THE INFLUENCE OF DIET ON INFANT GROWTH IN THE FIRST TWENTY SIX WEEKS

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SUMMARY

Two groups of infants *(35 breast and 53 bottle-fed)* were followed for the first *26* weeks of life in order to investigate if infant feeding practice had any influence on the growth of infants during this period. Infants were fed *ad libitum* with either breast or formula milk and the age of weaning the infants with solid food was at the mothers discretion.

Subjects were recruited from the Glasgow and surrounding areas by the mothers responding to calls for subjects either before or shortly after birth of the infants. The sample included healthy infants who were born after uncomplicated pregnancies greater than *37* weeks gestation.

Both groups had similar characteristics for mean gestational age, maternal age and parity. There was a similar distribution of males and females within each group. There was found to be an unequal representation of infants from each social class group. The breast-fed infants tended to mainly come from a higher social class group while the opposite was found with the bottle-fed infants.

Anthropometric measurements including naked weight, body length, head and mid upper arm circumferences and two skinfold thicknesses were carried out every two weeks from *2-26* weeks of age. A questionnaire was also completed at each visit to update the infants' feeding regime. An analyses of variance statistical test, with a significance level of $p<0.05$, was carried out on birthweights and on all measurements at *2,6,12,18,22* and *26* weeks of age.

There was found to be no significant difference between the birthweights of the infants in both feeding groups. Mean gains in weight were taken from birthweight and mean gains in other growth measurements were taken from *2* weeks of age. There was no significant difference found between the infants in both groups in

either the total mean or mean gains in all the growth measurements studied at the ages when statistical analysis was carried out.

Infants in the two feeding groups had similar mean weight gains at 26 weeks of age *(i.e. 4.24kg and 4.25kg for breast and bottle-fed infants respectively).* Both groups of infants had similar steady patterns in growth and there were no striking differences noted in any of the growth areas studied between the infants in the two feeding groups. However it was interesting to note that there was a tendency for the breast-fed infants to have a slightly more rapid weight gain over the first 8 weeks when compared to the bottle-fed infants. Breast-fed infants also tended to have a predominantly lower mean gain in the 2 skinfold thicknesses than the bottle-fed infants from 4-20 weeks of age. This consistently lower mean in the skinfold thicknesses, although it was not significant at any time, suggests that a larger study might show this to be an important difference in the components of weight gain in relation to the method of feeding.

Male infants were found to be significantly heavier and longer than female infants over the 26 weeks. Male infants had a significantly greater mean weight gain than female infants from 22 weeks of age. There was no significant difference found between the same sex of infants in relation to the method of feeding.

There was no significant difference found between infants when grouped by either social class group (I+II) and (III+IV) or by feeding group with any of the growth measurements when statistical analysis was carried out. It was interesting to note that infants from social class group (I+II) tended to be predominantly heavier than the infants from social class group (III+IV) irrespective of feeding method and that the difference in mean weight gain was found to be approaching significant levels from 22 weeks of age.

Linear regression analysis was used to establish any correlation between the birthweight and weight gain at 12 and 26 weeks of age in relation to the method of feeding. There was found to be no significant relationship between the gain in weight and the birthweight at *26* weeks of age with all infants. However there was noted to be a significant relationship between birthweight and the mean weight gain of breast-fed infants at *12* weeks of age.

Infants were further divided into groups according to the age that weaning was commenced by the introduction of solid food to the diet. Infants in the early group had been weaned before *8* weeks of age, other infants were weaned between *9-16* and *17-26* weeks of age for the middle and late groups respectively. The general linear model statistical test was carried out on all growth measurements at *26* weeks of age. There was no significant difference found with the mean gain from *2* weeks in any of the growth measurements at this age when the infants were grouped by either the method of feeding or the age of weaning. There was no significant difference found between the infants in the three weaning groups in the mean weight gained from birth at *6,12,18,22 and 26* weeks of age in relation to the method of feeding or the time of weaning.

It was interesting to note that there was a tendency for bottle-fed infants to have been commenced on solid food at an earlier age than breast-fed infants. There was 30% of all bottle-fed and 12% of breast-fed infants weaned before *8* weeks of age. Two breast-fed infants had still to be commenced on solids at the end of the study. All infants from social class groups III & IV had been weaned by *16* weeks of age. There were no infants from social class group I weaned before *8* weeks of age and 52% of infants from this social class group were weaned between *17-26* weeks.

In conclusion all infants in this study were found to grow equally well over the first *26* weeks of life irrespective of the method of feeding or the age when weaning was commenced.

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CHAPTER ONE

INTRODUCTION and LITERATURE REVIEW

1.1.0 INTRODUCTION

Until the turn of the century, human milk provided by breast-feeding was the sole source of nutrients for infants from birth, and it remained the principal source during the period of initial growth and high nutritional demand. The inability of some mothers to nurse successfully was an impetus to the use of modified cow's milk and to the development of present day infant formulas as a substitute. The convenience of formulas led to a decline in breast-feeding, a trend which continues throughout the world today.

Infant feeding should be considered in three overlapping stages; the nursing period during which breast milk or an appropriate formula is the only source of nutrients, a transitional period when specially prepared foods are introduced in addition to breast or formula milk, and a later modified adult period during which the majority of nutrients come from foods available to the rest of the family. Infancy is a period of rapid changes in growth rates and the pattern of growth has been said to be strongly influenced by feeding practice(1) since intake which is self-regulated in the successfully breast-feeding infant may be manipulated consciously or otherwise in bottle-feeding(2).

Mothers wish their infants to have the best possible nutritional start in life which will lead to normal growth both during infancy and later life. Research of the growth patterns of breast and bottle-fed infants over the initial few months of life has given conflicting results over the last few decades. Some researchers have reported that bottle-fed infants gain more weight(3,4,5), breast-fed infants initially gained weight more rapidly than bottle-fed infants(6), while others have found similar weight gains between the two groups of infants[7,8,9]. These studies will be dealt with in more detail in the literature review.

Exclusively breast-fed infants may at some stage gain weight rather slowly in relation to their bottle-fed counterparts and more recently it has been suggested that breast-fed infants may have a different growth pattern from bottle-fed infants[10,11]. Artificial feeding and the early introduction of solids have been blamed for much of the overnutrition and obesity reported in recent decades[3,5] while other reports indicate that the timing of the introduction of solids has no influence on weight gain during infancy[12,13].

The amount of human milk produced by a healthy nursing mother in developed countries is sufficient to nourish normal infants until between four to six months of age[10,11]. The adequacy of milk production for optimum growth is the main concern of the breast-feeding mothers[14,15] while women who bottle-feed should be mainly concerned about the risks of overfeeding and the long term effects of obesity on health[16].

The introduction of mixed feeding continues to pose problems not only to the mothers but to the health care providers who are responsible for advising on infant feeding. Some reported reasons for the earlier introduction of solid food are the desire of both mothers and the medical profession to encourage infants to gain weight more rapidly and the ready availability of convenient forms of solid foods. Unfortunately, the advice given to mothers is often inconsistent, which only serves to increase the mothers concern[14,15]. Some of the inconsistencies undoubtedly result from a need to satisfy the baby's individual requirements while at the same time trying to follow current recommendations[16].

1.2.0 LITERATURE REVIEW

Infant nutrition has received intense scientific attention throughout this century. Yet, despite the confluence of interest in infant nutrition from an unusually large number of clinical scientific disciplines, uncertainty pervades the field. There have been and continue to be major swings in fashion on almost every nutritional issue. These swings reflect the lack of consistent and scientifically robust messages from health professionals to the public.

One of the major controversial nutritional issues is the relative growth of breast-fed infants compared with those infants fed formula milk. The controversy can, however, usually be sorted out if one takes into account the era in which research studies were carried out.

1.2.1 Growth of Breast and Bottle-Fed Infants *1950-1972*

In the early 1950's the research finding that bottle fed infants gained weight more rapidly than breast-fed infants was not unique. From his national survey in England during 1950, Douglas suggested that breast-fed infants may have weighed less because they were unusually vigorous(17) whereas Vinings(18) in 1952 reported that underfeeding at the breast was ***"only too common"*** and could no longer be disregarded. He suggested it was now held that overfeeding during infancy was ***"a matter of opinion rather than a real disorder"*** and that it rarely, if ever, caused harm to the infants.

Stewart and Westropp studied the growth of 580 infants in Oxford in 1953 and found that previously bottle-fed infants were appreciably heavier at one year than their breast-fed counterparts and also reported that the latter were somewhat less mature in mobility. They suggested that these differences might have been due to minor degrees of underfeeding among breast-fed infants which had been overlooked in spite of continuous medical supervision(19).

It had now become widely assumed that artificially fed infants gained more weight than breast-fed infants. An important point to note was that this was assumed to be a desirable effect during this period. Both the medical professionals and the family encouraged this, as the popular notion of a ***"healthy and beautiful"*** baby was one with chubby cheeks and a fat body.

Many researchers reported that bottle-fed infants gained more weight than breast-fed infants and that overweight and obesity was confined to bottle-fed infants[3,5,20]. Ounsted & Sleigh studied the feeding practices in 191 two month old infants in Oxford. They suggested that there was a powerful self-regulatory control within breast-fed infants[2]. Fomon, in 1964, suggested that overfeeding by persistent coaxing, or by over-concentration of formula milk either by error or intent, could result in conditioning the infants to long term patterns of over-eating with chronic[21] and excessive energy intakes[3,5,21]. Fomon speculated that overfeeding was much less likely to have occurred in the breast-fed infants who were more able to successfully control milk intake.

Hooper[20] studied infant growth during the first year of life in 148 infants on the Isle of Wight in 1961. He suspected that the overweight condition found in many of the infants was potentially dangerous in medical terms and suggested that it could be controlled by diet for long term health reasons. He reported that bottle-fed infants showed a greater total gain and greater weekly gain than breast-fed infants. Bottle-fed infants were more prone to illness than breast-fed infants *(i.e.41% compared with 20%)* with the most common ailments including respiratory and ear infections and skin conditions which were found to be recurrent only with the bottle-fed infants.

A large Australian study[22] was carried out in 1964 to investigate infant growth over the first year of life This study revealed that the mean weights *(1119 infants)* in 1964 were significantly greater than a similar study carried out in 1933*(Fig.1)*.

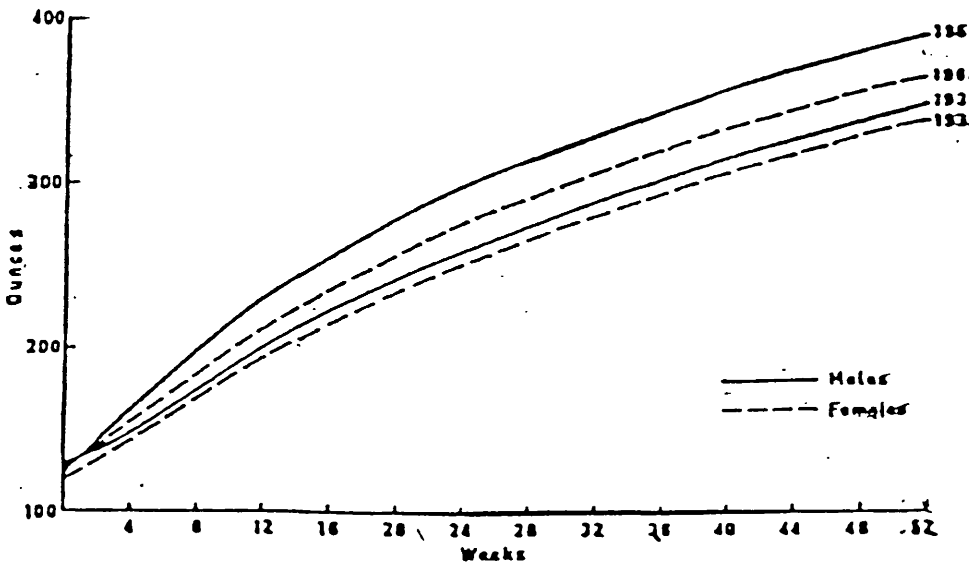


Figure 1. Mean weights of male and female infants 1933 and 1964. From Bell[22].

Eid in 1970[23] carried out a follow-up study of 474 children born in Sheffield in 1961 to determine whether excessive weight gain in the first 6 months of life was correlated with overweight and obesity at 6-8 years of age. The findings that unusually rapid weight gain in the early weeks of life, as early as 6 weeks, was related to overweight and obesity in later childhood was disturbing to those who had continued to claim that overfeeding was a myth.

Taitz studied weight gain in 240 infants in Sheffield in 1971[3]. He found that the weights of artificially-fed infants were substantially greater at 6 weeks of age than either predicted from birthweight or expected on the basis of the Tanner centile charts[59]. Taitz, like Eid[23], also found excess weight gain was more striking in males than females*(Table.I)*. Taitz postulated that the findings in his study represented part of a general trend to excessive weight gain in the neonatal period. He suggested that the mothers in this era had an apparently low resistance to the crying baby and there was a tendency for both medical professionals and baby milk manufacturers to encourage mothers ***"to provide instant gratification in a calorific form."*** Attention had also been drawn to the possibility that plasma hyperosmolarity due to high solute loads in artificial milk could have induced thirst which was misinterpreted as hunger and a vicious circle was set up when more milk was provided.

		>90	50–90	10–50	Total
Males— artificial feeding	Birth 6 weeks*	7 (6·1%) 46 (40·4%)	48 (42·9%) 52 (45·6%)	59 (51·8%) 16 (14%)	114 114
Females— artificial feeding	Birth 6 weeks†	9 (7·1%) 47 (37·3%)	70 (55·6%) 63 (50%)	47 (37·3%) 16 (12·7%)	126 126
Total ..	Birth 6 weeks	16 (6·7%) 93 (38·8%)	118 (49·1%) 115 (47·9%)	106 (44·2%) 32 (13·3%)	240 240
Breast-fed ..	Birth 6 weeks	1 (4·8%) 4 (19·1%)	12 (57·1%) 10 (47·6%)	8 (38·1%) 7 (33·3%)	21 21

*Males: $\chi^2 = 53{\cdot}51$. Significant, $P < 0{\cdot}001$.
†Females: $\chi^2 = 41{\cdot}41$. Significant. $P < 0{\cdot}001$.

Table 1. Comparison of Birthweight and 6 week Centile Distribution. From Taitz[3].

The practice of preparing artificial milk feeds from heaped scoops instead of complying with the manufacturer's advice held more sinister implications. Even when most dried milk formulae were correctly reconstituted they still provided a dietary solute load which was at least twice that of human milk. Davies[24] studied plasma osmolality in 60 infants aged 1-3 months in Cardiff during 1973. He found that the greatly increased solute load was provided by the combination of mixed feeding with artificial milk formulae produced even in apparently healthy infants, an alarmingly high proportion, who were already in an asymptomatic hyperosmolar state. This dietary solute overload greatly stressed the capacity of the immature kidney to maintain the normal tonicity of body fluids and only minimal water loss *(as would be expected with any common infant infection)* would be sufficient to precipitate a potentially dangerous situation[24,25]. The earlier introduction of solids to the diet before 3 months of age was also suggested to be a contributory factor in the rapid and excessive weight gain in the bottle-fed infants[3,5].

Towards the end of this era the attitudes of both the medical profession and mothers towards infant feeding and what constitutes desirable baby shape and size had been profoundly changing. More emphasis had been placed on improved health education to female adolescents and the teaching of infant feeding practices to pregnant women and young mothers. Potential mothers had now a different personal attitude towards diet and understandably therefore how they would like their own babies to look. There had also been dramatic changes in the recommended quantities of bottled milk consumed by infants and the present day mothers were now less likely to encourage their infants with more milk once they had indicated that they were satisfied. Unmodified milks had been replaced by much modified formula milks and strict instructions were given to ensure proper preparation of milk feeds.

1.2.2 The Prevalence of Breast-feeding in Great Britain *1975-1980*

Until this time the incidence of breast-feeding in Britain had been declining rapidly. However, the situation was found to have favourably changed as indicated by the results of national surveys[26,27] carried out during 1975, in England and Wales, and 1980, which also included Scotland, by the office of Population Census and Surveys *(OPCS)*. In 1980 one third more babies were breast-feeding at birth*(Fig.2)*. Only 30% of mothers claimed to be breast-feeding at 3 months in 1975 which had increased to 50% five years later. More babies in 1980 were still breast-feeding at 4 and 6 months than in 1975. There was also a corresponding shift in the introduction of "solids" such as commercial cereals. The major change observed over the 5 year period was that the proportion of mothers giving solid food before the age of 3 months had fallen from 85% to 56%. The median age for having introduced solids into the infants' diet had moved from 8 to 12 weeks of age. It was obvious from these reports that mothers or their advisors had clearly been influenced by the scare of overconcentrated formula milks, hypernatraemia and the possible long term effects of overfeeding in infancy which had almost certainly had been additional contributory factors.

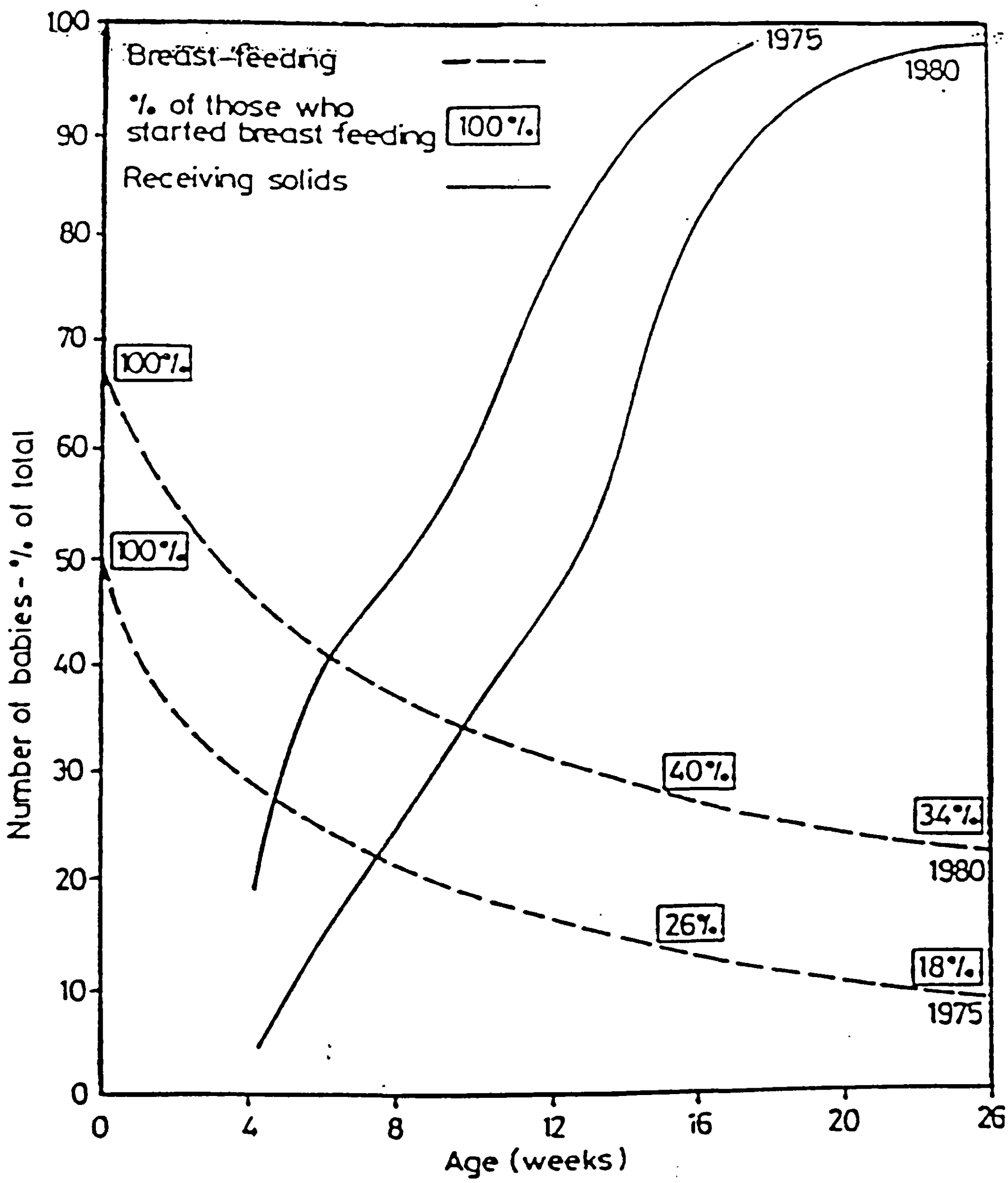


Figure 2. Proportion of babies in England and Wales being breast-fed and receiving solid foods during the first 6 months of life in 1975 and 1980.

From *OPCS* Surveys(26,27) by Wharton (28).

1.2.3 Growth of Breast and bottle-fed Infants *1974-1980*

Since the introduction of humanised artificial milks with modified formula, many researchers had reported that in early infancy, weight gain in bottle-fed infants was similar to that in breast-fed infants while other researchers found that there was no initial difference in weight gain but that bottle fed infants gained more weight between the ages of 7-16 weeks. Ritchie and Naismith studied 39 infants during the first 6 months of life in 1975[29]. They found no difference in the rate of increase in weight or length between breast and bottle-fed infants within the first 6 weeks of life. Thereafter, the bottle-fed infants continued to grow faster in both weight and length. They suggested that the high intake of protein was the major factor in the aetiology of accelerated growth in the bottle-fed infants. Meanwhile a large study was carried out with 357 healthy infants in America by Neumann and Alpaugh[30].They reported that bottle-fed infants gained more weight per unit of length than breast-fed infants during the first 6 months of life. Bottle-fed infants doubled their birthweight before the breast-fed infants *(113 days versus 124 days).* Solid food was also introduced to the bottle-fed infants significantly earlier *(mean 1.9 months)* than the breast-fed infants *(mean 3.9 months).* The bottle-fed infants, by the time they had doubled their birthweights, had gained disproportionately more weight than length compared to the breast-fed infants and this was indicative of the signs of the development of early obesity.

Holly and Cullen[7]in 1977 found similar weight gains in 157 breast and 223 bottle fed infants over the first 3 months in Exeter and suggested that there was possible regional differences which affected the attitudes of mothers and their feeding practices. They indicated that differences in weight gain would not be discriminating factor if artificial and breast milk were administered correctly.

Different results were obtained from research studies in certain regions where previous studies had been carried out a few years earlier. In South Wales in

1978 Evans[8] studied growth in 94 infants from birth to 6 months of age. He found that breast-fed and 3 groups of infants fed on the latest formulations had similar weight, length and head growth velocities but that the weight gains were considerably less than infants fed unmodified milks and had solids introduced before 12 weeks of age who were studied in the same region several years earlier.

There was also a changing situation found in the Sheffield region when Taitz and Lukmanji[6] studied a fresh cohort of infants, aged 5-7 weeks of age, between 1977-1978. They found that the breast-fed infants were now growing significantly faster than the bottle-fed infants. Entirely breast-fed male infants had gained more weight and skinfold thickness than bottle-fed males. Girls in both groups had similar weight gains and skinfold thickness. These findings did not corroborate the results of Oakley[31] 1977 who reported similar weight gains in the infants in both feeding groups at this age but significantly greater increase in skinfold thickness among breast-fed infants.

While previous studies had treated male and female infants in a common group[7,9], D'Souza and Black suggested that each should be studied in separate groups when investigating infant growth in relation to the method of feeding[32]. They had carried out a study with 65 breast and 106 bottle-fed infants in Manchester in 1979. Breast-fed infants were found to have gained significantly more weight than entirely bottle- fed infants at 5-7 weeks of age. The increase in length and head circumference was similar in all infants. Girls in both groups were found to have similar weight gain and skinfold thickness but there was a significantly greater increase in skinfold thickness and weight gain noted in entirely breast-fed males than those males who had been entirely bottle-fed.

Many researchers now reported that the earlier introduction of solid foods, before 12 weeks of age, did not affect the rate of weight gain during infancy. De Swiet and Fayers[9] studied 758 infants in London during 1977 and reported that there was no significant difference between the weights of breast and bottle-fed infants over the first 6 months of life. The timing of the introduction did not influence the weights of infants during this period. Similar results were also reported by Davies *et al*[12] who studied the effect of solid food on the growth of 821 bottle-fed infants *(of which 657 infants had been given solids by 6 weeks of age)* over the first 3 months of life during 1977 *(Table 2)*. In a small study of 50 infants from Leicester in 1978, Wilkinson and Davies[13] also reported that the age of weaning did not influence the weight gain, the increase in length and the increase in skinfold thickness over the first 6 months of life. These research findings just described, no longer supported the theory that bottle feeding and the associated early introduction of solid food was associated with the over weight infant and obesity and therefore did not accord with the much publicised work of Taitz in 1971[3].

Variable	Feeding group*			
	Solids started before age 6 weeks	Solids started between ages of 6 weeks and 3 months	Cow's milk alone for 3 months	Significance
Weight gain (g/week)				
Boys	277 ($\pm$6·1)	271 ($\pm$8·1)	270 ($\pm$28·0)	NS
Girls	237 ($\pm$8·2)	230 ($\pm$8·3)	233 ($\pm$10·1)	NS
Linear growth (mm/week)				
Boys	8·4 ($\pm$0·16)	8·3 ($\pm$0·15)	7·8 ($\pm$0·30)	NS
Girls	8·2 ($\pm$0·20)	7·9 ($\pm$0·13)	8·3 ($\pm$0·28)	NS

NS = Not significant.

Table 2. Mean weight gains and linear growth *(+-S.E.)* in the first three months after birth in the three feeding groups. From Davies *et al*[12].

1.2.4 Growth of Breast and Bottle-fed Infants *1981-1991.*

Although many researchers had contradicted this commonly held notion that bottle-feeding always resulted in greater weight gain, it was still not consistent. Boulton[4] carried out an extensive study in Adelaide, Australia in 1981. Breast-fed infants continued to gain both weight and height less rapidly than bottle-fed infants although the timing of the introduction of solids did not have any influence on the growth during the first 6 months of infancy. Jarvenpaa *et al*[33] studied the growth of 60 infants in Finland over the first 12 weeks of life. They found no consistent significant differences among 1 group of breast and 2 groups of bottle-fed infants with respect to the rate of gain in weight, crown-rump length, crown-heel length or head circumference. Another study carried out in Sweden by Kohler *et al*[34] reported that there were no significant differences seen in 1 group of 26 breast-fed and 2 groups of infants *(n.26 and 13 respectively)* fed different type of formula milk with respect to increase in both length and skinfold thickness. Although there were no significant differences noted in weight gain between breast and bottle-fed infants over the 6 month period, there was a slower weight gain noted with one of the formula-fed groups only over the first 6 weeks of life.

Researchers have continued to find similar weight gains between infants in relation to the method of feeding. Salmenpara *et al*[35] found that 116 breast-fed infants in Helsinki had a slower growth velocity when compared to a reference group of 32 infants fed formula milk. However, the weight for length index showed that breast-fed infants were heavier for their length than the formula-fed infants. This indicated that breast-fed infants did not have any calorie deficiency as had been postulated earlier by other researchers.

1.2.5 The Prevalence of Breast-feeding in Great Britain *1980-1985*

A third national survey in 1985 [36] revealed that there had been no significant change in either the number of infants being breast-fed or the age when infants were first offered solid food, over the preceding five years. This is in contrast to the major change observed between 1975 and 1980. It was clear that mothers were still starting solid foods earlier than was generally thought to be desirable*(Table 3,Fig.3)*. This overall picture of no change in the incidence of breast-feeding since 1980 did not occur in all subgroups of mothers examined. In particular among mothers of first babies the incidence of breast-feeding had fallen by 5%. There was also a substantial decrease of 8% in the incidence of breast-feeding with single mothers. This decrease in breast-feeding among mothers of first babies was of major national concern. All 3 surveys had clearly shown that whether or not a mother breast-fed a second or subsequent child depended mainly on her experience of feeding her first. It was seriously hoped that this would not lead to a future decline in breast-feeding in subsequent years. All surveys reported the highest incidence of breast-feeding mothers *(particularly those who had their first babies over twenty five years of age)* were in higher social classes and educated over the age of eighteen years.

Method of feeding at six weeks	1980	1985	*1980*	*1985*
	Percentage giving solid food		*Bases:*	
Breast	4	4	*1,666*	*1,711*
Bottle	21	14	*2,487*	*3,483*
Total	14	11	*4,208*	*5,194*

Table 3. The proportion of babies who had been given solid food by 6 weeks of age according to the method of feeding *(1980 and 1985 in Great Britain[36])*.

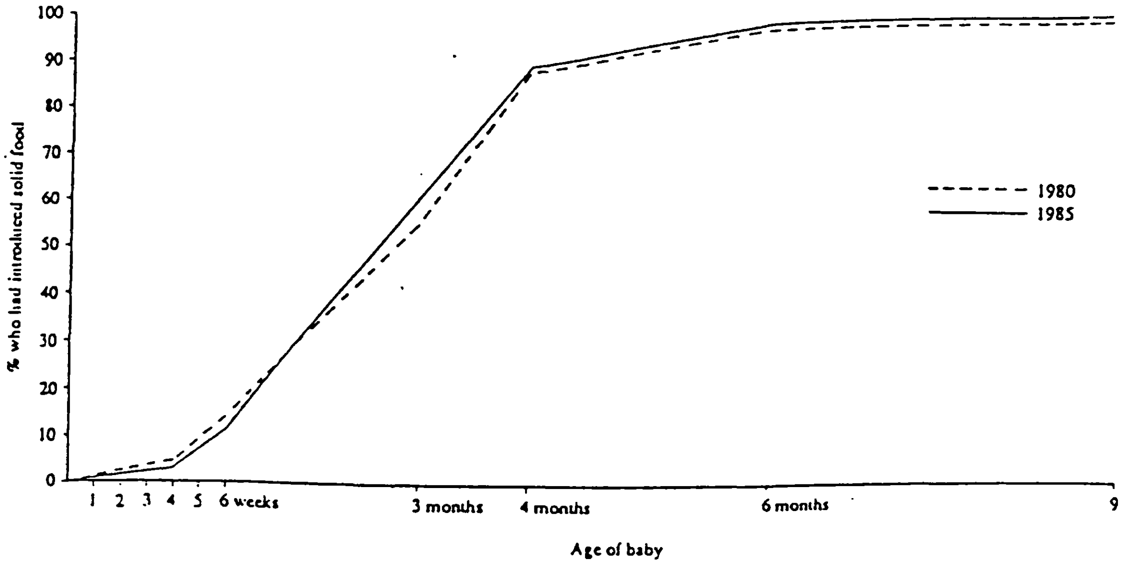


Figure 3. Proportion of babies who had been given solid food by different ages

(1980 and 1985 Great Britain from OPCS Surveys[36]).

1.2.6 Social Class and Infant feeding Practices

These findings were consistent with social class patterns of breast-feeding found as a result of a considerable amount of research carried out in recent decades on infant feeding practices in different countries. Different social class patterns of breast-feeding prevail in the western industrialised world and in developing countries[(37,38)]. In western industrialised countries, it is women from upper social classes and high levels of education who breast-feed more often and for longer durations[(38)], while the opposite is true for developing countries where the traditional, less educated women from lower social classes have the highest incidence of breast-feeding[(37,38)].

These social class differences have been an important factor in attempt to relate diet to growth as social class is also statistically related to the number of children[(39)]. It is not known to what extent socio-economic circumstances and other environmental factors influence growth patterns but there is clearly a danger of undesirable biases being introduced into any simple analysis.

1.2.7 Secular Trends and Growth Patterns.

The adequacy of infant nutrition can be evaluated only by relating it to what is considered as the normal growth expectation. There are many growth standards in use but the *NHCS* *(National Center Of Health Statistics)* standards from birth-eighteen years is one of the current commonly used international norm for weight and height[40]. They were compiled from measurements of a cross-section of the population of infants who were predominantly formula-fed at various times between 1929-1972 by Fels Research Institute and Ohio State University, U.S.A. Since that time, growth rates *(as well as skinfold thicknesses)* of formula-fed infants have been falling whereas those of breast-fed infants have remained virtually constant.

Hitchcock *et al*[41] studied the weight gain of 205 breast-fed infants during the first six months of life between 1975-1980. They found that weight gains were similar to the findings of a previous study carried out in 1933 when breast-feeding also prevailed*(Table 4 & Fig.4)*. They suggested that the patterns of weight gain in breast-fed infants should be further investigated.

	Mean body weight (kg)					
	Boys			Girls		
Age	1933	1964	1980	1933	1964	1980
Birth	3.74	3.51	3.56	3.62	3.45	3.47
Six weeks	4.67	5.18	4.81	4.52	4.95	4.60
Three months (13 weeks)	5.91	6.73	5.92	5.73	6.22	5.61
Six months (26 weeks)	7.63	8.84	7.85	7.49	8.18	7.44
Nine months (39 weeks)	8.97	10.17	9.11	8.71	9.40	8.56
One year	10.02	11.20	10.01	9.73	10.48	9.50

Table 4. Body weights of infants *(1933,1964 & 1980)*. From Hitchcock *et al*[41].

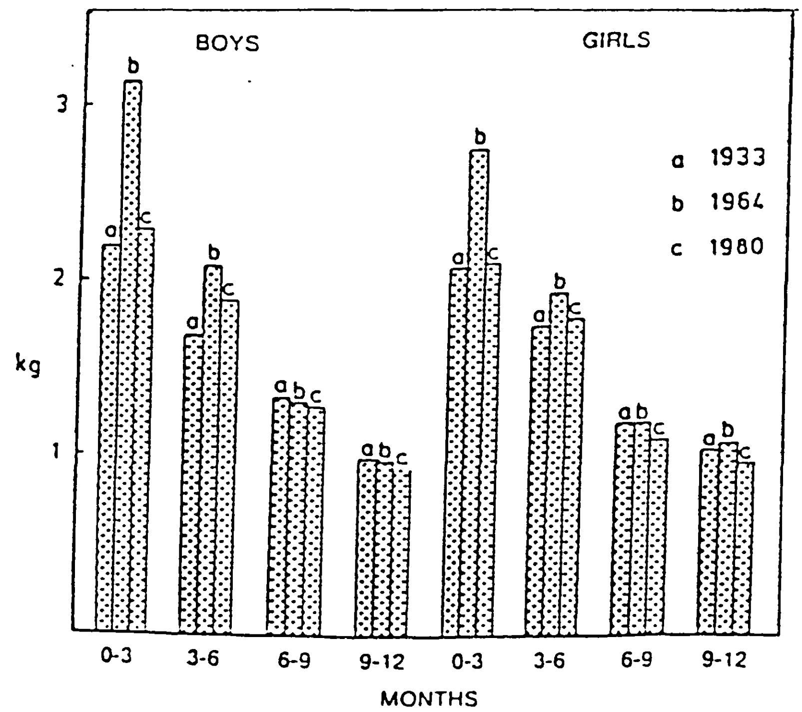


Figure 4. Comparison of mean quarterly weight increments of infants in the first year of life*(1933a, 1964b and 1980 c)*. From Hitchcock *et al*[41]

More recently, Hitchcock and Coy[42]carried out a large joint survey of infant feeding practices and infant growth in Western Australia and Tasmania in 1985. The study included data from 1300 infants from birth to one year. They reported that the pattern of growth from birth to three months of age of the bottle-fed infants resembled that of breast-fed infants. However, the greatest difference in weight gain occurred between those infants who were wholly breast or bottle-fed until 12 months of age. There was no significant difference found in either the gain in weight or length over the five years between the two Australian studies. This suggested that some stability in the growth patterns of infants, particularly in respect to weight, had been achieved. This stability was almost certainly the result of the widespread return to breast-feeding combined with the use of bottle-feeding mothers to offer infants those formula milks based on the model of breast milk composition.

A comparison of these results with those of two previous Australian surveys, when either breast*(1933)* or bottle-feeding*(1964)* predominated-feeding, demonstrated that the *' revolution'* of infant feeding practices that had occurred over the past 16-20 years appeared to be associated with very significant alterations both in the detailed pattern of growth as well as growth in general terms*(Fig.5)*.

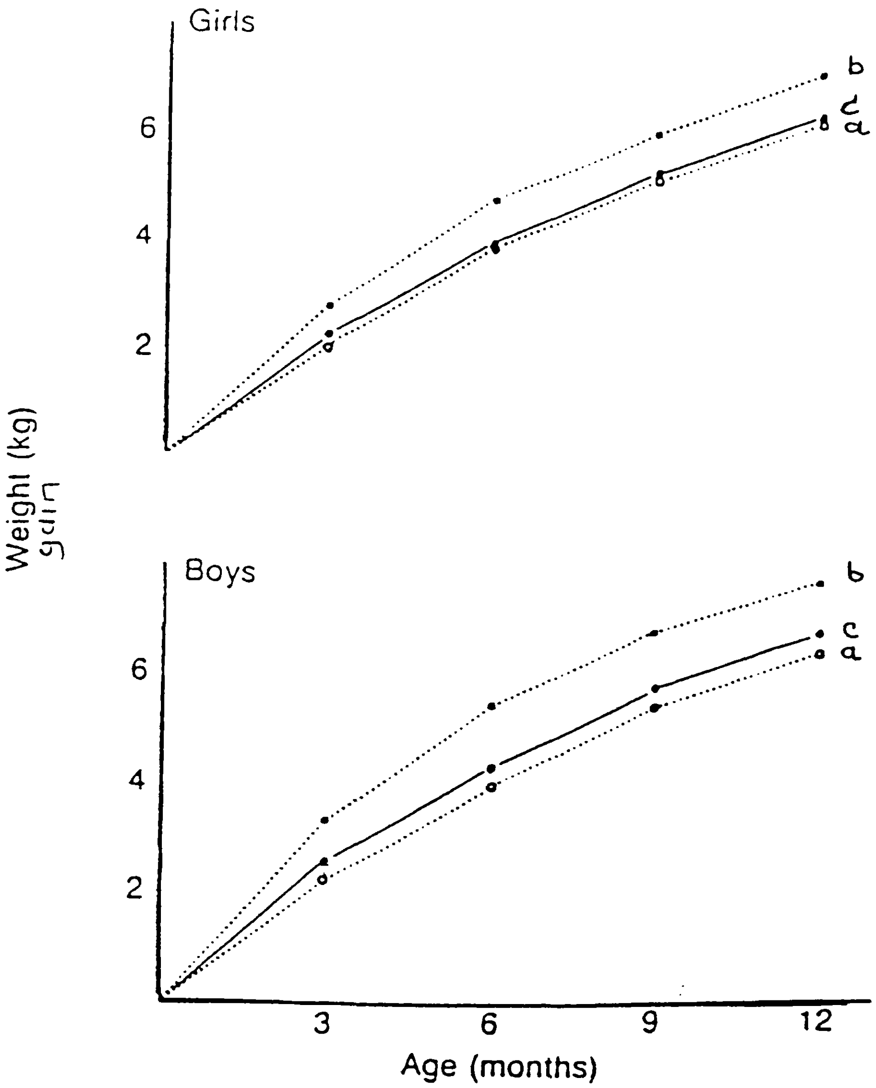


Figure 5. A comparison of cumulative weight gains *(birth to 12 months of age)* from studies carried out in *1933a ,1964 b ,and 1984c.* From Hitchcock and Coy[42]

There is now increasing concern that the ideal growth patterns of breast-fed infants may differ from the published norms of *NCHS*. Researchers in the United States, Canada, Chile and Great Britain have noted that breast-fed infants had an initial acceleration of weight gain during the first three months which was faster than the *NCHS* standards, with a slower rate of growth than the standards during the fourth, fifth and sixth months[43,44,45,46,47]. Similar deviations from *NCHS* standards were noted by Ahn and MacLean despite a large study being conducted on infant growth using an optimum group of breast-fed infants whose mothers were from La Leche League International and were highly motivated towards successful breast-feeding[10] *(Figs.6&7)*. In this study the average period of exclusive breast-feeding was 7 months. As with the Cambridge children[43] *(Fig.10)* the infants initially grew faster than the standard, the average reaching the 75th centile at 3 months. From 4 months onwards, however, the average growth curve started to fall back, crossing the 50th centile at 10 months *(Figs.6&7)*. The girls responded quantitatively and qualitatively in a similar manner. Woods *et al* also reported a similar pattern in the gain in weight, head circumference and length which started slowing down in comparison to *NCHS* standards earlier at about 14 weeks[48] *(Figs.8&9)*.

Waterlow and Thomson challenged, largely on theoretical grounds, the normality of growth patterns in the first 6 months of life and the nutritional adequacy of breast-feeding in sustaining optimum growth[49]. These objections were strongly criticised for several reasons[50]. They did not cite adequate longitudinal studies of growth and health of healthy breast-fed infants but used data mainly from infants fed, *ad libitum*, from the bottle with either pooled human milk or formula milk and therefore their relevance to breast-fed infants with fresh human milk on demand was conjectural. Theoretical extrapolations were inappropriate as were the comparisons made between data from industrialised countries and those from developing countries where maternal malnutrition existed. Studies such as

Ahn and MacLean have shown that all 96 exclusively breast-fed infants in their study remained above the 25th centile of *NCHS* standards for up to 9 months of age[10] *(Figs.6&7)*.

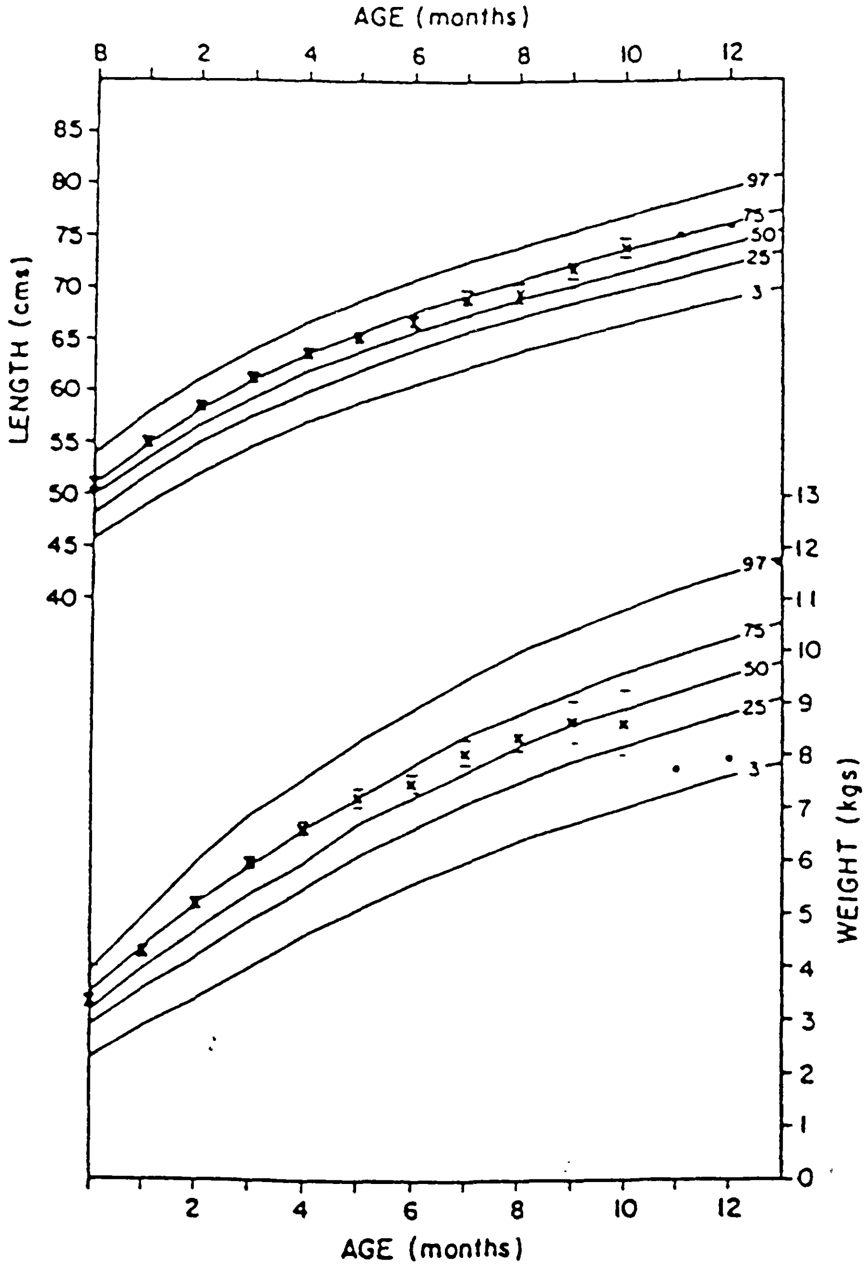


Figure 6. Weight and length of female infants while being exclusively breast-fed from birth to 12 months of age. X, mean *(+-SEM)*; points at 11 and 12 months denote one individual. Plotted on *NCHS* standards curves[40]. From Ahn & MacLean[10]

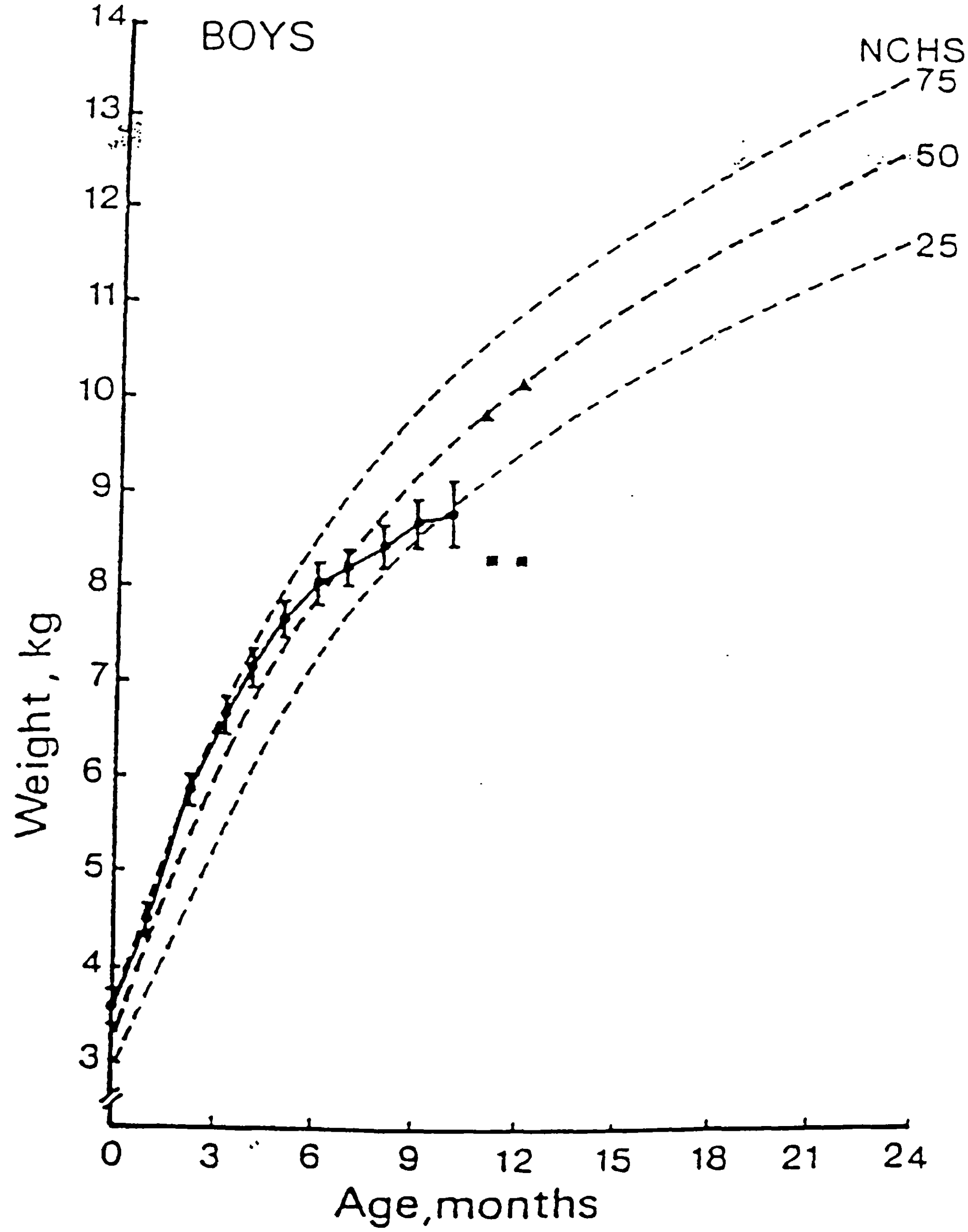


Figure 7. Body weights(*mean and SEM*) of exclusively breast-fed boys in relation to the *NCHS* standards[40]. ■ ■ and ▲ ▲ denote individuals at 11 and 12 months of age.

From Ahn and MacLean[10].

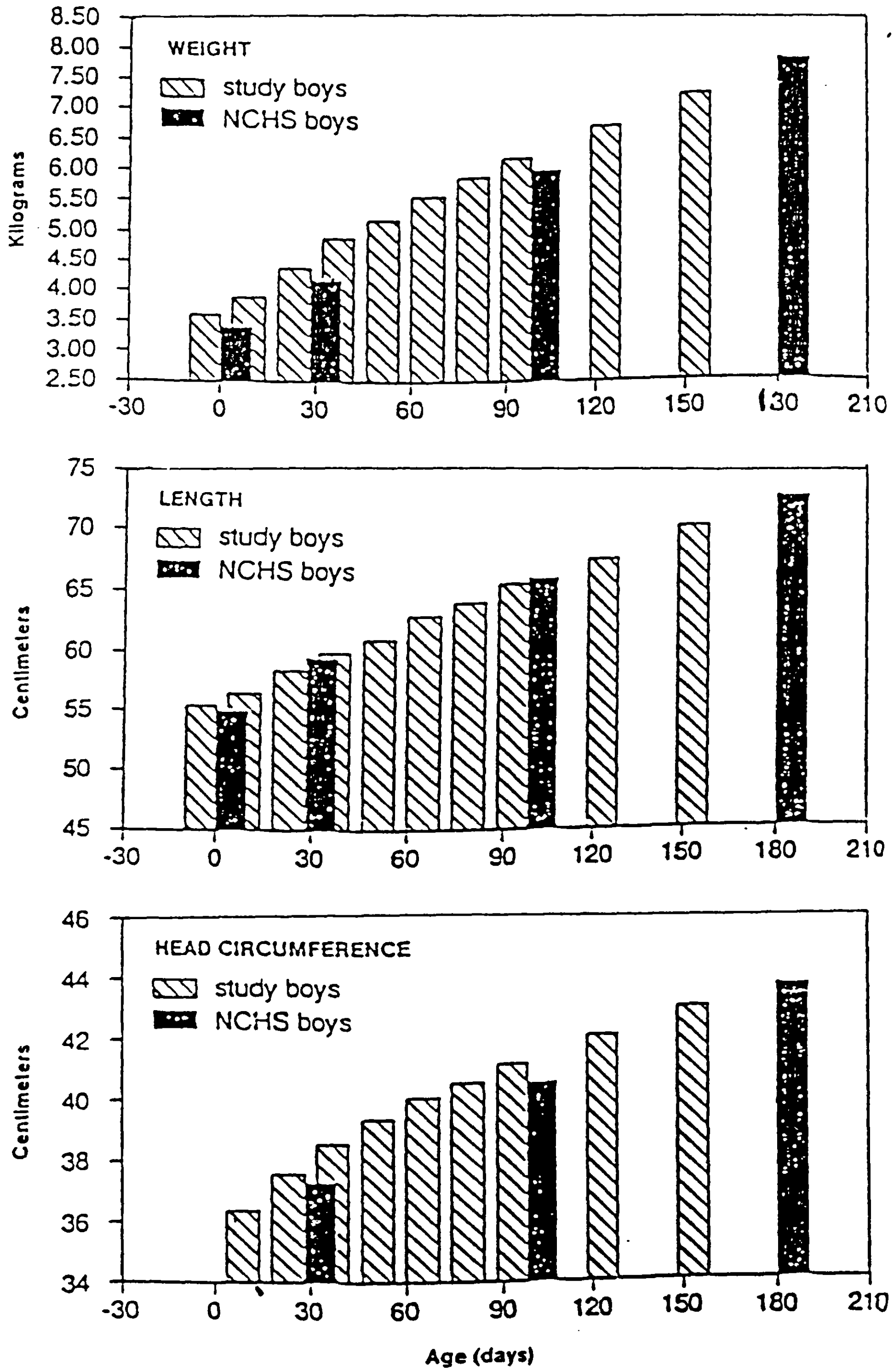


Figure 8. Mean weight, length and head circumference of boy study infants and *NCHS* 50 Percentile values[40] as a function of age. From Wood *et al*[48]

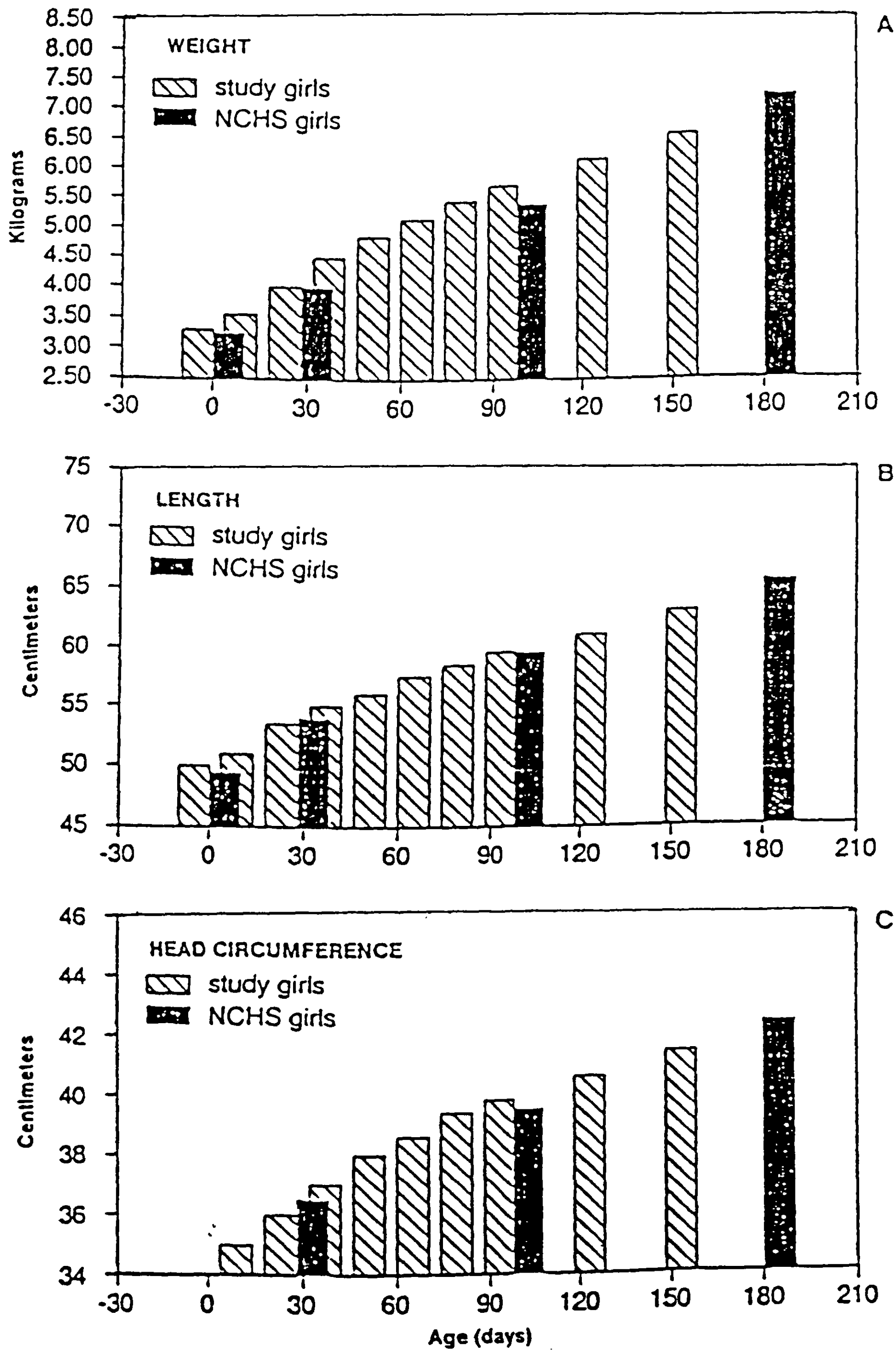


Figure 9. Mean weight, length and head circumference of girl study infants and *NCHS* 50 Percentile values[40] as a function of age.

From Wood *et al* [48].

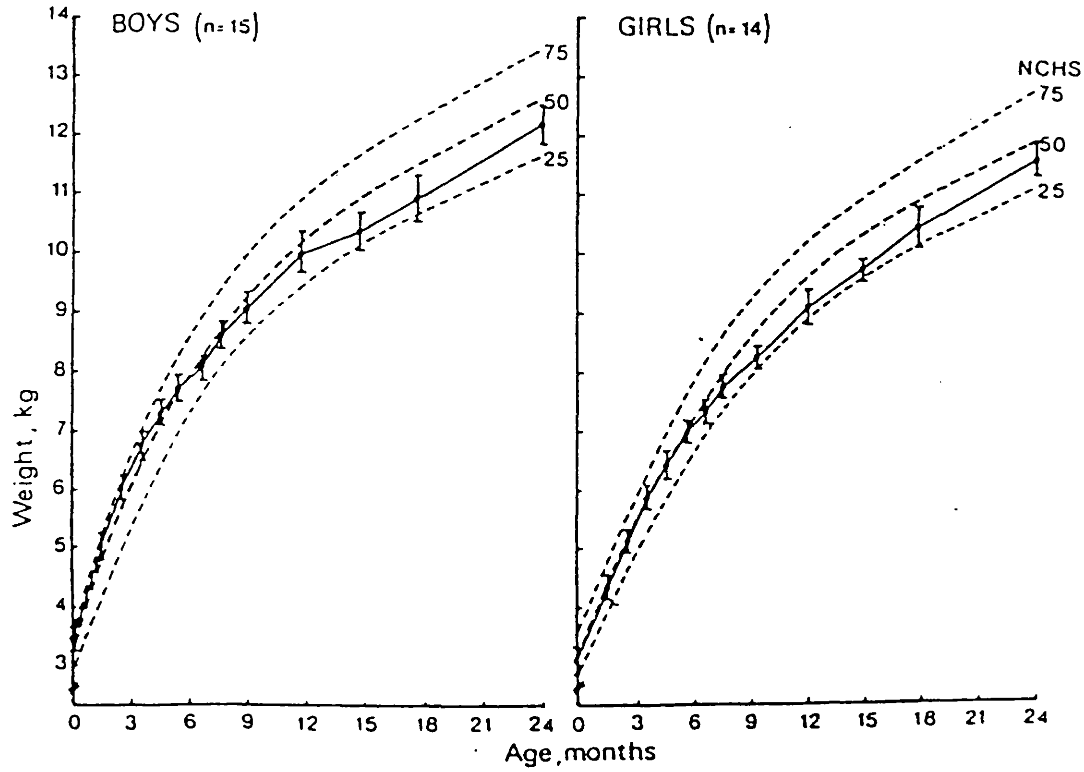


Figure 10. Body weights*(mean and SEM)* of two cohorts of Cambridge breast-fed boys and girls over the first 2 years of life in relation to the *NCHS* standards. From Whitehead and Paul(43).

The interpretation of this deviation in the growth of breast-fed infants from the *NCHS* growth standards remains controversial. The contention that human milk is inadequate is countered by the argument that the *NCHS* standards, based mainly on the data from formula-fed infants, are inappropriate for the evaluation of the growth performance of breast-fed infants(10,48).

If human milk were inadequate to sustain infant growth for 4-6 months, then *ad libitum* addition of solid foods to the diet of exclusively breast-fed infants would be expected to reverse the decline in weight for age percentiles observed during the exclusive breast-feeding period. Stuff and Nichols(51) found that the deviation from *NCHS* growth standards during this period was not only not reversed with supplementation but persisted throughout 10 weeks of mixed feeding.

There is now strong recommendations for separate growth charts for breast-fed infants. The major concern is that any deviation from current growth charts would intervene to correct a problem which may not exist[48]. Chandra[47] in 1981 recommended the use of supplementation to exclusively breast-fed infants between 4-6 months in his study as he did not regard the slowing down of weight gain to be normal during this period.

Roche *et al*[52] used serial data from 504 infants in the U.S.A. to develop reference data for one month increments in weight and recumbent length over the first 12 months of life. This data was to be used in conjunction with the *NCHS* standard to allow earlier evaluation of growth velocity than the 3-6 month increments previously available. However, they suggested that in evaluating the growth of individual infants, it was more important to consider gestational age, birthweight and length and parental size, ***"but it was less important to consider whether the infant was breast or formula-fed"***. Dewey *et al*[53] argued that the method of feeding was one of the most important criteria with regard to infant growth standards. They have noted that in their current study, 46 breast-fed infants were below the reference data presented by Roche *et al* whereas the data collected from formula-fed infants indicated weight and length to be similar to the reference data. They suggested that the slower growth velocity of breast-fed infants should be considered as a normal patterns of growth under optimal conditions.

Most investigations on large numbers of breast-fed infants for extended periods of time have taken place in the developing countries where low birthweight infants and maternal malnutrition are not uncommon. Results have been similar to western studies with an early accelaration in weight gain until 3 months followed by a slowing down of weight gain from 4-6 months. The initial accelerated increase in weight gain was assumed to be ***'catch-up growth'*** due to infants being light for dates at birth, while the faltering in weight gain beyond *4* months was totally attributed to the result of inadequate nutrition and also as weanling diarrhoea related to poor hygienic conditions which has long been recognised as a major health hazard in the developing world[55]. This has resulted in what is now considered to be an oversimplified interpretation of results. A study was carried out on a group of breast-fed infants who came from one of the wealthier villages on the Ivory Coast where mothers were well nourished. Lauber *et al*[56] reported a similar pattern of growth of 32 infants who were exclusively breast-fed and they grew well for the first *5* months and thereafter their weight for age decreased from *5-10* months of age to 80% of western growth standards.

Nutritionists had also assumed that growth deficit was predominantly the product of dietary inadequacy. Results from a study of 152 infants between the age of *6* months and *3* years, from the village of Keneba in *The Gambia,* have shown that growth quantitatively how both growth and even height were significantly affected by infection mainly gastroenteritis but also malaria. It is now thought that the initial interpretation of the results from the developing countries be reviewed in the light of the similar growth patterns of breast-fed infants which are emerging from the developed countries[57].

It is obvious from the described research findings that the adequacy of current standards remains a controversial issue. It is essential that the appropriate growth standards reflect ideal health and well-being. It is imperative that the current growth standards in relation to both breast-feeding and the latest formulations of milk, are looked at very closely prior to undertaking of the mammoth task of compiling new appropriate standards.

1.3.0 The Present Study

The uncertainties about infant growth, in relation to the infant feeding practices described above, has raised an interesting field for research. There is known to be rapid changes in the growth of infants during the initial period following birth. It remains a controversial issue as to whether the infant feeding practice has any influence on the growth pattern both during infancy and later life.

The methodology used in those research studies, previously discussed in the literature review, has been varied especially in both the duration of the study and the frequency in the collection of the growth measurements obtained from the infants. The duration of studies have ranged from very short studies, which observed growth of infants over the initial few weeks of life only, to much longer studies where the infants were followed until 1-2 years of age. There was also found to be a large variation in the time intervals between subsequent growth measurements of the infants recorded by the observers. The frequency of obtaining the growth measurements from infants varied from every 2-4 weeks, which was common for a study of short duration, to 1-monthly, 2-monthly, 3-monthly *and* 6-monthly measurements with those studies of longer duration. It was also common for those studies of longer duration to have an increased frequency of obtaining the growth measurents over the initial weeks of infancy followed by a decrease in the frequency as the infants grew older.

This following longitudinal study was undertaken to observe the changes in growth of infants every 2 weeks during the first 26 weeks of life in relation to infant feeding methods. Frequent measurements were made to detect any rapid changes in the growth patterns of infants which may not have been observed in those research studies where growth measurements were recorded less frequently and for a shorter duration of time.

The **AIMS** of the study are :

1. To **compare** the growth patterns of healthy male and female infants over the first *26* weeks of life in relation to the method of feeding.

2. To **investigate** whether there is any relationship between birthweight and weight gain of infants at *12 and 26* weeks of age in relation to the method of feeding.

3. To **investigate** if the age at which solid food was introduced into the diet has any influence on the growth of infants at *26* weeks of age.

Anthropometric measurements, which included naked weight, length, head and mid upper arm circumference and two skinfold thicknesses, were recorded at *2*-weekly intervals from *2-26* weeks of age on healthy infants. All infants were fed ***ad libitum*** with either breast or formula based milk. Solid food was offered to the infants, in addition to breast or formula milk at the discretion of the mother. I did not influence or give advice to the mothers of the subjects concerning either the infant's feeding regime or the age of the infant when solid food should first be introduced into the diet.

CHAPTER TWO

METHODOLOGY

2.1.0 Recruitment and Subjects

Subjects from the Glasgow and surrounding areas were recruited by two different methods between September, 1990 and March, 1991. Some women responded to calls for subjects to take part specifically in this present longitudinal study investigating weight gain during infancy. Other women who were already participating in an ante-natal study in the department of Physiology, were approached to extend their participation to this post-natal study.

Women were selected during the initial 2 week post-natal period using the criteria that pregnancies had been uncomplicated, were greater than 37 weeks gestation and had resulted in the birth of healthy infants.

An initial group of 142 subjects started the study. Data were excluded for those subjects who abandoned the study, who had been ill or had failed to have measurements recorded at the appropriate specified time intervals and for a few subjects who had been regularly partially fed with both breast and formula milk. Statistical analyses was carried out on the data of 88 subjects who had completed the study. The feeding groups consisted of 53 bottle-fed infants and 35 breast-fed infants. Twenty-eight of the mothers of infants in the breast-feeding group had successfully breast-fed previous infants. There were 6 members of La Leche League International and 13 members of The National Childbirth Trust included in the breast-feeding group.

2.2 0 Data Collection

2.2.1 Visit to the Subjects and Information Obtained.

An initial questionnaire to the mother was taken at the first visit. Information was obtained concerning socio-economic circumstances, maternal age, parity, and birth details which included birthweight, period of gestation and the method of feeding. Home visits to the subjects were scheduled every two weeks from 2-26 weeks of age. All anthropometric measurements were recorded at every visit. In addition to these measurements, a questionnaire was completed to update the method of feeding and the age of the infant when solid food was first introduced into the diet.

2.2.2 Anthropometry

I received initial instruction from an experienced observer on the technique of obtaining accurate measurements of the following specific anthropometric measurements necessary for this study. Supervision was also given to ensure that adequate reproducibility of measurements was being obtained prior to commencement of the recorded data

Body Weight. The naked weight of the infant was recorded on a set of portable electronic scales*(Seca Model 724)*. The weight was recorded to the nearest 0.01kg. The accuracy of the scales used was checked on a regular weekly basis using a known weight. The scales were switched on a protective cover was placed over the weighing bowl. The tarė was reset to zero. The infant was placed centrally on the weighing bowl. The weight lock-in display flashed when the exact weight was recorded.

Ease of Weighing. The exact weight could be recorded promptly with the young*(<14 weeks)*, smaller*(<5kg)* and settled infant. These infants could easily be placed comfortably within the weighing bowl and were less likely to have activity of their limbs unless crying or unsettled. It was very common for the older infant

(> 14 weeks) to have increased activity while the weight was being recorded. This resulted in several attempts of weighing the infants to be necessary.

Time of Weighing. I strived to weigh infants mid-way between their feeding times to avoid impaired accuracy of weight gains due to the amount of milk feed consumed if the infant had recently been fed.

Body Length. The spine length was recorded using a recumbent length mat. The mat was placed on a flat surface on which the infant was positioned on his/her back. The assistance of the mother was required to gently hold the infant's head in contact with the head board. The infant's leg were fully extended and I held the legs straight by applying gentle but firm downward pressure above the knees. The movable footboard was positioned flat against the bare heels of the feet which were held at right angles to the legs. Measurement was recorded to the nearest 0.5 centimetres.

Ease of Measurement

< 6 weeks: I felt that the length measurements may have been underestimated during this period as it was difficult to get the spine and the legs to uncurl and extend.

7-18 weeks: The reproducibility of the measurements was excellent during this period as the infants legs could be comfortably extended and the infant could be readily distracted by the mother during the measurement being recorded.

>18 weeks: I found it difficult to accurately measure the length when infants tended to be older than 18 weeks of age as the infants were reluctant to lie flat and tended to either arch their backs, lift their torso or head from the mat. A major problem resulted in the infants ability to rigidly point their toes downwards which resulted in difficulty in placing the foot board flat against the soles of the feet. There was a possibility that the measurements recorded may have been over estimated during this period.

Occipito-Frontal Head Circumference. This measurement was recorded, using a measuring tape made from non-elastic material, to the nearest millimetre. The occipito-frontal head circumference was measured by placing the tape over the occipital protruberance at the back of the head and bringing the tape ends to meet at the centre of the frontal bones.

Ease of Measurement. Measurements were confidently recorded with the inactive and settled infant. However, measurements were difficult to reproduce when the infant was active and moved the head vigorously from side to side in response to the tape being placed on the head.

Skinfold Thickness. Triceps and subscapular skinfold thicknesses were measured from the traditional left side of the body. They were recorded to the nearest millimetre using a Holtain skinfold caliper. The pressure of the caliper jaws was calibrated to a constant pressure of 10 grammes/sq.millimetre. The procedure for performing the skinfold measurements was the following: a fold of skin and subcutaneous tissue was picked up between the thumb and the fore finger and pinched away from the underlying muscle; the caliper jaws were applied at the marked level and just then the fingers released the fold. After the full pressure of the caliper jaws was applied, the actual measurement was read at the time the readings started to stabilise, usually after two or three seconds.

Specific skinfold measurements:

Triceps. The skin càlipers were applied at the back of the arm on the middle point between the inferior border of the middle point of the acromion process and the tip of the olecranon process, and directly in line with the point of the elbow and the acromion process.

Subscapular. The skinfold was picked up below the tip of the scapula at an angle of about 45^0 downwards from the spinal column.

Ease of Measurement. I placed the infant in one of the two following positions depending on either the age of the infant and/or the individual requirements. Once the most suitable position was adopted for the infant which allowed easy access to the skinfolds then measurements were confidently recorded.

1. I sat down on a chair and placed the infant face down over my knee. This allowed easy access to the skinfold required and was found to be more suitable for the infants aged 2-14 weeks.

2. The infant was placed on the mother's knee facing her and in a sitting position. The mother held the baby firmly by the hands or in any suitable position which still allowed me easy access to the skinfolds for measurement. This position also enabled the mother to keep eye contact with the infant and thus helping to distract the infant from turning the torso around while the measurements were being recorded. This position tended to be more favourably adopted for the infant >14 weeks. Activity of the infant did not interfere with the accurate recording of the measurements.

Mid Upper Arm Circumference (MUAC). This measurement was recorded using a measuring tape, made from non elastic material, to the nearest millimetre. The infant was placed in one of the two positions previously described for obtaining the skinfold thicknesses and the measurement was recorded from the left side of the body. The measuring tape was applied on the middle point between the inferior border of the acromion process and the tip of the olecranon process*(as for the triceps skinfold measurement)*. Measurements were easily recorded at all ages.

2.3.0 Data Analysis

2.3.1 Grouping by the Method of Feeding

Infants were categorised into the two feeding groups according to the method of feeding they were receiving at the second visit *(i.e.4 weeks of age)*. This particular time was chosen because all mothers who were breast-feeding at this time were successfully breast-feeding and were content to continue with this method of feeding.

2.3.2 Grouping by Social Class

Subjects were classified by social class according to the publication by the Office of Population Census and Surveys[58]. The occupation chosen to be coded was whichever of the parents occupation corresponded to the highest value of social class.

2.3.3 Grouping by the Timing of the Introduction of Solids

Infants were categorised into three weaning groups. The early weaning group consisted of those infants who had solids introduced into their diets before *8* weeks. Solids had been introduced to infants in the middle weaning group between *9-16* weeks and between *17-26* weeks of age in the late weaning group. Data of 2 subjects who had not been offered solids before *26* weeks of age was not included in the analyses of the weaning groups.

2.4.0 Statistical Analysis

Data was stored in Database IV and all analyses were carried out using Minitab*(a standard statistical package)*. A statistical significance level **$p < 0.05$** was used for all appropriate statistical tests.

A one-way "ANOVA" statistical test was carried out on the total mean values of all growth measurements at *2,6,12.18,22 and 26* weeks and similarly with the mean gain from birth with weight and from *2* weeks of age for the other growth measurements between the 2 feeding groups, sex of the infant and social class.

Linear regression analysis was used to establish the correlation between birthweight and weight gain of infants in relation to the method of feeding at *12* and *26* weeks of age.

The General Linear Model statistical test was carried out to investigate if either the age of weaning and/or the method of feeding had any influence on the growth of the infants at *26* weeks of age or in the mean weight gain from birth of infants at *6,12,18 and 26* weeks of age in each of the weaning groups.

CHAPTER THREE

CHARACTERISTICS OF THE SAMPLE

When the sample of subjects was split into two, with respect to the infant feeding methods, both groups were comparable in terms of the maternal characteristics of age and parity. The breast-feeding group consisted of 35 infants while the bottle-feeding group had 53 infants. Mean birthweight of breast-fed infants was 3.43kg*(S.D.0.52)* which was slightly lower than 3.63kg*(S.D.0.60)* for bottle-fed infants. There was a greater range of birthweights noted with the bottle-fed infants*(Table 5)*.

Table 5. Characteristics related to Birthweight, Gestational Age of the Infant, Maternal Age and Parity.

Characteristics	Breast-feeding n.35			Bottle-feeding n.53		
	Mean	S.D.	Range	Mean	S.D.	Range
Birthweight (Kg)	3.43	0.52	2.33–4.34	3.63	0.60	2.30–4.96
Gestational Age(wks)	39.7	1.9	37–41	39.7	0.3	38–42
Maternal Age (years)	28.4	2.9	22–39	28.9	4.0	20–36
Parity	1.9	0.9	1–4	1.9	0.7	1–4

More female infants were represented in both feeding groups than male infants. There was similar representation of each sex within the feeding groups. Females 66% and 62%, males 34% and 38% for breast and bottle-fed infants respectively.There was also found to be a similar distribution of first born infants within each group *(i.e 20% for breast and 25% for bottle-fed infants)* *(Table 6)*.

Table 6. Infants Grouped by Sex, Method of Feeding and Parity of Mother

Characteristics	Breast–fed infants n.(%)	Bottle–fed infants n.(%)	Total n.(%)
Sex			
Girls	23(66%)	33(62%)	56(64%)
Boys	12(34%)	20(38%)	32(36%)
Total	35(100%)	53(100%)	88(100%)
Parity			
Para 1	7(20%)	13(25%)	20(23%)
Para >2	28(80%)	40(75%)	68(77%)
Total	35(100%)	53(100%)	88(100%)

A large difference was noted in the representation of infants from each social class when the infants were divided into feeding groups(Table 7). The breast-fed group was found to have 57% of infants from social class I whereas there was only 13% of bottle-fed infants from this social class. A similar finding was noted with social class II where there were 37% from breast and 17% from the bottle-fed group. The opposite trend was noted with the infants from social class III and IV. There were 36% and 34% of bottle-fed infants from social class III and IV respectively. In contrast, there were 6% of breast-fed infants from social class III and there were no breast-fed infants represented from social class IV.

Table 7. Grouping of Infants by Feeding Group and Social Class

Social Class	Breast–fed infants n.(%)	Bottle–fed infants n.(%)	Total n.(%)
I	20(57%)	7(13%)	27(31%)
II	13(37%)	9(17%)	22(25%)
III	2(6%)	19(36%)	21(24%)
IV	0(0%)	18(34%)	18(20%)
Total	35(100%)	53(100%)	88(100%)

When the infants were divided into the three weaning groups it was found that 23% of infants had been offered solids before 8 weeks, 58% between 9-16 weeks and 19% between 17-26 weeks of age*(Table 8.)*. There was found to be dissimilarities in the age when solids were first introduced into the diet when the infants were grouped by feeding method. Only 12% of breast-fed but 30% of bottle-fed infants had been offered solids before 8 weeks of age. The middle weaning group was found to represent the most common age for both groups to be weaned*(i.e. 49% for breast and 64% for bottle-fed infants)*. The final 6% of bottle-fed infants had been weaned later than 17 weeks of age. There had been 39% of the breast-fed infants weaned during this late weaning period. Two infants were still being exclusively breast-fed at 26 weeks of age.

Table 8. Weaning Groups in relation to Method of Feeding.

Weaning Group	Breast-fed infants n.	Bottle-fed infants n.	Total n.
EARLY < 8 weeks	4(12%)	16(30%)	20(23%)
MIDDLE 9-16 weeks	16(49%)	34(64%)	50(58%)
LATE 17-26 weeks	13(39%)	3(6%)	16(19%)
Total	33(100%)	53(100%)	86(100%)

There were notable differences found when the weaning groups were further grouped by social class*(Table 9)*. There were not any infants weaned by 8 weeks of age from social class I while 48% and 52% of these infants were weaned between 9-16 and 17-26 weeks of age respectively.

Table 9. Weaning Groups and Social Class.

Weaning Group	Social Class 1 n.(%)	Social Class 11 n.(%)	Social class 111 n.(%)	Social Class 1V n.(%)	Total n(%)
Early <8 weeks	0(0%)	4(18%)	4(19%)	12(67%)	20(23%)
Middle 9–16 weeks	12(48%)	15(68%)	17(81%)	6(33%)	50(58%)
Late 17–28 weeks	13(52%)	3(14%)	0(0%)	0(0%)	16(19%)
Total	25(100%)	22(100%)	21(100%)	18(100%)	86(100%)

The opposite was found with the infants from social class IV where 67% were weaned before 8 weeks of age. Social class II and III had similar number of infants weaned in the early period*(i.e. 18 and 19% for social class II and III respectively).*The highest incidence of infants from social class II (68%) and social class III (81%)were weaned between 9-16 weeks of age All the infants in both social class III and IV had been weaned by 16 weeks of age.

CHAPTER FOUR

THE EFFECT OF INFANT FEEDING METHOD ON GROWTH

The areas of growth thought to be of importance when related to the method of feeding is weight, length, head and mid upper arm circumferences and tricep and subscapular skinfold thicknesses. Each of these measurements were recorded every *2* weeks but "ANOVA" statistical analysis was only carried out at those intervals of time thought to be the most appropriate. Time intervals included *2,6,12,18,22 and 26* weeks of age. Each progress in the individual growth area results will be dealt with separately but discussed cumulatively in the following discussion.

4.1.0 Results

4.1.1 Mean Weight and Gains in Weight

There was no significant difference found with either birthweight, total mean weight or mean weight gains from birth at any of the specific ages when statistical analysis was carried out. Bottle-fed infants were found to have a greater range in birthweights and were on average heavier than the breast-fed infants at birth. This trend in difference in mean weight between the infants in the two feeding groups continued throughout the *26* weeks *(Fig.11)*. The breast-fed infants were noted to have a larger standard deviation for mean weight than the bottle-fed infants from *4-26* weeks of age *(Appendix1)*.

However this pattern was found to be reversed when the mean gain in weight from birth was studied at *2* weekly intervals in the two feeding groups *(Fig.12)*. Both groups had virtually identical weight gains over the first *26* weeks although it was observed that there was greater variation in the mean weight gained by the breast-fed infants *(Appendix2)*. The breast-fed infants were noted to have gained weight slightly more rapidly than their bottle-fed counterparts over the first *8* weeks.

Initially at 2 weeks the difference in weight gain between the two groups was minimum at 0.04kg but this steadily increased over the first 8 weeks to reach a maximum of 0.18kg difference in gain between the two groups. The difference in weight gain decreased gradually until 18 weeks of age when the difference in mean weight gain between the two groups was 0.06kg more for the breast-fed infant.

The situation was temporarily reversed at 20 weeks of age when the bottle-fed infants gained 0.29kg in 2 weeks while the breast-fed infants gained 0.14kg over the same 2 week interval. Thereafter the breast-fed infants continued to gain weight slightly slower than bottle-fed infants between 22-26 weeks of age*(Fig.13)*. Both feeding groups had similar mean weight gain at 26 weeks of age *(i.e. 4.25kg and 4.24kg for bottle and breast-fed infants respectively.)*.

Figure 11. Column Graph of Mean Weight of Infants (Birth-26 wks)

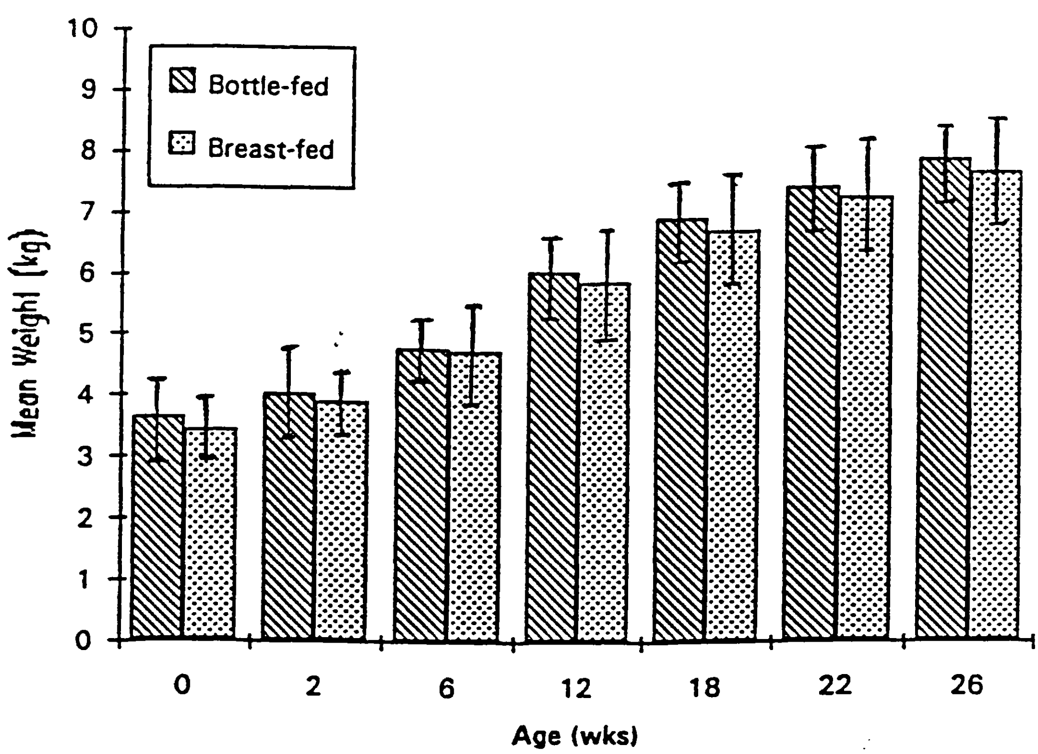


Figure 12. Line Graph of Mean Weight Gain of Infants from Birth

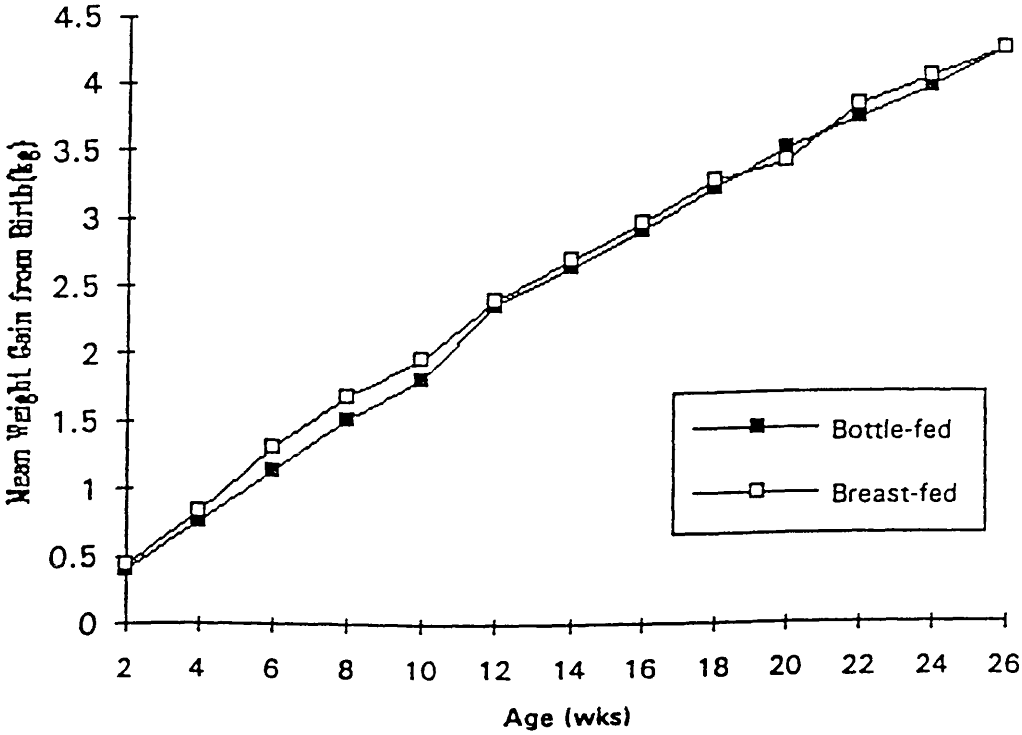
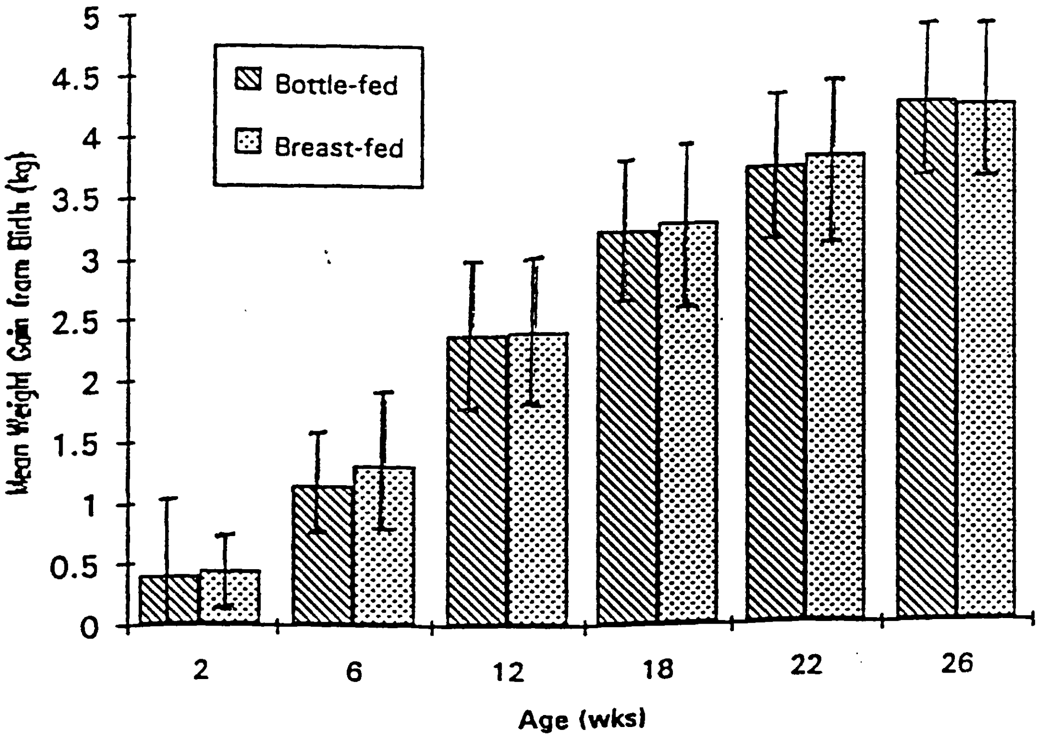


Figure 13. Column Graph of Mean Weight Gain of Infants from Birth



4.1.2 Mean Length and Mean Gain in Length

There was no significant difference found between the mean length or the mean gain in length from 2 weeks of age at any of the specific ages when statistical analysis was carried out. At 2 weeks of age the mean length of infants in both the feeding groups was similar and this pattern in length continued until 26 weeks of age*(Fig.14,Appendix 3)*.

The mean increment in length from 2 weeks of age followed a similar pattern to the overall mean length during the first 20 weeks of age with bottle-fed infants gaining on average 10.4cms*(S.D.3.1)* and 10.0cms*(S.D.3.1)* for the breast-fed infants*(Fig.15,Appendix4)*. This pattern then reversed with mean gain being 12.4cms*(S.D.2.4)* and 11.5cms*(S.D.3.0)* for breast and bottle-fed infants respectively at 24 weeks with infants in both groups having similar mean gain in length at 26 weeks of age.

Figure 14. Column Graph of Mean Length of Infants (2-26 wks)

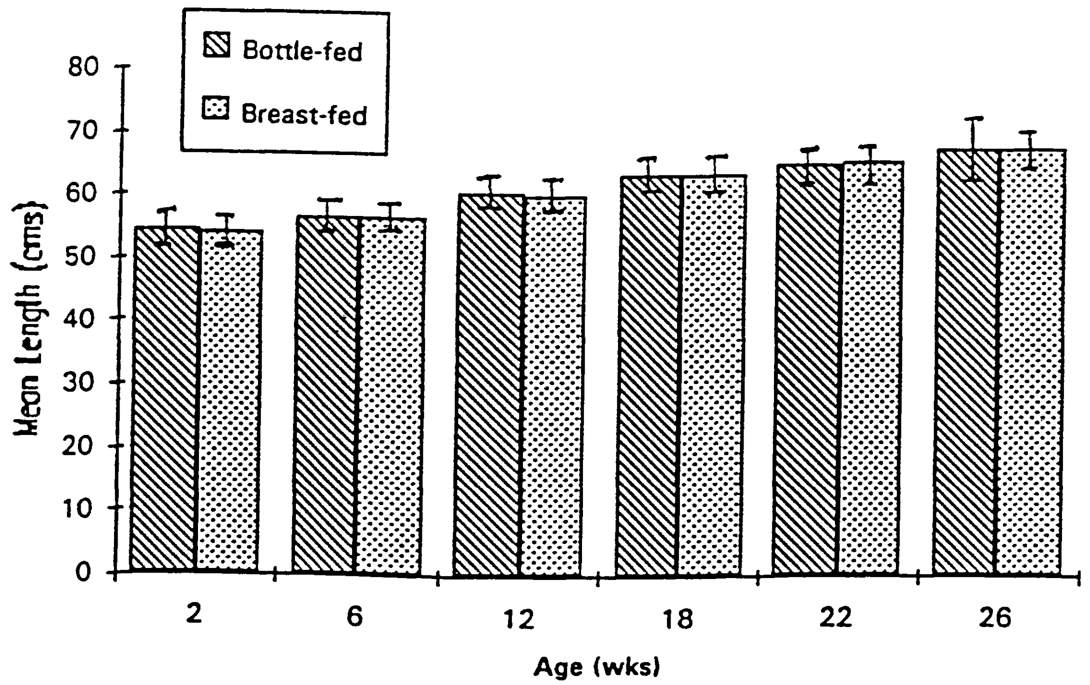


Figure 15. Line Graph of Mean Gain in Length of Infants from 2 wks

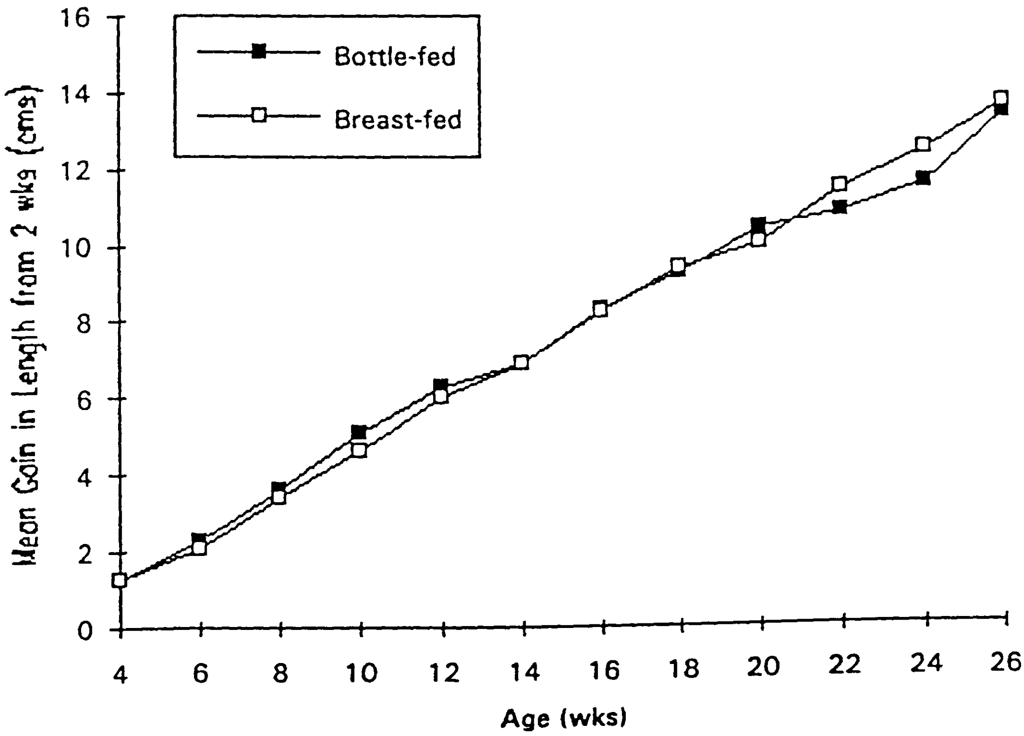
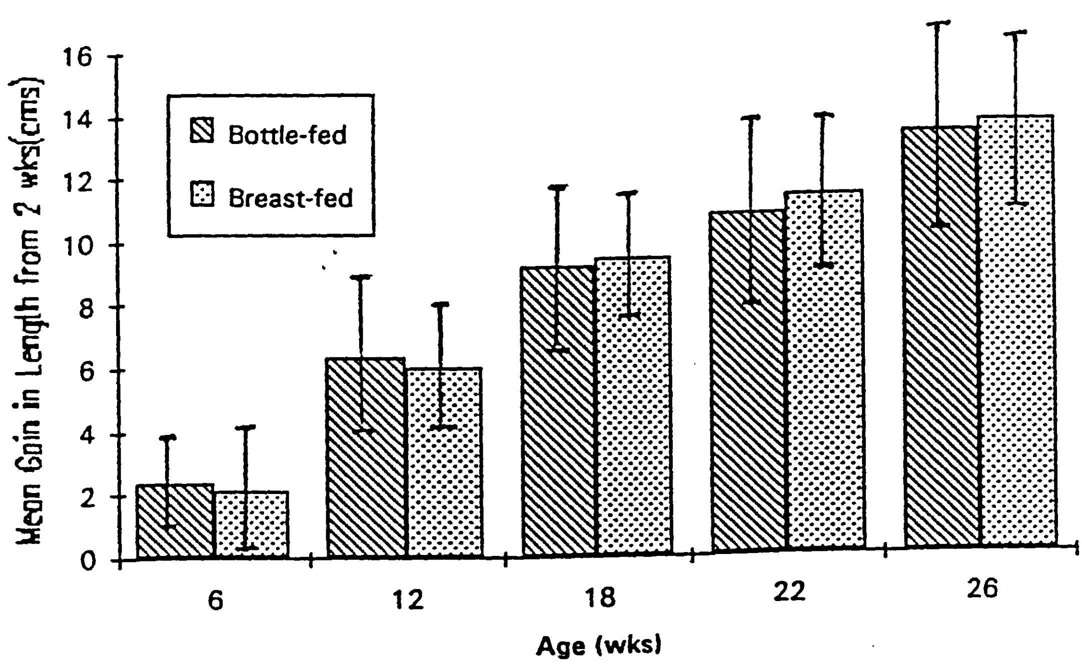


Figure 16. Column Graph of Mean Length Gain of Infants from 2 wks



4.1.3 Mean Head Circumference and Mean Gain in Head Circumference

There was no significant difference found between the mean head circumference or mean gain in head circumference from 2 weeks between the two feeding groups at any of the ages when analysis was carried out. A similar pattern in mean head circumference was noted between the infants in both feeding groups over the 26 week period.*(Fig.17)*. There was a larger standard deviation noted between the ages of 2-14 weeks of age with the bottle-fed infants*(Appendix5)*.

The bottle-fed infants had a predominantly greater average increase in head circumference between 4-26 weeks with mean gain being 11.0mm*(S.D.5.7)* and 73.8mm*(S.D.16.2)* for bottle-fed infants at 4 and 26 weeks of age respectively and 9.2mm*(S.D.5.8)* and 68.4mm*(S.D.11.4)* for the breast-fed infants at similar ages*(Fig.18,19)*. The bottle-fed infants were also noted to have a larger standard deviation than the breast-fed infants in the mean gain in head circumference between 8-26 weeks of age*(Appendix6)*.

Figure 17. Column Graph of Mean Head Circumference of Infants (2-26 wks)

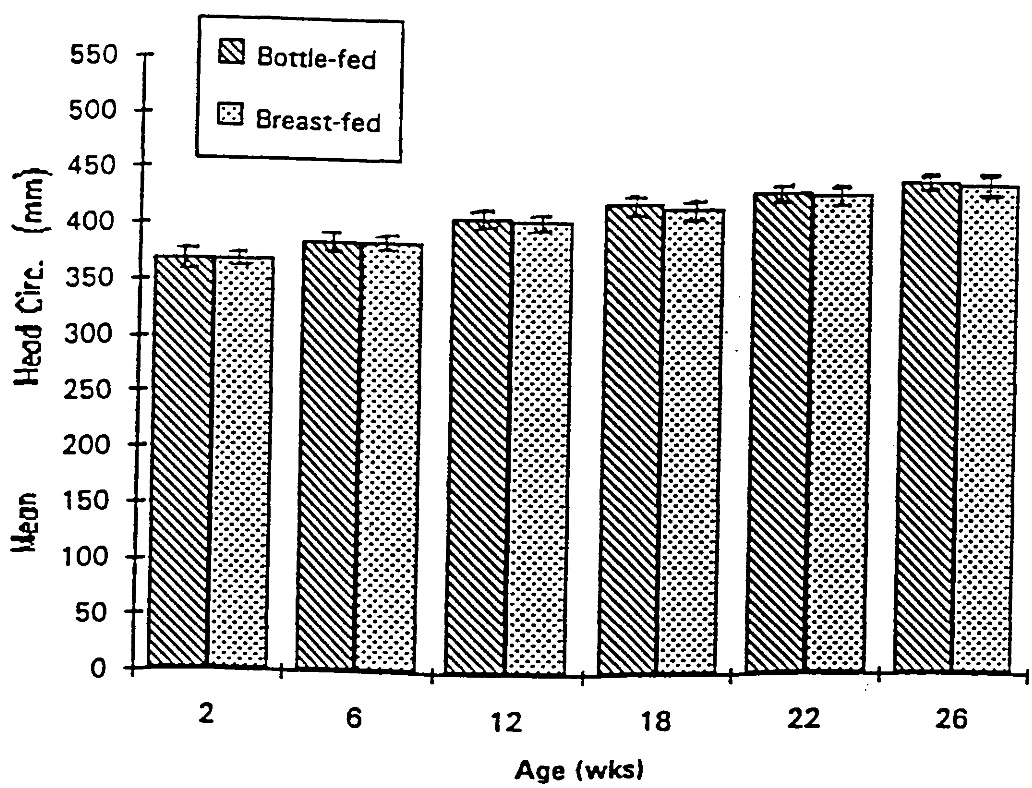


Figure 18. Line Graph of Mean Gain in Head Circumference of Infants from 2 wks

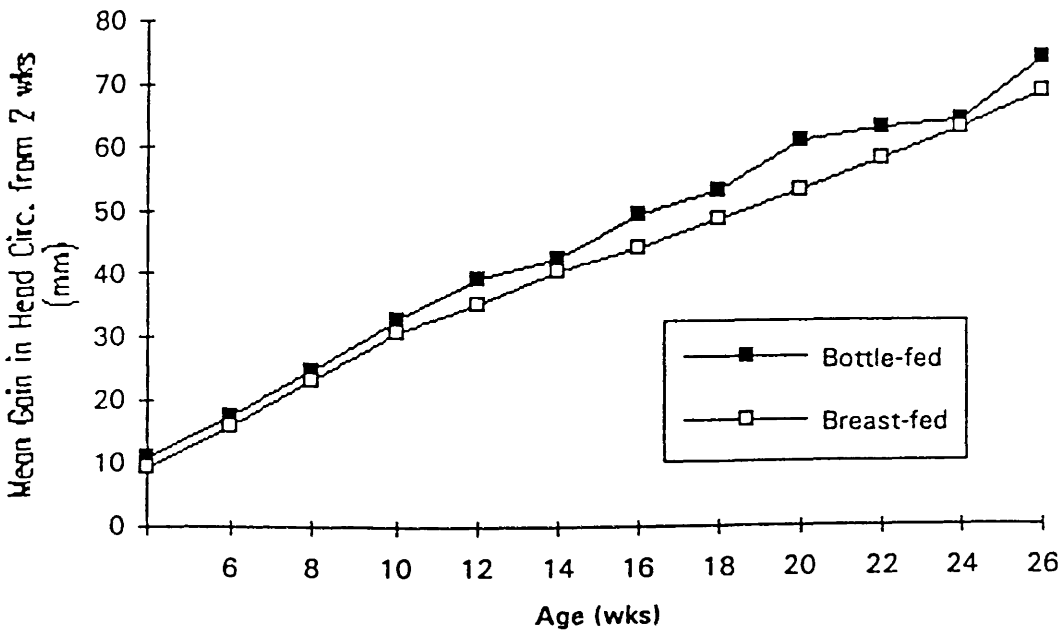
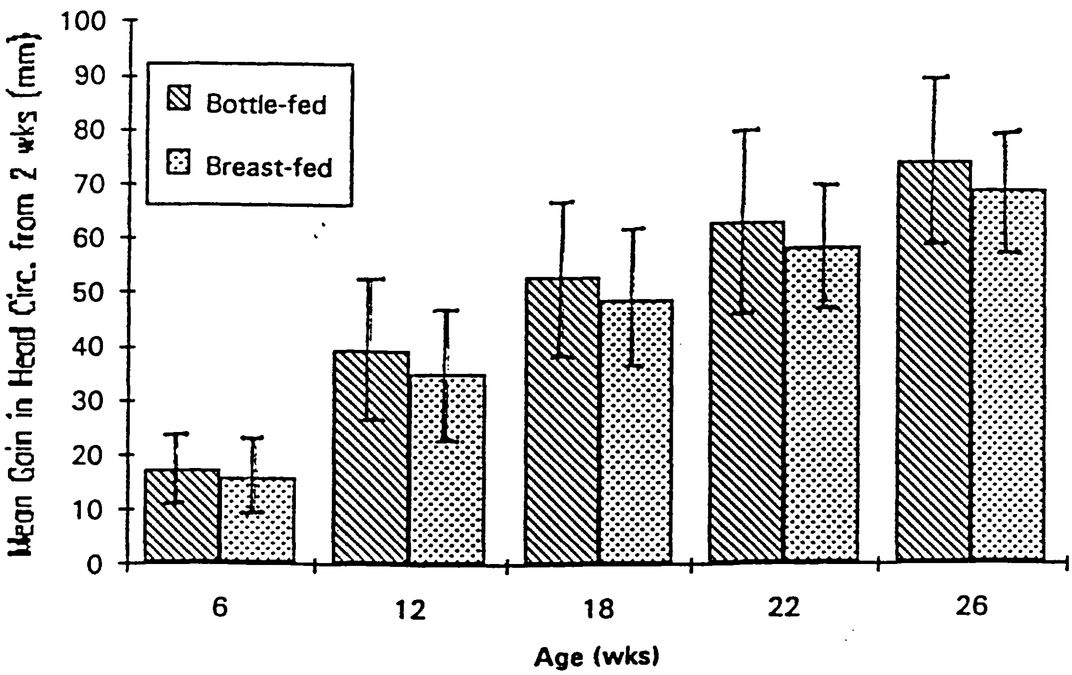


Figure 19. Column Graph of Mean Gain in Head Circumference of Infants from 2 wks



4.1.4 Mean Skinfold Thickness and Mean Gain in Skinfold Thickness (Triceps, Subscapular and Combined)

There was no significant difference found in either the total mean or the mean gain in the triceps, subscapular or combined skinfold thicknesses between the infants in the 2 feeding groups at any of the ages when statistical analysis was carried out. There was found to be a similar pattern in the total mean triceps*(Fig.20)* and subscapular*(Fig.21)* skinfold thicknesses between breast and bottle-fed infants. The bottle-fed infants had a predominantly higher total mean in both the triceps and subscapular skinfold thicknesses throughout the first 12 weeks, a marginally higher total mean until 22 weeks than the breast-fed infants and then both groups of infants had similar total mean gains at 26 weeks of age*(Appendix 7&9)*.

A similar pattern was found with the mean gain in both triceps and subscapular skinfold thicknesses. in both groups*(Appendix8&10)*. There was a marginally greater mean gain in both the skinfold thicknesses in the bottle-fed infants over the inital 12 weeks. Thereafter mean gains were similar in both groups of infants with the breast-fed infants gaining slightly more with the subscapular skinfold thickness at 26 weeks of age*(Fig.23,24,26.27)*. The total mean and mean gains of the combined triceps and subscapular skinfold thicknesses reflected these observations*(Figs.22,25,28)*.

Figure 20. Column Graph of Mean Triceps Skinfold Thickness of Infants (2-26 wks)

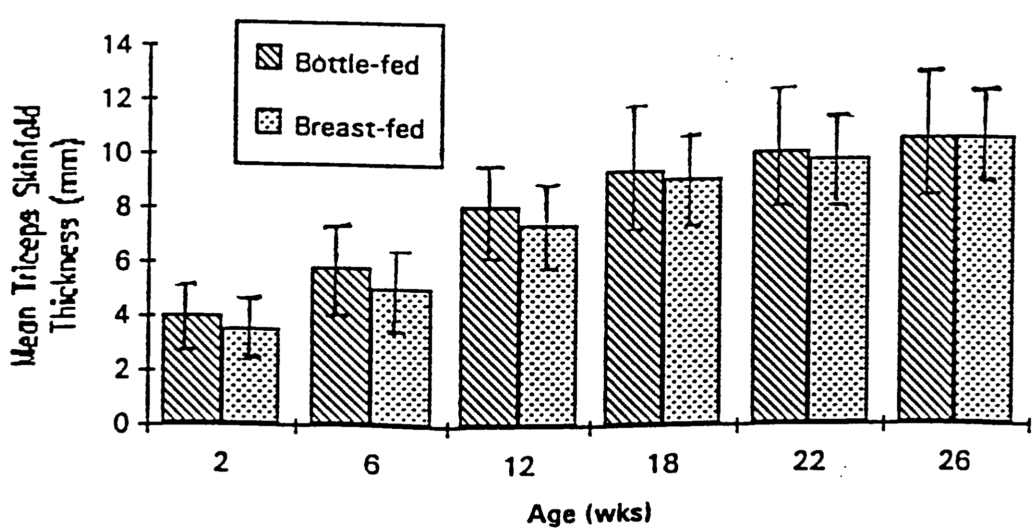


Figure 21. Column Graph of Mean Subscapular Skinfold Thickness (2-26 wks)

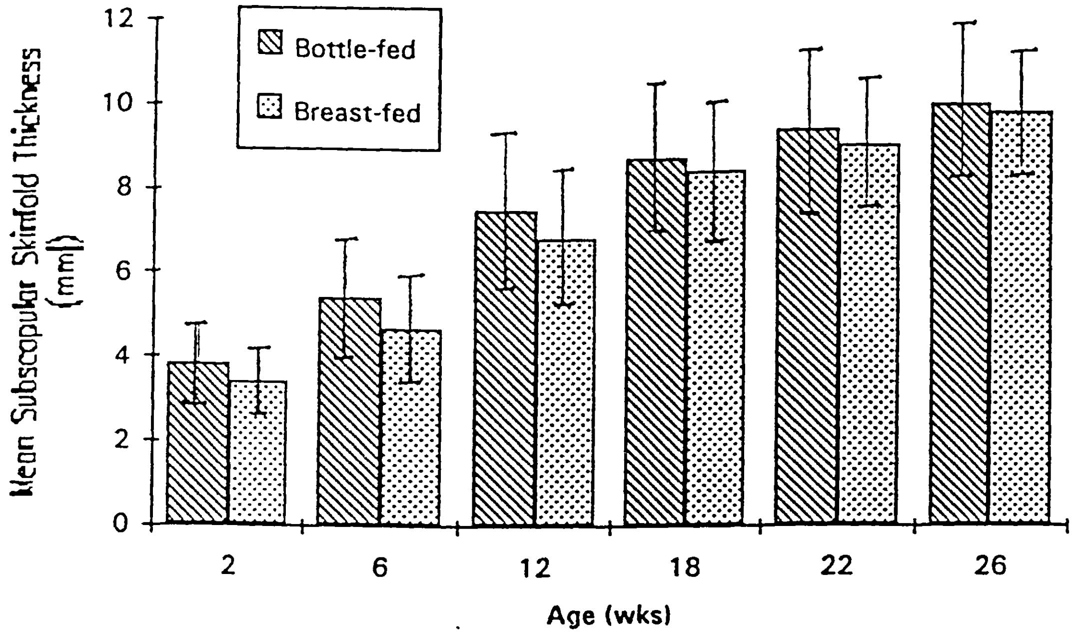


Figure 22. Column Graph of Mean Combined Triceps and Subscapular Skinfold Thicknesses of Infants (2-26 wks)

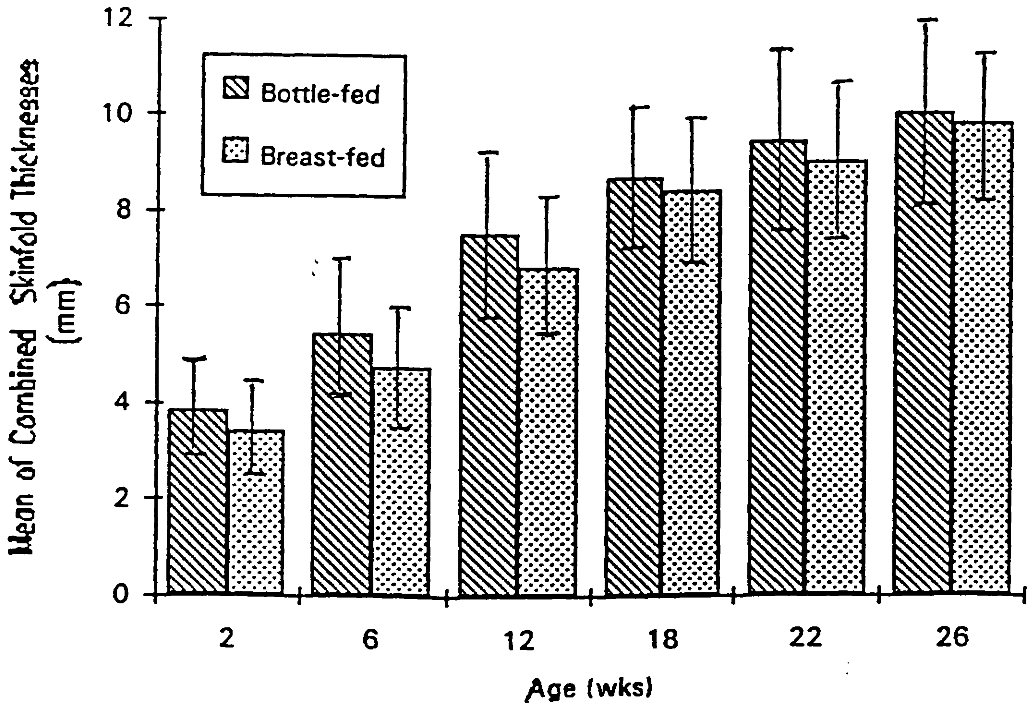


Figure 23. Line Graph of Mean Gain in Triceps Skinfold Thickness in Infants from 2 wks

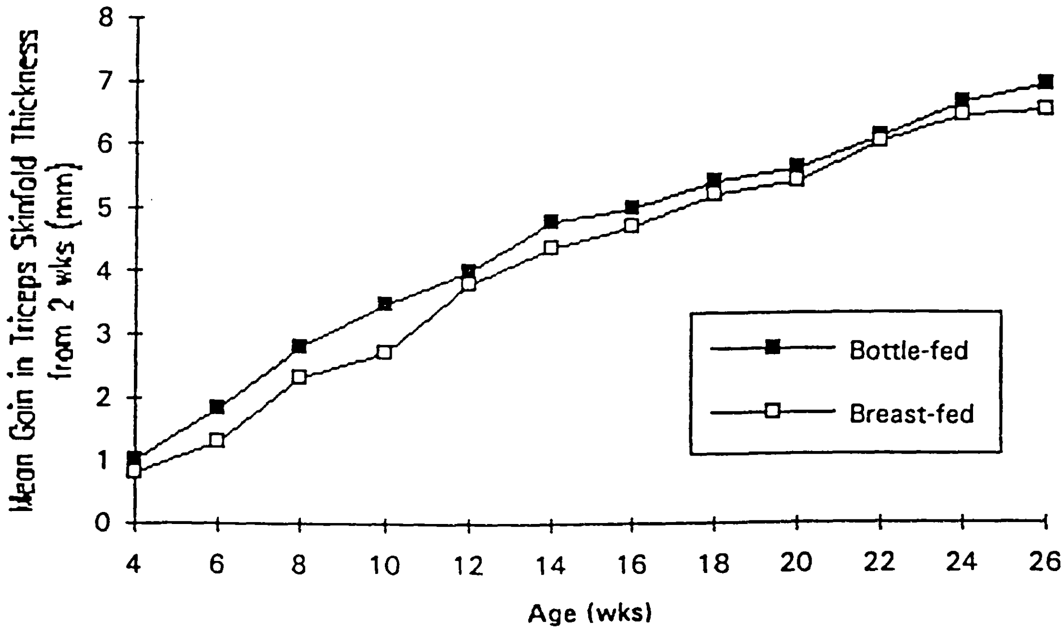


Figure 24. Line Graph of Mean Gain in Subscapular Skinfold Thickness from 2 wks

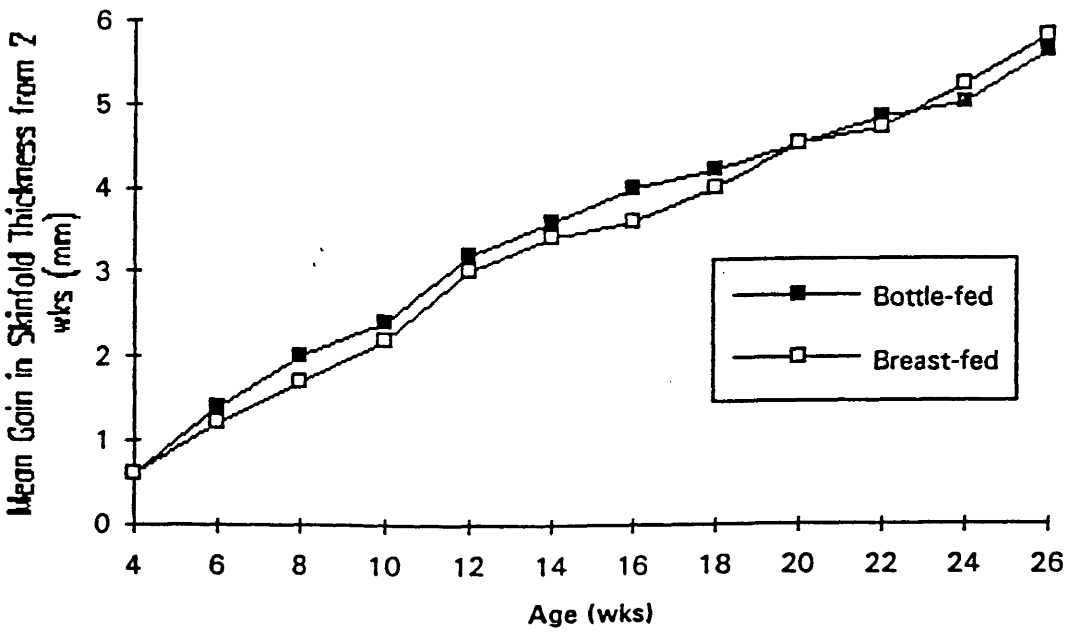


Figure 25. Line Graph of Mean Gain in Combined Triceps and Subscapular Skinfold Thicknesses from 2 wks

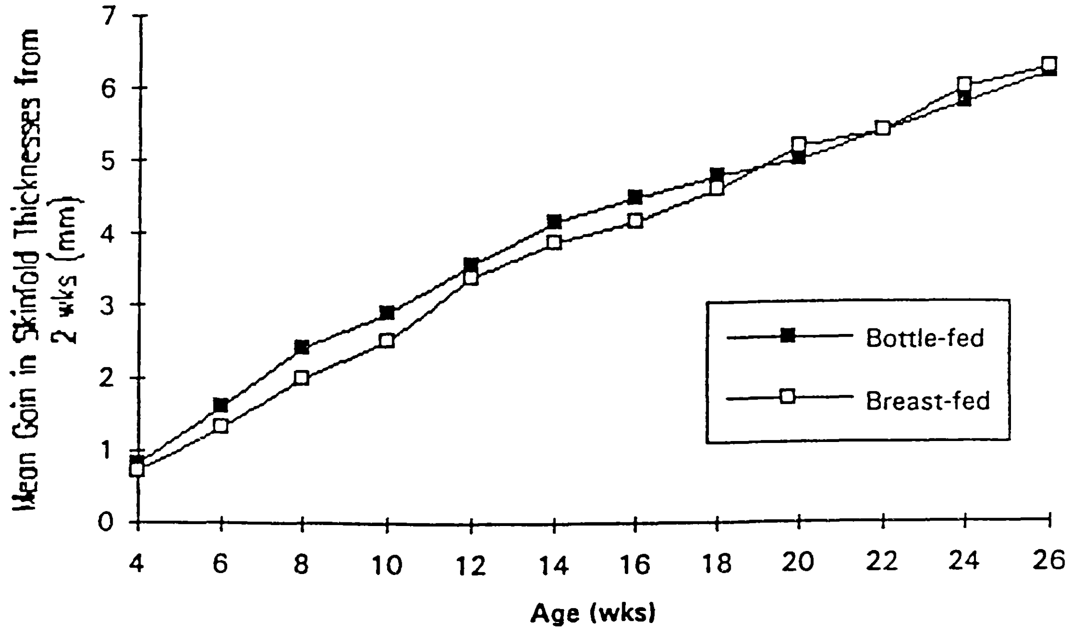


Figure 26. Column Graph of Mean Gain in Triceps Skinfold Thickness of Infants from 2 wks

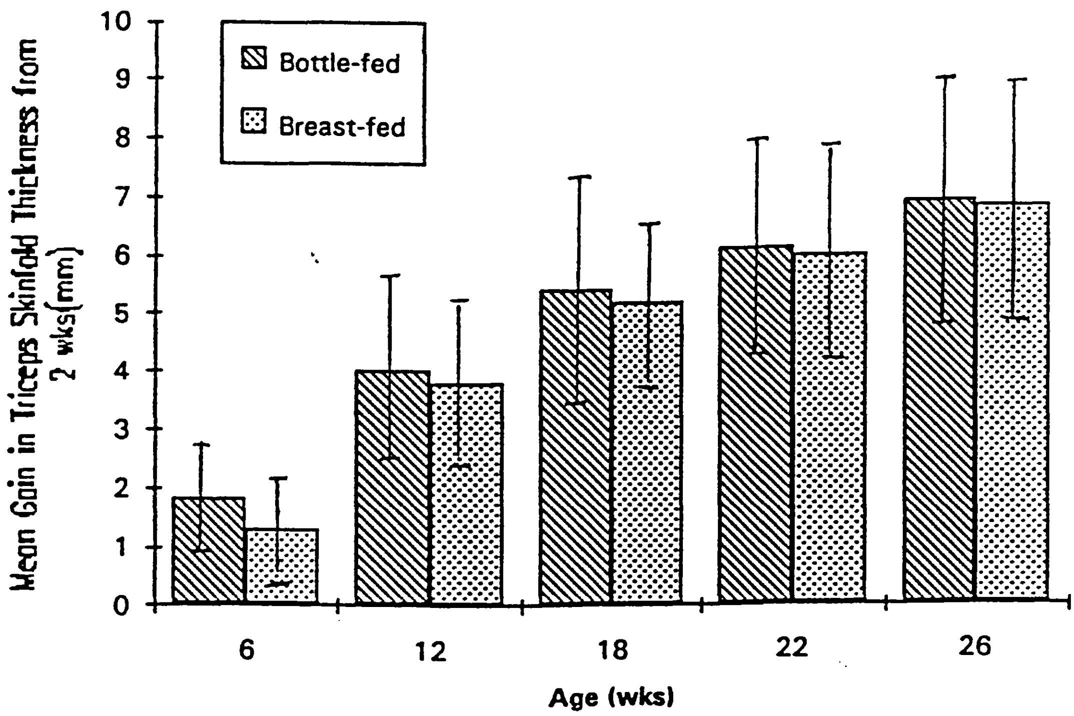


Figure 27. Column Graph of Mean Gain in Subscapular Skinfold Thickness of Infants from 2 wks.

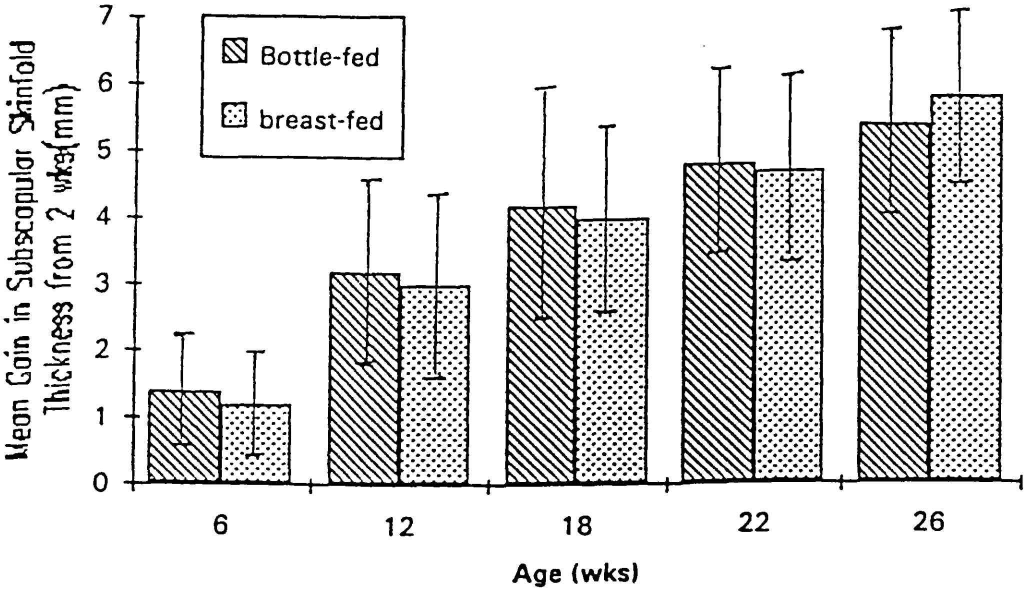
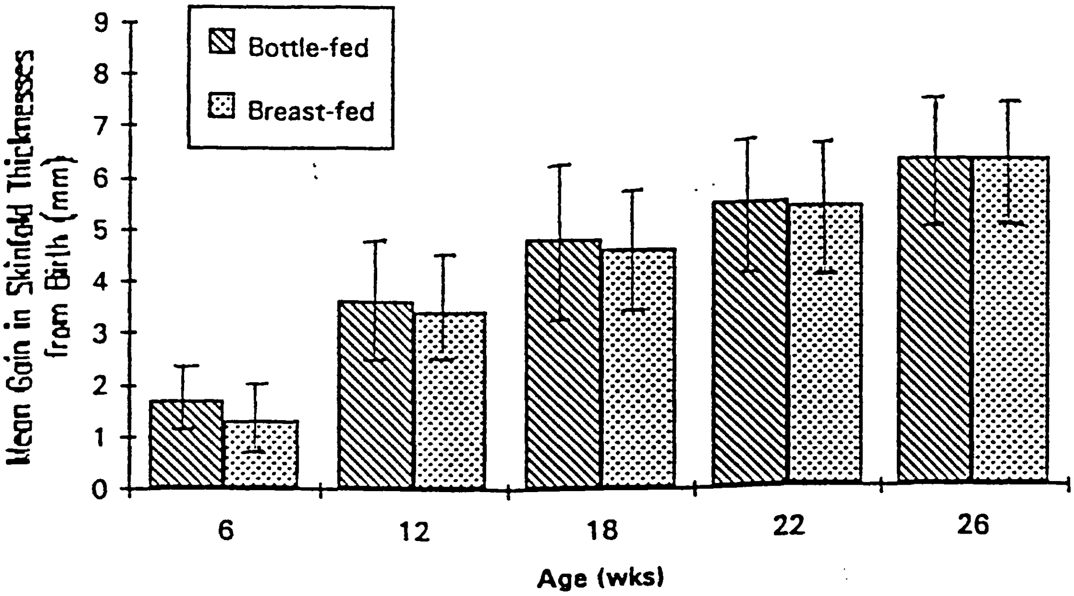


Figure 28. Column Graph of Mean Gain in Combined Triceps and Subscapular Skinfold Thicknesses of Infants from 2 wks



4.1.5 Mean Upper Arm Circumference and Mean Gain in MUAC.

There was no significant difference found in either the total mean or mean gain in MUAC between breast and bottle-fed infants at any of the ages when statistical analysis was carried out.

Infants in the two feeding groups followed a similar pattern in the total mean in MUAC throughout the 26 week period*(Fig.29,Appendix11)*. Both breast and bottle-fed infants had virtually identical mean gain in MUAC from 4-26 weeks of age*(Figs.30,31,Appendix 12)*.

Figure 29. Column Graph of Mean Mid Upper Arm Circumference of Infants (2-26 wks)

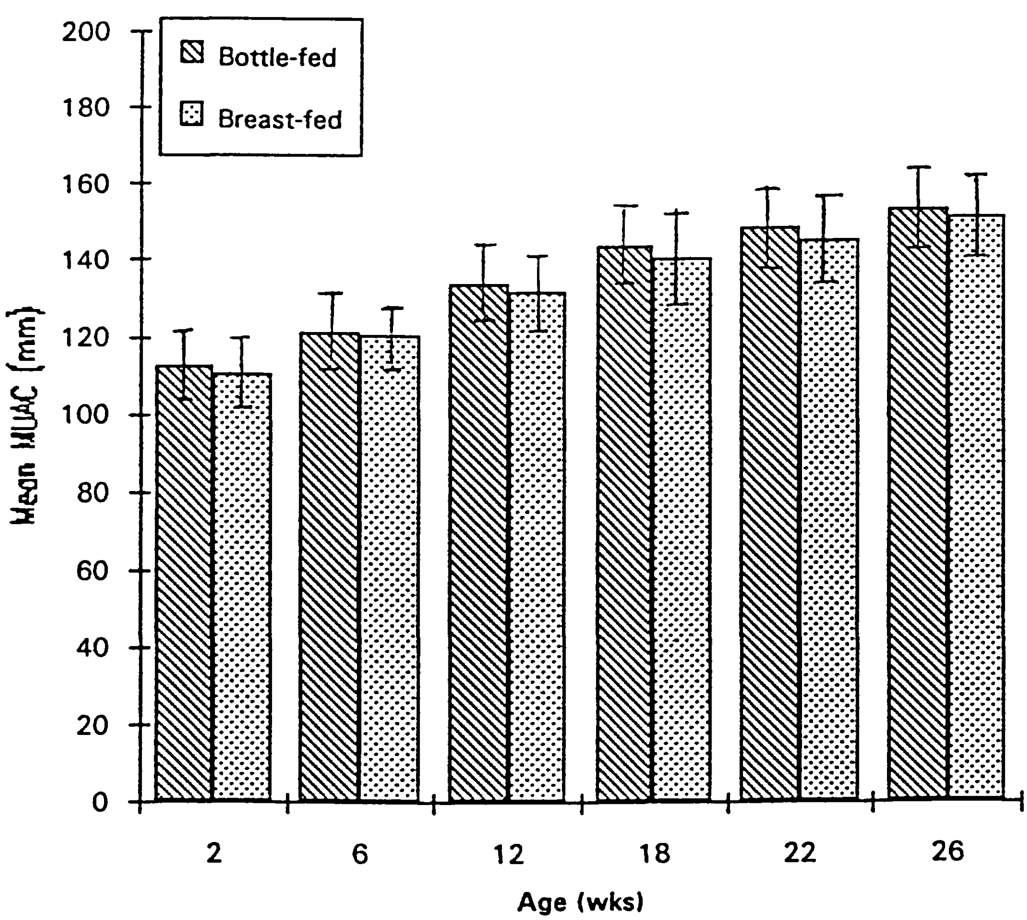


Figure 30. Line Graph of Mean Gain in Mid Upper Arm Circumference from 2 wks

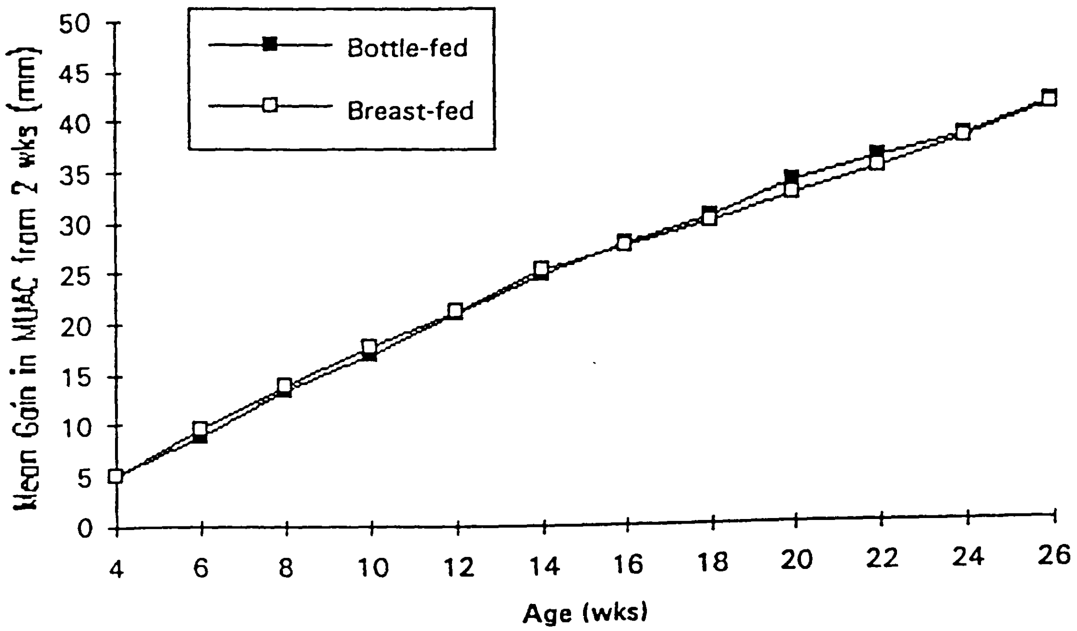
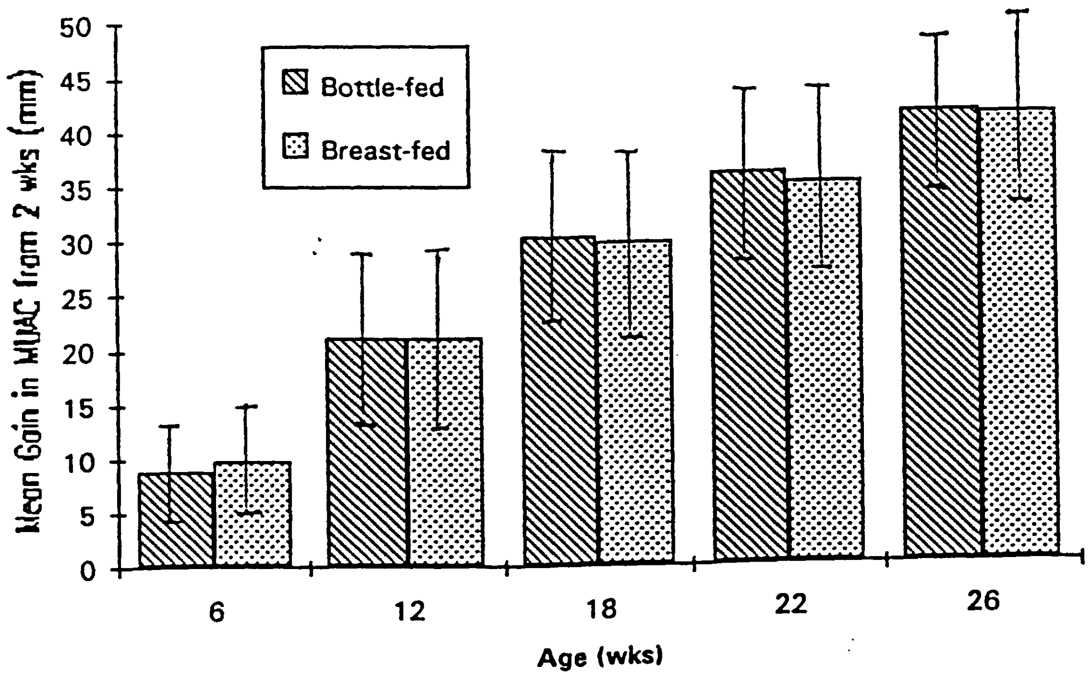


Figure 31. Column Graph of Mean Gain In Mid Upper Arm Circumference of Infants from 2 wks.



4.2.0 Results of Feeding Method and the Growth of Male and Female Infants.

There was no significant difference found with any of the growth measurements studied between the female or the male infants in relation to the method of feeding at *2,,6 12 18,22 and 26* weeks of age.

However when the infants were grouped into male and female groups, irrespective of the feeding method, then significant differences were noted with specific growth measurements at certain ages.

There was no significant difference found at any of the ages when statistical analysis was carried out between male and female infants with regard to the total mean and mean gain with head circumference, MUAC, triceps and subscapular skinfold thicknesses.

Male infants were significantly heavier than female infants at birth and this significant difference in total mean weight continued at all the specific ages when statistical analysis was carried out*(Fig32)*.

The mean gains in weight were similar for both male and female infants over the first *6* weeks and then male infants were noted to have gained more weight on average from *12-26* weeks of age*(Fig33)* This greater mean weight gain became statistically significant at *18* and *26* weeks of age.

There was also a significant difference found in the total mean length of male and female infants at all the ages when statistical analysis was carried out with the male infants tending to be on average longer than the females*(Fig34)*

There was no significant difference found between male and female infants with the mean gain in length at any of the ages when statistical analysis was carried out. Both groups of infants had similar mean gains in length until *18* weeks and then the male infants tended to have a greater increase in length until *26* weeks of age*(Fig35)*.

Figure 32. Column Graph of Mean Weight of Infants (Birth-26 wks)

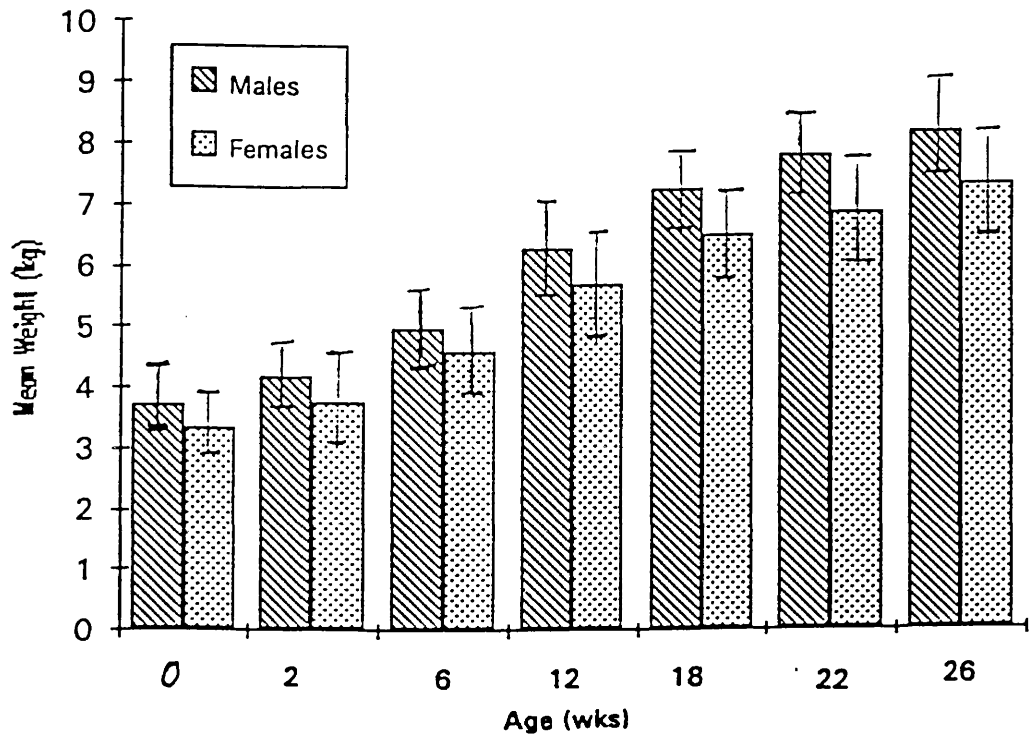


Figure 33. Mean Weight Gain of Infants from Birth

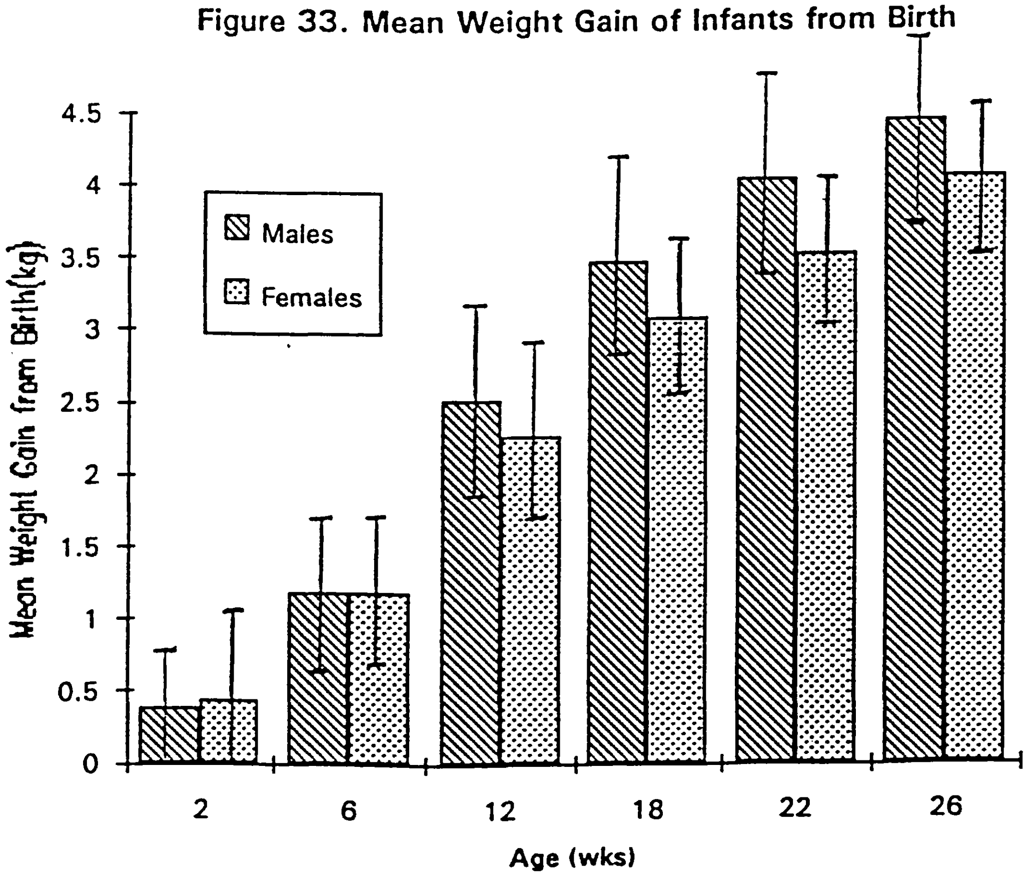


Figure 34. Column Graph of Mean Length of Infants (2-26 wks)

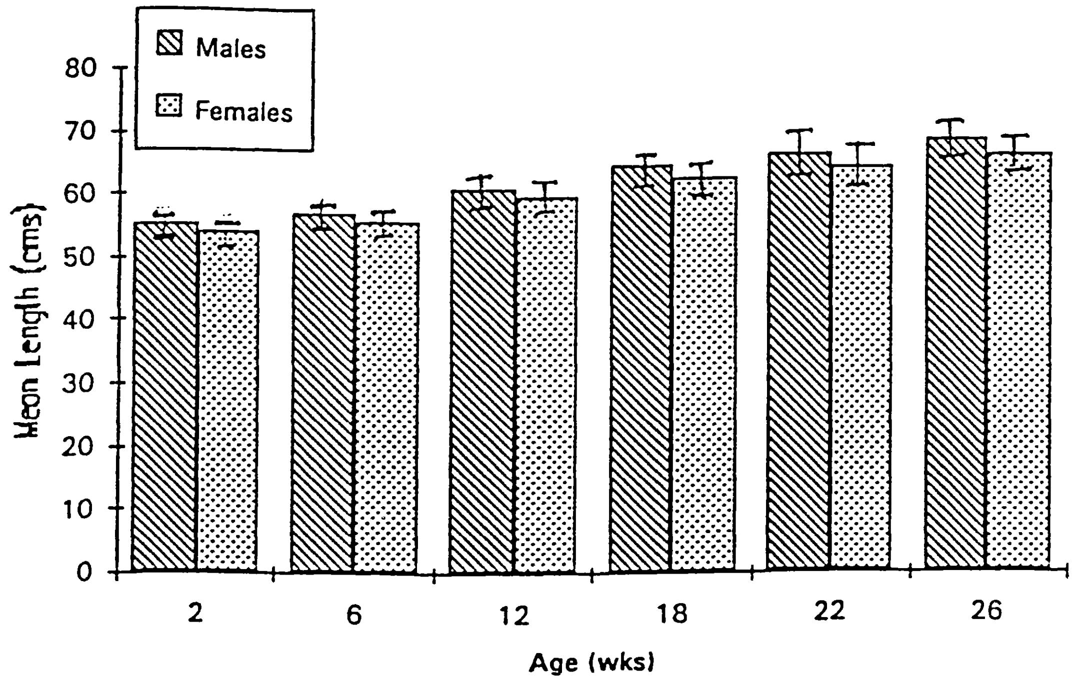
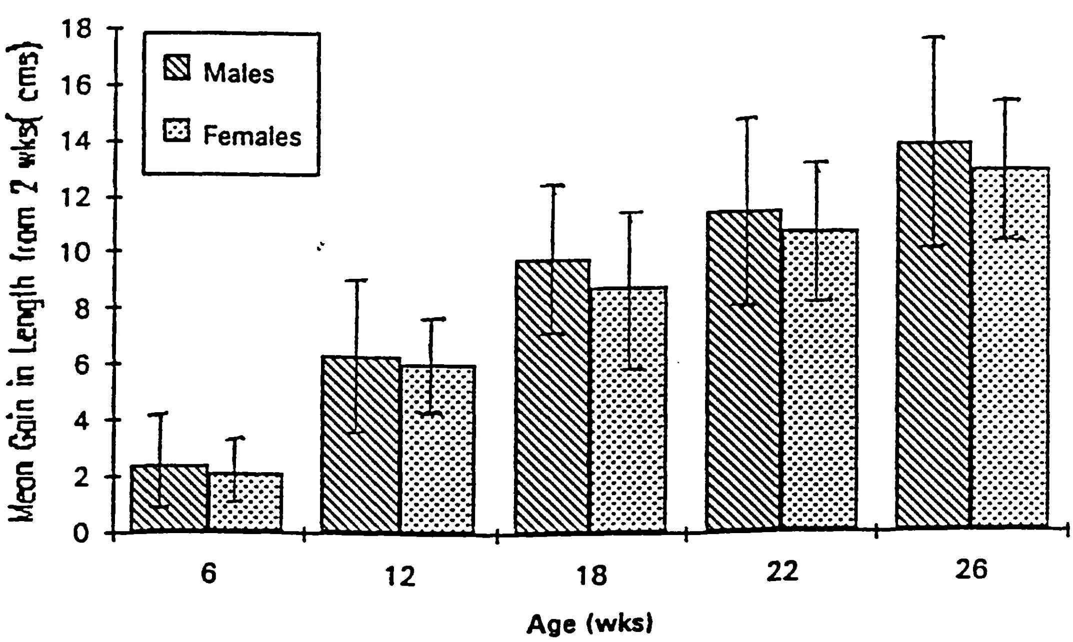


Figure 35. Column Graph of Mean Gain in Length of Infants from 2 wks



4.3.0 Results of Infant Growth in relation to Feeding Method and Social Class

There was no significant difference found with any of the growth measurements studied between the infants from social class group (I+II) and social class group (III+IV) in relation to infant feeding method at *2,6,12,18,22 and 26* weeks of age. *(Social class groups were combined due to the small numbers of subjects in certain social classes in relation to infant feeding method).*

There was also no significant difference found, with any of the growth measurements studied, between the infants from the 2 social class groups irrespective of feeding method, at any of the ages when statistical analysis was carried out.

It was interesting to note that the total mean weight of infants from the 2 social class groups, irrespective of feeding method, were similar until *12* weeks of age. Thereafter the infants in social class group (I+II) were noted to have a greater total mean weight than the infants from social class group (III+IV) although this was not statistically significant*(Fig36)*.

The mean weight gain of infants followed a similar trend between the 2 social class groups. Infants from social class group (I+II) were noted to have a greater mean gain in weight than the infants from social class group (III+IV) from *12-26* weeks of age*(Fig37)*.. The difference in weight gain was not statistically significant at any of the ages when analysis was carried out. However, it was interesting to note that the difference in the mean weight gain between unfants in the two groups was approaching significance at *22 and 26* weeks of age.

Figure 36. Column Graph of Mean Weight of Infants from Birth

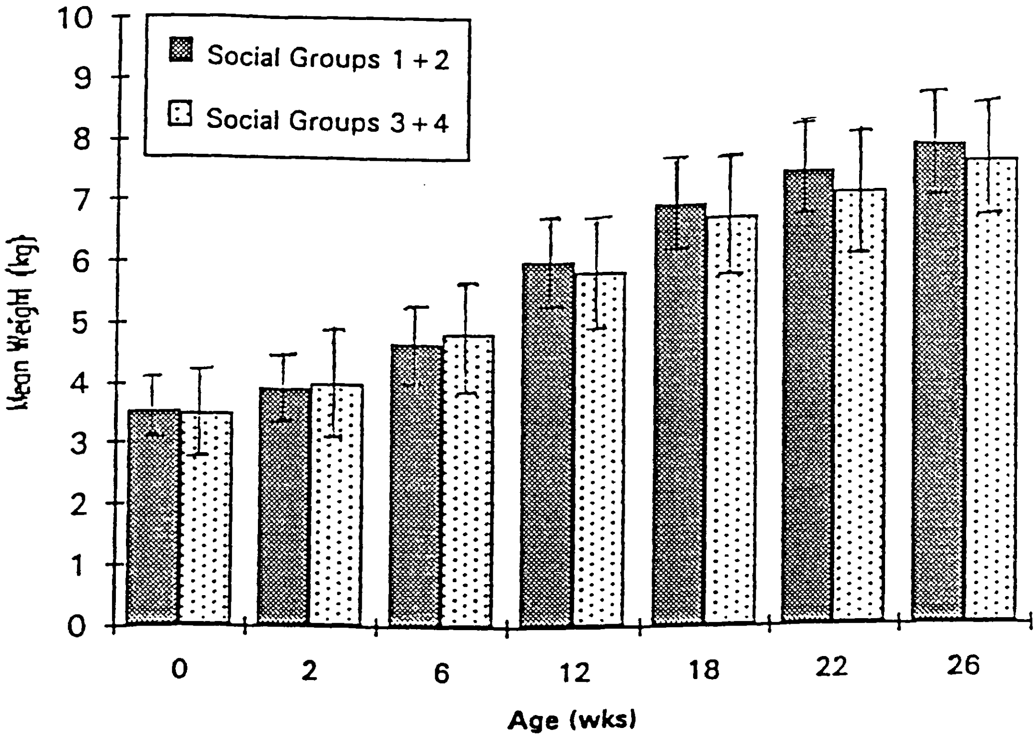
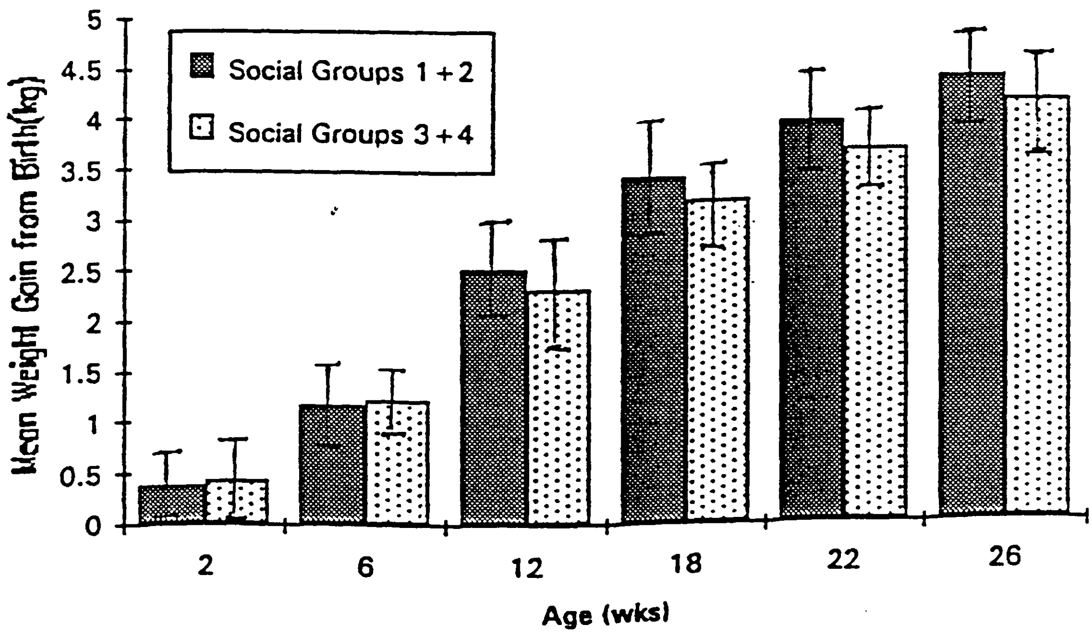


Figure 37. Column Graph of Mean Weight Gain of Infants from Birth



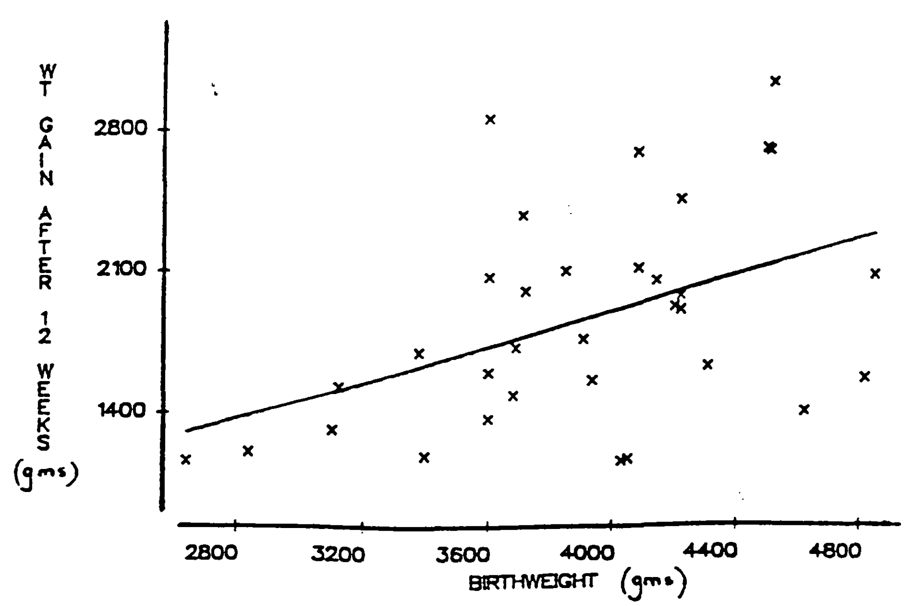
4.4.0 Results on the Relationship between Birthweight and Weight Gain in relation to the Method of Feeding.

Linear regression analysis was carried out to investigate the correlation between the birthweights of infants and the weight gain at 12 and 26 weeks of age in relation to the method of feeding*(Table10)*. There was no relationship found at 12 or 26 weeks of age with infants who were bottle-fed. The relationship with infants breast-fed was significant at 12 weeks*(Fig.38)* but not found to be significant at 26 weeks of age.

Table 10. Relationship between Birthweight and Weight Gain at 12 and 26 weeks of Age

Characteristic	Correlation Coefficients	Relationship
Bottle-fed Infants (12 weeks)	-0.046	Not significant
Bottle-fed Infants (26 weeks)	-0.014	Not significant
Breast-fed Infants (12 weeks)	+0.444	Significant
Breast-fed Infants (26 weeks)	+0.273	Not significant

Figure. 38 PLOT OF WEIGHT GAIN VS BIRTHWEIGHT (Breast-fed Infants)



4.5.0 Discussion

There were no striking differences observed between the infants with any of the areas of growth investigated in relation to the method of feeding. No significant difference was found in the birthweight, total mean weight or the mean gain in weight from birth to 26 weeks of age between the infants in the 2 feeding groups. Similar results were obtained for length, head and mid-upper arm circumference, and 2 skinfold thicknesses over the same period. Infants in both feeding groups were noted to have a similar steady pattern in most of the growth areas studied.

Weight gain is the main growth factor which has given cause for concern in relation to infant feeding practices. As in this study, many investigators have also found no significant difference in weight gained between breast and bottle-fed infants over the first 6(29,32), 12(33,42) and 26 weeks of life(7,8,9,31,34), while other investigators have found that breast-fed infants gained less weight over the initial 6(29) and 12 weeks(33,42) of life than their bottle-fed counterparts. This has remained one of the major controversial nutritional issues over the past few decades.

Other investigators have found that bottle-fed infants gained significantly more weight(4,17,19,20,30) or gained weight faster(35) than breast-fed infants over the first 26 weeks of life. Taitz(6) found that breast-fed infants grew significantly faster over the initial 6 weeks than bottle-fed infants. It was interesting to note, although it was not significant, that the breast-fed infants in this study gained weight slightly more rapidly than the bottle-fed infants over the initial weeks of life. The total mean weight gained by infants in both groups over 26 weeks was similar to the gain in weight of breast fed infants recorded by other researchers over the last few decades(19,20,42) There has been a different trend noted in the pattern of weight gained by the bottle-fed infants during the same period of time*(Table 11)*. The secular trends reported with regards to the patterns in weight gained by bottle-fed infants has reflected changes in the formulation of milk substitutes and feeding practices.

Table 11. A Comparison of Studies in Relation to Mean Weight Gain at 26 Weeks of Age and Method of Feeding.

Method of Feeding	Weight Gain (kg) 1953(19) (n.580)	Weight gain (kg) 1964(20) (n.148)	Weight Gain (kg) 1984(34) (n.65)	Weight Gain (kg) 1991(Present study) (n.88)
Breast	4.28	4.2 kg	4.3 kg	4.24 kg
Artificial	4.63	4.7 kg	4.2 kg	4.25 kg

The weight gain of breast-fed infants has remained virtually constant over the past years while the weight gained by bottle-fed infants has been gradually falling. This changing pattern in weight gain observed in bottle-fed infants must raise the question as to which pattern is the normal physiological pattern of weight gain during infancy. Previous researchers have suggested that there is a possible degree of underfeeding among breast-fed infants[19,47] while others have questioned the adequacy of breast-feeding to sustain normal growth during this period[49].

It is possible that the pattern in weight gain attained by the healthy breast-fed infant may more accurately represent normal growth during the first 6 months of life. In this study the rate of weight gain of the breast-fed infants was slightly faster over the first 8 weeks of life followed by a steady slower rate of weight gain until 22-26 weeks when compared to the bottle-fed infants. Other reports in the literature have found a consistently similar pattern with exclusively breast-fed infants over this same period of time with the rate of weight gain continuing to reduce with age[10.43.44.48]. There has been much speculation as to whether or not this is the normal physiological pattern of weight gain for healthy breast-fed infants. However, results from this study have not been directly compared with the findings of these investigators as the breast-fed infants in this study were weaned at varying ages during the 26 weeks period.

The patterns in weight gained by the bottle-fed infants are now approaching those of breast-fed infants. This is possibly due to the combined effect of improved health education of mothers, the concerns of long term effects of over feeding and the much modified formula milks which are now more closely resembling the constituents of breast-milk.

None of the small sex differences found in the weight gain in relation to infant feeding method, which have been reported in larger materials, were statistically significant in this present study. It has been generally accepted that male infants tend to be heavier than female infants from birth and the results from this study are in agreement with these expectations. Male infants were also noted to have gained more weight on average from birth than female infants. There is a genetic tendency for male infants to grow faster than their female counterparts and it has also been reported that male infants require both a higher daily energy intake requirement and consume more milk than female infants[43].

Social class groups present a complicating factor when trying to relate infant feeding method both to growth during infancy and subsequent future physical and intellectual development. The acceptance of breast-feeding tends to be highly polarised towards the upper two social class groups. while the opposite tends to be true for the acceptance of bottle-feeding. Therefore there is clearly a danger of introducing undesirable biases into any simple analysis.

In this present study, infants from both social class groups(I+II) and (III+IV) had no significant difference found between any of the growth measurements studied over the 26 week period. However it was interesting to note that infants from social class group(I+II) tended to have a higher mean weight gain than the infants from social class group(III+IV) throughout the study which were approaching significant levels from 22 weeks of age. These differences may possibly be attributed to the different attitudes of the mothers towards infant feeding practices.

All infants from social class group(III+IV) were found to have been weaned by *16* weeks of age whereas 19% of the infants from the other social class group had still to be offered solids by the same age. It was also not too uncommon, during this study, for infants to have the formula milk gradually replaced with weaning foods once weaning had been established. The nutritional adequacy of some of these weaning foods may not have been as valuable to the infant as the formula milk being replaced. and this may have been reflected in the subsequent weight gain of some of these infants.

In general there is normally no positive relationship between birthweight and subsequent weight gain. Infants who are heavier at birth can often have a slower rate of weight gain than those infants who may have been lighter at birth, born preterm or were *'light for dates'* infants who are also noted to have an inital rapid acceleration of weight gain compared to infants who are born within the weight range acceptable for their gestational age. This *'catch up growth'* continues for as long as the infant needs to attain the weight for age requirements and then rate of weight gain tends to slow down accordingly.

It was noted in this study that only the infants from the breast-feeding group had a significant relationship between birthweight and mean weight gain at *12* weeks of age. There was a also a tendency for breast-fed infants to have a slightly greater increase in mean weight gain over this initial period followed by a slower rate of gain towards the end of the study when compared to the bottle-fed infants. This may be attributed to the method of feeding as this pattern in weight gain has often been previously reported by many investigators who have studied infants exclusively breast-fed over this period of time and have argued that it is the possible normal physiological pattern of growth expected with breast-fed infants.

Breast-fed infants have also been reported to have a self-regulatory mechanism which allows them to successfully control their milk intake(2) and which may be directly related to the infants birthweight during the period of exclusive breast-feeding. Other factors, which were not studied during this study, such as the gestational age of the infants at birth may also be responsible. All infants in this study were healthy, of birthweights within 2.30-4.96kg and born after *37* weeks gestation. Both groups of infants had a similar mean gestational age *(i.e.39.7 weeks)* but there was noted to be a much larger standard deviation with breast-fed infants *(S.D.1.9)* compared to bottle-fed infants *(S.D.0.3)*. This may have resulted in some of those breast fed infants, who were born before term, not having achieved their intended birthweight by delivery and therefore have displayed a minor degree of *'catch up growth'* to enable them to attain this intended birthweight within the initial period after birth.

Other areas of interest in the growth of infants are length, head and mid upper arm circumference and both triceps and subscapular skinfold thicknesses. There were no striking or significant differences found in any of these measurements of infants in either of the 2 feeding groups over the *26* week period.

Some investigators have also found that there was no significant difference between the two feeding groups with regard to length[8,29,32,33,34], head circumference[8], and skinfold thickness[8,34,54] during infancy. While others have reported that breast-fed infants had gained less in length[40]and more[31,32] in skinfold thicknesses during infancy.

The length and ultimate height attained by individuals is strongly influenced by genetic component and there will be a wide variation in the rate of growth and the overall length increments of the individual infants. The parents genetic endowment for height would have to be taken into account for detailed studies of length gain. However for the purpose of this study both feeding groups had similar length gains and there was no deviations from the normal noted.

The patterns in the gain in head circumference were also very similar and there was no significant difference found between the two feeding groups. Bottle-fed infants had a consistent slightly higher mean gain in head circumference than breast-fed infants throughout the duration of the study. Gain in head circumference is expected to follow a similar trend in gain as the weight. This pattern was found with infants from both feeding groups. There was an initial rapid increase over the initial few weeks of life which was followed by a slower and more steady increase in head circumference.

The changes in total body fat occur rapidly during infancy. Skinfold thickness increases for about the first 6 months of life. The actual percentage change in total body fat from birth to age 6 months is unknown and the peak for fat deposition is known to vary widely. This was taken into account when carrying out this study and only the patterns of gain in skinfold thicknesses and mid upper arm circumference were studied in relation to the method of feeding. The patterns in gain in all of these measurements were found to follow a similar pattern and there was no striking deviation noted in the infants from both feeding groups during the period of the study. However, it was interesting to note that infants in both feeding groups had similar skinfold thicknesses at 2 weeks of age but that the bottle-fed infants consistently had a slightly higher mean gain in both skinfold thicknesses over the first 22 weeks of age. Thereafter mean gains in skinfold thicknesses were similar in the infants from both feeding groups. The mean of the combined skinfold thicknesses over the course of the study reflected this consistent pattern of the bottle-fed infants having a slightly higher mean gain in skinfold thicknesses than the breast-fed infants.

This suggests that there was a tendency for breast-fed infants in this study to have on average a lesser percentage of subcutaneous fat and a higher percentage of lean body mass when compared to the bottle-fed infants. The similar skinfold thicknesses observed towards the end of this study may possibly be attributed to the majority of infants who were previously exclusively breast-fed, now also having been established with solid food in addition to breast milk. This tendency for breast-fed infants to have less subcutaneous fat deposition may have some relevant importance in relation to the health, well-being and physical development in later adult life and therefore warrants further more detailed study.

It is apparent from the present data that healthy infants fed ***ad libitum*** with human or formula-based milk grow equally well as measured by the gross measurements used during this study.

CHAPTER FIVE

THE EFFECT THAT THE TIMING OF SOLIDS MAY HAVE ON THE GROWTH OF INFANTS AT 26 WEEKS.

Infants were grouped into three groups by the time that solids were introduced into the diet*(Table6)*. The General Linear Model was the statistical test used with the weaning group being the main factor analysed and then tested statistically for an interaction with the method of feeding.

5.1.0 Results

There was no significant difference in any of the growth measurements studied at 26 weeks of age between either the weaning groups or in relation to the weaning group and the method of feeding*(Table 9)*.

Weight gain is thought to be important when related to the time of weaning. There was no significant difference between the birthweights or the mean weight gained by infants in the 3 groups at *6,12,18,22 and 26* weeks of age.*(Table12&Fig.39)*.

The mean weight gained by the infants in the early weaning group*(<8 weeks)* was the highest of the 3 groups at 1.33kg between *6-12* weeks, compared with 1.13kg and 1.08kg for infants from the middle*(9-16 weeks)* and late weaning group*(17-26weeks)* respectively during the same time interval.

The middle group had the highest mean weight gain of 1.08 kg between *12-18* weeks compared with a mean gain of 0.98kg for infants from the other 2 groups during the same period.

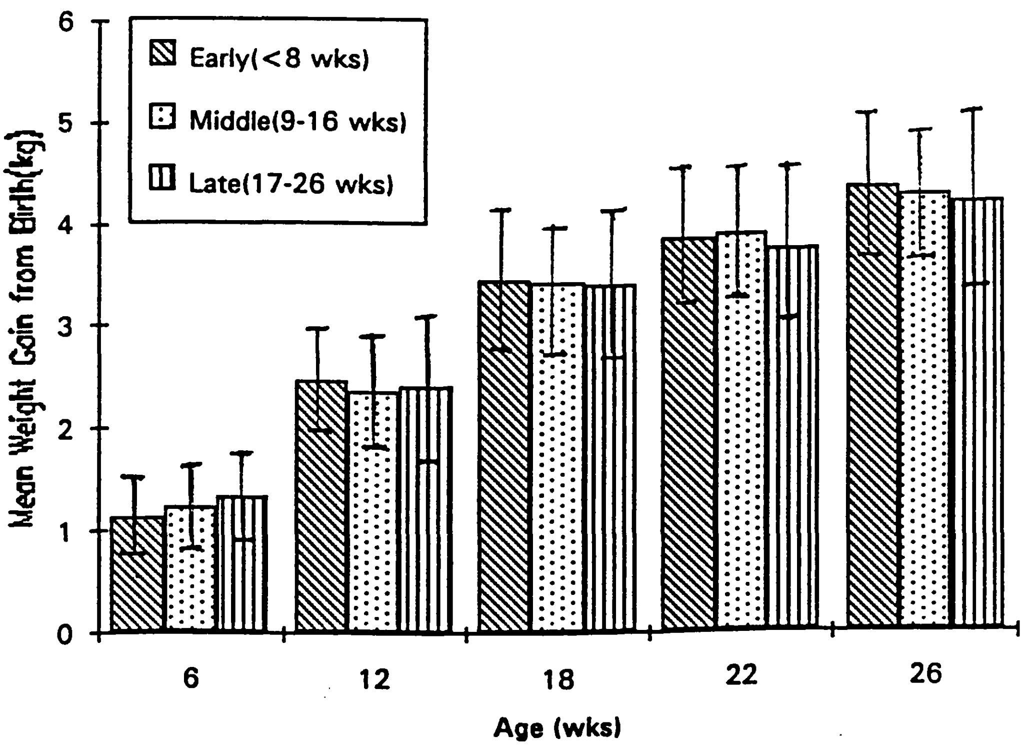
The late weaning group had the highest mean weight gain of the 3 weaning groups both at *6* weeks and between *22-26* weeks. of age.

Mean weight gain at *26* weeks of age was 4.34kg for infants in the early group and 4.26kg and 4.20kg for the middle and late weaning group infants respectively.

Table 12. Mean Weight Gain of Infants in Weaning Groups

Age (wks)	Early group (<8 wks) Gain Kg.(S.D.)	Middle group (9–16 wks) Gain Kg.(S.D.)	Late group (17–26 wks) Gain Kg.(S.D.)
Birth	3.54(0.60)	3.90(0.88)	3.33(0.57)
6	1.12(0.44)	1.23(0.40)	1.32(0.48)
12	2.45(0.61)	2.36(0.57)	2.40(0.70)
18	3.43(0.68)	3.42(0.60)	3.38(0.77)
22	3.84(0.70)	3.90(0.67)	3.75(0.76)
26	4.34(0.71)	4.26(0.63)	4.20(0.90)

Figure 39. Column Graph of Mean Weight Gain from Birth of Infants in Weaning Groups.



5.2.0 Discussion

Most infants tolerate solids at an early age but there is no evidence of advantages or benefits to health. On the contrary, available evidence shows the practice of early introduction *(before 12 weeks of age)* may be harmful as it contributes to the development of hyperosmolar states[24] and may possibly contribute to excessive weight gain[3,5] and obesity in later childhood[24].

The results from this study clearly agree with the findings of other investigators who also found that the earlier introduction of solids to an infants diet *(before 6 and 12 weeks of age)* did not influence the weight gained during infancy[9,12,13]. It was very interesting to note that the highest mean gain in weight of the infants observed by each group had occurred over the initial time interval that weaning was first commenced with those infants. This was most noticeable with the infants in the early weaning group who had the least mean weight gain of the 3 groups at *6* weeks of age but the highest mean weight gain at *12* weeks of age. This was not found to be of any significance statistically but it could possibly indicate that solid food may have given an initial short term boost to the weight gain. This may possibly have been due to the increase in the calorie intake to those infants who were already growing satisfactorily or infants who were possibly already slowing down in their weight gain due to insufficiency of the milk feeds to meet their requirements.

In this study weaning was classified as any drink or food offered to infants other than breast or formula milk. There was a great variation found in the frequency of offering solids to the infants in the early stages of weaning as well as the varying amounts and varieties of solid foods being given to the infants during the weaning period. Some infants were given only an occassional teaspoonful of cereal, while others received larger amounts of solids which included fruit, cereal, vegetables and meat as well as milk. It is unfortunate that the literature available contains very little quantitative data with regard to the measurements of food intake during the weaning period.

There was a wide variation in the distribution in the number of infants from each feeding group found in the 3 weaning groups. There was a total of 23% of all infants weaned before *8* weeks of age which included 4 breast and 16 bottle-fed infants. The middle group were offered solids between *9-16* weeks of age and consisted of 58% of all infants which included 16 breast and 34 bottle-fed infants. The late weaning group, the smallest group, had 19% of all infants offered solids between *18-26* weeks which included 13 breast and only 3 bottle-fed infants. These numbers indicate that there is a high incidence of mothers in this study who had offered their infants solids before *16* weeks of age. Current recommendation that ***"the early introduction of cereals or other solid foods to the diet of infants before about 4 months of age should be strongly discouraged"*** have been endorsed by the *DHSS* reports on infant feeding practices in previous years[27,36].

It was noted that 39% of the breast-fed infants and 6% of all bottle-fed infants waited until over *17* weeks of age before first introducing solids into the diet. The most common reason for mothers to introduce solids was hunger. Possibly mothers who breast-feed initially respond to signs of hunger in their infants by increasing the frequency of feeds before resorting to solids. Another possibility may be due to the formula milks not sufficiently satisfying infants. Alternatively, differences in maternal attitudes towards weaning might have been responsible.

Often mothers wanted to wait until the infant was older or heavier before weaning was commenced but many mothers often weaned infants simply in response to their interpretation of the needs of their own infants, often with the support of medical advice.

There was also a very noticeable difference in the age of weaning infants when infants were grouped by social class. All infants from social class III and IV had been weaned by *16* weeks of age, whereas 52% of infants from social class I were not weaned until between *17-26* weeks of age. It is not known to what extent socio-economic circumstances and other environmental factors influence the age at which weaning is commenced. However during this study it was readily apparent that certain mothers regarded the introduction of weaning foods as something quite separate from milk feeds and not as an integrated process.

Without a record of quantities of food taken, I can offer no explanation as to why solids given at an early age did not affect weight gain, despite findings that infants who are started on solids at an early age consumed extra energy[(20)]. If the theory that adults, who have an excessive energy intake, have less weight gain than expected since extra energy is expended in increased heat production, is applied to infants then this might explain why the early commencement of solids does not affect growth.

Failure to show that early mixed feeding affects weight gain does not mean that this practice should be encouraged. Nevertheless, some infants, even those aged less than 3 months of age, are dissatisfied on milk alone. Mothers should be aware of the current recommendations that it is advisable to delay the introduction of solids until 4 months of age and should be encouraged to adhere to these recommendations whenever the infants are content with milk feeds. However findings from this study may reassure the health professionals, who discourage early weaning, when it. may be necessary, because they fear that obesity might result.

GENERAL DISCUSSION

All the infants participating in this study grew equally well over the first 26 weeks of life irrespective of the method of feeding or the age when weaning was commenced. There were no striking differences noted in the growth patterns between the infants in the 2 feeding groups.

For obvious reasons, a group of mothers accepting to participate in a study like this, cannot be regarded as a random sample of the population. Many mothers of infants from both feeding groups were aware of the long term problems associated with the overweight infant, obesity and possible health risks. Some mothers expressed their reason for participating in this present study was to closely monitor weight gain in order to prevent the infant from gaining either too little or too much weight. A large number of the breast-feeding mothers had successfully breast-fed previous infants. There were also many of these mothers who were actively involved in specific breast-feeding awareness groups. These mothers were enthusiastic and highly motivated towards successful and possible exclusive breast-feeding for as long as possible. In view of these factors, it is highly likely that this resulted in a large selection of high lactating mothers within this study.

A study to compare the growth of infants must adequately encompass the whole broad spectrum of the population before it can accurately reflect the true average growth during infancy. Similar previous studies carried out on infant growth have also been complicated by the increased numbers of self select subjects participating in them. This has resulted in findings being specific for those infants included in the studies and not being extended to generally encompass all infants of the same age and socio-economic circumstances. Mothers from different ethnic background and social classes have different attitudes towards infant feeding practices which introduces a further complicating factor when trying to relate diet to infant growth.

The ideal study could possibly be achieved by the random selection of all newborn infants in a large study over a period of time. However this type of study is definitely not without unforseen complications. Measurements of infants would have to take place at a desirable and convenient time and location for the mothers. Co-operation of the mothers is vital for the successful completion of studies on infant growth. This study covered the period of *2* until *26* weeks of age and as the study progressed the number of subjects who withdrew was noted to increase as the infants became older.

Accurate monitoring of the velocity of longitudinal growth remains the most sensitive, available indicator of adequate nutrition. Improvement in the design of a study, like this one, could be achieved by the use of more sophisticated measuring equipment which would take into account the changing size and activity levels of the growing infant. This would possibly improve the accuracy of the specific growth measurements at the ages which gave cause for concern during this study and possibly detect subtle differences between infants in relation to the method of feeding which may possibly exist but may have been overlooked when using crude recording measurements.

Ideally, the growth measurements should have been recorded at exactly *2* weekly intervals, at the same time of day and before feeding. However, this was very difficult to achieve with all the subjects studied and sometimes it resulted that some subjects were not measured regularly on a *2* weekly basis but occassionally had *1-2*, or *3-4* weeks between subsequent measurements. Possibly by studying the rate of each growth area per day or week would have given more accurate results on the mean gain of the growth of infants over the time areas which have been noted to be of interest.

Often mothers partially feed infants with both breast and formula milk. This did not concern the subjects in this present study due to the successful breast-feeding of the mothers. However this category of feeding must be recognised and taken into account in future studies of infant growth in relation to the method of feeding.

In this present study, weaning was defined as any food or drink offered to infants other than breast or formula milk. Many mothers were found to have their own interpretation of when and how the infant was weaned. This resulted in doubt as to the accuracy of the actual age when many infants were truly weaned. Sometimes it occurred that mothers commenced solids for either a shorter or longer time interval and then decided to stop offering the infant solids for varying lengths of time. It may have been more beneficial for the purposes of data collection and analysis to have included clearer categories of the manner in which an infant was introduced to solid food.

The crucial question as to the normal expected pattern of infant growth in relation to the method of feeding still remains unanswered. The different trend in growth patterns between breast and bottle-fed infants by previous researchers has been a controversial issue over the last few decades. There is much more research needed in this area to decide conclusively which of the patterns of growth observed represent appropriate physiological growth or to identify those growth patterns which may reflect overnutrition, nutritional deficiency, and if so, whether this affects later functional or intellectual development.

Health care providers have a responsibility to ensure that women are given the best possible advice about the well-being of babies during infancy and in later years in relation to the method of feeding. The comparison that exists with regard to infant growth and the method of feeding gives little reassurance to alleviate the concerns of mothers. This confusion and the conflicting advice given to mothers, who have worries concerning the adequacy of breast milk or the growth of infants, has resulted in many mothers opting to bottle-feed infants in preference to breast-feeding. Many women feel more relaxed and confident when they can manipulate the amount of milk offered to the infant. Mothers want to give their infant the best possible chance in life, in order for them to be both healthy and thriving infants. In the light of this uncertainty about infant feeding practices it is clear that many mothers may possibly be given incorrect advice from the health care providers with regard to the method of feeding.

Clearly, we have lost sight of a number of basic principles in infant feeding derived from the composition of human milk and the rate of weight gain of the normal breast-fed infant. Breast-feeding is one of the most important measures for the protection of maternal and child health and it remains a major task for health workers in the coming decades.

CONCLUSIONS

In this study, breast and bottle-fed infants were followed for a period of *26* weeks after birth. Both groups were similar for maternal characteristics of age and parity. There were similar representations in the number of each sex within the 2 feeding groups. However, breast-fed infants were noted to come from a higher social class group than the bottle-fed infants.

There was no significant difference found between the infants in both feeding groups with either birthweight, total mean weight or weight gain *(from birth)* at *2,6,12,18,22 and 26* weeks of age. Infants in both groups had similar total mean length, head and MUAC circumferences, triceps and subscapular skinfold thicknesses at *2* weeks of age and there was no significant difference found between the total mean or mean gain *(from 2 weeks)* between the infants with any of the growth measurements at the ages when statistical analysis was carried out.

There were no striking differences noted over the *26* weeks period between the infants in either feeding group with any of the areas of growth studied. However it was interesting to note that the breast-fed infants had a slightly higher initial rapid mean weight gain over the first *8* weeks of the study when compared with the bottle-fed infants. Thereafter the rate of weight gained by the breast-fed infants tended to gradually slow down with age but still predominantly remained marginally higher until *18* weeks of age when compared to their bottle-fed counterparts. Both groups of infants had almost identical mean weight gains at *26* weeks of age*(i.e. 4.25kg and 4.24kg for bottle and breast-fed infants respectively).*

Infants in both feeding groups had similar steady growth patterns in the other areas of growth studied. The only other interesting observation made was the tendency for breast-fed infants to have a consistently lower mean gain in skinfold thicknesses over most of the *26* week period. Although, at any time, the difference in skinfold thicknesses between the infants in the 2 feeding groups was not significant, the consistently lower mean skinfold thicknesses up to 20 weeks of age in the breast-fed infants suggests that a larger study might show this to be an important difference in the components of weight gain in relation to the method of feeding.

Male infants were found to be significantly heavier and longer than female infants over the 26 week period. Male infants were also noted to have a significantly greater mean weight gain than female infants from 22 weeks of age. There was no significant difference found between the same sex of infants in relation to growth and the method of feeding.

There was no significant difference noted between the infants in relation to feeding method and social class groups (I+II) and (III+IV) with any of the growth measurements studied at the ages when statistical analysis was carried out. However it was noted that the infants in social class (I+II) tended to have a higher mean weight and the mean weight gain which was approaching significance at 22-26 weeks of age.

Infants were characterised into 3 groups by the age when solid food was introduced into the diet and by the method of feeding. Three weaning groups were identified as, early *(<8 weeks of age)*, middle *(between 9-16 weeks of age)* and late *(17-26 weeks of age)* groups. There was no significant difference in any of the areas of growth studied at 26 weeks of age either by age of weaning or the method of feeding. There was also no significant difference between the mean weight gain at *6,12,18,22 and 26* weeks of age between the infants in the 3 weaning groups either by method of feeding or the age of weaning.

It is a pity that there is so little recent data on the precise intake of formula-fed infants, but understandably interest has mostly concentrated on the nutritional adequacy of lactation. More research is needed in the longitudinal detailed study of the patterns of growth in exclusively breast-fed, partially breast-fed and bottle-fed infants during infancy and early childhood. This is necessary to establish the normal physiological growth pattern for infants in relation to the different feeding practice. Growth standards need to be thoroughly reviewed in order to clearly define the normal from the abnormal growth pattern during infancy.

More quantitative data is needed in which the intake of both breast and formula milk and other foods have been simultaneously measured until the time that the infant has been fully weaned. Solutions to many of the controversial issues which have encompassed infant health experts and the infant food industry in recent years require information in this important area.

Studies of infant feeding practices and growth should be followed up in relation to the long term effects of weight gain, obesity, and health in adult years. Future research is needed to include the study the energy requirements of infants which reflect levels of energy intake that will promote health, adequate growth, optimal body composition and levels of physical activity appropriate for the developmental age of the child.

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APPENDICES

Appendix 1. Mean Weight (Birth–26wks)

Bottle-fed Infants | Breast-fed Infants

Age (wks)	n.	Mean Weight (Kg)	S.D.	S.E.M.	Range (Kg)	n.	Mean Weight (Kg)	S.D.	S.E.M.	Range (Kg)
Birth	53	3.63	0.60	0.1	2.30–4.96	35	3.43	0.52	0.1	2.33–4.34
2	46	4.02	0.79	0.1	2.94–5.34	32	3.87	0.53	0.1	2.64–4.82
4	48	4.40	0.71	0.1	3.00–6.38	29	4.25	0.72	0.1	2.86–5.80
6	51	4.75	0.66	0.1	3.32–6.43	32	4.74	0.77	0.1	3.09–6.42
8	47	5.12	0.62	0.1	3.70–6.80	28	5.08	0.76	0.1	3.32–6.63
10	40	5.40	0.67	0.1	3.77–7.31	27	5.41	0.80	0.1	3.60–7.44
12	42	6.02	0.77	0.1	4.20–8.17	27	5.84	0.88	0.2	3.80–7.54
14	38	6.32	0.71	0.1	4.72–8.40	27	6.13	0.88	0.1	4.07–8.14
16	44	6.55	0.72	0.1	4.88–8.48	25	6.42	0.93	0.2	4.25–8.42
18	42	6.90	0.70	0.1	5.33–8.56	27	6.68	0.94	0.2	4.56–8.81
20	38	7.17	0.70	0.1	5.53–8.76	24	6.89	0.81	0.1	4.73–8.93
22	40	7.38	0.71	0.1	5.73–8.93	28	7.23	0.95	0.2	4.97–9.82
24	31	7.62	0.69	0.1	6.07–9.24	26	7.48	0.96	0.2	5.19–9.98
26	42	7.86	0.71	0.1	6.24–9.78	28	7.63	0.93	0.2	5.42–10.15

Appendix 2. Mean Weight Gain(from birth)

Bottle-fed Infants | Breast-fed Infants

Age (wks)	n.	Mean Weight Gain (Kg)	S.D.	S.E.M.	Range (Kg)	n.	Mean Weight Gain(Kg)	S.D.	S.E.M.	Range (Kg)
2	46	0.40	0.63	0.1	0.65–1.84	32	0.44	0.29	0.1	0.40–1.02
4	48	0.75	0.38	0.1	0.20–2.17	29	0.83	0.51	0.1	0.40–1.07
6	51	1.13	0.42	0.1	0.40–2.43	32	1.30	0.63	0.1	0.03–2.70
8	47	1.51	0.44	0.1	0.46–3.04	28	1.69	0.56	0.1	0.42–2.86
10	40	1.82	0.43	0.1	0.30–2.66	27	1.97	0.60	0.1	0.96–3.49
12	42	2.37	0.62	0.1	1.18–4.14	27	2.40	0.64	0.1	1.39–3.69
14	38	2.66	0.54	0.1	1.75–4.45	27	2.72	0.63	0.1	1.64–4.19
16	44	2.91	0.58	0.1	1.96–4.87	25	2.97	0.67	0.1	1.84–4.87
18	42	3.22	0.60	0.1	2.34–5.07	27	3.28	0.68	0.1	2.04–4.37
20	38	3.51	0.53	0.1	2.58–4.96	24	3.42	0.57	0.1	2.21–4.87
22	40	3.73	0.60	0.1	2.69–6.60	28	3.82	0.67	0.1	2.49–6.87
24	31	3.97	0.57	0.1	2.98–5.75	26	4.04	0.66	0.1	2.78–6.03
26	42	4.25	0.65	0.1	3.24–6.92	28	4.24	0.65	0.1	3.01–6.20

Appendix 3. Mean Length (2–26 weeks)

Bottle-fed Infants | Breast-fed Infants

Age (wks)	n.	Mean Length (cms.)	S.D.	S.E.M.	Range (cms.)	n.	Mean Length (cms.)	S.D.	S.E.M.	Range (cms.)
2	60	54.2	2.5	0.4	48.5–58.5	35	54.1	2.2	0.4	49.5–58.0
4	50	55.5	2.4	0.3	50.0–59.5	32	55.3	1.9	0.3	50.5–58.5
6	53	56.4	2.4	0.3	51.5–61.5	35	56.2	2.0	0.3	51.5–59.5
8	49	57.6	2.5	0.4	52.0–62.5	31	57.4	2.3	0.4	52.5–62.0
10	42	58.9	2.4	0.4	53.5–63.5	30	58.6	2.2	0.4	53.5–63.0
12	44	60.4	2.2	0.3	56.0–65.0	30	60.1	2.2	0.4	55.0–65.5
14	40	61.5	1.8	0.3	57.0–66.5	32	61.0	2.5	0.4	55.0–65.5
16	46	62.4	1.8	0.3	58.5–66.0	29	62.3	2.7	0.5	56.5–67.0
18	43	63.5	2.2	0.3	59.5–69.0	30	63.3	2.7	0.5	57.5–67.5
20	40	64.5	2.5	0.4	60.5–72.0	28	64.4	2.2	0.4	58.5–68.5
22	42	65.1	2.5	0.4	60.5–72.0	33	65.5	2.6	0.5	59.5–72.0
24	33	65.3	5.2	0.5	61.0–72.0	32	66.5	2.6	0.5	60.0–72.0
26	44	67.3	4.9	0.5	62.0–75.5	33	67.5	2.6	0.5	60.5–74.5

Appendix 4. Mean Length Gain (from 2 weeks)

Bottle-fed Infants | Breast-fed Infants

Age (wks)	n.	Mean Length Gain (cms.)	S.D.	S.E.M.	Range (cms)	n.	Mean Length Gain (cms.)	S.D.	S.E.M.	Range (cms.)
4	47	1.3	1.1	0.2	0.5–4.5	32	1.3	0.8	0.1	0.0–3.5
6	50	2.3	1.4	0.2	0.5–6.5	35	2.1	1.1	0.2	0.0–6.0
8	46	3.6	1.6	0.2	1.0–8.5	31	3.4	1.5	0.2	0.5–7.0
10	39	5.1	2.1	0.3	1.5–10.0	30	4.6	1.7	0.3	1.0–8.5
12	42	6.3	2.4	0.4	2.5–13.0	30	6.0	2.1	0.4	1.5–10.5
14	39	6.9	2.2	0.4	3.0–11.5	32	6.9	2.0	0.3	1.5–11.0
16	43	8.3	2.3	0.4	4.0–12.5	29	8.2	2.3	0.4	2.5–15.5
18	40	9.2	2.8	0.4	4.0–15.0	30	9.4	2.1	0.4	5.0–16.5
20	37	10.4	3.1	0.5	5.0–17.0	28	10.0	2.1	0.4	4.0–14.0
22	39	10.8	3.0	0.5	5.5–17.0	33	11.4	2.4	0.4	5.5–17.5
24	32	11.5	3.0	0.3	6.5–19.0	32	12.4	2.4	0.4	5.5–17.5
26	41	13.3	3.3	0.6	7.5–22.5	33	13.6	2.5	0.5	6.0–20.0

Appendix 5. Mean Head Circumference(2–26 weeks)

	Bottle-fed Infants					Breast-fed Infants				
Age (wks)	n.	Mean Head Circ. (mm.)	S.D.	S.E.M.	Range (mm.)	n.	Mean Head Circ. (mm.)	S.D.	S.E.M.	Range (mm.)
2	50	367.2	14.2	2.0	341–400	35	368.8	9.3	1.5	346–384
4	50	377.3	13.5	1.9	356–408	32	377.2	9.8	1.7	350–398
6	53	383.9	13.2	1.8	364–414	35	384.5	9.7	1.6	360–403
8	49	391.2	11.7	1.7	370–418	31	391.1	9.1	1.6	366–410
10	42	399.3	13.1	2.0	374–425	30	399.8	11.4	2.1	372–420
12	44	406.2	13.6	2.1	384–432	30	403.7	12.4	2.2	378–425
14	40	410.9	14.5	2.3	380–434	32	409.1	13.2	2.3	380–432
16	46	416.3	12.9	1.9	388–438	29	414.1	14.3	2.6	382–440
18	43	421.3	13.1	2.0	390–440	30	416.5	14.5	2.6	384–450
20	40	427.4	13.2	2.0	394–445	28	423.6	12.5	2.3	388–445
22	42	429.3	12.7	1.9	400–449	33	427.2	13.6	2.3	390–456
24	33	433.0	12.0	2.1	402–450	32	431.8	12.7	2.2	392–457
26	44	439.7	10.5	1.6	408–460	33	436.5	12.8	2.2	396–460

Appendix 6. Mean Gain in Head Circumference (2–26 wks)

	Bottle-fed Infants					Breast-fed Infants				
Age(wks)	n.	Mean Gain in Head/circ(mm)	S.D.	S.E.M.	Range (mm)	n.	Mean Gain in Head/circ(mm)	S.D.	S.E.M.	Range (mm.)
4	47	11.0	5.7	0.8	2–25	32	9.2	6.8	1.0	2–30
6	50	17.3	7.4	1.0	5–35	35	15.7	7.5	1.3	3–34
8	46	24.7	10.5	1.5	6–50	31	22.9	8.6	1.6	8–40
10	39	32.7	12.7	2.0	10–60	30	30.9	9.7	1.8	12–55
12	42	39.2	13.7	2.1	14–73	30	35.2	12.0	2.2	10–60
14	38	42.5	14.9	2.4	16–79	32	40.6	11.8	2.1	13–67
16	43	49.6	14.6	2.2	21–81	29	44.4	11.6	2.2	18–75
18	40	53.2	15.9	2.5	20–85	30	48.8	13.1	2.4	23–83
20	37	60.8	16.2	2.7	24–97	28	53.3	11.0	2.1	32–84
22	39	62.9	17.7	2.8	30–101	33	58.2	12.4	2.2	38–91
24	32	64.0	15.1	2.8	32–104	32	62.7	11.5	2.1	38–92
26	41	73.8	16.2	2.5	38–107	33	68.4	11.4	1.9	46–95

Appendix 7.Mean TRICEPS Skinfold Thickness (2–26 weeks)

Bottle-fed Infants | Breast-fed Infants

Age (wks)	n.	Mean skinfold Thickness (mm.)	S.D.	S.E.M.	Range (mm.)	n.	Mean skinfold Thickness(mm)	S.D.	S.E.M.	Range (mm.)
2	50	4.0	1.2	0.2	2–7	35	3.5	1.1	0.1	2–6
4	50	5.0	1.4	0.2	3–8	32	4.6	1.3	0.1	3–8
6	53	5.8	1.6	0.2	3–10	35	5.0	1.4	0.1	3–8
8	49	6.7	1.7	0.2	3–10	31	6.0	1.4	0.2	4–10
10	42	7.3	1.8	0.2	4–10	29	6.6	1.5	0.2	4–10
12	44	8.1	2.0	0.2	4–11	30	7.4	1.4	0.2	5–10
14	41	8.6	1.9	0.3	4–12	32	8.1	1.4	0.3	5–11
16	46	9.0	1.7	0.3	4–14	29	8.6	1.6	0.3	6–11
18	43	9.4	1.9	0.3	4–14	30	9.2	1.5	0.3	6–12
20	40	9.8	1.9	0.3	4–14	28	9.5	1.6	0.3	6–12
22	42	10.1	1.9	0.3	4–14	33	9.8	1.6	0.3	6–13
24	33	10.6	2.5	0.4	35–16	32	10.1	1.5	0.3	6–14
26	44	10.9	2.0	0.2	6–16	33	10.6	1.5	0.3	8–14

Appendix 8. Mean Gain in TRICEPS Skinfold Thickness from 2 wks.

Bottle-fed Infants | Breast-fed Infants

Age (wks)	n.	Mean skinfold Gain (mm.)	S.D.	S.E.M.	Range (mm.)	n.	Mean skinfold Gain (Kg.)	S.D.	S.E.M.	Range (mm.)
4	47	1.0	0.5	0.1	0–3	32	0.8	0.6	0.1	1–2
6	50	1.8	0.8	0.1	1–5	35	1.3	0.8	0.1	1–3
8	46	2.8	1.1	0.2	1–5	31	2.3	1.1	0.2	1–7
10	39	3.5	1.2	0.2	2–7	29	2.7	0.8	0.1	1–4
12	42	4.0	1.5	0.2	2–7	30	3.8	1.3	0.2	2–7
14	39	4.8	1.7	0.3	2–7	32	4.4	1.5	0.3	2–7
16	43	5.0	1.7	0.3	2–9	29	4.7	1.6	0.3	2–7
18	40	5.4	1.9	0.3	2–9	30	5.2	1.5	0.3	3–8
20	37	5.6	2.0	0.3	2–9	28	5.4	1.8	0.3	2–9
22	39	6.1	1.8	0.3	2–11	33	6.0	1.8	0.3	2–10
24	32	6.6	2.2	0.3	3–13	32	6.4	1.9	0.3	2–10
26	41	6.9	2.1	0.3	3–11	33	6.8	1.9	0.3	2–10

Appendix 9. Mean SUBSCAPULAR Skinfold Thickness(2–26 wks)

Bottle–fed Infants | Breast–fed Infants

Age (wks)	n.	Mean skinfold thickness (mm.)	S.D.	S.E.M	Range (mm.)	n.	Mean skinfold thickness (mm.)	S.D.	S.E.M.	Range (mm.)
2	50	3.6	1.2	0.2	2–6	35	3.2	0.9	0.2	2–5
4	50	4.2	1.4	0.2	2–7	32	3.8	1.4	0.2	2–7
6	53	5.0	1.6	0.2	2–8	35	4.4	1.5	0.2	2–7
8	49	5.6	1.7	0.2	3–9	31	4.8	1.6	0.3	3–8
10	42	5.9	1.7	0.3	3–9	29	5.5	1.6	0.3	3–8
12	44	6.9	2.0	0.3	3–10	30	6.2	1.9	0.3	3–9
14	40	7.2	2.1	0.3	3–11	32	6.6	2.0	0.3	3–11
16	46	7.6	1.9	0.3	3–11	29	6.7	1.8	0.3	3–12
18	44	7.9	2.1	0.3	3–11	30	7.6	1.9	0.3	3–12
20	40	8.2	2.2	0.3	3–12	28	8.0	1.9	0.4	4–12
22	42	8.6	2.1	0.3	3–12	33	8.2	1.9	0.3	4–12
24	33	8.6	2.0	0.4	4–12	32	8.4	1.8	0.3	4–12
26	43	9.1	2.0	0.3	4–12	33	9.0	1.7	0.3	4–12

Appendix 10. Mean Gain in SUBSCAPULAR Skinfold Thickness from 2 weeks)

Bottle–fed Infants | Breast–fed Infants

AGE (wks)	n.	Mean gain (mm.)	S.D.	S.E.M.	Range (mm.)	n.	Mean gain (mm.)	S.D.	S.E.M.	Range (mm.)
4	47	0.5	0.6	0.1	0–2	32	0.8	0.6	0.1	0–2
6	50	1.4	0.9	0.1	0–3	35	1.2	0.9	0.1	0–3
8	46	2.0	1.1	0.2	0–4	31	1.7	1.1	0.2	0–5
10	39	2.4	1.3	0.2	0–4	29	2.2	1.0	0.2	1–4
12	42	3.2	1.5	0.2	1–6	30	3.0	1.5	0.3	1–7
14	38	3.5	1.7	0.3	1–7	32	3.4	1.6	0.3	1–8
16	43	4.0	1.6	0.2	1–7	29	3.6	1.5	0.3	1–7
18	41	4.2	1.9	0.3	1–8	30	4.0	1.5	0.3	2–8
20	37	4.5	1.8	0.3	1–8	28	4.5	1.7	0.3	2–8
22	39	4.8	1.6	0.2	1–8	33	4.7	1.6	0.3	2–9
24	32	5.0	1.8	0.3	2–8	32	5.2	1.5	0.3	2–9
26	40	5.8	1.6	0.3	2–9	33	5.8	1.5	0.3	3–9

Appendix 11. Mean Mid Upper Arm Circumference(2–26 wks)

Bottle–fed Infants | Breast–fed Infants

Age (wks)	n.	Mean MUAC (mm.)	S.D.	S.E.M.	Range (mm.)	n.	Mean MUAC (mm.)	S.D.	S.E.M.	Range (mm.)
2	50	112.3	9.0	1.3	94–127	35	110.4	9.2	1.6	90–128
4	50	116.5	9.8	1.5	98–141	32	114.4	8.8	1.6	95–128
6	53	120.7	9.5	1.3	100–142	35	120.1	8.8	1.5	102–136
8	49	125.0	9.3	1.4	104–146	31	124.3	8.8	1.6	108–142
10	42	127.2	9.9	1.4	105–148	29	128.2	9.2	1.7	110–143
12	44	133.6	10.1	1.5	108–152	30	131.6	10.2	1.9	112–153
14	40	135.2	10.2	1.6	111–152	32	135.5	10.0	1.8	115–155
16	46	139.5	10.7	1.5	114–155	29	137.9	10.6	2.0	118–160
18	43	143.5	10.1	1.6	118–166	30	140.5	11.2	2.0	120–162
20	40	145.9	10.1	1.6	124–166	28	144.7	10.1	1.9	122–164
22	42	148.5	10.1	1.6	128–169	33	145.2	10.6	1.8	124–164
24	33	150.7	10.7	1.9	128–166	32	148.9	9.9	1.8	124–164
26	44	153.2	10.1	1.5	130–170	33	150.9	10.2	1.8	128–168

Appendix 12. Mean Gain in Mid Upper Arm Circumference from 2 weeks

Bottle–fed Infants | Breast–fed Infants

AGE (wks)	n.	Mean MUAC (mm.)	S.D.	S.E.M.	Range (mm.)	n.	Mean MUAC (mm.)	S.D	S.E.M.	Range (mm.)
4	47	5.1	4.0	0.6	0–20	32	5.1	4.3	0.8	1–16
6	50	8.8	4.6	0.6	2–22	35	9.7	4.9	0.8	3–20
8	46	13.4	5.8	0.8	4–26	31	13.8	5.6	1.0	5–25
10	39	17.0	6.5	1.0	5–28	29	17.8	7.4	1.4	5–36
12	42	21.1	8.2	1.2	6–46	30	21.2	9.0	1.6	8–49
14	38	24.9	7.5	1.2	6–48	32	25.3	9.9	1.8	10–51
16	43	27.9	8.0	1.2	8–48	29	27.7	10.3	1.7	11–52
18	40	30.4	7.9	1.2	10–48	30	29.8	9.1	1.3	11–54
20	37	33.8	7.7	1.3	14–49	28	32.5	8.8	1.5	19–58
22	39	35.9	7.8	1.2	18–58	33	34.9	8.7	1.5	18–57
24	32	38.0	8.1	1.3	19–62	32	37.9	8.4	1.5	18–57
26	41	41.4	7.3	1.1	20–64	33	41.1	8.9	1.6	24–62

Appendix 13. Grouping in Relation to Parity of Mother and Method of Feeding, before Birth, at Birth and 2 weeks Post-Partum.

Method of Feeding	Primigravida (Baby no.1) n.(%)	Para >1 (Baby no.2+) n.(%)	Total n.(%)
Intention to:			
1. Breast-feed	18(90%)	48(71%)	66(75%)
2. Bottle-feed	2(10%)	20(29%)	22(25%)
Total	20(100%)	68(100%)	88(100%)
At Birth:			
1. Breast-fed	12(60%)	36(53%)	48(55%)
2. Bottle-fed	8(40%)	32(47%)	40(45%)
Total	20(100%)	68(100%)	88(100%)
Feeding Method at 2 weeks:			
1. Breast	7(35%)	28(41%)	35(40%)
2. Bottle	13(65%)	40(59%)	53(60%)
Total	20(100%)	68(100%)	88(100%)

Appendix 14. Grouping in Relation to Mode of Delivery and Infant Feeding Method at Birth and 2 weeks Post-Partum.

Method of Feeding	Normal Delivery n.(%)	Forceps Delivery n.(%)	C/Section n.(%)	Total n.(%)
Breast at Birth	38(56%)	10(67%)	0(0%)	48(55%)
Bottle at Birth	30(44%)	5(33%)	5(100%)	40(45%)
Total	68(100%)	15(100%)	5(100%)	88(100%)
Breast at 2 weeks	35(51%)	0(0%)	0(0%)	35(40%)
Bottle at 2 weeks	33(49%)	15(100%)	5(100%)	53(60%)
Total	68(100%)	15(100%)	5(100%)	53(60%)