FRONTO-OCCIPITAL HEAD CIRCUMFERENCE OF KENYAN INFANTS OF AFRICAN ORIGIN AGED 0-12 MONTHS LIVING IN AND AROUND TWO MAJOR TOWNS IN KENYA

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D E C L A R A T I O N

CANDIDATE

I certify that this dissertation is my original work and has not been submitted for a degree in any other University.

Signed: .....

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SUPERVISOR

This dissertation has been submitted for examination with my approval as University Supervisor.

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SUMMARY

A cross sectional study to determine fronto-occipital head circumference was done on 890 healthy Kenyan infants of African origin living in and around the towns of Mombasa and Nairobi. The mean head circumference at birth was 35.0 cm. (SD 1.1) for male and 34.4 cm. (SD 1.0) for female infants. The mean increase in head circumference was 1.4cm. per month in the first six months and 0.4 cm. per month in the next six months for both sexes. The mean head circumference for boys and girls in infancy compared favourably with the practical composite international and interracial graphs for boys and girls computed by Nellhaus (1) from reports appearing in the world literature since 1948 to 1968. Boys had significantly larger head circumference than girls ($0.01 < P < 0.05$). There was no statistical difference in head circumference between infants of various tribal backgrounds in Kenya.

INTRODUCTION AND OBJECTIVE

Head circumference determination is a useful anthropometric measurement in infancy and childhood. Permelee, Stern, Chervin and Minkowisk (2) analysing weight, length and head circumference in relationship to gestational age for 1,535 preterm babies found that head circumference had the highest correlation with gestational age and that prediction of gestational age from head circumference measures was as good as using all the above physical measures as indicated by multiple regression analysis. During the first year of life, head circumference reflects age rather than health or nutrition (3). However, the size of the brain and the skull and the thickness of the scalp may vary with nutritional status, so that head circumference is slightly affected in protein calorie malnutrition (3). During the first two years of life, head circumference is a useful measure of physical growth and growth of the brain (3). During this same period head circumference determination is useful in detecting, assessing and evaluating treatment to intracranial pathology such as hydrocephalus, cyst, abscess, subdural haematoma and effusion (4). Finally head circumference determination may be used to reassure parents in case they show anxiety about the size of their child's head.

Accurate interpretation of head circumference measurements requires that serial determinations be made (1).

A single 'normal' head circumference (or that lying within plus or minus twice standard deviation from the mean) may be misleading as it gives no clue as to the rate of head growth. A single"abnormal"reading may equally be misleading for the same reason. Rapid increase in head circumference may signify correctable conditions such as hydrocephalus, subdural haematoma or effusion.. Marked slowing or arrest of head growth offers a poor prognosis for mental development(1) Microcephaly often signifies mental subnormality although there is no linear relationship between it and decreasing head size (5,6).

Many factors including genetic constitution, nutritional status, endocrine and enviromental factors influence growth. Bray, Shields, Wolcott and Madsen (7) working on a group of 56 children of different ages in Lake Salt City, Utah, in 1969 demonstrated through x-ray technique that fronto-occipital head circumference accurately measures intra-cranial volume and in the absence of brain pathology causing raised intracranial pressure, intracranial volume is an accurate measure of brain size.

A full term infant has a head circumference which is about two thirds of what it will ultimately be in adult life (8). Two thirds of total brain growth in humans therefore occurs in intrauterine life and only one third postnatally. Two thirds of this postnatal growth of the

brain is attained during the first two years making this period a crucial one for brain growth in extrauterine life(1).

Children are maturing early and getting bigger in terms of weight, height, head and chest circumferences than children in the succeeding generations (9,10). In a cross-sectional study on 2,292 female and 2,430 male infants in Edinburgh in 1956, Thomson (10) showed that the above physical measurements were larger than those reported by Paton and Findlay in 1926 or by Low in 1952 as quoted by him. The three sets of study were carried out in the same geographical region utilising infants from the same ethnic background. This tendency for one generation to be bigger, taller and heavier than the preceding one necessitates that periodic revisions of the standards be carried out to keep pace with changing patterns of growth.

A review of literature shows no evidence of work having been done to determine head circumference of African infants aged 0 - 12 months. Some attempt was made along this line by Gebre-Medhin, Sterky and Tambe(12) in Ethiopia in 1978 and Okeahialam (13) in Dar-es-Salaam in 1975. These groups of workers however restricted their research to measuring head circumference of newborn infants only. The lack of a local reference head circumference chart and the realization for the need for such a chart prompted the author into carrying out this survey whose objective was to determine fronto-occipital head circumference of Kenyan infants of African origin

MATERIALS AND METHODS

The study was carried out in Coast Provincial Hospital, Mombasa, and Kenyatta National Hospital, Nairobi, between the months of June and December, 1981. Nairobi and Mombasa are the two largest towns in Kenya with a population of 827,775 and 341,148 respectively (14). The two hospitals were chosen for the study because they are situated in towns with high proportions of various tribes in the country (Annex 1) and it was hoped therefore that a good cross-section of infants from various tribes in Kenya would be covered. Patients attending these hospitals mainly come from low and middle income groups. It was not possible to include infants from high income groups because they hardly attend these hospitals.

The author collected data from postnatal wards, the filter clinics and the well baby clinics of each hospital at a time interval on specific days in a week. The study was divided into two phases. Phase I was carried out in Mombasa during the months of June and August inclusively. Phase II was carried out in Nairobi during the months of. September to December inclusively. It was planned to include at least sixty infants from each age group of one montly intervals from birth into this study. Once the figure required for an age group had been realized more attention was directed to screening infants from the age group whose required numbers had not been filled.

SELECTION OF STUDY SAMPLE

Infants aged 12 - 24 hours on the morning of the author's visit to the postnatal ward, and those attending the filter and well baby clinics on the day of a similar visit to that particular area qualified for inclusion into the study provided they satisfied the following criteria:-

i. The baby must have been born to Kenyans of African origin.

ii. The baby must have been born at term. Term baby was defined as that born between 37 and 41 completed weeks of gestation (15). Dubowitz scoring system (16) was employed in assessing gestational age in addition to estimating from dates.

iii. The baby must have been a singleton.

iv. The baby must have been born with no obvious congenital anomalies. Physical examination was performed on every newborn infant specifically to look for congenital anomalies and any clinical evidence of congenital infection. Infants who were physically unfit were excluded.

v. The baby's birth weight must have been equal to or above 80% of the modified Harvard Standard weight chart used in well baby clinics in Kenya. The weights were taken with the baby naked using a standardised beam balance.

vi. The baby must have been born to a mother with uncomplicated pregnancy. Thus babies born to mothers with cardiac, renal or endocrine disease or those delivered through Caesarian section or vacuum extraction were excluded from the study.

FOR OTHER INFANTS

This was a group of infants aged one week to 12 months. They had to satisfy the above criteria also. Information regarding gestation age and birth weight were obtained from the mother and/or the baby's hospital card given at the time of discharge from the postnatal ward. Infants who were not accompanied by their mothers were excluded. An infant whose weight at the time of examination was below 80% of the modified Harvard standard weight chart or who was found physically unfit was excluded. However an infant with minor ailments such as coryza, and minor skin disorders were included.

Infants who satisfied the above criteria were then identified by name, sex, Hospital number and tribe. Their weights at the time of examination were then recorded.

Head circumference was measured by a method described by various authors (3,4,11,17,18,19). A non stretch fibre glass tape measure was applied firmly so as to encircle the head at the most prominent part of the occiput posteriorly and the region just above the supraorbital ridges anteriorly. The readings were recorded to the nearest 0.1 cm. The

author found the procedure to be less cumbersome if performed with the baby lying supine and comfortably in an examination couch than if seated in the mother's lap.

To ensure that no infant appeared in the study more than once, the author signed and entered the date of examination on the cards of all infants in the study. The mothers were requested to bring these cards with them on subsequent visits to the hospital.

DATA ANALYSIS

All infants studied in Nairobi and Mombasa were grouped together and regarded as a homogenous sample. They were divided into groups of one monthly intervals, and the mean head circumference and standard deviation(SD) from the mean for the group worked out for each sex. The values were drawn in the head circumference charts for boys and girls computed by Nellhaus (1) for comparison. Student's t-test was employed in testing whether the difference between the mean head circumference of boys and girls were of any statistical significance at all age groups of one monthly interval from birth to twelve months. Mean head circumference and standard deviation for both sexes combined was also calculated for each month of age for infants from four tribes which formed the majority in the study. With analysis of variance, it was tested whether tribal background had any influence on head circumference. The mean increase in head

circumference per month for each sex was worked out through getting the difference between the mean head circumference of the infants belonging to one sex at two consecutive months. The rate of head growth at 6 monthly intervals was worked out from these increments. Deceleration in head growth was obtained through getting the differences in monthly increases in head circumference. Thus if the mean increase in head circumference was 1.9 cm. in the first month and 1.6 cm. in the second month, then the deceleration in head growth between the first and second month was -0.3cm. If, however, it was 1.6cm. in the first month and 1.9 cm. in the second month, then deceleration of head growth in this period was +0.3 cm.

RESULTS

Eight hundred and ninety infants were studied; five hundred were from Kenyatta National Hospital, three hundred and ninety from Coast Provincial Hospital. Table 1 shows their distribution by age and sex. Males and females were in equal proportions. Only 19 males compared to 42 females were seen at the age group 9 - 10 months.

TABLE 1

DISTRIBUTION OF INFANTS BY AGE AND SEX

AGE IN MONTHS	MALE	FEMALE	TOTAL
0	59	52	111
-1	36	27	63
-2	34	33	67
-3	31	35	66
-4	34	36	70
-5	28	35	63
-6	39	27	66
-7	27	35	62
-8	28	36	64
-9	33	37	70
-10	19	42	61
-11	34	28	62
-12	42	23	65
TOTAL	444	446	890

TABLE 2

TRIBAL DISTRIBUTION

TRIBE	NUMBER	%OF TOTAL
Kikuyu	310	34.8
Luo	194	21.8
Luhya	124	13.9
Kamba	81	9.1
Miji Kenda	73	8.2
Taita	37	4.2
Meru	21	2.4
Kisii	10	1.1
Teso	6	0.7
Pokomo	6	0.7
Taveta	6	0.7
Somali	5	0.6
Kalenjin	5	0.6
Embu	5	0.6
Boran	3	0.3
Masai	2	0.2
Samburu	2	0.2
TOTAL	890	100

This table shows that 17 tribes were represented in the study and that Kikuyus, Luos, Luhyas and Kambas in that order formed the majority.

The mean head circumference and standard deviation from the mean for each age group are shown in table 3 and figures 1 and 2.

TABLE 3

MEAN HEAD CIRCUMFERENCE BY AGE AND SEX

AGE IN MONTHS	MEAN HEAD CIRCUMFERENCE (cm.) ± 2SD	
	MALE	FEMALE
0	35.0 ± 2.2	34.4 ± 2.0
-1	36.9 ± 2.4	36.1 ± 2.2
-2	38.7 ± 2.2	38.1 ± 2.4
-3	40.3 ± 3.2	39.5 ± 3.0
-4	41.6 ± 2.8	41.0 ± 3.2
-5	42.8 ± 1.8	41.8 ± 2.6
-6	43.8 ± 2.6	42.9 ± 2.2.
-7	44.7 ± 2.0	43.2 ± 2.6
-8	44.9 ± 3.2	44.2 ± 3.2
-9	45.1 ± 2.4	44.5 ± 2.6
-10	45.5 ± 2.4	44.7 ± 2.8
-11	46.0 ± 2.2	45.2 ± 2.4
-12	46.1 ± 2.6	45.6 ± 3.0

It is apparent from table 3 that the mean head circumference of male infants are higher than that of female infants at all age groups.

FIG I

HEAD CIRCUMFERENCE OF MALE KENYAN AFRICANS

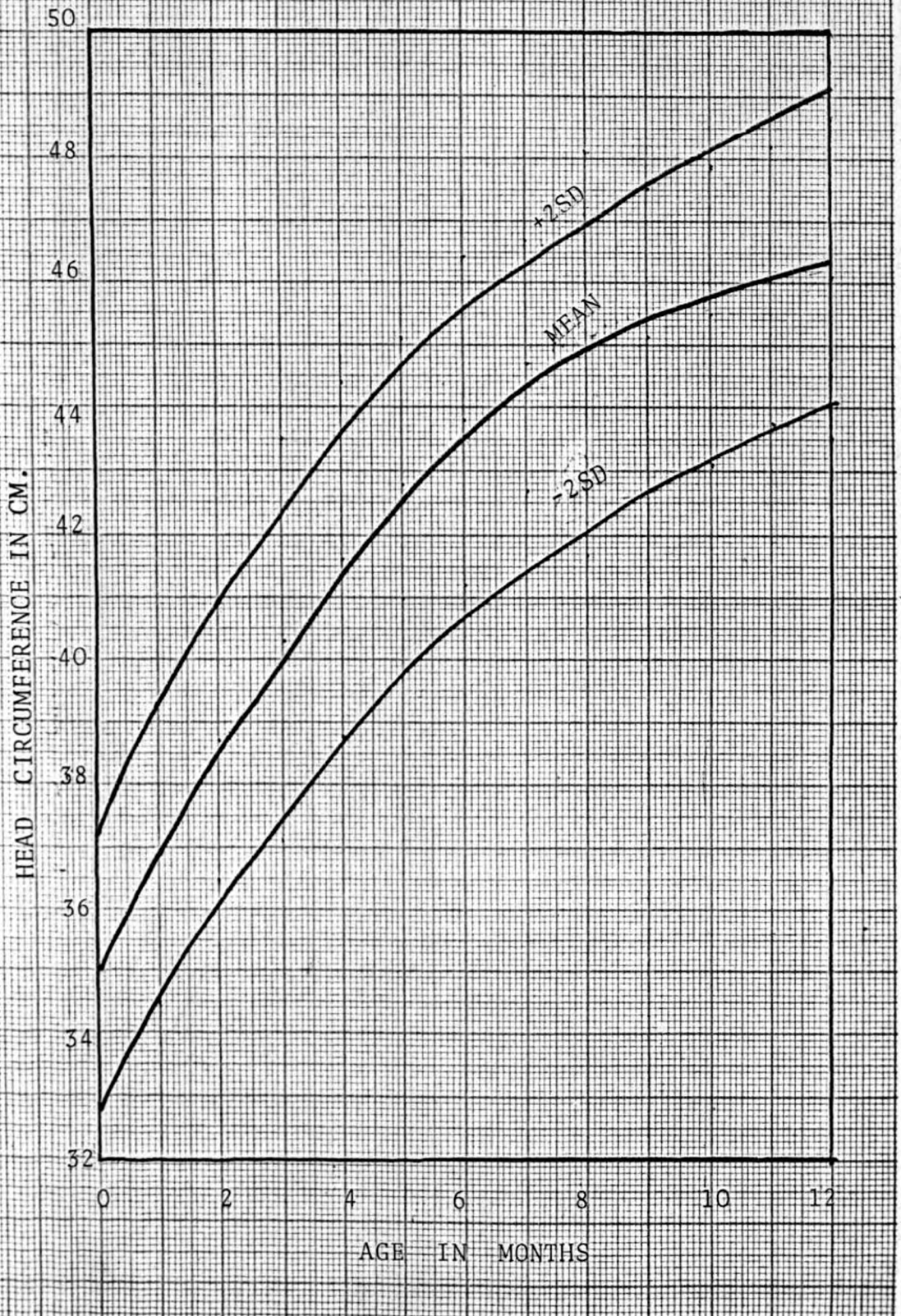
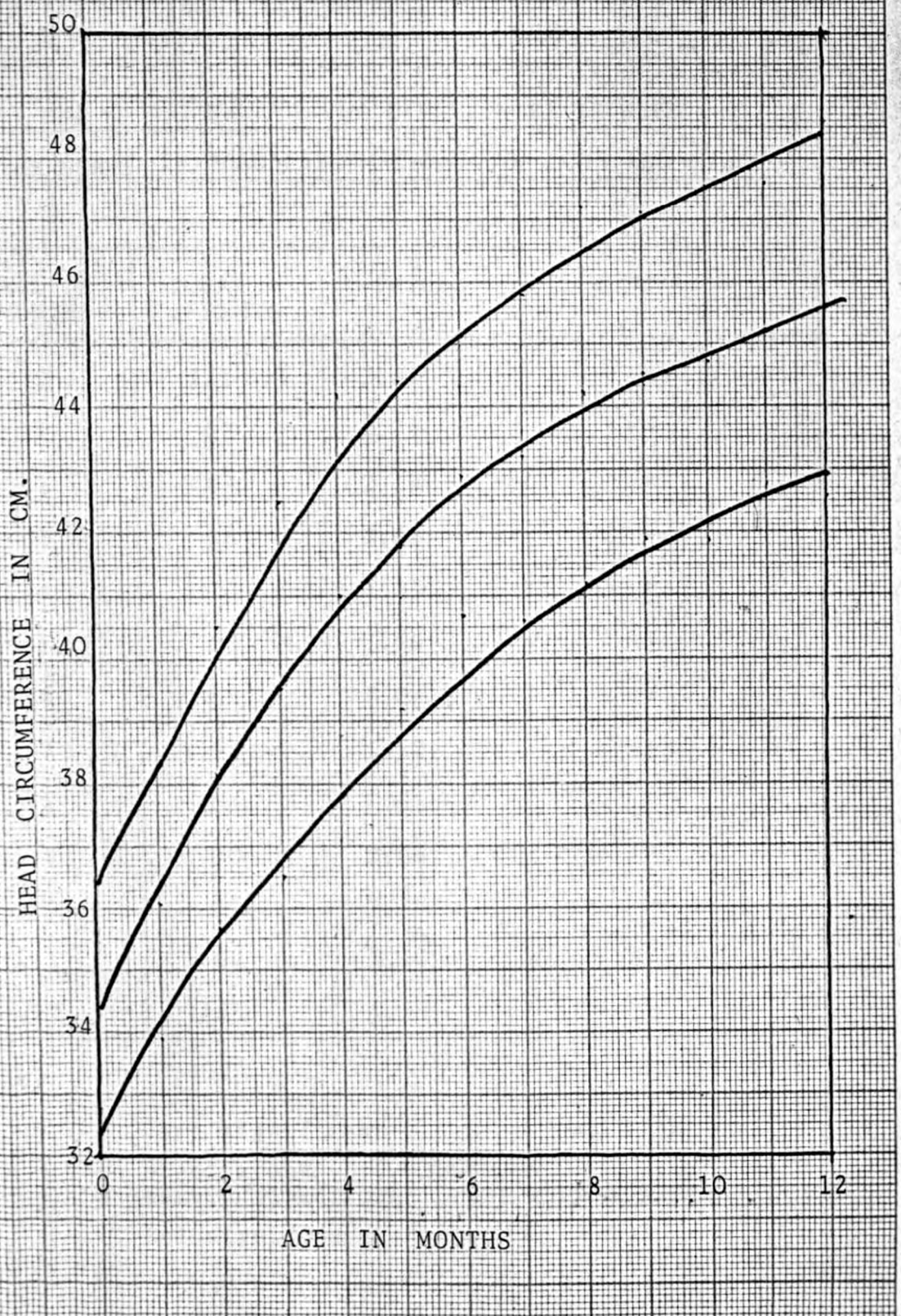


FIG 2

HEAD CIRCUMFERENCE OF FEMALE KENYAN AFRICANS



The differences between the mean head circumferences of boys and girls at various age groups at monthly intervals t-tested are shown in table 4.

TABLE 4

t- AND p- VALUES FOR THE DIFFERENCES BETWEEN THE MEANS IN HEAD CIRCUMFERENCE OF BOYS AND GIRLS

AGE IN MONTHS	TOTAL INFANTS	t-values	p- values
0	111	3.42	++
- 1	63	2.73	++
- 2	67	2.19	++
- 3	66	2.09	+
- 4	70	1.67	$\pm$
- 5	63	3.58	++
- 6	66	3.04	++
- 7	62	5.50	++
- 8	64	0.51	-
- 9	70	2.00	+
-10	71	2.26	+
-11	62	2.72	++
-12	65	1.39	-

Key

++ = Very significant $P < 0.01$

\+ = Significant $0.01 < P < 0.05$

$\pm$ = Nearly significant $0.05 < P < 0.1$

\- = Not significant $0.1 < P < 0.5$

.../cont.

This table shows that boys have significantly larger head circumfernece than girls at all age groups in infancy except at 7 - 8 and 11 - 12 months.

The results of mean head circumference for Kenyan infants in various age groups in infancy were graphically compared to head circumference charts computed by Nellhaus from different ethnic groups. These are shown in figures 3 and 4.

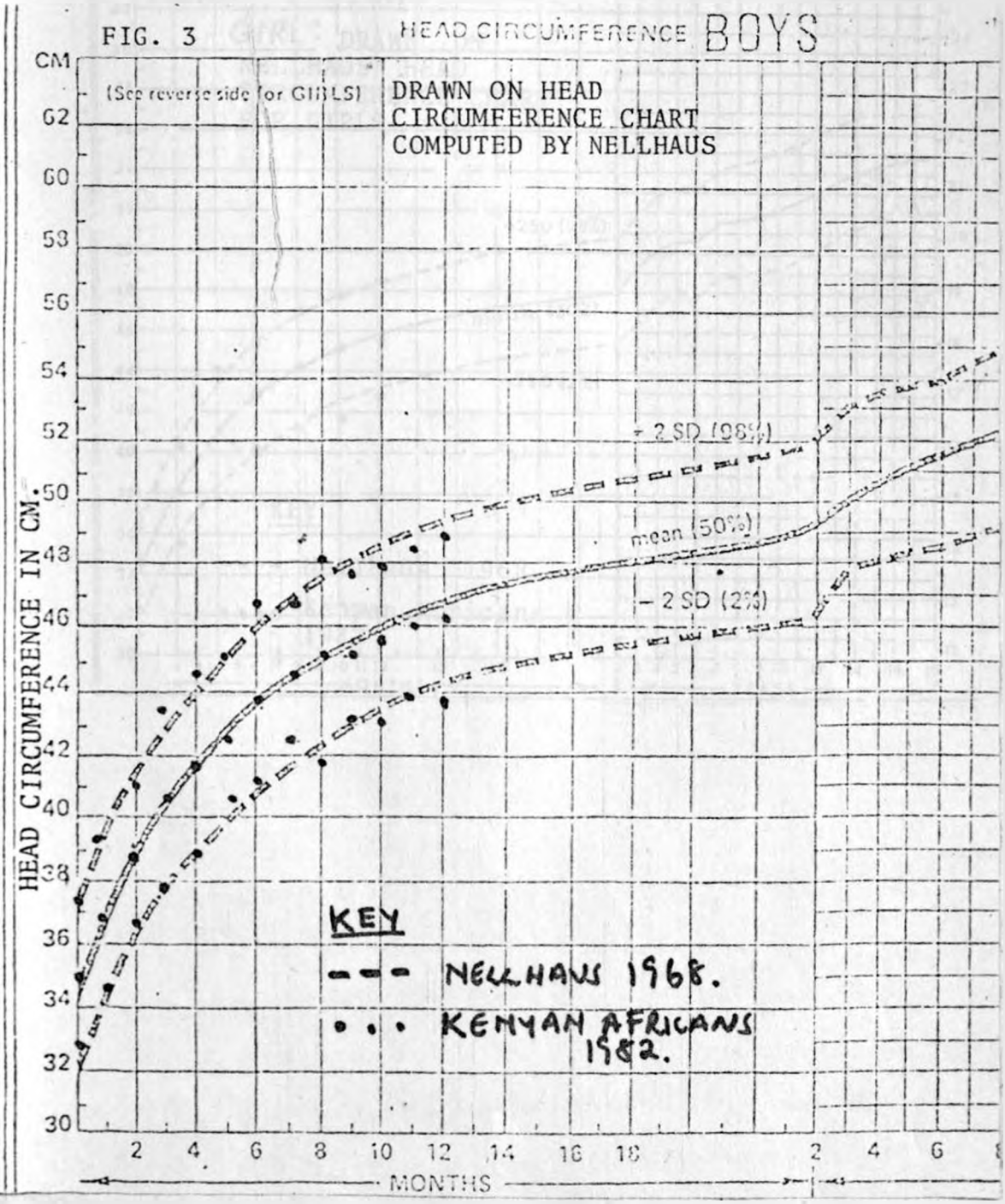
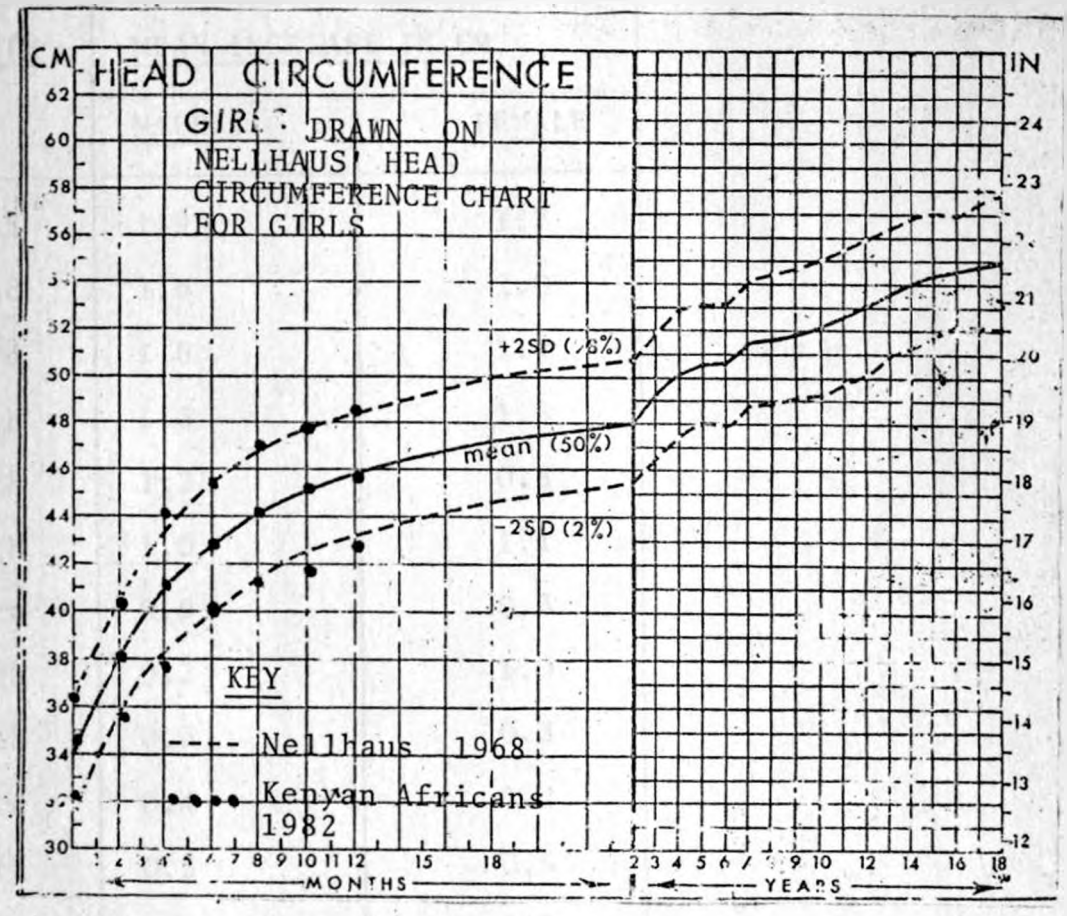


FIG. 4


CM
HEAD CIRCUMFERENCE
GIRLS
DRAWN ON
NELLHAUS' HEAD
CIRCUMFERENCE CHART
FOR GIRLS
IN
+2SD (98%)
mean (50%)
-2SD (2%)
KEY
---- Nellhaus 1968
Kenyan Africans
1982
MONTHS
YEARS

The results of mean monthly increase in head circumference is shown in table 5.

TABLE 5

MEAN MONTHLY INCREASE IN HEAD CIRCUMFERENCE

MONTH	MEAN INCREASE IN CM.	
	MALE	FEMALE
1st	1.9	1.7
2nd	1.6	2.0
3rd	1.6	1.4
4th	1.3	1.5
5th	1.2	0.8
6th	1.0	1.1
7th	0.9	0.3
8th	0.2	1.0
9th	0.2	0.3
10th	0.4	0.2
11th	0.5	0.5
12th	0.1	0.1
TOTAL	10.9	11.2

This table shows that the total increase in head circumference of the male and female infants are 10.9 cm. and 11.2 cm. respectively in 12 months; and the mean increase in head circumference per month is 1.4 cm. for boys and girls for the first six months of life and 0.4 cm. for both sexes in the next six months.

TABLE 6 DECELERATION IN HEAD GROWTH

INTERVAL (MONTHS)	DECELERATION IN CM.	
	BOYS	GIRLS
1st and 2nd	-0.3	+0.3
2nd and 3rd	0.0	-0.6
3rd and 4th	-0.3	+0.1
4th and 5th	-0.1	-0.7
5th and 6th	-0.2	+0.3
6th and 7th	-0.1	-0.8
7th and 8th	-0.7	+0.7
8th and 9th	0.0	-0.7
9th and 10th	+0.2	-0.1
10th and 11th	+0.1	-0.3
11th and 12th	-0.4	-0.4
TOTAL	-1.8	-2.2

This table shows that head growth decelerates by 1.8 cm. and 2.2 cm. in boys and girls respectively in the eleven intervals in the first year. This gives deceleration of -0.16 cm./month in boys and -0.2 cm./month in girls.

The mean head circumference and standard deviation for both sexes combined and worked out for each month of age for the four top tribes in the study are shown in table 7.

TABLE 7

MEAN HEAD CIRCUMFERENCE OF INFANTS OF BOTH SEXES FROM THE FOUR TRIBES FORMING THE MAJORITY IN THE STUDY

AGE IN MONTHS	MEAN HEAD CIRCUMFERENCE IN CM.											
	Kikuyu			Luo-			Luhya			Kamba		
	MEAN	SD	N	MEAN	SD	N	MEAN	SD	N	MEAN	SD	N
0	35.3	1.2	9	34.7	1.0	23	34.7	1.0	21	34.5	1.3	15
- 1	36.8	1.2	28	36.2	1.2	18	36.6	0.9	6	35.9	1.3	6
- 2	38.5	0.9	27	38.4	1.1	11	37.8	1.4	9	38.3	1.2	6
- 3	40.0	1.1	22	39.8	1.2	15	40.2	1.5	11	40.1	1.9	7
- 4	41.2	1.5	18	41.9	1.7	14	42.0	1.2	9	41.2	1.3	7
- 5	42.4	1.2	23	42.2	1.0	17	41.9	1.3	9	42.0	1.8	6
- 6	43.7	1.2	27	43.3	1.6	14	43.0	1.5	8	42.8	2.7	4
- 7	44.3	1.2	25	43.3	1.3	11	42.9	1.3	12	44.5	2.4	2
- 8	44.8	1.2	28	44.7	1.9	11	44.8	1.1	7	44.3	1.6	10
- 9	45.1	1.1	35	44.5	1.3	12	45.5	1.4	4	44.4	0.9	4
-10	45.6	1.3	22	44.4	1.1	16	44.3	1.6	7	44.8	0.9	6
-11	45.7	1.2	25	45.8	1.1	18	45.3	1.7	9	45.5	1.1	4
-12	46.3	1.3	21	45.9	1.4	14	46.1	1.2	12	45.0	1.3	4

With analysis of variance for four samples, it was tested whether the means in this table differed from each other. The results are shown in table 8.

TABLE 8

ANALYSIS OF VARIANCE OF THE MEAN FOR THE FOUR TOP TRIBES

AGE IN MONTHS	DF_2 (n=4)	F-VALUE	CRITICAL F-VALUE P = 0.05	LEVEL OF SIGNIFICANCE
0	64	0.97	2.75	-
- 1	52	1.63	2.78	-
- 2	49	1.10	2.80	-
- 3	51	0.17	2.79	-
- 4	44	1.04	2.82	-
- 5	51	0.50	2.79	-
- 6	46	0.77	2.81	-
- 7	46	4.12	2.81	+
- 8	52	0.37	2.78	-
- 9	51	1.20	2.79	-
-10	47	3.65	2.80	+
-11	52	0.40	2.78	-
-12	47	1.17	2.80	-

Key

DF_2 = Degree of freedom 2

\- = Not significant $P > 0.05$

\+ = Significant $0.01 < P < 0.05$

The results in tables 6 and 7 show that there is no statistical difference between the mean head circumference of Kikuyus, Luos, Luhyas, and Kambas throughout infancy except at 6 - 7 months and 8 - 9 months of age.

DISCUSSION

Equal number of boys and girls seen in this study are in keeping with sex ratio of 1:1 of children aged 1 - 4 years in Kenya (14). However, the author is unable to explain the small number of boys, compared to girls, seen at the age group 9 - 10 months.

The proportions formed by the Kikuyus (34.8%), Luos (21.8%), Luhyas (13.9%), and Kambas (9.1%) in this study compare closely with the proportions formed by these tribes in Mombasa and Nairobi together where Kikuyus form 29.3%, Luos 19.3%, Luhyas 15.9%, and Kambas 14.1% as shown in annex I. Similar close comparisons are obtained for other tribes in the study meaning therefore that utilization of maternal and child health services in the two hospitals,by the tribes in these two towns, is directly proportional to their population percentage in the towns. It may also be inferred from this that the study samples were representative of the population of Kenyans of African origin in the two towns.

The findings in this study that boys have statistically larger head circumference than girls ($P < 0.05$) at all age groups is in keeping with those of other workers (1,10, 13,20,21,22,23,24). The author, however, has no explanation for the finding that the mean head circumference of boys and girls at 7 - 8 and 11 - 12 months are statistically not different ($P > 0.05$) and

belives it occurred by chance since the authors above have not mentioned this variation.

The rate of increase in head circumference of 1.4 cm. per month for the first six months of life and 0.4 cm. per month for the next six months for both sexes found in this study compares favourably with that computed by Nellhaus (1) whose findings were 1.5 cm. per month and 0.5 cm. per month for similar periods of growth in infancy. Harvard School of Public Health (19) found rates of 1.6 cm./month and 0.5cm./month respectively. Falkner, (22) in a longitudinal study on British children in London in 1958 also demonstrated that the mean increments in head circumference was identical in both sexes.

The head growth deceleration of -0.20cm. per month in girls and -0.16cm. in boys in this study is not in keeping with findings of Scott, Hialt, Clark, Kessler, and Ferguson (18) who, in a longitudinal study on 111 Negro infants in Washington D.C., U.S.A., showed graphically that the growth in head circumference decelerates more in males than in females. Nellhaus (1) pointed out that the rate of head growth is more accurately determined by a longitudinal study than by a cross sectional one. Although this does not appear to be true in this particular study, it probably applies when considering the rate of deceleration in head growth. This may explain the difference noted between the findings in this study concerning deceleration of head growth and that of Scott et al (18).

The mean head circumferences for boys and girls, at all ages in infancy in this study, compare favourably with international and interracial graphs, computed by Nellhaus(1) in 1968, from studies on head circumference appearing in world literature between 1948 and 1968, as shown in figures 2 and 3. With analysis of variance ($P < 0.05$) it is shown that the mean head circumference of 35.0 cm. for boys and 34.4 cm. for girls at birth found in this study compares favourably with that of the newborn Indians in New Delhi of 33.8 cm. and 33.7 cm. for boys and girls respectively as reported by Ghosh, Hooja, Ahmad, Acharyulu and Bhargava in 1974 (20). Similar analysis shows that the head circumference of newborn infants of Kenyans of African origin in this study compares favourably with that of white infants in Boston found to be 35.3 cm. and 34.7 cm. for boys and girls respectively (18); and that of newborn Africans in Dar-es-Salaam reported by Okeahialam in 1974 (13) which was found to be 34.5 cm. for boys and 34.2 cm. for girls.

The findings in this study regarding the favourable comparison of head circumference of the African infant with that of other races however differs from that of Amarasinghe (11) and Gebre-Medhin et al(12). Amarasinghe(11) found in 1966 that the mean head circumference of Ceylonese newborn infants was 33.7 cm. for boys and 33.2 cm. for

girls and comparing this with that of Caucasians concluded that Ceylonese babies had smaller head circumference than their Caucasian counterparts. Gebre-Medhin et al (12) also found the mean head circumference of the Ethiopian newborn infants to be 33.9 cm. and 33.6 cm. for boys and girls respectively at 40 weeks of gestation and compairing this with that of the Scandinavian newborn babies concluded that Ethiopian newborn infants had a smaller head circumference than their Scandinavian counterparts. These studies by Amarasinghe and Gebre-Medhin included both term and preterm infants. It is possible therefore that the inclusion of preterm infants could have influenced the mean head circumference of these infants at birth and, hence the differences in conclusions drawn in the present study and their study.

It is the author's opinion, following the present study, that racial background probably plays, if any, a minimal influence on head circumference in infancy.

CONCLUSIONS

The following conclusions can be drawn from this study:-

1. The mean head circumference of Kenyan infants of African origin does not differ significantly from that of other races at corresponding age groups of monthly intervals.
2. Head circumference is not influenced by tribal background in infancy.
3. Head growth proceeds at an equal rate in both sexes in the first year of life.

RECOMMENDATIONS

A study should be done to determine fronto-occipital head circumference of Kenyan children above one year of age and comparisons made with findings in other races. In this way a local reference chart can be constructed. Differing patterns of head circumference in different generations can thus be easily compared.

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ANNEX I

TOTAL POPULATION IN MOMBASA AND NAIROBI

(MODIFIED FROM KENYA POPULATION CENSUS 1979)

TRIBE	TOTAL POPULATION MOMBASA	NAIROBI	MOMBASA AND NAIROBI	PERCENTAGE OF TOTAL AFRICAN POPULATION IN MOMBASA AND NAIROBI
1. Kikuyu	21,576	276,593	298,161	29.3%
2. Luo	45,979	150,334	196,313	19.3%
3. Luhya	28,053	134,237	162,390	15.9%
4. Kamba	40,355	103,185	143,540	14.1%
5. Miji Kenda	87,863	4,022	91,885	9.0%
6. Taita	23,284	6,524	29,808	2.9%
7. Kisii	2,055	13,621	15,676	1.5%
8. Meru	2,592	10,081	12,673	1.2%
9. Kalenjin	1,647	9,586	11,233	1.1%
10. Somali	3,033	7,076	11,233	1.1%
11. Embu	763	5,224	5,987	0.6%
12. Boran	564	3,490	4,054	0.4%
13. Masai	437	3,425	3,862	0.4%
14. Pokomo	2,879	400	3,279	0.3%
15 Teso	457	1,517	1,974	0.2%
16 Samburu	120	1,175	1,295	0.1%
17. Taveta	606	224	830	0.08%

This annex shows only the tribes which were represented in the study. Adults and children are included. The percentage was however worked out from the total Kenyans of African origin in Mombasa