47·38	47·55	47·14	46·92
9 —	49·97	49·51	49·44	49·59	49·10	49·20
10 —	51·53	50·91	51·16	51·26	50·72	50·80
11 —	53·23	52·89	52·61	53·22	52·59	52·90

TABLE 3

DIFFERENCES IN AVERAGE INITIAL WEIGHTS OF THE THREE GROUPS.*

(C. = CONTROL ; R.M. = RAW MILK ; P.M. = PASTEURISED MILK.)

Age.	Boys.			Girls.		
	C. – R.M.	C. – P.M.	R.M. – P.M.	C. – R.M.	C. – P.M.	R.M. – P.M.
5 –	−0·21 ± 0·91	1·02 ± 0·93	1·23 ± 0·80	3·07 ± 0·65	0·58 ± 0·94	−2·49 ± 0·96
6 –	1·27 ± 0·23	1·63 ± 0·22	0·36 ± 0·25	0·51 ± 0·22	1·46 ± 0·22	0·96 ± 0·26
7 –	0·81 ± 0·23	0·50 ± 0·26	−0·31 ± 0·29	0·69 ± 0·24	0·68 ± 0·24	−0·01 ± 0·28
8 –	0·94 ± 0·24	1·08 ± 0·25	0·13 ± 0·29	0·53 ± 0·26	1·65 ± 0·24	1·12 ± 0·28
9 –	0·53 ± 0·27	1·07 ± 0·26	0·54 ± 0·31	0·73 ± 0·28	0·93 ± 0·27	0·20 ± 0·32
10 –	1·54 ± 0·33	1·15 ± 0·34	−0·39 ± 0·38	1·36 ± 0·34	2·24 ± 0·35	0·87 ± 0·38
11 –	0·84 ± 0·45	1·69 ± 0·47	0·85 ± 0·52	2·34 ± 0·42	1·07 ± 0·49	−1·27 ± 0·54

TABLE 4

DIFFERENCES IN AVERAGE INITIAL HEIGHTS OF THE THREE GROUPS.

Age.	Boys.			Girls.		
	C. – R.M.	C. – P.M.	R.M. – P.M.	C. – R.M.	C. – P.M.	R.M. – P.M.
5 –	0·60 ± 0·37	1·10 ± 0·37	0·50 ± 0·30	1·28 ± 0·35	1·26 ± 0·33	−0·02 ± 0·39
6 –	0·58 ± 0·10	0·86 ± 0·09	0·28 ± 0·11	0·46 ± 0·09	0·85 ± 0·10	0·39 ± 0·11
7 –	0·49 ± 0·09	−0·08 ± 0·10	−0·57 ± 0·11	0·44 ± 0·10	0·48 ± 0·10	0·04 ± 0·12
8 –	0·57 ± 0·09	0·50 ± 0·09	−0·07 ± 0·11	0·41 ± 0·10	0·63 ± 0·09	0·22 ± 0·11
9 –	0·46 ± 0·09	0·53 ± 0·09	0·07 ± 0·11	0·49 ± 0·10	0·39 ± 0·09	−0·10 ± 0·11
10 –	0·62 ± 0·11	0·37 ± 0·11	−0·25 ± 0·13	0·54 ± 0·11	0·46 ± 0·11	−0·08 ± 0·13
11 –	0·34 ± 0·14	0·62 ± 0·14	0·28 ± 0·16	0·63 ± 0·14	0·32 ± 0·14	−0·31 ± 0·16

* The figures after ± signs are the probable errors (see footnote to Table 5).

The differences in weight and height of the two milk-fed groups are smaller, generally insignificant and inconstant in sign. In view of the fact that there were definite differences of weights and heights in the controls compared with feeders at the beginning of the experiment, it was considered advisable to inquire whether the amount of growth within this period was affected to any appreciable extent by original physique, *i.e.*, whether the heavier or taller child added more or less to its weight or height than the lighter or shorter child. For this purpose, coefficients of correlation between original weight and change in weight and original height and change in height were calculated for the control group, and are given in Table 5. From these results it will be inferred that there is no uniform tendency for gain in weight or height to be influenced by initial weight or height. The possibility that relationship of a

kind not adequately described by a coefficient of correlation may exist has been eliminated by calculation of the average change in weight and height for groups of children of a given initial weight or height. (It has not, however, been considered necessary to reproduce these figures.) The change of weight and height, within the period of experiment is, therefore, substantially independent of initial measurements, so that within certain limits it would appear that the selection which does exist within the groups is insufficient to nullify the comparison merely of average changes without entering into the detail of comparing children of the same age and sex and of equivalent initial heights and weights.

TABLE 5

CORRELATION BETWEEN (1) ORIGINAL WEIGHT AND CHANGE IN WEIGHT, AND (2) ORIGINAL HEIGHT AND CHANGE IN HEIGHT (CONTROLS).

Age.	Original Weight—Change in Weight.		Original Height—Change in Height.	
	Boys.	Girls.	Boys.	Girls.
5 —	−·2333±·0984	·1691±·0917	·0238±·1040	·0115±·0944
6 —	−·0818±·0258	·0117±·0257	·0290±·0260	−·0153±·0257
7 —	−·1098±·0246	−·0403±·0252	−·0111±·0249	·0462±·0252
8 —	·0127±·0231	·0843±·0237	−·0466±·0231	−·1054±·0234
9 —	−·0896±·0236	−·0316±·0235	−·0629±·0237	·0160±·0236
10 —	−·0656±·0245	·1415±·0245	−·0091±·0246	·1680±·0243
11 —	−·0371±·0310	·1121±·0300	·0539±·0310	·1381±·0298

A coefficient of correlation is a numerical measure of the degree of association between two varying factors, and can vary between 0 (representing absence of direct relationship) to ±1 (complete association). A positive sign indicates that as one variable increases, the other also increases; a negative, that as one increases the other tends to decrease.

The figure after the ± sign in this and other tables is the probable error, which affords a measure of the reliability of the result. A difference or a coefficient of correlation equal to or greater than three times this figure is generally regarded as significant. At the same time, in any series of results, such as is given in Table 5, great importance must not be attached to isolated "significant" coefficients. Attention should rather be paid to the general run of the results.

The average increases in weights and heights for the several groups by age and sex are collected in Tables 6 and 7. The increase in weight in the control group shows in boys a fairly uniform decline with age, the average absolute increase in the younger age groups being almost twice as great as in the final age group. In girls this tendency is not apparent and at the beginning of the tenth year the growth in weight shows the normal tendency to increase. In heights a similar trend of events is seen. In boys the changes in height become smaller as age advances up to the eleventh year, and in girls these decrease from the fifth till the ninth year and thereafter increase.

TABLE 6

AVERAGE INCREASE IN WEIGHTS (IN OUNCES) IN THE THREE GROUPS.

Age.	Boys.			Girls.		
	Control.	Raw Milk.	Pasteurised Milk.	Control.	Raw Milk.	Pasteurised Milk.
5 —	11·64	14·88	15·65	7·00	14·50	6·62
6 —	13·75	13·51	9·96	11·21	10·61	10·05
7 —	11·17	14·85	15·55	8·90	11·22	12·94
8 —	11·38	14·21	15·21	9·77	13·40	13·37
9 —	9·53	13·43	11·83	7·87	13·81	12·52
10 —	7·10	13·53	10·39	9·51	15·08	18·96
11 —	6·14	12·74	11·05	12·62	24·92	17·08

TABLE 7

AVERAGE INCREASE IN HEIGHTS (IN INCHES) IN THE THREE GROUPS.

Age.	Boys.			Girls.		
	Control.	Raw Milk.	Pasteurised Milk.	Control.	Raw Milk.	Pasteurised Milk.
5 —	0·75	0·95	0·94	0·86	0·64	0·87
6 —	0·80	0·87	0·87	0·80	0·86	0·84
7 —	0·76	0·87	0·82	0·75	0·84	0·81
8 —	0·74	0·82	0·79	0·71	0·81	0·78
9 —	0·69	0·80	0·74	0·66	0·76	0·78
10 —	0·68	0·76	0·68	0·71	0·79	0·72
11 —	0·69	0·74	0·70	0·77	0·86	0·81

To facilitate comparison between these changes in the various groups, Tables 8 and 9, in which the individual differences, together with their respective probable errors are collected, have been prepared.

TABLE 8

DIFFERENCES OF CHANGES IN WEIGHT BETWEEN CONTROLS AND FEEDERS.

Age.	Boys.		Girls.	
	R.M. – C.	P.M. – C.	R.M. – C.	P.M. – C.
5 –	3·24 ± 2·39	4·01 ± 3·06	7·50 ± 3·82	−0·38 ± 3·04
6 –	−0·24 ± 0·85	−3·79 ± 0·79	−0·60 ± 0·80	−1·16 ± 0·82
7 –	3·68 ± 0·88	4·38 ± 0·91	2·32 ± 0·89	4·04 ± 0·85
8 –	2·83 ± 0·85	3·83 ± 0·86	3·63 ± 0·88	3·60 ± 0·85
9 –	3·90 ± 0·84	2·30 ± 0·88	5·94 ± 0·93	4·65 ± 0·96
10 –	6·43 ± 1·06	3·29 ± 1·04	5·57 ± 1·04	9·45 ± 1·12
11 –	6·60 ± 1·34	4·91 ± 1·24	12·30 ± 1·49	4·46 ± 1·44

TABLE 9

DIFFERENCES OF CHANGES IN HEIGHT BETWEEN CONTROLS AND FEEDERS.

Age.	Boys.		Girls.	
	R.M. – C.	P.M. – C.	R.M. – C.	P.M. – C.
5 –	0·20 ± 0·069	0·19 ± 0·056	−0·22 ± 0·066	0·01 ± 0·057
6 –	0·07 ± 0·016	0·07 ± 0·014	0·06 ± 0·017	0·04 ± 0·015
7 –	0·11 ± 0·017	0·06 ± 0·015	0·09 ± 0·017	0·06 ± 0·014
8 –	0·08 ± 0·016	0·05 ± 0·017	0·10 ± 0·015	0·07 ± 0·014
9 –	0·11 ± 0·016	0·05 ± 0·015	0·10 ± 0·014	0·12 ± 0·016
10 –	0·08 ± 0·017	0·00 ± 0·016	0·08 ± 0·016	0·01 ± 0·015
11 –	0·05 ± 0·020	0·01 ± 0·019	0·09 ± 0·020	0·04 ± 0·021

In considering these differences regard must be had to the conditions under which the weights were taken. The children were weighed in indoor clothes and at the commencement of the inquiry in February the weather was cold, and compared with the end of the inquiry, in a hot spell in June, the amount of clothing might possibly have been somewhat more. This, however, would operate presumably to an equal degree in each group, so that the comparability of feeders and controls is unaffected. Again too there is, as is generally known, definite seasonal fluctuation in the rate of growth; but this again would operate equally within the groups. As a fact, the conditions of the experiment were such that factors which might militate against the comparison of the average weights and heights and the increases found in this study with those in other reports are affecting to an equal degree all groups, so that with regard to the most important point of the inquiry, the differences shown by the three groups, the changes in weight and height are really comparable one with another. It will be seen from Tables 8 and 9 that with few exceptions the differences are in favour of the

milk-fed groups. The exceptions are, with regard to change in weight, in both raw and pasteurised milk groups of boys aged 6–7 years; the pasteurised milk group of girls aged 5–6 years and in both raw and pasteurised milk-fed girls aged 6–7 years. In the case of heights, the only difference in favour of controls is found when comparison is made with the female group aged 5–6 years fed on raw milk. It will, however, be seen that of the six out of the total number of comparisons made, in only two, namely, the difference in weights of pasteurised milk and control boys aged 6–7 years and of heights in raw milk-fed, compared with control girls aged 5–6 years, do these appear to be significant in the statistical sense. At ages over 7 years in both boys and girls the differences in the increase of weight and height are uniformly in favour of both the raw and pasteurised milk-fed groups, and further that the majority of these, as will be seen from the size of the probable errors, are not likely to be chance differences. Comparison of the results found at different ages does not suggest any uniform or significant differences in the absolute amount of improvement in the several age groups. Nor, too, is there any constant difference in the effect registered in the two sexes. In the raw milk versus control female group of weights there is a suggestion that the amount of improvement increases with age; but it is doubtful if this represents a real phenomenon.

In Tables 10 and 11 are shown the coefficients of correlation between the initial weight and height and change of weight and height respectively for the pasteurised and raw milk-fed groups of boys and girls. In general these are small and of inconstant sign, more particularly in boys, and indicate that the average change in weight and height is not greatly different in children of the same age but of varying initial weight or height. That is, the tall or heavy children do not increase more on the average than the short or light children. In the case of boys this conclusion seems justified but in girls there is some evidence of a more definite relation. In the raw milk group it would appear that in younger girls the heavier child added less to its weight than the lighter, the converse being the case among older girls. In the case of height all the coefficients are negative, indicating a tendency for the child initially taller to add less to its height than the shorter child; but this relationship only seems definite in the first two age groups. In the pasteurised group the increases in weights and heights of boys show no definite or consistent relationship to their weights or heights initially; but in the case of weights it would appear that in the older girls there was a positive association indicating a greater gain on the average among heavier children. In heights the correlations show no definite trend with age and with a single exception are quite insignificant.

These findings suggest that the effects of the added milk in some of the age groups varied according to the original weight and height of the child; but comparison of the average increases

in controls and milk feeders according to initial weight and height gave such irregular results that we are not prepared to draw any conclusions as to the relative effect of milk on children of the same age but of varying physique.

TABLE 10

CORRELATION BETWEEN (1) ORIGINAL WEIGHT AND CHANGE IN WEIGHT, AND (2) ORIGINAL HEIGHT AND CHANGE IN HEIGHT (RAW-MILK GROUP).

Age.	Original Weight—Change in Weight.		Original Height—Change in Height.	
	Boys.	Girls.	Boys.	Girls.
5 —	−·1398±·1296	−·1649±·1640	·2404±·1247	−·3778±·1445
6 —	−·0789±·0372	−·1315±·0364	−·0261±·0374	−·1282±·0364
7 —	·0104±·0350	−·0272±·0368	·0028±·0350	−·0284±·0368
8 —	−·0661±·0328	·0978±·0328	−·1013±·0326	−·0514±·0331
9 —	·0096±·0312	·0952±·0331	−·0106±·0312	−·0865±·0331
10 —	−·0549±·0353	·2193±·0334	−·0608±·0353	−·0414±·0349
11 —	·0538±·0413	·2112±·0399	−·0959±·0412	−·0079±·0417

TABLE 11

CORRELATION BETWEEN (1) ORIGINAL WEIGHT AND CHANGE IN WEIGHT, AND (2) ORIGINAL HEIGHT AND CHANGE IN HEIGHT (PASTEURISED-MILK GROUP).

Age.	Original Weight—Change in Weight.		Original Height—Change in Height.	
	Boys.	Girls.	Boys.	Girls.
5 —	·0062±·1298	−·0118±·1322	·0038±·1298	−·2328±·1251
6 —	−·0056±·0356	·0397±·0358	−·0462±·0355	·0624±·0358
7 —	·0311±·0369	·0137±·0359	·0767±·0367	−·0532±·0359
8 —	·0042±·0351	·0086±·0333	·0375±·0351	·0119±·0333
9 —	−·0715±·0335	·1978±·0322	−·1200±·0332	−·0189±·0334
10 —	−·0678±·0365	·1610±·0356	·0325±·0369	·0908±·0363
11 —	−·0141±·0419	·2428±·0405	·0154±·0422	·1668±·0418

12. Comparison of the Effects of Pasteurised and Raw Milk

The differences in growth, with their probable errors in these two groups, are given in Table 12. In the case of changes in weights it will be noticed that the differences are small, non-uniform and statistically in the majority of cases quite insignificant. Only three of these, namely boys aged 6–7 years and girls aged 10–11 and 11–12 years attain the conventional standard of significance, and two of these are in favour of raw and one in favour of pasteurised milk. In view of the lack of uniformity in the differences found, the general deduction seems justifiable that there is no evidence of greater effect on growth in weight

in raw compared with pasteurised milk or *vice versa*. In the case of heights the raw milk group shows in boys a uniform though very small advantage over the pasteurised milk group, and in two of these 9–10 and 10–11 years are apparently significant. In girls the differences are not constantly in favour of one group. In two of the instances these are in favour of pasteurised milk and in the remainder in favour of raw milk; but only in two, namely, girls 5–6 and 10–11 years, are the differences apparently trustworthy. Here again, then, one is not justified in believing that there is a substantial advantage of one over the other type of milk.

TABLE 12

DIFFERENCES OF CHANGES OF WEIGHT AND HEIGHT IN RAW AND PASTEURISED MILK-FED GROUPS.*

Age.	Weight.		Height.	
	Boys.	Girls.	Boys.	Girls.
5 –	−0·77±3·19	7·88±4·02	0·01±0·075	−0·23±0·055
6 –	3·55±0·94	0·56±0·94	0·00±0·018	0·02±0·015
7 –	−0·70±1·08	−1·72±1·04	0·05±0·019	0·03±0·019
8 –	−1·00±1·00	0·03±1·00	0·03±0·018	0·03±0·017
9 –	1·60±0·98	1·29±1·12	0·06±0·017	−0·02±0·016
10 –	3·14±1·24	−3·88±1·28	0·08±0·019	0·07±0·018
11 –	1·69±1·44	7·84±1·68	0·04±0·021	0·05±0·026

* A negative sign indicates a difference in favour of the pasteurised milk-fed group.

13. Conclusions

1. The influence of the addition of milk to the diet of school children is reflected in a definite increase in the rate of growth both in height and weight.

2. There is no obvious or constant difference in this respect between boys and girls, and there is little evidence of definite relation between the age of the children and the amount of improvement. The results do not support the belief that the younger derived more benefit than the older children. As manifested merely by growth in weight and height the increase found in younger children through the addition of milk to the usual diet is certainly not greater than, and is probably not even as great as, that found in older children.

3. In so far as the conditions of this investigation are concerned the effects of raw and pasteurised milk on growth in weight and height are, so far as we can judge, equal.

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