ADDIS ABABA UNIVERSITY

SCHOOL OF GRADUATE STUDIES

THE SIZE OF ANTERIOR FONTANEL IN NEONATES AND INFANTS IN ADDIS ABABA

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JULY 2004

THE SIZE OF ANTERIOR FONTANEL IN NEONATES AND INFANTS IN ADDIS ABABA

THESIS

A Thesis submitted to the School of Graduate Studies of Addis Ababa University in partial fulfillment of the requirements of Master of Science degree in Anatomy

By

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ABBREVIATIONS

A.A. - Addis Ababa

AAU - Addis Ababa University

AF - Anterior fontanel

ANOVA- Analysis of variance

cm - Centimeter

FOM - Faculty of Medicine

gm - gram

IUGR-Intrauterine growth retardation

LNMP- Last normal menstrual period

mm -Millimeter

N- Number of cases

S.D. - Standard deviation

SPSS -Statistical package for social science

ST.E - Standard error

ABSTRACT

The size and the time of closure of anterior fontanel (AF) is often used in the diagnosis of disorders like altered skeletal morphogenesis, increased intracranial pressure, hormonal

disorders and others. In order to properly utilize AF size in the diagnosis of different disorders, it is necessary to establish a normal range of AF sizes related to age. Racial differences in the size of AF and its time of closure has been reported and there are many countries with their own national standard. To my knowledge, there is no study done to determine the AF size and its time of closure in Ethiopian neonates and infants.

The present study aims to establish mean AF size for Addis Ababa (A.A.) neonates and infants at the ages of 3, 46, 76, 106 and 270 days.

The study is a cross sectional design carried out from January 2003 to December 2003 in A.A. and the study sites chosen were Tikur Anebessa Specialized Hospital, Zewditu Memorial Hospital, Tekele Haymanot and Wereda 23 Health Centers. The subjects were 687 neonates and infants, of which 363 were males and 324 were females. All cases fulfilling the inclusion criteria were included in a row until the targeted sample size was attained. The AF size, body weight, body length and head circumference were measured. When measuring AF size, first the four vertices were identified. After marking the vertices with washable ink, the marks were transferred on a sheet of paper. From the marks transferred on the sheet of paper, the anterior-posterior and the lateral dimensions were measured. The mean of the anterior-posterior and the lateral dimensions was taken as AF size.

The mean AF size progressively decreased with age except at 106 days measurement which showed increase over the 76 days measurement. In all ages considered, no significant difference ($p>0.05$) was found in neonates and infants of different gender,

birth order, gestational age and economic status. AF closure was observed beginning at the age of 76 days (0.8%) and the percent of closure increased with age. In Infants at the age of 270 days, 39.6% of them had closed AF. There were no significant ($p>0.05$) correlations between AF size and body weight, body length and head circumference while there was negative significant ($p<0.05$) correlation between AF size and age.

The result of the present study shows congruence with the study on Nigerian and Indian neonates but disagrees with the study done on Arab, Israeli, China and white neonates and infants.

Further study in different parts of Ethiopia is recommended to establish a national age-related standard for AF size and its time of closure.

Key words: Anterior fontanel, Anterior-posterior dimension, lateral dimension, Neonate and infant

1. Introduction

Anthropometric data on neonates and infants gives useful information that can be used to follow the development status of the child (Nelson, 1992). Anthropometric measurement includes weight, length, head circumference and anterior fontanel (AF) size. Size of AF provides an index of cranial development from birth until the second year of life (Illingsworth, 1987). There are different studies conducted to see the distribution of birth weight in the Ethiopian children (Young, 1968, Zein, *et al.*, 1985, Green, 1986, Sheferaw, 1990 and Madebo, 1994). A study conducted by Feleke and Enquoselassie (1999) showed the distribution of head circumference and length in relation to maternal age, parity and gestational age in the new borns of A.A.

1.1. Definition and anatomy of the fontanel

The fontanels are soft spots on the head of neonates and infants. It is a place where the skull bones do not completely cover the brain. The word fontanel is derived from the Latin word, fonticulus and the old French word, fontaine, meaning fountain or spring (Soames, 1995). They are covered by fibrous membrane. The fontanels are created because of juxtaposition of cranial bones.

In a newborn, there are six fontanels, namely anterior, posterior, anterolateral (two) and posterolateral (two). The largest and the most prominent that close last is the rhomboid-shaped anterior fontanel (Figure 1). It is reported that this fontanel closes around the age of 24 months (Sadler, 1995).

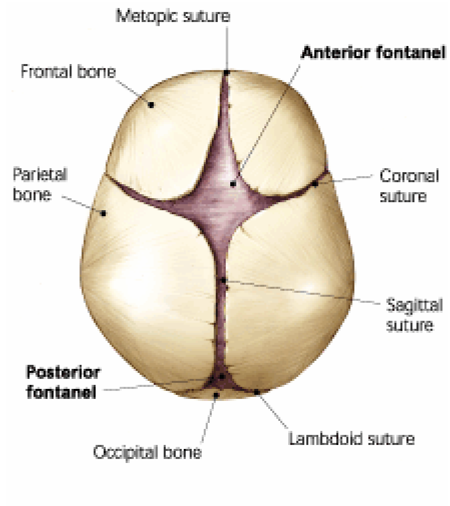


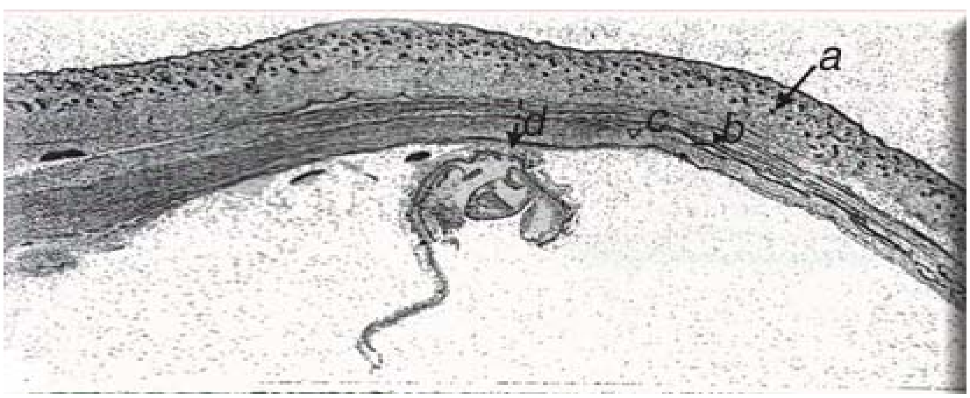
Figure 1: Superior view of the newborn skull (Sadler, 1995)

Studying the embryology of the skull is important in understanding the development of fontanel and its measurement. Skull, like other bones, is derived from the embryonic connective tissue, the mesenchyme, which gives origin to the osteoblasts. In the head region, the mesenchyme is derived from the neural crest cells (Sadler, 1995).

Flat bones of the skull are formed by direct differentiation of the mesenchyme (membranous ossification). In membranous ossification, the needle-like bony spicules radiate from the primary ossification center toward the periphery. This continues even after birth (Sadler, 1995).

The flat bones, namely, the parietal, the frontal, the temporal and the occipital are separated by narrow connective tissue called sutures derived from the neural crest cells. A place where two or more sutures meet is called the fontanel. The sutures and the fontanels allow the bones of the skull to overlap each other to facilitate the process of delivery. This process is called molding and is the secret behind the passage of the bigger skull through the narrower birth canal. After birth, the skull moves back to the original position to become large and round. These sutures and fontanels persist during the postnatal life up to the second year of life and give ample time for the growing brain (Moore, 1998).

The bony plates delineating the lateral edges of the fontanels appear during the 12th week of gestation. The vertical structure of the fontanel (Figure 2) consists of skin, connective tissue and the dura matter from outside to inside (Sundaresan *et al.*, 1990).



Key a - Skin

b -Connective tissue and islands of bones

c - Connective tissue beneath second layer

d- Dura matter (outer and inner layer)

Figure 2: Layers of a developing fontanel (Sundaresan *et al.*, 1990)

1.2 Clinical significances of the anterior fontanel

The palpation of anterior fontanel during the first few months after birth is a routine medical practice in neonatology and pediatrics. The physical examination of the anterior fontanel includes the size (including tension) and the time of closure. The anterior fontanel by its nature is slightly depressed. The key feature of the anterior fontanel is its variation in size and time of closure (Lyall *et al.*, 1991). The size and the time of closure of the anterior fontanel are used to monitor the development of the brain and the general state of health (Nelson, 1992). It is often used in the diagnosis of disorders like, increased intracranial pressure, altered skeletal morphogenesis, endocrine disorders, genetic problems, cardiac diseases and intrauterine growth retardations. In addition, it is used as a window for intracranial ultrasound imaging. Inorder to utilize properly AF size in the diagnosis of different disorders, it is necessary to establish a normal range of AF sizes related to age.

1.2.1 Intracranial pressure monitoring

An increase in intracranial pressure is associated with etiologies like hydrocephalus, cerebral edema and infection. The increase in intracranial pressure leads to neurological damage if not treated as early as possible. An increase in intracranial pressure is mostly manifested in bulging fontanel (Nelson, 1992).

1.2.2 Skeletal disorders

There are reports showing changes in size of anterior fontanel associated with skeletal malformations. Craniocynostosis, achondroplasia, hypophosphatasia, osteogenesis imperfecta, pyknodystosis and rickets are the most commonly mentioned malformations that involve change in size of anterior fontanel (Popich and Smith, 1972).

Craniocynostosis is a condition where one or more cranial sutures prematurely close resulting in abnormal head shape. Craniosynostosis is manifested in small anterior fontanel or its early closure (Tunnessen and Roberts, 1999).

Achondroplasia is a dominant autosomal disorder of the epiphyseal plate cartilage that results in dwarfism (Robbins *et al*., 1989). Achondroplasia in newly born is characterized by large anterior fontanel and enlarged head circumference (Fletcher, 1998).

Hypophosphatasia is a rare (1/100,000) inherited disorder characterized by defective mineralization of skeletal structures and shortage of alkaline phosphate activity (Nelson, 1992). The anterior fontanel bulges in such situations (Forfar *et al*., 1984).

Osteogenesis imperfecta is a condition in which joints are hyper-extensible and bones are more fragile. In this abnormality, the AF size enlarges and there is delayed closure of the anterior fontanel (Nelson, 1992).

Another skeletal disorder associated with enlarged anterior fontanel is pyknodystosis. This abnormality is manifested in short stature and unusual jaws (Popich and Smith, 1972).

Rickets is one of the five most common diseases of childhood in developing nations which is characterized by delayed closure and enlarged anterior fontanel (Tunnessen and Roberts, 1999).

1.2.3 Hormonal disorders

There are endocrine disorders that affect the anterior fontanel size and the time of closure. These are hypothyroidism, hyperthyroidism and hypoparathyroidism.

Congenital hypothyroidism is the production of inadequate thyroid hormone that can occur because of either anatomic defect in the gland or due to defective thyroid metabolism. Congenital hypothyroidism is characterized by enlarged anterior fontanel and delayed closure (Smith and Popich, 1972). On the other hand, hyperthyroidism, which is characterized by over-production of thyroid hormone, causes early closure and small size of anterior fontanel (Lyall *et al.,* 1991).

Hypoparathyroidism is a condition where there is inadequate production of parathyroid hormone. This condition manifests in a bulging anterior fontanel (Rothman and Lee, 1998).

1.2.4 Genetic disorders

There are genetic diseases that result in a change of the anterior fontanel size and time of closure. These are Down syndrome, trisomy 18 and 13 and duplication of short arm chromosome 7. Abnormally large AF size is reported in these genetic disorders (Popich and Smith, 1972, Bamforth *et al.,* 1986 and Odell *et al*., 1987). The Russel-Silver syndrome, a condition with abnormal feature of the long arm of chromosome 7, is characterized by late closure of the anterior fontanel (Tunnessen and Roberts, 1999*)*.

1.2.5. Cardiac diseases

Delayed fontanel closure is a characteristic of cyanotic cardiomyopathies, while bulging fontanel is seen in congestive heart failure (Tunnessen and Roberts, 1999).

1.2.6. Intrauterine growth retardation

Infants with intrauterine growth retardation (IUGR) are quite likely to have retardation of both endochondrial and membraneous ossification, as evidenced by reduced epiphyseal size (at knee) and unusually large AF for age (Philip, 1974).

A study conducted in pre-term, term and post-term infants showed an increase in the size of the anterior fontanel with increase in the gestational age. However, infants with small for dates of gestational age have the largest anterior fontanel (Philip, 1974 and Davies *et al*., 1975).

1.2.7. Congenital infections

Neonates born with Rubella infection have enlarged anterior fontanel and those born with syphilis have enlarged and delayed closure of anterior fontanel (Rothman and Lee, 1998).

1.2.8. Others

Babies born from mothers who were on drug with toxins like aminoptrin and infants who suffer from fetal hydantoin syndrome show enlarged and delayed closure of anterior fontanel (Rothman and Lee, 1998).

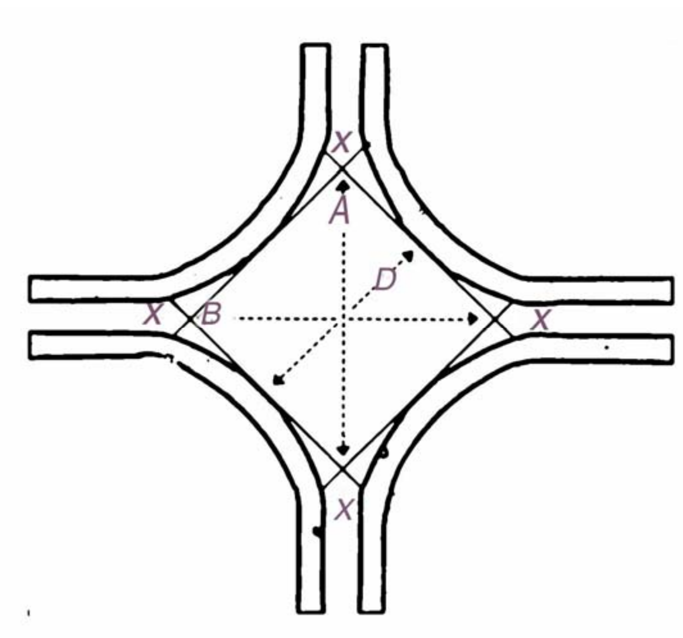
Microcephaly, a condition of abnormal smallness of the head, is characterized by small anterior fontanel and early closure. The potential causes of microcephaly are perinatal trauma, maternal alcohol abuse and postnatal trauma (Rothman and Lee, 1998).

The anterior fontanel is also used as a window to see developing brain of the neonate and infant while using ultrasound imaging. This procedure also facilitates diagnosis of cerebral hemorrhage and evaluation of ventricular dilatations (Merrill and Machado, 1998). This method of investigation is cheaper than that of Computerized Tomography (CT) and Magnetic Resonance Imaging (MRI).

1.3 Methods of measuring anterior fontanel size

There are many approaches to calculate the size of AF (Figure 3). One method used by many researchers is the method of Popich and Smith (1972). According to Popich and Smith (1972), mean of the anterior-posterior dimension (length) and lateral or transverse dimension (width) is considered the size of the AF. The second method is calculating the area of the AF. The area of the quadrilateral formed by the four vertices of the anterior fontanel is equal to the product of the length of the diagonals divided by two (Davies *et al.*, 1975). A third method considers only the lateral dimension as the size of AF (Brandt *et al.*, 1986). A fourth method uses the mean of the two oblique diameters as the size of the anterior fontanel (El-Mougi *et al.*, 1988). The oblique diameters are the lengths from the mid point of one edge of the fontanel to the opposite edge of the fontanel.

The vertices of each corner can be traced and marked by introducing the index finger turn by turn according to Davies *et al.* (1975).



Key

A =Anterior posterior dimension

B=Lateral dimension

D=oblique dimension

X= vertex

Figure 3: Methods of measuring AF size (Philip, 1974)

1.4 AF Standards of different nations

Various studies have shown that the size of anterior fontanel and time of closure vary from race to race and from gender to gender (Faix and Durham, 1982 and Mir and Weislaw, 1988).

1.4.1 AF size by gender and age

According to Popich and Smith (1972), AF size is variable from child to child. In their study, the mean AF size of a newly born was 2.1 cm ± 2 with a range of 0.6 cm to 3.6 cm. They reported no significant difference in AF size between male and female new borns. The mean of the anterior-posterior and the lateral dimension was considered the size of anterior fontanel. In their study, the subjects were full term Caucasian babies that were taken from nurseries, private medical offices and private homes. Neonates with any clinical malformation were excluded. The measurement was taken 24 or 48 hours after delivery.

Omotade and his colleagues (1995) reported the mean AF size in neonates to be 3.4 cm $\pm$ 0.6 for neonates in the Nigerian city, Ibaadan. The study also showed a decrease in the AF size with subsequent ages to 2.8 $\pm$1.0 cm, 2.5 $\pm$ 1.2 cm, 1.5 $\pm$ 1.3 cm and 0.8 $\pm$1.3 cm for the ages 1-3, 4-6, 7-9, and 10-12 months respectively. AF size was measured according to the method of Popich and Smith (1972) and the extent of the vertices was identified using the method of Davies *et al.* (1975). No significant difference was noted in the AF size between male and female neonates and infants. For newly borns measurement was taken at the age of three days.

A race-based study on the size of anterior fontanel was conducted by Faix and Durham (1982) on black and white term-infants in USA. The mean of the AF size for the white (2.67 $\pm$ 0.7 cm) and for the black (3.08 $\pm$ 0 cm) infants was significantly different ($p<0.001$). They took the methods employed by Popich and Smith (1972) and Davies *et al.* (1975) to measure the size of anterior fontanel and to determine the vertices of the fontanel respectively. Measurement was taken 48 hrs after birth. There was no significant difference between the two genders in the same race.

Cohen (1989) studied anterior fontanel size of children of African origin in Jamaica. He measured the AF size by stretching a string from posterior to anterior vertices along the line continuous with the sagital suture. He also measured the lateral dimension in a similar way. The string was then stretched along a rigid cm ruler. The mean calculated for the male infants with the age between 0-2 months was 33 mm

±15 for the anterior-posterior dimension and 32 mm ±12 for the lateral one. In the case of female infants, it was 33 mm ± 13 for the anterior-posterior and 30 mm ± 10 for the lateral dimensions.

In Scotland, Lyall and his collaborators (1991) did a base line study for Scottish full-term (37-42 weeks of gestational age) infants. Their result indicated that the AF size of males is larger than that of females for the first six months of life but without significant difference. The AF size was calculated according to Popich and Smith (1972) and the extents of the vertices were determined using the method of Davies *et al.* (1975).

Until 1988, there had not been base line data in Egypt pertaining to anterior fontanel size. El-Mougi *et al.* (1988) studied 480 infants (231 males and 249 females) from pediatric out patient clinic in Bab El-Shareya University Hospital. The mean of the two oblique diameters was taken as the size of anterior fontanel. Measurement was taken using a tape and done twice to minimize error. The size of the AF during the first month was 2.2 cm for both genders and this decreased to 0.8 and 1.1 cm in males and females respectively by the age of 9 months. No significant difference in AF size ($p>0.05$) was shown between the two genders.

Mir and Weislaw (1988) studied 100 male and 100 female neonates delivered normally in Bengazi, Libya. Their result showed that there was a significant difference ($P<0.001$) in AF size between male (2.92 ± 0.51 cm) and female (2.51 ± 0.74 cm) neonates. AF size was measured on the second day of life. The four vertices were determined using the method of Davies *et al.* (1975) and the size of the AF was calculated according to Popich and Smith (1972).

In India Mathur *et al.* (1994) did a cross sectional study to determine the AF size of newborns and infants less than 2 years of age. They studied 445 cases and found that the mean AF size of neonates was 3.34 ± 0.61 cm. This decreased to 0.37 ± 0.06 cm. at 24 months of age. They used the method of Popich and Smith (1972) to determine the size of the anterior fontanel. There was no contrast made between the two genders.

In another study in India, Chakrabarti (1989) found a significant difference ($p<0.05$) in anterior fontanel size between infants that were born in hilly and non-hilly areas. He reported that the mean AF size for new borns in non-hilly areas as 3.80 ± 1.95 cm and for the ones born in hilly areas as 3.35 ± 1.07 cm. Size of the AF was taken according to Popich and Smith (1972). This result indicated influence of topography in the size of AF and stated the importance of establishing one's national standard.

Assessment of the AF size in the Chinese neonates and infants by Chang and Hung (1990) revealed that the mean AF sizes for age groups 3 days, 1, 2, 4, 6, 9, 12, 15, 18, and 24 months as 26.7 mm, 25.8 mm, 24.9 mm, 25.7 mm, 20.2 mm, 14.9 mm, 11.5 mm, 10.2 mm, 13.0 mm and 12.1 mm respectively. The mean of the anterior-posterior and the transverse (lateral) dimensions was considered as the size of the AF. The difference in size and in the time of closure was not significant between the two genders.

Srugo and Berger (1987) measured 303 Israeli neonates to establish normal value of AF size for Israeli Jews and non-Jews ethnic groups. They chose the methods of Popich and Smith (1972) and Davies *et al.* (1975) to determine the size of AF and its vertices respectively. Their result indicated the mean for the whole population to be 2.06 ± 0.6 cm. They reported no significance difference ($p>0.05$) between the different ethnic groups. The same was true between the two genders.

Germany is one of the countries with standard of AF size for its own nation. Brandt *et al.* (1986) conducted a longitudinal study to determine the normal value and the time of closure of AF. They did a study whereby the anterior-posterior and the transverse (lateral) dimensions of the AF were measured monthly beginning at birth. They took only the transverse dimension (lateral) as the size of AF. They reported that at birth, the AF in 50% of full term infants measured 2.0 cm in width and this decreased to 0.6 cm at the age of 12 months. They reported that although male neonates, at birth, possessed larger head size than that of females they had smaller AF than female neonates. Nevertheless, the difference was not significant.

Duc and Largo (1986), in Switzerland surveyed AF size from birth to 24 months. They reported no significant difference between male and female neonates and infants. In their measurement, they took the oblique diameter as the size of the anterior fontanel.

1.4.2 Status of AF closure

Similar to the variations in the size of AF, different studies indicated variations in its closure time. Omotade *et al.* (1995) reported early closure of AF in 3.5% of Nigerian infants between the age of one and three months. In the same study, infants in the age groups of 4-6, 7-9 and 10-12 months had a closure percent of 11.1, 34.6 and 53 respectively. In Jamaican children of African origin, infants younger than two months of age had a measurable AF (Cohen, 1989). Cohen reported early closure of AF at the age of 6 months and 95% of infants at the ages of 24-30 months interval had closed AF. Arab infants in Egypt had 1.7% of AF closure between the ages of 3 and 6 months while 15% of infants in the age group of 21-24 months had open AF (El-Mougi *et al*., 1988). For Indian infants, early closure of AF was reported in 4.5% at 6 months age (Mathur *et al.*, 1994). The percent of AF closure for 8, 9, 10, 11, 12, 15, 18, 21, and 24 months of age was reported as 4.8, 6.7, 8.7, 22.7, 40, 56.2, 71.4, 83.3 and 91.3 respectively.

In the study done on Chinese neonates and infants, AF was closed in 5% at 6-months of age while 8% of infants at the age of 24 months had patent AF (Chang and Hung, 1990). In the same study, the median age of closure of AF was 14.5 and 14.3 months in male and female infants respectively with out significant difference ($p>0.05$).

About 1% of infants in Switzerland at the age of 3 months had closed AF (Duc and Largo, 1986). In the same study, 38% and 96% had closed AF at the age of 12 and

24 months respectively. The median age of AF closure was 13.8 months and male infants showed higher percentage of closed AF than female infants with out significant difference ($p>0.05$).

1.4.3 AF size correlation with growth parameters and comparison between pre-term and term infants

Duc and Largo (1986), studied the relationship of AF size to the growth parameters and gestational age in 111 term and 128 pre-term infants. The study indicated no significant difference in AF size between the term and pre-term infants. In similar topic, Davies *et al.* (1975) reported an increase of AF size with an increase in gestational age. They underlined although the mean value of AF size for pre-term (33-36 gestational ages) infants was higher than that of the more immature pre-term (28-32 gestational ages) group, the difference was not significant ($p>0.05$). A similar result was reported for term and pre-term (33-36 gestational ages) infants. However, Davies *et al.* (1975) reported a significant difference ($p<0.01$) between immature pre-term (28-32 gestational ages) and term infants.

Duc and Largo (1986) reported positive correlation between the AF size and body weight and length at birth. After term, body weight and body length were negatively related consistently to AF size in term and pre-term infants but the correlation was not statistically significant ($p>0.05$). In another study, El-Mougi *et al.* (1988) investigated the correlation between AF size and body weight, body length and head circumference. They reported that AF size is negatively correlated with body weight, body length and head circumference but the correlations were not statistically significant ($p>0.05$). The age at which AF closure appeared was not significantly related to any of the growth parameters. Lyall *et al.* (1991) also stated that there was no significant relation (p>0.05) between AF size and body weight in Scottish infants while there was non- linear relation between age and AF size. In a similar way, another study in Nigerian neonates and infants indicated negative significant correlation (p=-0.54) between AF size and age (Omotade *et al.*, 1995).

In Ethiopian neonates and infants, to my knowledge, there is no study conducted to determine the size of anterior fontanel although the assessment of AF size is a part of a routine examination in children below the age of 24 months.

2. Objectives

2.1 General Objective

- To establish a mean AF size for neonates and infants born in A.A

2.2 Specific Objectives

- To measure the anterior-posterior and lateral dimensions of the AF in order to calculate the mean size of AF
- To compare the AF size between male and female neonates and infants
- To compare the mean AF size in neonates and infants among different birth orders (1, 2, 3, 4, 5, 6 and so on)
- To assess the AF size at different gestational ages for term infants (36-42)
- To study if difference exists in AF size in neonates and infants born from parents of different economic status
- To see if there is correlation between AF size and body weight, length and head circumference

3. Subjects and Methods

3.1 Sample area

The study was conducted in Addis Ababa (A.A), Ethiopia. Cases were taken from Tikur Anbessa Specialized Hospital, Zewditu Memorial Hospital, Tekele Haymanot and Wereda 23 Health centers.

3.2 Subjects

A total of 687 neonates and infants were assessed from January 2003 to December 2003 in the study setting. The cases were singleton neonates and infants at the ages of 3, 46, 76, 106 and 270 days who were apparently healthy (cases with out congenital malformation, Caesarean delivery, pre-term and post-term deliveries, birth injury and cephalohaematoma). During selection of cases, days of $\pm$ 10 from the scheduled age was tolerated. The study subjects are given in Table 1.

Table 1: The study subjects by gender and age

Age (Days)	Male		Female		Total
	Number	Percent	Number	Percent	
3	40	51.12	38	48.71	78
46	109	56.77	83	43.22	192
76	58	45.66	69	54.33	127
106	77	58.77	54	41.22	131
270	81	50.94	78	49.05	159
Total	363	52.84	324	47.16	687

3.3 Study design

This project was a Cross sectional study undertaken to determine the mean size of AF. In the study, all the neonates and infants fulfilling the inclusion criteria were included one after the other until the targeted sample size was achieved.

3.4 Exclusion criteria

Neonates and infants with congenital malformation, Caesarean delivery and pre-term (<36) and post-term deliveries (>42) were excluded. Newborns with abnormal presentation of labor, birth injury and cephalohaematoma were also excluded from the study.

3.5 Data collection

The data incorporated anterior-posterior length of AF, lateral dimension of AF, crown-heel length and body weight as well as the occipito-frontal (head) circumference. All measurements were in centimeters and grams. The age of the neonates and infants was in terms of days after birth. The gestational age was determined by the first date of last normal menstrual period (LNMP) reported by the mother. The conditions during delivery, socio- economic status of the parent and birth order of the infant were obtained from the mother and the attending physician (appendix 1).

Before measuring the AF size, the four vertices were identified by introducing index finger turn by turn in to each corner of the AF. This was done using the method of Davies *et al.* (1975), whereby the vertices were marked with washable ink, and the marks were transferred on a sheet of paper, properly labeled for each neonate and infant by firmly pressing over the fontanel.

From the mark, the anterior-posterior and the lateral dimensions of the AF were measured using a ruler. The mean of the two dimensions was considered as the size of AF (Popich and Smith, 1972). This method was chosen for the present study because it has been used by most previous studies. This allowed comparison of AF size of A.A neonates and infants with sizes of other nations. Any fontanel that was too small to be measured accurately was considered to be closed for the purpose of this study.

Only the investigator took all the measurements and this was taken twice to minimize error. The mean of the first and second measurements was recorded as the AF size. Measurement for newly born babies was taken three days after delivery in order to allow the effect of molding to disappear (Davies *et al.*, 1975).

Body weight was obtained by using an infant scale of a spring type sensitive to 50 gm.

The supine length was measured on supine measuring board. The crown of the head was tightly held against the headboard and positioned so that the upper margin of the external auditory meatus and the lower margin of the orbit were perpendicular. The mother stretched the body and the legs of her child. The sliding footboard was then brought into firm contact with the sole of the feet. The measurement was read to the nearest 0.5 cm.

A plastic tape calibrated in mm was used to measure the head circumference. The tape was placed around the child's head at the same level on each side crossing the forehead superior to the supra-orbital ridges and passing over the occipital prominence posteriorly. Measurement was taken to the nearest 0.1 cm

3.6 Data analysis

The mean, range, S.D and median of the AF size, body weight, body length and head circumference were analysed for the two genders of each age group. Two-tailed student t-test was used to compare the difference in AF size between male and female neonates and infants. One-way ANOVA test was utilised to compare neonates and infants of different birth orders, gestational ages and parental economic status in the mean difference of their AF size. The same test was performed to compare the difference in means of AF size for different ages. Pearson Correlation was used to see if there is any correlation between AF size with body weight, body length and head circumference. In the same manner, the correlation between age and the AF size was also analysed. Percentiles of the AF size were also drawn. Data entry and data analysis was performed by the investigator using SPSS (statistical package for social sciences).

3.7 Ethical consideration

The necessary ethical clearance was obtained from FOM, A.A.U. and the respective Regional Health Office. All data involving measurement was collected without any risk to the subjects. All information obtained was secured and kept confidential. Each case for the study was included after the consent of the mother was obtained to include her baby in the study (appendix 2). In the course of the study, those having weight below and above the standard were advised to see a physician. Those with bulged and sunken fontanel were also advised to be seen by a physician.

4 Results

4.1 AF size and closure status

4.1.1 AF size by age and gender

Table 2 gives the mean, S.D., median and range of AF size with respect to age and gender. At the age of 3 days the mean AF size was found to be 3.35 ± 0.94 cm. and the range was 1.5 - 5.8. The mean AF sizes for males and female neonates were found to be 3.53 ± 1.0 cm and 3.19 ± 0.85 cm respectively.

The mean AF size at the age of 46 days was 3.20 ± 0.76 cm. For males, the mean AF size was 3.17 cm while it was 3.24 cm for female infants at this age.

The values of the mean AF size for both male and female infants at the ages of 76, 106, and 270 days were 2.80 ± 0.78, 2.87 ± 0.83 and 1.39 ± 1.27 cm. respectively.

The results in the present study showed that the mean size of AF was variable in various age groups. This study showed a gradual decrease in the mean size of AF with an increase in age. The significant decline of AF size was noticed between 106 and 270 days old infants.

In all ages considered in the study, mean size of the male neonates and infants is larger than female neonates and infants (Figure 4) except at the age of 46 days where the mean AF size for the female infants was larger than for the male infants. The difference between the mean AF size of male and female neonates and infants was not significant (p>0.05) for any of the age groups (Table 2).

Age (Days)	**Gender**	**No of cases**	**Mean AF size**	**S. D**	**Median**	**Range**	**P**
3	**Male**	40	3.53	1.0`	3.29	1.5-5.88	.11
	Female	38	3.19	.85	3.10		
	Total	78	3.35	.94	3.25		
46	**Male**	109	3.17	.81	3.13	1.7-7.1	.54
	Female	83	3.24	.69	3.00		
	Total	192	3.20	.76	3.15		
76	**Male**	58	2.97	.73	2.86	0-5.38	.11
	Female	69	2.66	.79	2.55		
	Total	127	2.80	.78	2.76		
106	**Male**	77	2.93	.89	2.80	0-4.63	.28
	Female	54	2.77	.73	2.81		
	Total	131	2.87	.83	2.80		
270	**Male**	81	1.40	1.30	1.45	0-4.70	.90
	Female	78	1.38	1.26	1.67		
	Total	159	1.39	1.27	1.53		

Table 2: Mean, S.D., median and range of AF size by gender and age

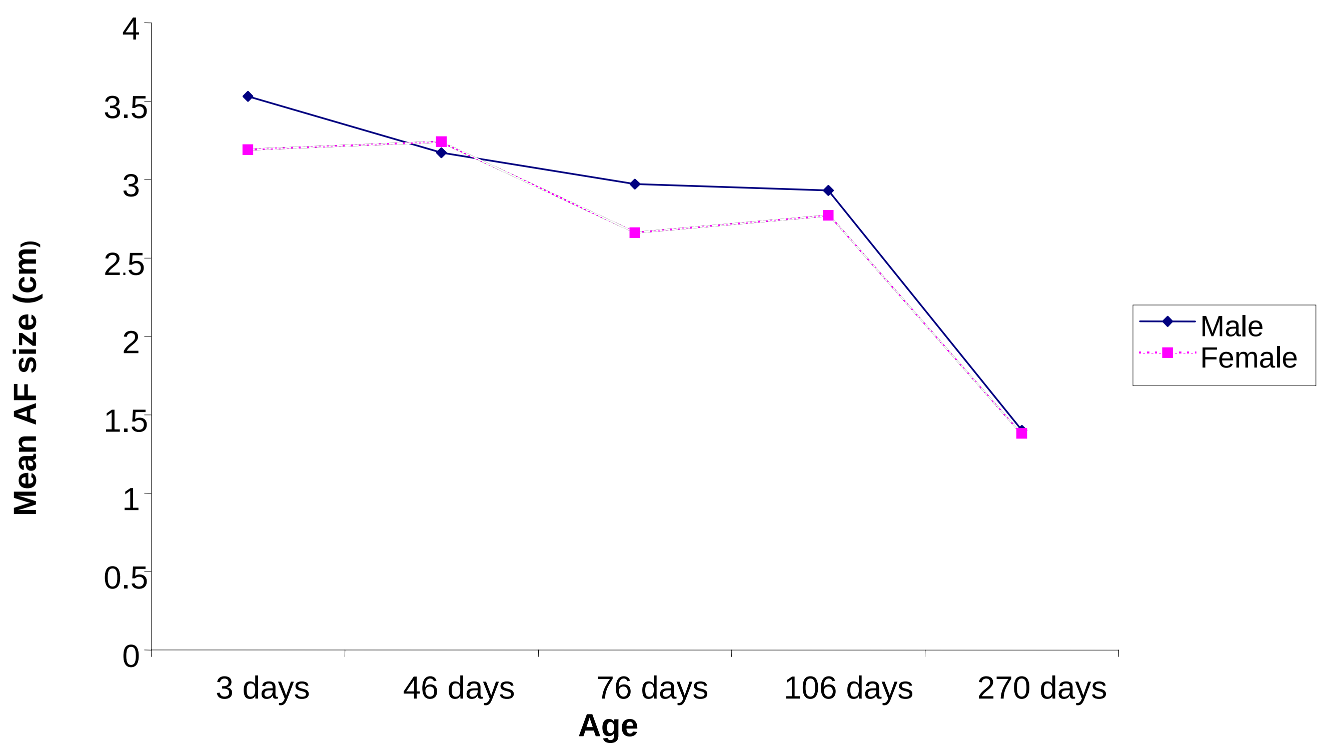


Figure 4 : Mean AF size by age and gender

Figure 5 gives the frequency distribution of AF size. Accordingly, at the ages of 3 and 46 days 59.5% and 47.9% respectively of neonates and infants had AF size ranging from 3.00 - 3.99 cm. At the ages of 76 days and 106 days, 47.7% and 45% respectively of infants had AF size ranging from 2.00-2.99 cm. In 39.6% of infants, the AF had closed at the age of 270 days. The frequency distribution skews to the left as age increases indicating a gradual decline of the size of AF.

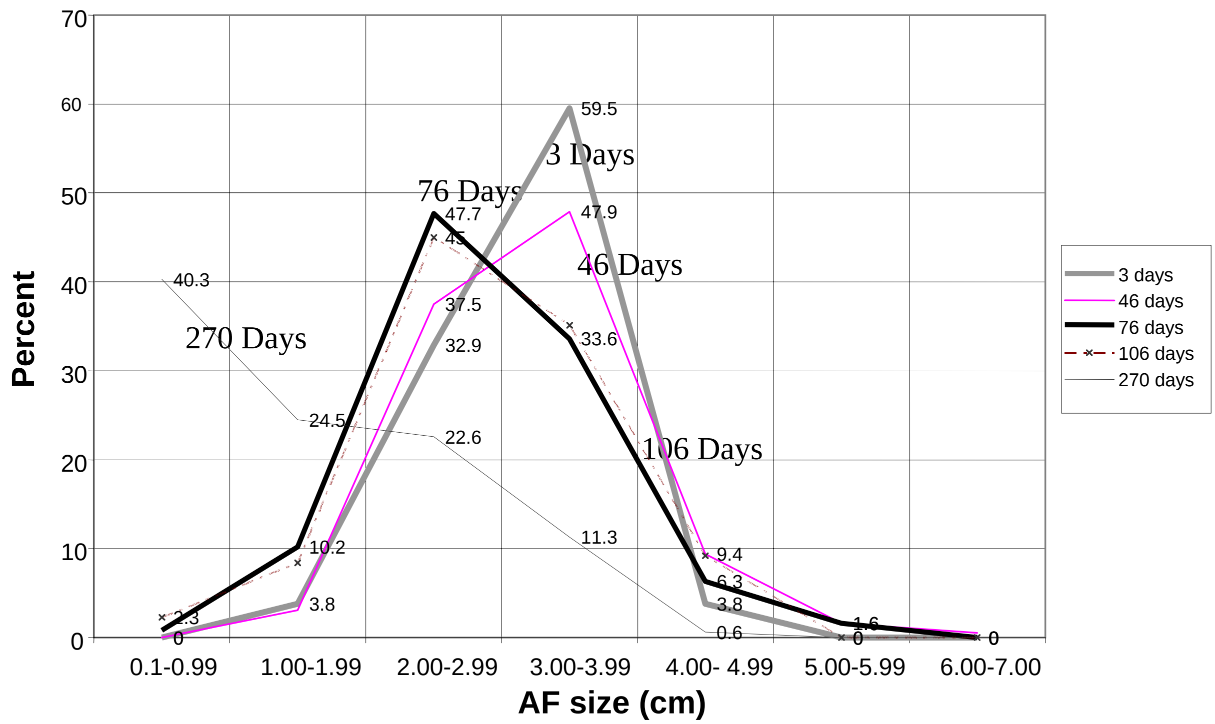


Figure 5: Frequency distribution of AF size by age

Table 3 indicates the percentiles distribution of AF size. Less than three percent of neonates had an AF size below 1.82 cm and three percent had an AF size above 5.53 cm. This indicated 94% of the sample had a size between 1.82 and 5.33 cm. Based on the percentile distribution, at this age, the first (25th percentile), second (50th percentile) and the third (75th percentile) quartiles were 2.55, 3.25 and 4.00 cm respectively.

In infants at the age of 46 days, 2.73, 3.16 and 3.65 cm were the first (25th percentile), second (50th percentile) and the third (75th percentile) quartiles respectively. Less than three percent had an AF size smaller than 1.94 cm and same proportion had greater than 4.72 cm indicating 94% of the sample had an AF size between 1.94 and 4.72 cm.

For infants at the ages of 76 and 106 days, less than three percent of the sample had an AF size less than 1.55 and 1.64 cm respectively. Less than three percent of the sample at the age of 76 and 106 had an AF size greater than 4.47 and 4.48 cm respectively. For infants at the age of 76 days, the first (25th percentile), second (50th percentile) and the third (75th percentile) quartiles were 2.33, 2.76 and 3.13 cm respectively. For infants at the age of 106 days, the first (25th percentile), second (50th percentile) and the third (75th percentile) quartiles were 2.35, 2.80 and 3.35 cm respectively.

For Infants at the age of 270 days, the first (25th percentile), second (50th percentile) and the third (75th percentile) quartiles were 0, 1.53 and 2.33 cm respectively. At this age 94% of the sample had an AF size between 0 and 3.35 cm.

The third, 10th and 25th percentiles increased between the age group of 3-day neonates and 46-day infants (Figure 6). These were neonates with delayed resolution of molding of their skull. The remaining percentiles were of neonates who nearly completed resolution of their cranial molding.

Table 3: percentiles of AF size (cm) by age

Age (days)	Percentiles						
	3rd	10th	25th	50th	75th	90th	97th
3	1.82	2.22	2.55	3.25	4.00	4.70	5.53
46	1.94	2.36	2.73	3.16	3.65	4.11	4.72
76	1.55	1.85	2.33	2.76	3.13	3.86	4.47
106	1.64	1.94	2.35	2.80	3.35	3.85	4.48
270	.00	.00	.00	1.53	2.33	3.13	3.55

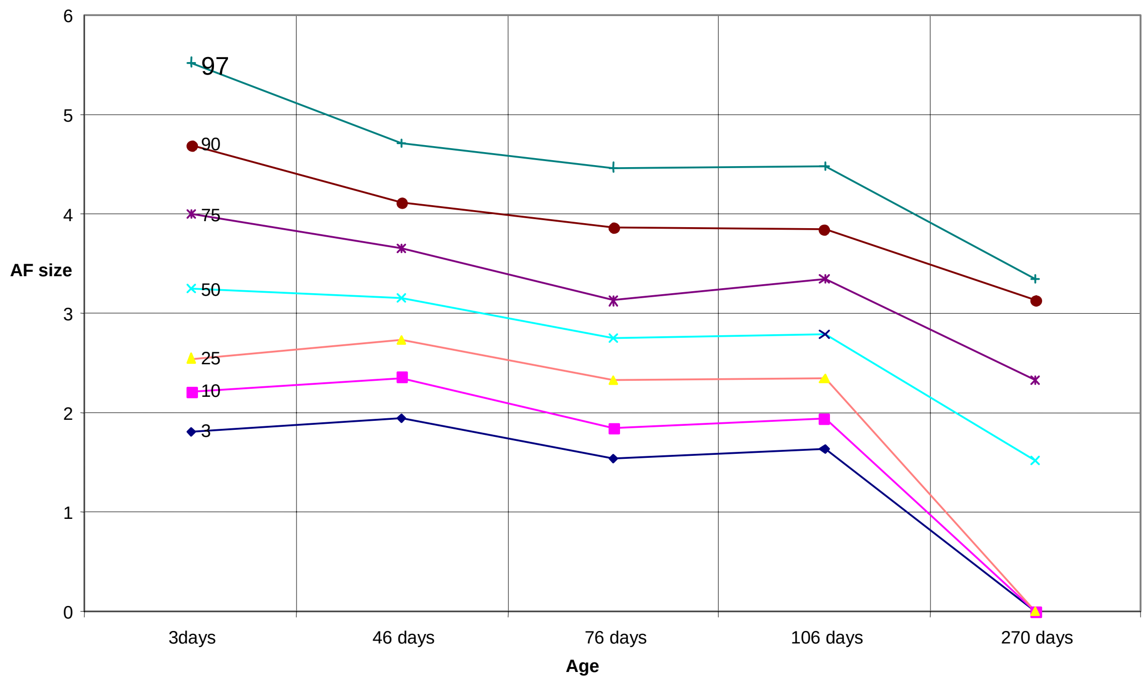


Figure 6: Percentiles of AF size (cm) by age

The mean difference in AF size between the ages 3, 46, 76, 106 and 270 days indicated no significant difference ($p>0.05$) between neonates of age 3 days and infants of 46 days of age (Table 4). The same was true between the infants of 46 and 106 and 76 and 106 days. The rest showed significant difference ($p<0.05$). This indicated gradual decline of AF size.

Table 4: Multiple comparison of AF size at different ages at 95% confidence interval

Age(days)		Mean difference	ST. E	Sig. (p=0.05)	Lower Boundary	Upper Boundary
3	**46**	.14	.12	.934	-.26	.55
	76	.54(*)	.13	.005	.001	.97
	106	.49(*)	.13	.019	.001	.92
	270	2.06(**)	.13	.000	1.63	2.48
46	**3**	-.14	.12	.934	-.55	.26
	76	.39(*)	.10	.015	.001	.74
	106	.34	.10	.058	-.001	.69
	270	1.91(**)	.10	.000	1.58	2.25
76	**3**	-.53(*)	.13	.005	-.97	-.001
	46	-.39(*)	.10	.015	-.74	-.001
	106	-.001	.11	.999	-.43	.33
	270	1.52(**)	.11	.000	1.15	1.89
106	**3**	-.48(*)	.13	.019	-.92	-.001
	46	-.34	.10	.058	-.69	.001
	76	.001	.11	.999	-.33	.43
	270	1.57(**)	.11	.000	1.20	1.94
270	**3**	-2.06(**)	.12	.000	-2.48	-1.63
	46	-1.91(**)	.10	.000	-2.25	-1.58
	76	-1.52(**)	.11	.000	-1.89	-1.15
	106	-1.57(**)	.11	.000	-1.94	-1.20

*The mean difference is significant at the .05 level.

** The mean difference is significant at the .01 level

4.1.2 AF closure status

The present study in A.A. infants signifies the prevalence of early closure of AF before 9 months. Table 5 gives the percent of AF closure at different ages for each gender.

Table 5: Closure status of anterior fontanel with respect to age gender

Age (Days)	**No of cases**	**Percent closed**		
		Male	**Female**	**Total**
3	78	0	0	0
46	192	0	0	0
76	127	0	1.4	0.8
106	131	2.6	0	2.3
270	159	38	40	39.6

No cases with closed AF were seen at the ages of 3 and 46 days of postnatal ages. Early closure of AF was found at the age of 76 days in 0.8 percent of infants. The percent of AF closed increased to 2.3 in 106-days aged infants. At the age of 270 days, the AF had closed in 39.6%. Of these, 38% were male and 40% were female infants.

4.1.3 AF size by birth order and gestational age

The mean AF sizes of neonates and infants that had different gestational age and birth order were compared for mean difference. With respect to birth order, there was no significant difference ($p>0.05$) between the mean AF sizes in neonates and infants of different birth orders and no clear trend was noticed (Table 6). In similar way, the mean AF size difference between infants of different gestational age also showed the same result. Nevertheless, at the age of 3 days, although the difference was not statistically significant ($p>0.05$), there was an affinity of an increase in the mean AF size with an increase in gestational ages. At the age of 3 days, neonates having gestational age between 36 and 37 had a mean AF size of 3.53 cm and those between 37 and 38 weeks of gestation had a mean AF size of 3.16 cm. These values changed to 3.75 and 3.90 cm for the gestational age groups 39-40 and 40-41 respectively.

Table 6: The mean AF size and S.D. by age, birth order and gestational age

AGE (Days)	Birth Order	N	Mean (cm)	S. D.	Gestational Age (weeks)	N	Mean (cm)	S. D.
3	**1**	45	3.47	.93	**36-37**	11	3.53	.83
	2	24	3.12	.91	**37-38**	49	3.16	.92
	3	8	3.12	1.02	**38-39**	-	-	-
	4	1	4.43	.	**39-40**	13	3.75	1.13
	5	1	4.55	.	**40-41**	4	3.90	.47
	6	-	-	-	**41-42**	-	-	-
	7	-	-	-	**Total**	77	3.35	.95
	Total	79	3.35	.94				
46	**1**	92	3.16	.68	**36-37**	68	3.28	.82
	2	62	3.21	.96	**37-38**	53	3.01	.66
	3	21	3.34	.64	**38-39**	16	3.20	.54
	4	7	3.31	.46	**39-40**	33	3.27	.57
	5	5	3.40	.37	**40-41**	8	3.23	.59
	6	2	3.11	.01	**41-42**	3	2.88	1.31
	7	3	2.81	.49	**Total**	181	3.17	.71
	Total	192	3.20	.76				
76	**1**	70	2.77	.71	**36-37**	43	2.76	.89
	2	39	2.88	.88	**37-38**	34	2.81	.57
	3	13	2.87	.83	**38-39**	13	2.82	.86
	4	6	2.35	.85	**39-40**	14	3.03	.58
	5	-	-	-	**40-41**	4	3.09	1.47
	6	-	-	-	**41-42**	6	2.81	1.17
	7	-	-	-	**Total**	114	2.83	.78
	Total	128	2.80	.78				
106	**1**	65	2.88	.84	**36-37**	56	2.89	.94
	2	36	2.69	.90	**37-38**	27	2.91	.70
	3	16	3.16	.69	**38-39**	14	2.88	.85
	4	3	2.84	.63	**39-40**	21	2.79	.86
	5	2	3.13	.31	**40-41**	2	2.59	.80
	6	3	2.66	.01	**41-42**	2	2.46	.22
	7	4	2.66	.86	**Total**	123	2.87	.85
	Total	129	2.85	.82				
270	**1**	76	1.33	1.28	**36-37**	80	1.36	1.24
	2	44	1.40	1.35	**37-38**	41	1.82	1.28
	3	23	1.30	1.19	**38-39**	5	1.39	.85
	4	11	1.70	1.49	**39-40**	19	.99	1.21
	5	3	1.78	.01	**40-41**	-	-	-
	6	2	1.98	.00	**41-42**	9	1.03	1.59
	7	-	-	-	**Total**	154	1.42	1.26
	Total	159	1.39	1.28				

$p>0.05$ for all cases

N=Number of cases

4.1.4 AF size by economic status

The mean AF size of neonates and infants born from parents with permanent income was compared with neonates and infants born from parents with sporadic or no income (Table 7). Neonates and infants at the of the ages 3 and 270 days who born from parents with permanent income had greater mean AF size than those neonates and infants born from parents with inconsistent or no income. In the other age groups, infants born from parents with permanent income had smaller mean AF size than those of infants born from parents with sporadic or no income. In all cases, the difference was not statistically significant ($p>0.05$).

Table 7: The mean and S.D. of the AF size by age with respect to economic status

AGE (DAYS)	Economic Status	No of cases	Mean	S. D.
3	Permanent income	70	3.36	.99
	Sporadic/ No income	7	3.18	.47
	Total	77	3.34	.95
46	Permanent income	152	3.20	.77
	Sporadic/ No income	40	3.22	.70
	Total	192	3.21	.74
76	Permanent income	115	2.78	.75
	Sporadic/ No income	13	2.98	1.07
	Total	128	2.88	.78
106	Permanent income	115	2.86	.84
	Sporadic/ No income	16	2.96	.82
	Total	131	2.87	.81
270	Permanent income	141	1.42	1.28
	Sporadic/ No income	16	.83	1.00
	Total	157	1.39	1.26

$p>0.05$ for all cases

4.2 Body weight, body length and head circumference

During the study period, body weight, body length and head circumference of each case was assessed for those with normal delivery in order to correlate with AF size. In the study, age was taken as plus/minus 10 days from the specified ages (3, 46, 76, 106 and 270 days).

4.2.1 Body weight

The mean (S.D.) body weight was 3504.13 (394.76), 4870.43 (752.59), 5835.17 (793.5), 6564.57 (908.71) and 8966.89 (1312.25) gm at the ages of 3, 46, 76, 106 and 270 days respectively (Table 8). In all ages, males were significantly heavier than females except at the age of 76 days.

Table 8: Mean, S.D., median and range of body weight (gm) by gender and age

*The mean difference is significant at 0.05 level.

EVNA= equal variance not assumed

AGE (Days)	Gender	No of cases	Mean (gm)	S. D	Median (gm)	Range	P
3	**Male**	30	3621.67	360.48	3650	2780-4250	.034*
	Female	32	3412.81	395.42	3400		
	Total	62	3504.13	394.76	3500		
46	**Male**	103	4997.18	787.27	5500	3000-6500	.008* EVNA
	Female	81	4709.26	677.04	4750		
	Total	184	4870.43	752.59	4957		
76	**Male**	56	5940.18	855.49	6000	3700-8050	. 15
	Female	63	5731.27	728.86	5725		
	Total	119	5835.17	793.5	5900		
106	**Male**	76	6807.24	970.32	6800	4100-9500	.000* EVNA
	Female	51	6202.94	667.64	6200		
	Total	127	6564.57	908.71	6500		
270	**Male**	78	9260.26	1305.16	9150	5700-12900	.004*
	Female	73	8653.45	1254.14	8500		
	Total	151	8966.89	1312.25	8900		

4.2.2 Body length

Table 9 shows the mean body length of neonates and infants of different ages. For neonates at the age of 3 days, the mean ± S.D. of body length was 50.93 ± 2.11. Infants at the ages of 46, 76, 106 and 270 days had a mean ± S.D of body length of 57.25 ± 2.92, 60.91 ± 2.23, 62.76 ± 2.64 and 69.36 ± 3.11 cm respectively. The difference in body length between the male and female infants was statistically significant ($p<0.05$) for each age group except at 3 and 106 days of age.

Table 9: Mean, S.D., median and range of body length (cm) by gender and age

AGE (Days)	Gender	No of case	Mean (cm)	S. D	Median (cm)	Range	P
3	Male	35	51.13	2.13	50.50	45.50-58.00	.490
	Female	37	50.78	2.12	50.50		
	Total	72	50.93	2.11	50.50		
46	Male	89	57.74	3.03	58,00	48.00-64.00	.014*
	Female	64	56.57	2.64	56.25		
	Total	153	57.25	2.92	57.5		
76	Male	40	61.53	1.91	62.00	54.00-67.00	.02*
	Female	52	60.44	2.37	60.50		
	Total	92	60.91	2.23	61.00		
106	Male	72	62.92	2.98	64.00	52.00-68.00	.385
	Female	44	62.48	1.99	62.50		
	Total	116	62.76	2.64	63.00		
270	Male	58	70.21	3.28	70.00	59.00-81.00	.003*
	Female	63	68.58	2.76	69.00		
	Total	121	69.36	3.11	70.00		

*The mean difference is significant at 0.05 level.

4.2.3 Head Circumference

The mean head circumference at the age of 3 days was 35.66 ± 1.26 cm while for those infants at the age of 46 days, the mean value increased to 38.72 ± 1.35 cm (Table 10). For infants at the ages of 76, 106 and 270 days, the mean ± S.D. was 40.20 ± 1.16, 41.37 ± 1.50 and 45.06 ± 2.01 cm respectively. Male infants were significantly ($p<0.05$) larger than the female infants except at the age of 3 days.

Table 10: Mean, S.D., median and range of head circumference (cm) by gender and

AGE (Days)	Gender	No of cases	Mean (cm)	S. D	Median (cm)	Range	P
3	**Male**	39	35.83	1.27	36.00	32.20-38.00	.313
	Female	40	35.54	1.23	35.60		
	Total	79	35.66	1.26	36.00		
46	**Male**	108	39.01	1.25	39.00	35.0-42.6	000*
	Female	80	38.33	1.33	38.00		
	Total	188	38.72	1.35	38.50		
76	**Male**	56	40.56	1.12	40.25	37.5-43.8	.01*
	Female	69	39.89	1.11	40.00		
	Total	124	40.20	1.16	40.10		
106	**Male**	74	41.88	1.51	41.85	38.6-46.5	.000*
	Female	53	40.65	1.06	40.50		
	Total	127	41.37	1.50	40.10		
270	**Male**	81	45.50	2.19	45.50	39.8-54.0	.004*
	Female	75	44.59	1.70	45.00		
	Total	156	45.06	2.01	45.00		

age

*The mean difference is significant at 0.05 level.

4.3 Correlation of AF size with body weight, body length, head circumference and age

The correlation analysis (Table 11) indicated positive correlation (goes in line) of AF size with body weight at the ages of 3, 46 and 76 days. This showed that at these ages, those neonates and infants with heavier body weight possessed larger AF size than those neonates and infants having lighter body weight. For the ages of 106 and 270 days, the correlation was negative (shows opposite direction). Except at the age of 270 days, all correlations were statistically insignificant ($p>0.05$).

With respect to body length, AF size was negatively correlated to body length in all ages except at the age of 76 days indicating cases with longer body length had smaller AF size than those neonates and infants with shorter body length except at the age of 76 days, which was correlated positively, with body length. However, all these correlations were statistically insignificant ($p>0.05$).

Head circumference correlated positively with AF size except at the age of 270 days. However, significant correlation was found only at the age of 76 days ($p<0.05$). This positive correlation indicated neonates and infants with larger head circumference had larger AF size than those neonates and infants with smaller head circumference.

Significant Negative Correlation ($p<0.05$) was noticed between AF size and age (Table 12). This showed as age increased, AF size decreased.

Table 11: Correlation of AF size with body weight, body length and head circumference

Age (Days)	Correlation of AF size	Body weight	Body length	Head circum.
3	**Pearson Correlation**	.034	-.077	.140
	Sig. (2-tailed)	.795	.518	.221
	No of cases	62	72	78
46	**Pearson Correlation**	.015	-.056	.033
	Sig. (2-tailed)	.839	.492	.658
	No of cases	184	153	188
76	**Pearson Correlation**	.002	.181	.208(*)
	Sig. (2-tailed)	.981	.085	.020
	No of cases	120	92	126
106	**Pearson Correlation**	-.071	-.161	.123
	Sig. (2-tailed)	.427	.085	.171
	N	126	116	126
270	**Pearson Correlation**	-.187(*)	-.177	-.014
	Sig. (2-tailed)	.022	.053	.862
	No of cases	151	121	156

* Significant correlation at p=0.05

Table 12: Correlation of AF size with age

5. Discussion

5.1. Technical and analytical limitations

The age of the study subjects is one of the determinant factors for anterior fontanel size. Literatures are not uniform in the scheme of categorizing the ages of their study subjects. Conversely, the measurement of the size of the AF for neonates is uniform throughout literature. Most authors preferred well baby clinics to select their sample where most parents take their infants for routine check-up. These are the best settings for researches involving apparently healthy neonates and infants. The investigator took the opportunity of immunization units in hospitals and health centers for the purpose of the present study. The nationally set basic immunization schedules made the investigator to stick to specific ages namely, 46, 76, 106 and 270 days of postnatal ages. Mothers who delivered at the chosen sites were informed to bring their babies at the age of 3 days after they were informed about the purpose of the study. All

		Age	AF Size
Age	**Pearson Correlation**	1.000	-.536(**)
	Sig. (2-tailed)	.	.000
	No of cases	687	687
AF Size	**Pearson Correlation**	-.536(**)	1.000
	Sig. (2-tailed)	.000	.
	No of cases	687	687

** Correlation is significant at the 0.01 level (2-tailed).

infants involved in this study were chosen at immunization centers. This had a limiting effect on discussion, as the ages chosen by other investigators were different.

5.2 AF size and time of closure

5.2.1 AF size by gender and age

The present study in A.A. neonates and infants showed a decrease in AF size from 3.35 cm in 3-days aged neonates to 3.20, 2.80, 2.87 and 1.39 cm in the respective postnatal ages of 46, 76, 106 and 270 days except at the age of 106 days which showed an increase over the 76 days measurement. This exceptional increase was not statistically significant ($p>0.05$) and might be due to statistical error. The finding about the variation of the mean AF size with age in A.A. neonates and infants agrees with the findings in Caucasian, Switzerland, and Egyptian neonates and infants (Popich and Smith, 1972, Duc and Largo, 1986 and El-Mougi *et al.*, 1988). Similar result was reported in Jamaicans of African origin, Indian and Nigerian neonates and infants (Cohen, 1989, Mathur *et al.*, 1994 and Omotade *et al.*, 1995). On the other hand, the variations in the mean sizes of AF reported by the previous authors were not uniform specifically during the first few postnatal months. Some reported a slight increase in the mean size of AF during the first few postnatal months (Popich and Smith, 1972, Duc and Largo, 1986 and El-Mougi *et al.*, 1988) while others reported a decrease in the mean size of AF during this postnatal period (Cohen, 1989 and Mathur *et al.*, 1994). In this study, the mean AF size decreased with an increase in age including the first few months of postnatal ages indicating conformity with the later reports. The inconsistency of the A.A. cases with the former reports suggests that A.A. neonates complete the resolution of molding of their skull during the first few days of postnatal age. The slight increase during the first few postnatal months in some reports has been explained to be due to delayed resolution of molding of the skull or the measurement is taken one or two days after birth before complete resolution of molding (Popich and Smith, 1972 and Duc and Largo, 1986).

In A.A. neonates and infants, there is no significant difference ($p>0.05$) between males and females in their mean AF size although males have larger mean AF size than females except at the age of 46 days. This finding is consistent with several previous studies (Popich and Smith, 1972, Faix and Durham, 1982, Brandt *et al.*, 1986, Srugo and Berger, 1987, El-Mougi *et al.*, 1988, Chang and Hung, 1990, Lyall e*t al.*, 1991, and Omotade *et al.,* 1995). However, the report of significant difference ($p<0.001$) between male and female Libyan neonates in the mean AF size (Mir and Weislaw, 1988) does not agree with the finding in A.A.

The mean AF size in A.A. neonates (3.35 ± 0.94 cm) is greater by 0.05 cm from Nigerian neonates (3.4 ± 0.6 cm) as reported by Omotade *et al.* (1995). In comparison to the study done by Mathur *et al.* (1994) for Indian neonates, the mean AF size of A.A. neonates is smaller by only 0.02 cm. Yet at the age of 120 days, Indian infants have a mean AF size of 3.09 cm while their younger A.A. infants at the age of 106 days have 2.87 cm. Similarly, at the age of 270 days, the mean size of AF for Indian infants is greater by 1.39 cm from A.A. infants. This suggests faster closure rate of AF in A.A. infants than Indian infants. The mean AF sizes of A.A. and Indian neonates living in hilly areas are equal but it is lower by 0.45 cm from Indian neonates living in non-hilly areas (Chakrabarti, 1989). This may suggestive that altitude may have an effect on the size of AF but further investigation is needed to reach to a conclusion.

The mean AF size of A.A. neonates is smaller by 0.65 cm from Chinese neonates obtained by Chang and Hung (1990). The larger difference in mean AF size during the early ages narrows by 0.1 cm at the age of 270 days. This is possibly due to faster rate of AF obliteration in A.A. infants than that of Chinese infants.

The mean AF size of A.A. neonates is larger by 0.65 and 1.18 cm from neonates in Libya (Mir and Weislaw, 1988) and Israel (Srugo and Berger, 1987) respectively. Likewise, the mean size of AF in A.A. neonates is found to be larger than that of Scottish neonates (Lyall e*t al.*, 1991). The mean AF size of A.A neonates is larger from white American neonates by 0.65 cm as reported by Faix and Durham (1982) where as, the difference between black American and A.A. neonates is only 0.25 cm. The mean AF size of A.A. neonates is larger by 1.25 cm from Caucasian neonates reported by Popich and Smith (1972).

The study of neonates and infants in Switzerland and Egypt by Duc and Largo (1986) and El-Mougi *et al.* (1988) respectively considered the diagonals of AF as measurement of AF size. These are slightly smaller from the anterior-posterior and the lateral diagonals. Thus, the mean AF sizes reported in both studies are smaller as compared to A.A. neonates. This difference may be due to the methodology used by the different studies.

The above comparisons show that the mean AF size of A.A. neonates is slightly different from Nigerian and Indian neonates. Nevertheless, there is larger mean difference in AF size between A.A. neonates and Arab, Israeli, Chinese and western neonates. For infants at the age of 270 days, the mean difference between A.A. and Chinese infants is smaller than the difference between A.A. and Indian infants. This again shows having large or small AF during early ages does not predict the status of AF size at older ages. Therefore, as previous authors stated (Faix and Durham, 1982 and Chakrabarti, 1989), there is a variation of AF size between neonates and infants of different races. Thus, there is a need to establish a national standard. The reason for the difference in size of AF in different races is unclear but might be due to genetical, environmental or nutritional differences.

5.2.2 AF closure status

The present study in A.A. infants signifies the prevalence of early closure of AF before 9 months. In our infants, 0.8 and 2.3 percent at the ages of 76 and 106 days have closed AF. This explained that as long as the infant has normal anthropometric values, early closure of AF after the second month of postnatal age could be considered normal. Different studies confirm the incidence of AF closure before 9 months of age (Duc and Largo, 1986, El-Mougi et *al*., 1988, Cohen, 1989, Chang and Hung, 1990, Mathur *et al.,* 1994 and Omotade, *et al.,* 1994).

The percent of AF closure in our infants at the age of 106 days (2.3) is smaller by about one percent from Nigerian infants as reported by Omotade *et al.* (1995). This suggests lower prevalence of early AF closure in A.A. infants than Nigerian infants.

Early closure appeared at the age of 76 days in A.A. infants while for Indian infants it was at the age of 6 months (Mathur *et al.*, 1994). At the age of 270 days, the percent of AF closure in the current study is larger by 32% from Indian infants of the same age. The above findings are suggestive of early age AF closure in our infants than infants of India. In the same manner, there is higher prevalence of early AF closure in A.A infants than that of Chinese infants as reported by Chang and Hung (1990).

The negative correlation of AF size with age in this study correlates with Omotade *et al.* (1995).

5.2.3 AF size by birth order, gestational age and economic status

Literatures relating AF size with birth order and economic status of the mother are rare. AF size comparison in neonates and infants of different birth order and from mothers of different economic status were studied because anthropometric measurements are reported to be affected by birth order and economic status of the family (Feleke and Enquoselassie, 1999). The results of this study indicates that neonates and infants of different birth order are not different statistically ($p>0.05$) in their mean AF size. Similar result was obtained when comparing neonates and infants of different parental economic status. The result of the present study is suggestive of the fact that, rather than economic status and birth order, gestational age has a propensity to affect AF size in neonates. In A.A. neonates, there is a tendency to increase in AF size with increasing gestational age and this is in accordance with the finding of Davies *et al.* (1975) and Duc and Largo (1986).

5.2.4 AF size correlation with growth parameters

The study of the correlation of AF size with body weight, body length, and head circumference is not homogeneous throughout the ages considered. Low negative correlations in infants at the ages of 106 and 270 days is indicative of the idea that most infants with apparently better growth status have smaller AF than those with poor anthropometric size. In general, the correlation of AF size with body weight, body length and head circumference was not statistically significant ($p>0.05$) except in few cases only. This finding is consistent with the finding in Scottish infants by Lyall *et al.* (1991) where there was no correlation of AF size with body weight. The present result cannot be compared with Duc and Largo (1986) and El-Mougi *et al.* (1988) for methodological reasons.

6. Conclusion

Examination of anterior fontanel size and time of closure gives evidence of altered intracranial pressure and less consistently as an index of rate of development and ossification of the calvarium, which may be altered in a wide variety of disorders affecting morphogenesis. For proper utilization of anterior fontanel size as an indication of disorder delineation, it is necessary to have age-related national standard, as there is variation of AF size and time of closure in different races. The finding in the present study can be summarized as

- The mean AF size of A.A. neonates is 3.35 cm that declines to 3.20, 2.80, 2.87 and 1.39 cm in the respective infantile ages of 46, 76, 106 and 270 days.
- In all ages considered, there is no significant difference (p>0.05) between neonates and infants of different gender, gestational age, birth order and economic status in the same age group.
- There is early closure of AF in 0.8 % of 76-day aged infants and this raise to 2.3% and at the age of 106 days. In infants at the age of 270 days, 39.6% of them have closed AF.
- There is no significant relationship (p>0.05) between AF size and body weight, and body length and head circumference.
- This study correlates more with Nigerian and Indian neonates and infants than Scottish,

American, Arab, Israeli and Chinese neonates and infants. This study is in agreement with the previous studies that suggested differences in the mean AF size and time of closure in

different races.

7. Recommendations

- An abnormal anterior fontanel size in neonates and infants can indicate a serious medical condition when present. Therefore, it is important to establish a standard of AF size and its time closure.
- The present study could be a base line to establish AF size standard for A.A. neonates and infants. There may also be variation of anterior fontanel size between different ethnicity of Ethiopian neonates and infants and among those living at different altitude. Therefore, it is the recommendation of the investigator that nation wide cohort study for infants less than 2 years of age be carried out:
    - ❖ To establish a national standard of age-related anterior fontanel size
    - ❖ To determine the median age of AF closure

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9. APPENDICES

Appendix 1

Data collecting format

1. Identification

1.1. Mother's name________________________________

1.2. Ethnic group Amhara ______Oromo ____Tigre _______Gurage _____ Others, Specify______

1.3. Infant's gender M [ ] F [ ]

1.4. Form completed on_____________________________

2. General information

2.1 Date of birth_________________________

2.2 Place of birth hospital [ ] home [ ] health center [ ]

2.3 Age in weeks (days)____________________________

2.4 Type of delivery code [ ]

2.4.1 Normal vaginal

2.4.2 Breech

2.4.3 Forceps

2.4.4 Vacuum

2.4.5 Caesarean section

2.5 Birth weight ___________________gm.

2.6 Current weight ___________________gm.

2.7 Plurality yes [ ] no [ ] if yes, specify______out of

2.8 Gestational age at birth _____________weeks

2.9 Height ________________cm.

2.10 Head circumference ________cm.

2.11 AF length ________________cm.

2.12 AF width ________________cm.

3. Interview with the mother

3.1. Age of the mother______

3.2. Parity________

3.3. Birth order__________

3.4. Marital status

3.4.1 Married

3.4.2 Widowed

3.4.3 Separated

3.4.4 Single

3.4.5 Free union

4. Educational status

4.1 mother		4.2 father
[ ]	illiterate	[ ]
[ ]	literate	[ ]
[ ]	primary	[ ]
[ ]	intermediate	[ ]
[ ]	secondary	[ ]
[ ]	university	[ ]

5. Socio-economic status

5.1 Mother		5.2 Father
[ ]	Employed	[ ]
[ ]	Sporadic employment	[ ]
[ ]	Unemployed	[ ]

6. Does your child have any medical problem? Yes_____ No________

If yes, specify _________________________

First mark of AF

Second mark of AF

Appendix 2

Consent form

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KcÖ<˜ k"" SM"U ƒww` UeÒ"Â ¾Lk '¨<::

Declaration

I, the undersigned, declared that this thesis is my original work, has not been presented for a degree in any other University and that all sources of material used for the thesis have been duly acknowledged.

Investigator Tarekegn G/meskel

Sign ___________________

Place Addis Ababa, Ethiopia

Date of submission ____________________

The thesis has been submitted with my approval as a university advisor.

Name Dr. Yamrot Kinfu

Sign _________________