Growth of preschool coloured children in Cape Town

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Summary

The growth of a random sample of coloured children in Cape Town was studied from birth until 5 years. At birth they were relatively light and short for gestational age. Size at birth correlated with social class. A rapid postnatal weight gain rendered them relatively overweight between 3 and 6 months. Thereafter they became lighter and shorter than the NCHS reference values and this persisted throughout the preschool period. Genetic factors, reflected by parental growth, were found to predict growth during childhood, but they were more predictive of weight and head circumference than of length. From 12 months onwards, socio-economic factors played a significant role in determining growth even after the effects of the genetic factors had been taken into account.

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Growth during childhood is determined by a continuous interaction between genetic and environmental factors. The individual's genetic make-up establishes a potential for growth in a predetermined sequence that will be fulfilled if the environment, both social and physical, is compatible at each stage of the developmental process. When the environment is unfavourable, particularly if the diet is deficient or unbalanced, the full growth potential will not be reached and the child's body measurements will fall below the normal range of values for children who have not experienced adverse circumstances. The present study was designed to investigate the growth and development of preschool coloured children in Cape Town. We have already reported on the characteristics of the cohort and sample, indicating marked variations in the socio-economic circumstances with family incomes, education and occupational density ranging from satisfactory to grossly unsatisfactory.[1] The purpose of this paper is to describe the growth of the children from birth until 5 years and to analyse the factors influencing the growth variables.

Subjects and methods

A pilot study survey based on the families of 93 infants born consecutively in the Cape Town municipal area was conducted to establish the feasibility of obtaining information about factors to be included in the study. The cohort comprised 1 000 coloured infants born between 1 May and 8 June 1976 in the study area. From the cohort, a random sample of 187 was selected for study over the 5-year period. Details of the pilot study, cohort and sample have been described.[1]

The sample children were visited at home every 3 months until they were 24 months old, 6-monthly until 36 months and then yearly until they reached 5 years of age. At each visit the weight and length/height, the feeding methods, illnesses since the previous visit, developmental details and social data were recorded on a prescribed proforma. The head circumferences were obtained at birth, 12 months and 5 years. The mother's weight and height were measured 6 months after delivery, but the father's height could only be obtained from the mother's report.

Social class was determined according to the occupation of the breadwinner based on the UK Registrar General's classification.[2] During the pilot study only 3 out of 93 families were found to fall within categories I and II. We therefore grouped class I and II together with III. The families were classified according to the status at the birth of the index child. Very few families changed in occupation grading over the 5 years of study.

In addition to social class by occupation grading of the breadwinner, the income, occupational density and family stability were recorded. The available income ratio (AIR) was calculated by expressing, as a percentage, what was earned against what each individual in the household required according to the Primary Household Subsistence Level of Potgieter.[3] Occupational density was determined from the Batson Scale[4] and family stability referred to a subjective assessment based on the family cohesiveness, child centredness, the presence or absence of social pathology and the housing.

The birth weight, length and head circumference were obtained from the neonatal records. During infancy weights were recorded on standardised clinic scales and recumbent lengths obtained using a measuring board. The older children were weighed in their underclothes on a Seca scale. Heights were measured on a specially constructed apparatus and head circumferences measured with a non-stretchable tape measure. Standard methods for obtaining accurate readings were used as described by Falkner.[5] All measurements after birth were taken by members of the research team.

The results were compared with the National Center for Health Statistics percentiles[6] and expressed as percentages of expected (the 50th percentile) weight, height and head circumference for age. The weights were also expressed as a percentage of expected weights for given heights. The 95% confidence limits of the mean relative value are shown on the graphs.

Pearson correlation coefficients (r), Spearman rank correlation coefficients (r_s) and odds ratios (OR) with the approximate 95% confidence intervals (95% CI) were used to describe the association between growth and various factors depending on whether the factors were continuous, ordinal or binary measurements respectively. Logistic regression using a backward selection procedure was used to undertake the multivariate analyses. The goodness of fit is described by the R statistic which represents the proportion of the log likelihood explained by the model.

Results

Three of the 187 children died and one was excluded owing to brain damage at the time of birth, leaving an effective sample size of 183 children. The follow-up achieved in this study is summarised in Table I. By the age of 60 months, 12 children had moved out of the area and 2 could not be visited despite the vigorous attempts of the researchers. The means and standard deviations for the growth measurements from birth to 60 months are shown in Table II.

TABLE I. FOLLOW-UP OF THE CHILDREN DURING THE STUDY

	% of 183
Birth	100,0
3 months	96,1
6 months	91,8
12 months	95,6
30 months	93,4
60 months	92,4

The birth weights were significantly lower than the NCHS values (average 92,5%), whereas by 3 months the weights were higher than expected. The relative weight declined (but was not different from the standard at 6 and 9 months) until 12 months, when weights were significantly below the NCHS expected weights. Thereafter the weights continued to be 95% of expected, which was statistically below the reference value (Fig. 1).

Fig. 1. Mean and 95% CI of the percentage of expected weight for age of the children followed up from birth to 5 years.

At birth the babies were significantly shorter than the NCHS values. The heights relative to the reference values declined until 30 months, when they were 95% of expected. The heights improved slightly until 60 months, when they were 96,5% of expected (Fig. 2).

TABLE II. SUMMARY STATISTICS OF THE GROWTH OF THE CHILDREN

	Boys			Girls		
	No.	Mean	SD	No.	Mean	SD
Birth						
Weight (kg)	97	3,06	0,59	86	2,95	0,46
Length (cm)	80	49,3	4,2	79	48,9	3,2
Head circumference (cm)	76	34,5	2,9	75	33,4	1,6
12 months						
Weight (kg)	94	9,53	1,27	81	8,97	1,5
Length (cm)	94	73,6	3,3	81	72,0	3,0
Head circumference (cm)	94	46,3	1,5	81	45,4	1,5
30 months						
Weight (kg)	90	12,9	1,7	81	12,5	1,5
Length (cm)	90	87,7	4,6	81	86,8	4,0
60 months						
Weight (kg)	90	17,3	2,1	79	17,1	2,0
Length (cm)	90	105,4	5,3	79	105,3	4,5
Head circumference (cm)	90	50,8	1,4	79	50,4	1,4

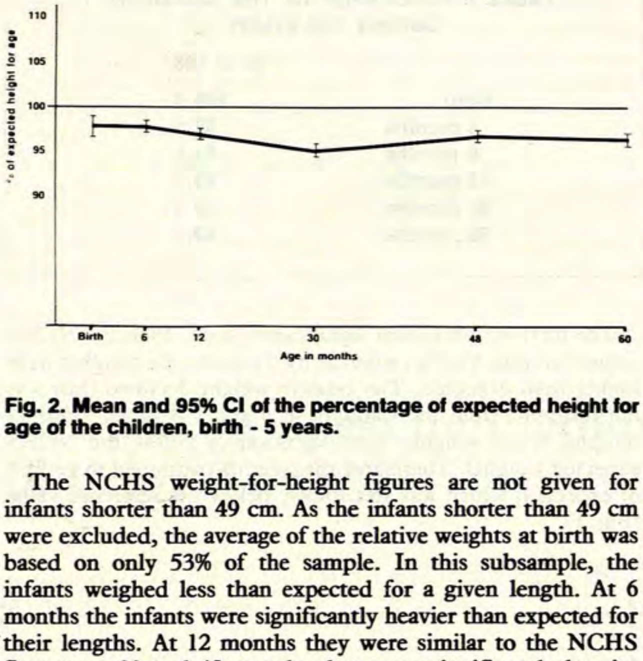

Fig. 2. Mean and 95% CI of the percentage of expected height for age of the children, birth - 5 years.

The NCHS weight-for-height figures are not given for infants shorter than 49 cm. As the infants shorter than 49 cm were excluded, the average of the relative weights at birth was based on only 53% of the sample. In this subsample, the infants weighed less than expected for a given length. At 6 months the infants were significantly heavier than expected for their lengths. At 12 months they were similar to the NCHS figures, at 30 and 48 months they were significantly heavier than expected, and at 5 years they were equal to the reference values (Fig. 3).

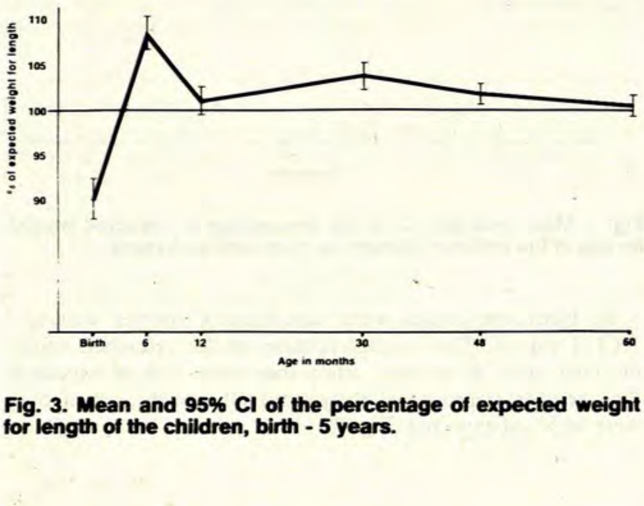

Fig. 3. Mean and 95% CI of the percentage of expected weight for length of the children, birth - 5 years.

The average head circumference at birth was significantly lower than the NCHS figures, being 98,2% of the expected. At 6 months it was similar to the expected, but by 12 months it was again slightly below the expected at 98,9% (Fig. 4).

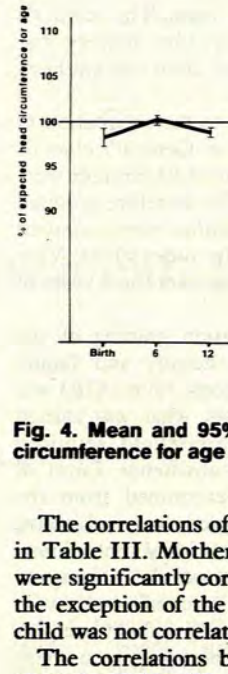

Fig. 4. Mean and 95% CI of the percentage of expected head circumference for age of the children, birth - 1 year.

The correlations of growth with parental attributes are given in Table III. Mother's weight and height and father's height were significantly correlated with the growth of the child, with the exception of the length at birth. Growth velocity of the child was not correlated with the parents' attributes.

The correlations between growth and social variables are given in Table IV. A lower birth weight and height were significantly related to lower social class by occupation of the breadwinner, to increased occupational density and to poorer family stability. There were no other significant correlations at birth. Head circumference at birth was not related to these variables and none of the growth measurements were related to income. By 12 months growth correlated well with all the social variables. This also applied at 30 and 60 months. Over the age range studied parallel patterns were followed by each class (Fig. 5); class I - III (group I) was always heaviest and class V (group 3) was always lightest. At birth only class I -III was not significantly below the NCHS values. The same correlation with social class was observed in the lengths (Fig. 6). At birth class V (group 3) was significantly below the

TABLE III. CORRELATION BETWEEN THE PARENTS' ATTRIBUTES AND THE INFANT'S GROWTH

	Mother's weight		Mother's height		Father's height	
	No.	r	No.	r	No.	r
Birth						
Weight	166	0,335***	171	0,179*	171	0,181*
Length	147	0,136	152	0,103	149	0,142
Head circumference	137	0,286**	143	0,069	139	0,264**
12 months						
Weight	160	0,235**	165	0,165*	164	0,194*
Length	160	0,273***	165	0,262***	164	0,336***
Head circumference	160	0,250**	165	0,170*	164	0,155*
30 months						
Weight	158	0,257**	163	0,181*	160	0,187*
Length	158	0,243**	163	0,251**	160	0,323***
Velocity: birth - 30 months						
Weight	156	−0,136	161	−0,023	158	0,049
Length	137	0,013	142	0,038	137	−0,102
Velocity: 12 - 30 months						
Weight	155	0,005	160	0,001	158	−0,017
Length	155	−0,001	160	0,030	158	−0,046

* $0,01 < P < 0,05$.
** $0,001 < P < 0,01$.
*** $P < 0,001$.

TABLE IV. CORRELATION BETWEEN SOCIAL MILIEU AND GROWTH

	Social class		AIR		OD		Family stability	
	No.	r_s	No.	r_s	No.	r_s	No.	r_s
Birth								
Weight	183	−0,246***	181	0,120	182	−0,203**	183	−0,157*
Length	160	−0,263***	159	0,095	159	−0,177*	160	−0,244*
Head circumference	150	−0,090	149	−0,072	149	−0,136	150	−0,085
12 months								
Weight	175	−0,236**	173	0,374***	173	−0,199**	175	−0,320**
Length	175	−0,254***	173	0,369***	173	−0,254***	175	−0,368**
Head circumference	175	−0,265***	173	0,337***	173	−0,122	175	−0,276**
30 months								
Weight	171	−0,323***	168	0,377***	169	−0,248**	169	−0,337**
Length	171	−0,336***	168	0,461***	169	−0,326***	169	−0,441***
60 months								
Weight	169	−0,231**	168	0,367***	168	−0,287***	168	−0,420***
Length	169	−0,290***	168	0,394***	168	−0,267***	168	−0,465***
Head circumference	169	−0,225**	168	0,290***	168	−0,223**	168	−0,215**

* $0,01 < P < 0,05$.
** $0,001 < P < 0,01$.
*** $P < 0,001$.
AIR = available income ratio; OD occupational density; r_s = Spearman rank correlation.

CHS value. Each social class had the same pattern of weight r length (Fig. 7), which indicates that the weight-for-height lationship was independent of social class.

Head circumference at birth was not related to social factors, it it did correlate with social class, income, occupation nsity and family stability from 12 months onwards. At 6 onths only head circumference for social class I - III (group was significantly greater than the NCHS figures, and at 12 onths classes IV (group 2) and V (group 3) fell significantly below the reference values while class I - III (group 1) remained similar to them (Fig. 8).

Growth generally correlated poorly with childhood illnesses (Table V). Gastro-enteritis correlated with poor growth, although none of the associations were statistically significant. At 12 months, having had a respiratory illness in the preceding 3 months was significantly associated with being above the NCHS expected length for age, and having had some other illness was significantly associated with being above the NCHS

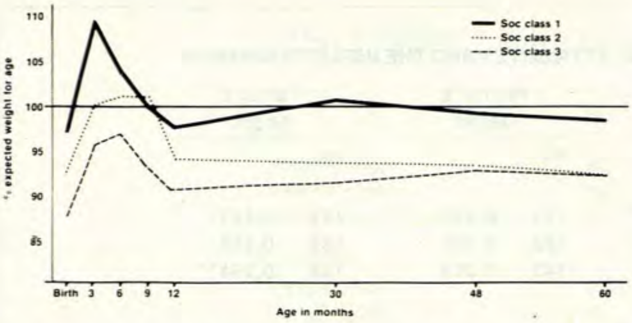

Fig. 5. Mean percentage of expected weight for age for the three social classes.

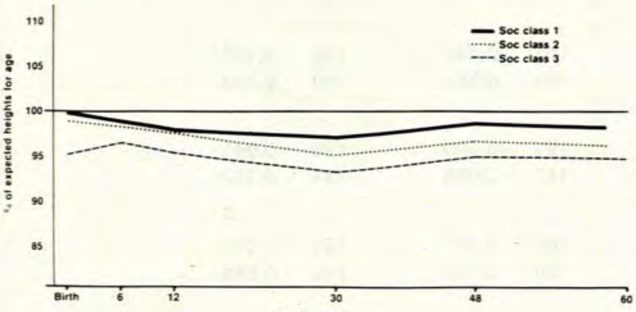

Fig. 6. Mean percentage of expected heights for age for the three social classes.

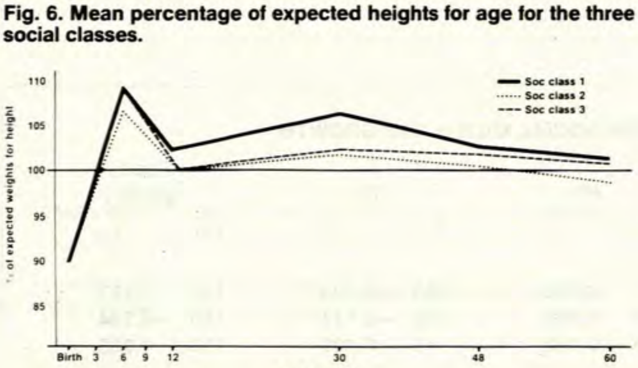

Fig. 7. Mean percentage of expected weights for height for the three social classes.

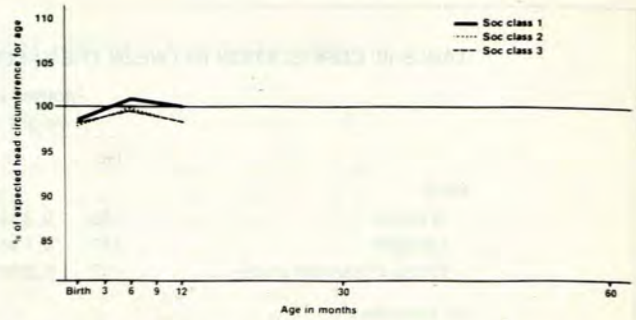

Fig. 8. Mean percentage of expected head circumference for age for the three social classes.

expected weight for age. Regular clinic attendance was generally associated with above-expected growth, but was only significantly associated with length at 12 months. The duration of breast-feeding is given in Fig. 9. Over 80% of mothers breastfed their infants initially but by 4 months the percentage had fallen to 30. On the other hand, 10% were still breast-feeding at 18 months. The reasons for discontinuing breast-feeding were given as insufficient milk in 43,2% of cases, the mother returning to work in 19,4%, and maternal illness or being advised to stop in 16,1%.

Logistic regression was used to model the odds of a child falling below the NCHS expected values. Table VI shows the results of these analyses and the factors included in each model. The fit of the logistic regressions were not very good

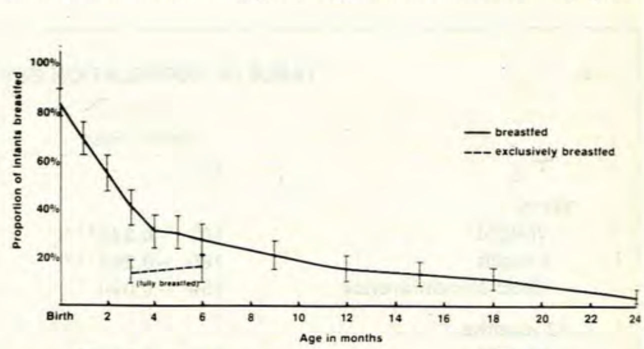

Fig. 9. Proportion and 95% CI for infants breast-fed at each age.

TABLE V. OR† (AND APPROXIMATE 95% CI IN BRACKETS) DESCRIBING THE RELATIONSHIP BETWEEN RELATIVELY POOR GROWTH AND ILLNESS, CLINIC ATTENDANCE AND BREAST-FEEDING

	Gastro-enteritis (ill v. not)	Respiratory (ill v. not)	Other illnesses (ill v. not)	Regular clinic attendance (yes v. no)	Breast-feeding (breast v. not)
12 months					
Weight	**1,7 (0,8-3,5)**	**0,7 (0,4-1,3)**	**0,5*(0,3-1,0)**	**0,8 (0,5,-1,5)**	**1,2 (0,5-2,8)**
Length	**1,1 (0,5-2,6)**	**0,4*(0,2-1,0)**	**0,7 (0,3-1,7)**	**0,4*(0,2-0,8)**	**0,7 (0,2-2,3)**
Head circumference	**1,4 (0,6-3,0)**	**1,0 (0,5-1,8)**	**1,1 (0,5-2,2)**	**0,9 (0,5-1,8)**	**0,7 (0,3-1,8)**
Velocity: birth - 12 months					
Weight	**1,0 (0,5-1,9)**	**0,9 (0,5-1,6)**	**0,9 (0,5-1,7)**	**1,1 (0,6-2,0)**	**0,9 (0,4-2,0)**
Length	**1,5 (0,7-3,0)**	**0,9 (0,5-1,8)**	**0,8 (0,4-1,7)**	**0,8 (0,4-1,6)**	**1,7 (0,7-4,1)**
Head circumference	**0,9 (0,4-2,0)**	**0,9 (0,5-1,8)**	**1,2 (0,5-2,5)**	**0,8 (0,4-1,6)**	**0,9 (0,3-2,1)**
30 months					
Weight	**1,2 (0,4-3,7)**	**1,0 (0,5-1,9)**	**0,9 (0,5-1,7)**	**1,4 (0,7-2,6)**	**2,1 (0,5-9,7)**
Length	**2,1 (0,3-17,1)**	**0,5 (0,2-1,2)**	**0,8 (0,4-2,0)**	**0,8 (0,3-2,0)**	**1,1 (0,1-9,3)**

* 0,01 $< P <$ 0,05.
† Odds of being below the expected NCHS value or of dropping over time.

TABLE VI. SUMMARY OF MULTIVARIATE ANALYSIS USING LOGISTIC REGRESSION TO MODEL THE ODDS OF A CHILD BEING BELOW THE NCHS EXPECTED VALUES

Outcome	Variables	Categories	OR	95% CI	*R*
Birth					
Weight (*R* = 0,233)					
	Mother's weight	**Below median v. above**	**2,8****	**1,4 - 5,6**	**0,179**
	Father's weight	**Short v. medium or tall**	**2,3***	**1,1 - 0,5**	**0,114**
Length (*R* = 0,293)					
	Social class	**3 v. 1 or 2**	**4,1****	**1,8 - 9,3**	**0,223**
	Family stability	**Unstable v. stable**	**6,7***	**2,7 - 16,9**	**0,125**
Head circumference (*R* = 0,218)					
	Mother's weight	**Below median v. above**	**2,3***	**1,0 - 5,0**	**0,122**
	Father's height	**Short v. medium or tall**	**2,8***	**1,1 - 7,0**	**0,140**
12 months					
Weight (*R* = 0,229)					
	Income	**Below median v. above**	**3,0****	**1,5 - 6,2**	**0,191**
	Mother's height	**Below median v. above**	**2,1***	**1,0 - 4,4**	**0,106**
Length (*R* = 0,338)					
	Family stability	**Unstable v. stable**	**8,8*****	**2,4 - 32,0**	**0,260**
	Respiratory illness	**Yes v. no**	**0,4***	**0,2 - 0,9**	**0,136**
Head circumference (*R* = 0,331)					
	Occupational density	**Below median v. above**	**4,0****	**1,7 - 10,0**	**0,224**
	Head circumference at birth	**Below median v. above**	**2,9***	**1,2 - 7,0**	**0,153**
	Income	**Below median v. above**	**2,5***	**1,1 - 5,9**	**0,129**
30 months					
Weight (*R* = 0,178)					
	Mother's height	**Below median v. above**	**2,3***	**1,1 - 4,6**	**0,134**
	Social class	**Class 1 and 3 v. 2**	**2,5***	**1,1 - 5,7**	**0,111**
Length (*R* = 0,267)					
	Family stability	**Unstable v. stable**	**10,3***	**1,3 - 81,1**	**0,172**

* $0,01 < P < 0,05$.
** $0,001 < P < 0,01$.
*** $P < 0,001$.

(*R* ranged from 0,178 to 0,338), indicating that the variables measured could only account for a part of the variations observed in the growth of the children. From the results it can be seen that genetic factors play a more important role in predicting growth in weight and head circumference than they do for length. Even at birth, length can best be predicted on the basis of social class and family stability. From 12 months onwards, socio-economic factors play a significant role in determining growth even after the effects of the genetic factors have been taken into account.

Discussion

At birth coloured infants in Cape Town weighed less and were shorter and lighter for length than the American infants on whom the NCHS values were based. This finding has also been reported by Woods *et al.*[7]

There was a rapid postnatal weight gain but not an equivalent increase in length so that between 3 and 6 months the infants were heavier than the NCHS values. By a year, however, they are once again below standard for weight and length, and this persisted throughout the preschool period. Thomson[8] has described three phases in early childhood growth. During the first 6 months there is a period of optimal growth. From 6 - 18 months disease and other adverse circumstances cause a setback, and from then until 5 years growth 'maintains station' but fails to achieve full recovery from the setback. These trends correspond to the patterns seen in our study.

Growth is determined by a continuous interaction between genetic and environmental forces. The genetic influence manifested in this study as a correlation between growth variables and mother's height and weight and father's height. The only exception was length at birth. This could be explained by the fact that anthropometric data at birth were obtained from the neonatal records and length at birth is a less reliable measure than weight. After birth all measurements were obtained by members of the research team.

The postnatal environment exerts a major influence on growth during early childhood. Social class was related to all growth variables except for head circumference at birth. Although income did not correlate with size at birth, it did so from 12 months onwards. From 12 months there was a strong association between height, weight and head circumference and social class, income, occupational density and family stability.

It must be postulated in a population such as ours that suboptimal nutrition is responsible for the growth trends, especially as social class and income played a significant role. However, when the weight/height ratio is considered there was clearly no period during which the infants were acutely malnourished. In fact, during infancy they were overnourished. Graham *et al.*[9] found that among poor children in Peru those from better-off families were taller and heavier, but, as in our study, they did not differ in height/weight ratio. As more money became available for food, their families tended to increase carbohydrate consumption moderately and fat and protein intake proportionately more, but vegetable protein remained almost constant. With further increases in disposable income, there was no further increase in carbohydrate intake but a continued increase in fat and animal protein intake. Thus the urban poor of Peru make qualitative improvements in diet without increasing total energy intake. These trends of improved diet are associated with significantly better growth of children. Graham *et al.* do, however, suggest that the correlation between nutrient intake and achieved growth could be coincidental. It is possible, they claim, that taller and heavier children whose families can spend more on food also have a greater genetic potential for growth or live in slightly healthier environments with less constraints to the most efficient utilisation of food.

Growth during early childhood was not particularly affected by illness. The only significant correlations were between respiratory illness and length and 'other illnesses' and weight at 12 months. Gastro-enteritis was generally correlated with poor growth, although the associations were not statistically significant. Martorell[10] has reviewed a number of studies on the relationship between illness and physical growth. Separation of country of origin revealed contrasting results. In developed countries no childhood ailments, in particular diarrhoeal disease, were clearly associated with poor growth. The poor correlation between growth and gastro-enteritis is a tribute to the primary health care available in Cape Town, particularly the network of maternal and child health clinics and day hospitals. A positive association between respiratory and 'other' illnesses and growth at a year is unexpected, but could be explained by the fact that the illnesses recorded were those for which medical treatment was sought. It is possible that the families of the higher social class groups were more likely to take their children for treatment of respiratory and 'other' illnesses. There was a significant association between social class and growth during infancy.

Because the infants were all born within 1 month the possibility of seasonal influence on growth arises, particularly with regard to the rapid but transient weight gain during the first 6 months of life. Marshall[11] has studied the relationship between growth rate and seasonal climatic variations and concluded that they exert at most a small effect on growth rate and perhaps none at all. Excessive energy intake was probably responsible for the weight gain. As it was not accompanied by an increase in length it is probably related to the importance placed on infant weight at maternal and child welfare clinics. The rapid weight gain coincided with a sharp decline in breast-feeding. Whitehead and Paul[12] have drawn attention to the trend in developed countries towards reduced energy intake associated with increased breast-feeding. This has led to anthropometric measurements falling well below the reference figures based on children who were predominantly bottle-fed before 1970. There is therefore a marked difference in weight between our predominantly artificially fed infants and those of developed mainly breast-feeding communities, with the Cape Town infants above and breast-fed infants below the NCHS expected values.

The growth of the children in this study was characterised by a tendency toward intra-uterine growth retardation, followed by a rapid but transient weight gain between 3 and 6 months of age, probably associated with early weaning and excessive energy intake. Thereafter they became lighter and shorter than the NCHS reference values, and this persisted throughout the preschool period. Intervention to attain optimal growth would therefore have to include improved maternal nutrition during pregnancy, the promotion of breast-feeding during infancy and an improvement in the social milieu, as well as nutritional supplementation for those children who fall below the normal percentiles during the preschool period.

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