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Relationship of crown heel length, head circumference and chest circumference of newborn with gestational age

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Abstract
In the study done by WHO, they have recommended that in areas where the accurate, early weighing of neonate is not feasible, community health workers should be trained to measure the Chest Circumference. Newborns with chest circumference <29 cm should be designated as "highly at risk". And those with circumference>/-29 cm but <30 cm as "at risk". It should be noted, however, that this measures has been validated only in terms of its relationship to birth weight and not to perinatal outcomes. All the singleton live born babies born in the hospital were examined within 48 hours of birth. Gestational age was calculated by enquiring into 1st day of mothers last menstrual period and will be subsequently confirmed by New Ballard Score. In the present study it was observed that there is a linear relationship of CHL with the increasing gestational age, which started declining after 39-40 weeks gestation. In the derived normogram based on chest circumference and gestational age it was observed that there is a linear relationship of the chest circumference with increasing gestational age. There is a linear rise of chest circumference with the increasing gestational age, which started declining after 40 weeks gestations.

Keywords: crown heel length, head circumference, chest circumference

Introduction
Anthropometry is the single most portable, universally applicable, inexpensive and non-invasive method available to assess the proportion size and composition of the human body. It provides a simple and objective method of assessment of fetal growth at the time of birth. Anthropometry has been widely used and successfully applicable to the assessment of health and nutritional risk, especially in children.

The body measurements commonly employed in anthropometry are weight, length, head circumference, chest circumference, abdominal circumference, skin fold thickness etc.

The average full term baby's head circumference is between 33-38cms, then increases by 2 cm per month for the 1st three months 1 cm per month for next 3 months, and 0.5 cm per month for the next 6 months till the age of 1year [1].

The average rate of growth of HC in a healthy premature infant is 0.5cms in the 1st 2 weeks, 0.75cm in the third week and 1cm in the 4th week and thereafter until the 40th week of the development [1].

Birth head circumference-for-age can be measured more reproducibly than birth length [2], although the presence of head moulding (particularly after a difficult or forceps-assisted delivery) may affect the measurement. As with birth length, head circumference as an indicator of brain volume may provide important diagnostic and prognostic information beyond that provided by birth weight alone.

A decreased rate of head growth manifested by flat curve or by dropping to a lower percentile may indicate poor brain growth, atrophy or premature cranial synostosis.

At the beginning of the 3rd month the head constitutes approximately half of the CRL. By the beginning of the 5th month the size of the head is about one third of the CHL and at birth it is approximately one fourth of CHL. This is one of the most striking changes taking place during fetal life, with the relative slowdown in growth of the head compared with the rest of the body. Studies done shown that birth weight followed a linear pattern in relation to HC measurement [3]. HC are also useful for assessing the degree of compromise in nutrition of neonates in intrauterine growth retardation by measuring the MAC/HC ratio.

CHL of the term infant of normal weight is 48-53cm. The increase in birth weight follows a linear pattern in relation to CHL. The rate of increase in CHL occurs most rapidly in early gestation and then continues at a steady, somewhat slower pace [4].

During the second trimester of pregnancy increase in the length of the fetus is proportionately greater as comparable to increase in weight. During fourth and fifth months the fetus lengthens rapidly. By the end of 28 wks CHL is 35 cm. At 40 wks average Indian baby has CHL of 48 cm [5].

Birth length is another indicator of neonatal size. This can be useful when birth weight is not available, which frequently provides useful additional information. Studies done show that CHL has a linear relationship with gestational age and birth weight. Beyond 40 wks of gestation this increase in length is not evident. It is a good tool to determine birth weight, but the limitation of its use are due to posture, muscle tone of the newborn during measurement and that it is very disturbing for the neonate.

As the gestational age increases CHL also increases and it is correlated well with the gestational age [5]. Another advantage of using CHL is that it will not be affected by acute illness resulting in significant weight loss.

If a CHL falls below the percentile for weight and height, measuring the CRL establishes leg and trunk proportionality, which may be abnormal in congenital dwarfism.

At birth HC is larger than ChC by about 2.5cm.By 6-12mnths of age, both are equal. After1st year of life, ChC tends to be larger by 2.5cm. By the age of 5 years, it is more or less 5cm greater in size than the HC. In undernourished Indian children, it may not equal to HC even by the end of the 2nd year [6].

In the study done by WHO9, they have recommended that in areas where the accurate, early weighing of neonate is not feasible, community health workers should be trained to measure the ChC. Newborns with chest circumference <29 cm should be designated as “highly at risk”. And those with circumference>/-29 cm but <30 cm as “at risk”. It should be noted, however, that this measures has been validated only in terms of its relationship to birth weight and not to perinatal outcomes.

Those babies diagnosed to be at risk through complication associated with LBW could then be either given specialized home care or referred to the nearest health center for appropriate treatment. The tape used to measure ChC should be color coded to overcome the problems of illiteracy. A three-color tape could be used to identify babies at high risk, at risk and those at low risk.

They have suggested that where community health workers are likely to be absent at the time of birth, it is important that the mothers are given a color coded tape, to measure and instructed in its use. This tape measure should be part of delivery kit containing for example soap, a razor blade, a bandage and a dressing set each of which would promote a healthy delivery.

They have stated that further studies need to be done to know whether the relationship between birth weight and ChC remains the same in situations where community health worker cannot visit the mother until a few days after the birth. In a study done in Bangladesh, a three-colored tape was used; the devise used was a flat, flexible non stretchable tape and suitably colored in red, yellow and green or any other contrasting colors, so that these can be used and understood easily by the illiterate traditional birth attendants. Hence in the absence of weighing machine the measurement of ChC of newborn may indicate the possible birth weight [7].

ChC has many bony landmarks for measurement, which will not vary and will not be affected by acute problems like body water and fat distribution. It also has large cross sectional area with less chance of systemic or random errors in measurement [8].

Use of the nipple line is not recommended as the position of the nipple may vary. Measurement of the ChC requires undressing, which is discomforting to the neonate. There might be errors in measurement due to the influence of phases of respiration. The measurement of ChC may also have some errors especially in the hands of paramedical workers.

Methodology

All the singleton live born babies born in the hospital were examined within 48 hours of birth. Gestational age was calculated by enquiring into 1st day of mothers last menstrual period and will be subsequently confirmed by New Ballard Score. If any disparity of more than 2 weeks between gestational age by enquiring LMP and by NBS, were excluded from the study. Their gestational ages ranged from 29 to 42 weeks. As there were few babies in less than 30 weeks gestation they were grouped together.

Newborns were subjected to the following anthropometric measurements within 48 hours of birth by standard techniques.

Birth weight: Babies were weighed naked immediately after birth on lever actuated weighing scales to the nearest 50 g. The weighing machine was checked periodically by known standard weights.

Crown heel length: The baby was placed supine on an Infantometer. The head is held firmly in position against a fixed upright headboard. Legs are straightened keeping feet at rights to legs with toes pointing upwards. A free footboard is brought into firm contact with the baby's heels. Length of the baby is measured from a scale, which is set into the board.

Head circumference: A flexible non-stretchable fiber glass tape was used. The head circumference in the largest dimension around the head (the occipito-frontal circumference) was obtained with a tape placed snugly above the ears. The tape is placed over the mid forehead and is extended circumferentially to include the most prominent portion of the occiput. The measurement was taken to the nearest 0.1cms.

Chest circumference: The Chest circumference was measured to the nearest of 0.1cm at the level of the xiphisternum, below the inferior angle of the scapula during quite respiration by a flexible non-stretchable fiber glass tape.

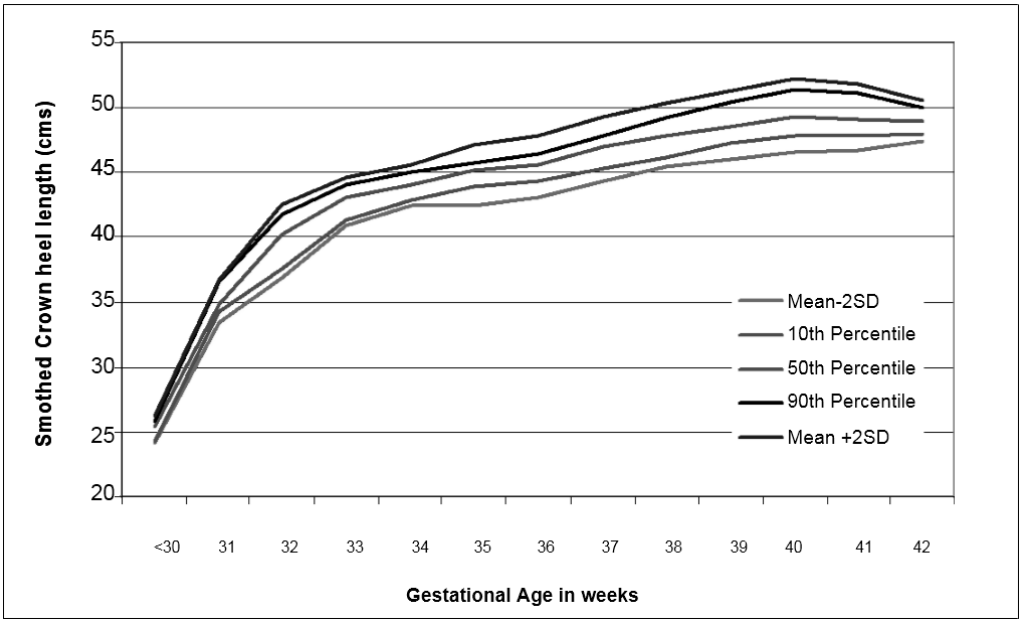
Statistical Method Used: A pre-tested proforma was used to collect data. The data obtained was subjected to a computer-based analysis to derive mean, standard deviation, 10th, 50th, 90th percentile values and normograms. Single exponential Smoothing technique has been used to smooth the data obtained to derive intrauterine growth curves.

Results

The mean length of the 1284 newborn analyzed was 48.74 cm, with the standard deviation of 2.04 cm.

It was found that CHL was correlated well with the gestational age in the present study. It gave a correlation coefficient "r" value of 0.726 ($p < 0.0001$)

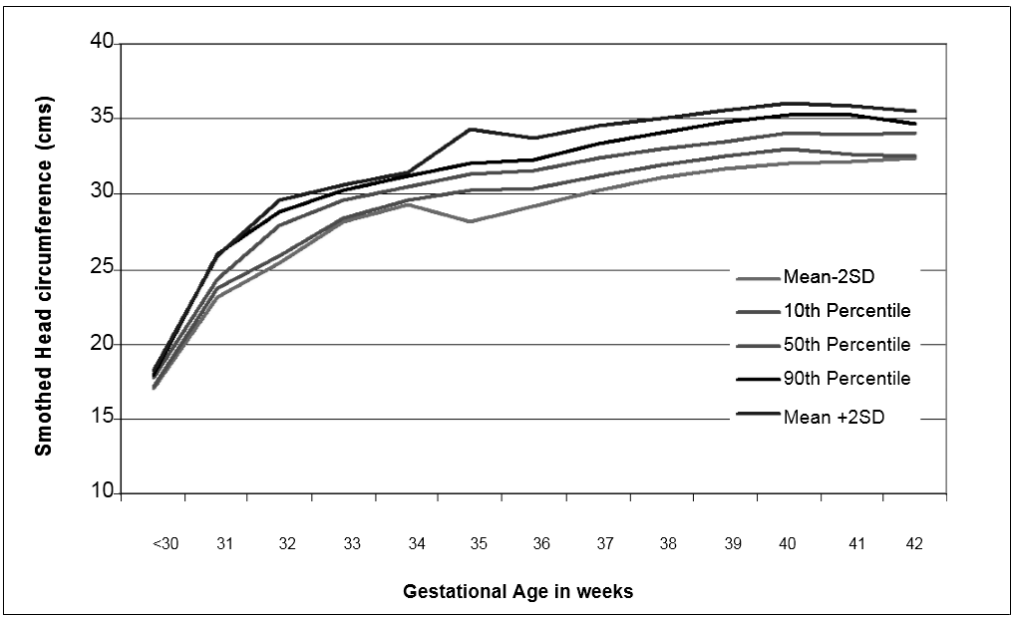
In the present study it was observed that there is a linear relationship of CHL with the increasing gestational age, which started declining after 39-40 weeks gestation.



Graph 1: Shows the normogram of crown heel length with 10th, 50th, 90th percentiles and mean ± 2SD.

The mean head circumference of the babies analyzed was 33.64 cm, with the standard deviation of 1.40 cm.

It was found that HC was correlated well with the gestational age. It gave a correlation coefficient "r" value of 0.680 ($p < 0.0001$). In the derived normogram based on head circumference and gestational age it was observed that there is a linear relationship of the head circumference with increasing gestational age.



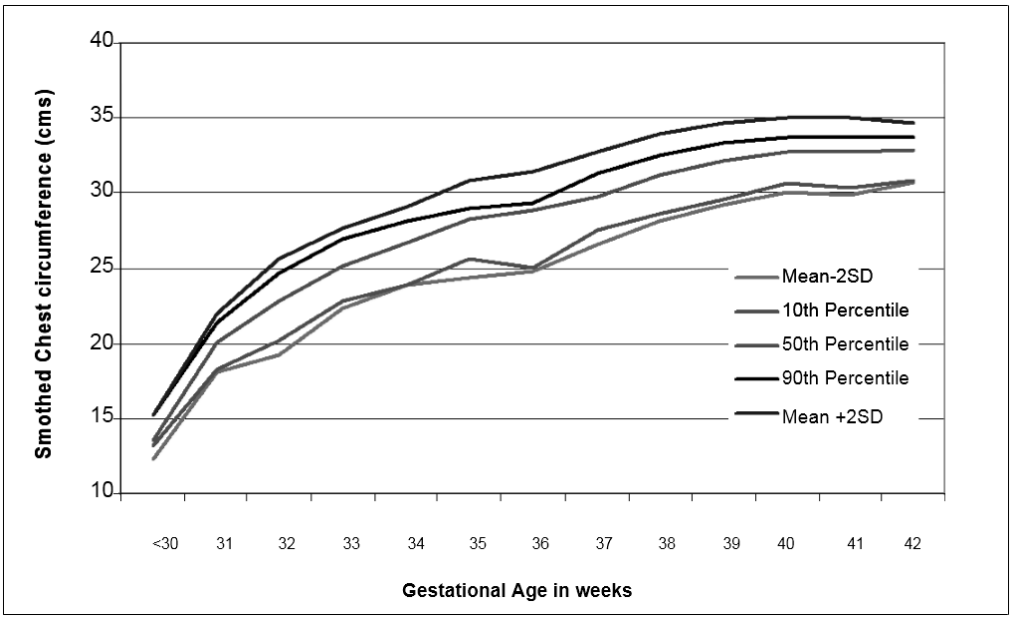
Graph 2: Shows the normogram of head circumference with 10th, 50th, 90th percentiles and mean ± 2SD.

The mean chest circumference of the babies analyzed was 31.85 cm, with the standard deviation of 2.19 cm.

It was found that chest circumference was correlated well with the gestational age. It gave a highest correlation coefficient "r" value of 0.763 ($p < 0.0001$)

In the derived normogram based on chest circumference and gestational age it was observed that there is a linear relationship of the chest circumference with increasing gestational age. There is a linear rise of chest circumference with the increasing gestational age, which started declining after 40 weeks gestations.

There is slight depression in the curve noticed at 36 wks of gestation. This is possible because of only 46 babies are there in 36 wk gestational group constituting only 3.56 % of the total study group.



Graph 3: Shows the normogram of chest circumference with 10th, 50th, 90th percentiles and mean ± 2SD

Discussion

Chest circumference has the highest correlation with birth weight in studies conducted by many authors, Bhargava *et al*. [9] Dhanajay *et al*. [10] Huque *et al*. [11] WHO also recommends, if weighing scales are unavailable and birth weight cannot be determined, chest circumference should be measured as an alternative surrogate.

Chest circumference has many bony landmarks for measurement, which will not vary and will not be affected by acute problems like body water and fat distribution. It also has large cross sectional area with less chance of systemic or random errors in measurement

In the early neonatal period, when body weight is variable and dependent on numerous factors, including physiological shifts in body fluids, chest circumference remains unaffected, and could therefore be used to longitudinally assess growth and nutritional status of newborn.

Studies done by Bhatia *et al*. [12] and Sharma *et al*. [13] also show Birth weight, crown heel length, and abdominal girth, mid arm, calf, and head circumference are correlated well with gestational age.. Highest correlation with gestational age was found with Crown heel length in Bhatia *et al*. [12] while Birth weight has maximum correlation in Sharma *et al*. [14]. The normograms are presented as 10th, 50th, 90th percentiles with mean ± 2 SD for all the ten anthropometric parameters.

These derived normograms shows there is a linear relationship between all the anthropometric measurements studied with the varying gestational age. There is uniform increase in all the anthropometric parameters up to 39- 40 weeks, after which it started declining.

Similar uniform increase up to 40 weeks of gestation but comparatively less after that in the fetal growth of birth weight, length, Head circumference and Chest circumference is noted from study by Parmar *et al*. [15].

In the intrauterine growth curves of MAC and TC constructed by Shiv prasad *et al*. both the parameters increased up to 40 wks gestation then declined.

This decline in growth after 40 wks is because after reaching the maximum growth, fetus is believed of declining growth support from the intrauterine environment especially that coming from the placenta.

In the present derived normograms there is some deviation in the ± 2 standard deviation curves noticed in the growth curve of head circumference specially noticed between 34-35 weeks of gestation age groups. There is also slight depression noticed in the growth curves of Chest circumference, abdominal circumference, mid arm circumference and Calf circumference.

These variations are possibly because of less number of babies in the 35-36 weeks of gestational age group. In the present study there are only 21 babies in 35 week and 46 babies in 36 week of gestational age group constituting only1.64 % and 3.58 % respectively of the total study group.

Conclusion

These norm grams can be gainfully employed for further studies to know whether simple anthropometric measurements other than birth weight will be useful to quantitate fetal growth and to identify at risk babies in rural community level.

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