

# Is it appropriate to use WHO Multicentre Growth Reference Study standards to assess the growth parameters of Sri Lankan babies? A single-centre cross-sectional study

Ishanya Ayeshini Abeyagunawardena,<sup>1</sup> Arundhi Abeynayake,<sup>1</sup> Thushani Anuththara,<sup>1</sup> Kasun Alawaththegama,<sup>1</sup> Sakuni Amanda,<sup>1</sup> Vishaka Abeyrathne,<sup>1</sup> Prabhadi Amaradasa,<sup>1</sup> Buddhika Anuradha,<sup>1</sup> Hanan Ahmed,<sup>1</sup> Chathupa Abeykoon,<sup>1</sup> Dinesh Malcolm Gerard Fernando<sup>2</sup>

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<sup>1</sup>Faculty of Medicine, University of Peradeniya, Kandy, Sri Lanka  
<sup>2</sup>Department of Forensic Medicine, Faculty of Medicine, University of Peradeniya, Kandy, Sri Lanka

## Correspondence to

Ishanya  
Ayeshini Abeyagunawardena;  
ishanya1993@gmail.com

## ABSTRACT

**Objective** To compare the anthropometric measurements of newborns in a tertiary care hospital in Sri Lanka, with WHO standards.

**Methods** Birth weight, length and occipitofrontal circumference (OFC) of 400 consecutive, term newborns of healthy mothers were measured in a tertiary care hospital.

**Results** 400 subjects were approached and seven were excluded, concluding the study population to 184 boys and 209 females. Medians of birth weight, length and OFC were 3000 g, 49.95 cm and 34.15 cm of males and IQRs were 555.00, 2.70 and 1.70, respectively. For females, the medians of birth weight, length and OFC were 2900 g, 48.9 cm and 34.00 cm with IQRs of 450.00, 2.70 and 1.50, respectively. The two-tailed t-test revealed that median weights of males ( $t=9.632$ ) and females ( $t=12.04$ ) and OFC of males ( $t=3.98$ ) were significantly lower than the WHO medians. There was a significant association of birth weight, with mother's prepregnancy weight, in males ( $\beta$  coefficient=12.629 with 95% CI 6.275 to 18.982) and females ( $\beta$  coefficient=5.880, 95% CI 1.434 to 10.325). Significant associations of length ( $\beta$  coefficient=0.046, 95% CI 0.012 to 0.080) and OFC ( $\beta$  coefficient=0.033, 95% CI 0.014 to 0.053) with mother's prepregnancy weight in males and length ( $\beta$  coefficient=0.084, 95% CI 0.022 to 0.145) and weight ( $\beta$  coefficient=10.780, 95% CI 0.93 to 20.629) with maternal age in females were found. Furthermore, birth weight in males was significantly associated with maternal height ( $\beta$  coefficient=10.899, 95% CI 0.552 to 21.247). Education level, ethnicity and parity showed no significant associations with above parameters.

**Conclusion** The median weights of both sexes and OFC in males were significantly lower than the WHO standards. Island-wide studies are indicated to evaluate the appropriateness of applying WHO standards to Sri Lankan newborns.

## INTRODUCTION

### Background

The developing fetus is affected by social and environmental influences such as maternal undernutrition, alcohol, cigarette smoke,

## What is already known on this topic?

- ▶ WHO undertook the Multicentre Growth Reference Study between 1997 and 2003.
- ▶ Data were collected from 8440 healthy breastfed infants and young children from Brazil, Ghana, India, Norway, Oman and USA.
- ▶ Standards for length for age, weight for age, weight for length, weight for height and body mass index for age were formulated for worldwide use.

## What this study hopes to add?

- ▶ This study compares the anthropometric parameters of term babies born in a tertiary care hospital in Sri Lanka with WHO standards.
- ▶ Median weights of Sri Lankan neonates were significantly lower than WHO standards.
- ▶ Median occipitofrontal circumference of male Sri Lankan neonates were significantly lower than WHO standards.

drug use and psychological trauma. The complex interplay between these forces and the somatic and neurological transformations occurring in the fetus influence the growth and behaviour at birth, through infancy, and potentially throughout the individual's entire life. Therefore, growth parameters at birth vary with intrauterine environment, maternal factors and the fetal genotype.<sup>1</sup>

Low birth weight (LBW) is defined as weight of less than 2500 g (up to and including 2499 g) irrespective of gestational age.<sup>2</sup> According to DHS 1999 (reanalysed in 2003), the percentage of low birthweight infants in India was 30%.<sup>3</sup> The prevalence of LBW in Sri Lanka is 16.7% according to the

DHS (Demographic and Health Survey) 2006/2007 and 18.1% in 2010.<sup>4</sup>

Macrosomia is a major growth-related disorder encountered in paediatrics and is defined as a condition where a baby has an excessive birth weight (birth weight greater than 4000 g or greater than 90% for gestational age). It is reported in 0.5% of babies born in India.<sup>5</sup>

Growth parameters at birth are useful in determining the postnatal health status of a newborn.<sup>6</sup> Misclassification of newborns, either as healthy or suffering from a growth disorder such as macrosomia or LBW, will lead to various unfavourable consequences for the baby during the neonatal period, childhood and even up to adulthood.<sup>1</sup>

Growth standards from the WHO Multicentre Growth Reference Study (MGRS) are used to interpret growth parameters in term newborns<sup>7</sup> and Fenton Growth Charts in preterm newborns in Sri Lanka.<sup>8</sup> Yet, several studies signify the importance of using ethnicity-specific/country-specific growth charts, pointing out that fetal growth of different populations vary with environmental, maternal and genetic factors in those individual populations.<sup>9–12</sup>

A LBW baby erroneously determined as normal will not be appropriately managed, which in turn may lead to neonatal complications such as hypothermia, hypoglycaemia and infections.<sup>13</sup> A truly macrosomic baby deemed to be healthy on assessment will suffer from neonatal complications such as hypoglycaemia, polycythaemia and electrolyte imbalance, and obesity, metabolic syndrome and diabetes mellitus in their adult life.<sup>14</sup> On the contrary, a healthy newborn viewed as having a growth-related disease will be the cause of unnecessary wastage of resources, deprivation of limited facilities to those in need and undue stress to the family.

## Objectives

### General objective

This study aims to compare the birth weight, length and occipitofrontal circumference (OFC) of term babies born at the Teaching Hospital, Peradeniya, with the WHO standards used to assess growth.

### Specific objective 1

To measure the birth weight, length and OFC of Sri Lankan term babies within 24 hours of birth, born at the Teaching Hospital, Peradeniya, from 26 September 2016 to 21 October 2016.

### Specific objective 2

To construct a distribution and obtain the median and range for the growth parameters of those babies.

### Specific objective 3

To compare the median and range obtained in our study with the median and range obtained from the WHO standards used to assess growth.

### Specific objective 4

To assess possible correlations of the anthropometric parameters of newborns with maternal factors such as parity, education level, prepregnancy weight and age.

## METHODS

After ethical clearance was obtained from the Ethical Review Committee of the Faculty of Medicine, University of Peradeniya under protocol number 2016/EC/SP/02, a cross-sectional predominantly descriptive study was conducted at Teaching Hospital, Peradeniya. The study population was all the newborns who met the inclusion criteria, born in Teaching Hospital, Peradeniya, from 26 September 2016 to 21 October 2016. It can be considered a representative sample of the draining area of Teaching Hospital, Peradeniya, which includes urban areas like Kandy city, suburban areas like Gampola, Mawanella and the most rural estate regions of Deltota and so on. Hence, all the population sectors were well represented. The consecutive sampling method was used. The inclusion criteria were babies born at term (37 weeks to 41 weeks+6 days) at Teaching Hospital, Peradeniya, to mothers who were never smokers. The duration of gestation calculated from the first day of mothers' last menstrual period must be consistent with the duration obtained using the ultrasound scan.

Babies of multiple pregnancies or having complicated births were excluded. Babies born to intellectually disabled mothers, mothers with congenital disorders and diseases such as diabetes mellitus and hypertension were excluded. Babies born after being transferred from another hospital due to complications were also excluded.

Informed consent was obtained from the mother after an information sheet detailing the scope of the study was made available to the prospective participants. The babies' length, birth weight and OFC were measured within 24 hours of birth by two third-year medical students trained in the correct method of taking measurements. All measurements were taken, adhering strictly to recommended aseptic techniques. There was minimum handling of the neonate by the investigators to prevent infection. Whenever possible, the mother or bystander was asked to handle the neonate. The weight, in grams, was recorded using a digital scale (Camry acs-6) at birth including the umbilical clip (weighing 5 g). The OFC, in millimetres, was measured just above the supra-orbital ridges anteriorly, external occipital protuberance posteriorly and above the ears laterally with a flexible non-stretchable standard tape. Infant length, in centimetres, was measured with the infant placed on his or her back in the centre of the infantometer, so that the child was lying straight and the shoulders and buttocks were flat against the measuring surface. The infant's eyes were facing straight up, the crown of the head in contact with the headpiece in the Frankfurt horizontal plane (plane passing through the upper margin of each

**Table 1** Comparison of the calculated ranges and medians with the WHO standards of males

| Parameter  | WHO standard median | Calculated median | P      | WHO standard range | Calculated range |
|------------|---------------------|-------------------|--------|--------------------|------------------|
| Length, cm | 49.9                | 49.9              | >0.8   | 46.3–53.4          | 45.96–55.56      |
| Weight, g  | 3300                | 3000              | <0.001 | 2500–4300          | 2229.75–3895.00  |
| OFC, cm    | 34.5                | 34.1              | <0.001 | 32.1–36.9          | 31.71–36.89      |

OFC, occipitofrontal circumference.

external auditory canal opening and the lower margin of each orbit). Both legs were kept fully extended with the toes pointing upwards, with feet flat against the foot piece. Interobserver errors were minimised by the proper training of the investigators and reviewing of the collected data regularly. The investigators were 10 third-year medical students who had completed the Growth and Development module of their curriculum. Intraobserver errors were minimised by allocating a reasonable number of infants<sup>5–10</sup> per measurer per day. Instrument errors were reduced by the use of mechanical instruments as mentioned above.

An interviewer-administered questionnaire was filled by the investigators according to information provided by the parents to obtain general information and relevant information required about the parents and the baby. Confidentiality was maintained. Maternal prepregnancy weight and height at the booking visit (before 12 weeks' gestation) measured in the antenatal clinic was recorded from the pregnancy card. Maternal education level was categorised as postgraduate, undergraduate, advanced level, ordinary level and lower.

Sample size was calculated using the following formula. To estimate a population proportion with specified relative precision,

$$n = Z^2 p(1-p) / d^2 \text{ where}$$

$n$  = sample size

$Z$  = Z value for 95% CI (1.96<sup>2</sup>)

$p$  = expected prevalence/proportion (0.5)

$d$  = precision (0.05)

$$(1.96)^2 (0.5 \times 0.5) / (0.05)^2 = 384.2 \approx 385 \text{ patients}$$

After adding 5% to compensate for possible dropouts, the final sample size was calculated as 400. Seven questionnaires with missing data were excluded.

The data collected were entered into an Excel datasheet and were analysed after completion of data collection.

Using the data collected, median values for birth weight, length and OFC for males and females were calculated separately. Using the 3rd to 97th percentiles, ranges for the above were also calculated. Prepregnancy

weight, mother's age, parity and education level of the mother were assessed against the birth weight, length and OFC of the baby to analyse possible correlations.

## RESULTS

Of the 400 participants approached, seven were excluded due to incomplete data, concluding the study population to 393 babies of which 184 were males and 209 were females.

The median values of birth weight, length and OFC of males in the study population were 3000 g, 49.9 cm and 34.1 cm, respectively. The mean values of birth weight, length and OFC for males were 3009 g, 49.84 cm and 34.19 cm, respectively.

For females, the median values of birth weight, length and OFC were 2900 g, 48.95 cm and 34.00 cm, respectively, and the mean values were 2888 g, 48.81 cm and 33.9 cm, respectively.

The median values of birth weight, length and OFC of males according to WHO standards were 3300 g, 49.9 cm and 34.5 cm, respectively, and 3200 g, 49.1 cm and 33.9 cm for females, respectively.<sup>15</sup>

According to WHO standards, the 3rd–97th centile ranges for males are 46.3–53.4 cm for length, 32.1–36.9 cm for OFC and 2500–4300 g for birth weight. The WHO standards for females are stated as 45.6–52.7 cm for length, 31.7–36.1 cm for OFC and 2400–4200 g for birth weight.<sup>15</sup>

Tables 1 and 2 illustrate the comparison between the calculated ranges from 3rd to 97th percentile and medians with the WHO standard ranges and medians of males and females, respectively.

As the sample size of the WHO MGRS was large, the median and the mean can be assumed to be equal. The distribution of our study was found to be normal, and therefore the median and mean fall on approximately the same point. Hence, the two medians of the two study groups for each parameter were compared using the two-tailed t-test to assess if the difference is statistically

**Table 2** Comparison of the calculated ranges and medians with the WHO standards of females

| Parameter  | WHO standard median | Calculated median | P      | WHO standard range | Calculated range |
|------------|---------------------|-------------------|--------|--------------------|------------------|
| Length, cm | 49.1                | 48.95             | >0.2   | 45.6–52.7          | 44.59–53.00      |
| Weight, g  | 3200                | 2900              | <0.001 | 2400–4200          | 2215.0–3727.5    |
| OFC, cm    | 33.9                | 34                | >0.2   | 31.7–36.1          | 31.3–36.14       |

OFC, occipitofrontal circumference.

**Table 3** Significant associations of maternal factors with male anthropometric parameters

| Maternal factor     | Birth weight |                 | Length  |                | OFC     |                |
|---------------------|--------------|-----------------|---------|----------------|---------|----------------|
|                     | $\beta$      | 95% CI          | $\beta$ | 95% CI         | $\beta$ | 95% CI         |
| Prepregnancy weight | 12.629       | 6.275 to 18.982 | 0.046   | 0.120 to 0.080 | 0.033   | 0.014 to 0.053 |
| Height              | 10.899       | 0.552 to 21.247 | –       | –              | –       | –              |

OFC, occipitofrontal circumference.

significant. For males, the calculated t-test values for birth weight, length and OFC were 9.632, 0.000 and 3.98, respectively. The t table value at a significance level of 5% was 1.96. As the calculated t value is greater than the table value, the difference between the two means of birth weight and OFC was statistically significant in males.

For females, the calculated t values for birth weight, length and OFC were 12.04, 0.925 and 1.06, respectively. The t table value at a significance level of 5% was 1.96. Hence, the difference between the two means of birth weight was statistically significant in females as well.

The analysis of birth weight, length and OFC with maternal factors showed the following variations. A P value of <0.05 was considered significant.

Of the 393 participants, prepregnancy weights of 356 participants were recorded. There was a significant correlation of birth weight with mother's prepregnancy weight in both males ( $\beta$  coefficient=12.629 with 95% CI 6.275 to 18.982) and females ( $\beta$  coefficient=5.880, 95% CI 1.434 to 10.325). Length ( $\beta$  coefficient=0.046, 95% CI 0.012 to 0.080) and OFC ( $\beta$  coefficient=0.033, 95% CI 0.014 to 0.053) showed a significant positive correlation with mother's prepregnancy weight only in males.

The maternal age of all participants were recorded. There was a significant positive correlation of length ( $\beta$  coefficient=0.084, 95% CI 0.022 to 0.145) and birth weight ( $\beta$  coefficient=10.780, 95% CI 0.93 to 20.629) with maternal age in females. However, the study did not show any significant correlation of the above parameters in males and OFC in both genders with maternal age.

Maternal height was recorded in 329 participants. It was found that birth weight in males was significantly associated with maternal height ( $\beta$  coefficient=10.899, 95% CI 0.552 to 21.247).

Of the 393 participants, parity of 390 participants and maternal educational level of 388 participants were recorded. Contrary to common belief, we found no correlation of maternal education level with birth weight (males,  $P=0.161$ ; females,  $P=0.091$ ), length (males,  $P=0.964$ ; females,  $P=0.255$ ) or OFC (males,  $P=0.893$ ;

females,  $P=0.138$ ). Birth weight, length and OFC parameters did not show any significant correlation in both genders with parity. **Tables 3 and 4** summarise the significant associations of maternal factors and anthropometric parameters.

In addition, birth weights of 130 Sinhala males and 48 Muslim males were recorded. The mean birth weight of Sinhala males was 3020.58g and 3049.79g for Muslim males with a difference of 29.21g. Birth weights of 142 Sinhala females and 51 Muslim females were recorded with a mean birth weight of 2889.08g and 2936.18g, respectively, with a difference of 47.1g. Muslim babies had a higher birth weight than Sinhala babies; however, these differences were not statistically significant. Further, there were no significant associations between ethnicity and other anthropometric parameters.

## DISCUSSION

The mean birth weights of both male and female babies were significantly lower than the birth weights of babies as stipulated by WHO standards. In addition, the mean OFC of males was also significantly lower than the WHO mean. However, the mean length of both male and females as well as the mean OFC in females are comparable to WHO standards. Our study included participants of all social strata and population sectors as Peradeniya tertiary hospital drains urban, suburban as well as the most rural or estate populations. Hence, it is reasonable to assume this population reflects the population of Sri Lanka. However, data collection was done in a specific period of the year and hence possible variations along the year may be missed. In addition, the low sample size is a weakness of this study.

When considering the maternal factors that may affect the growth parameters of the newborn, there was an increase of birth weight with mother's prepregnancy weight in both genders. Studies conducted in São Paulo,<sup>16</sup> Southeast United States<sup>17</sup> and Tianjin, China,<sup>18</sup> showed similar results. However, a study conducted in Taiwan

**Table 4** Significant associations of maternal factors with female anthropometric parameters

| Maternal factor     | Birth weight |                 | Length  |                | OFC |        |
|---------------------|--------------|-----------------|---------|----------------|-----|--------|
|                     | $\beta$      | 95% CI          | $\beta$ | 95% CI         | B   | 95% CI |
| Prepregnancy weight | 5.880        | 1.434 to 10.325 | –       | –              | –   | –      |
| Age                 | 10.780       | 0.93 to 20.629  | 0.084   | 0.022 to 0.145 | –   | –      |

OFC, occipitofrontal circumference.

found that mothers whose body mass index (BMI) was 24–27 (normal) had significantly higher neonatal birth weight than those mothers with a BMI >27 and <18.5.<sup>19</sup> Length and OFC increased with mother's prepregnancy weight only in males. There was an increase in length and birth weight with maternal age in females, but no significant correlation of above parameters in males and OFC in both genders with maternal age.

Birth weight, length and OFC parameters did not show any significant correlation in both genders comparative with parity and maternal education level. A study conducted in the USA showed that the difference in parity was not responsible for significant portion of birth weight variations for any race.<sup>20</sup> A study conducted in Kegalle, Sri Lanka, also found no association with parity and birth weight.<sup>11</sup> In addition, a study in East Midlands United Kingdom found that a woman delivering a first baby weighing more than 3720g could expect a lighter baby for her second delivery provided that all other factors remained constant. This study states that generally a woman's second baby is likely to be heavier than her first but maternal physiological factors differ in the two pregnancies and these differences have additional effects on birth weight.<sup>21</sup>

However, the study conducted in Addis Ababa showed that parity had significant effects on the birth weight of the neonates.<sup>22</sup> Similar results were found in Karachi,<sup>23</sup> Utah<sup>24</sup> and Gampola, Sri Lanka.<sup>25</sup> A study conducted in New York found that birth weight similarly increased from parity 1 to parity 3, but dropped markedly in the higher parity groups.<sup>26</sup>

With regard to ethnicity, a study conducted in Kegalle, Sri Lanka, found that Moor male and female newborns were heavier, taller and had a greater head circumference than Sinhalese male and female newborns. However, the differences in our study were not statistically significant.<sup>11</sup>

The overall findings therefore indicate that there are variations of anthropometric parameters with maternal factors and the possible need for the development of country-specific/race-specific standards.

To assess the growth of children around the world, WHO generates growth curves. Before generating those curves, NCHS (National Centre for Health Statistics)/WHO growth references were used, which were recommended since 1970. However, as those references were not adequate, WHO undertook the MGRS between 1997 and 2003 to generate new curves for assessing the growth and development of children world over. For that, 8440 healthy breastfed infants and young children from widely diverse ethnic backgrounds and cultural settings (Brazil, Ghana, India, Norway, Oman and USA) born to mothers who were non-smokers were recruited.<sup>7</sup> Despite the diverse nature of the populations involved, when individual countries are concerned, these standards may still be inappropriate.

A study conducted regarding standards for the measurement birth weight, length and head circumference at term in neonates of European, Chinese and South

Asian ancestry focused on the differences between ethnic groups with respect to fetal growth and the misclassification of constitutionally small or large babies as having abnormal growth for their gestational age. It was found that the birth weights of European infants were heavier than South Asian infants and Chinese infants. Regarding mean birth length, European babies were found to be significantly longer than Chinese babies.<sup>12</sup> Therefore, average growth parameters differ in different populations, hence growth standards for one population may not be applicable to another and may result in erroneous classification and diagnosis.

The immediate and long-term management of LBW and macrosomic babies differs from babies with weights appropriate for their gestational age.<sup>27,28</sup> Hence, correctly classifying newborns at birth is important to ensure a healthy childhood and adulthood. Adhering to inappropriate standards of birth weight in Sri Lanka may lead to the misdiagnosis of LBW leading to unnecessary stress to the parents and the newborn and wastage of resources. Furthermore, overfeeding a healthy baby may lead to obesity, diabetes mellitus and so on in adulthood. In addition, a macrosomic baby thought to be healthy may lead to complications in adulthood. It is apparent that maternal factors, ethnicity, country and so on may affect the anthropometric parameters of a newborn, and these differences should be taken into account when establishing norms for these parameters in a population. Similar studies could be carried out island-wide to ultimately formulate growth standards applicable for Sri Lankan newborns. However, this process is laborious, time consuming and costly. Another novel approach is generating synthetic growth reference charts by incorporating information from a large set of growth studies conducted in the locality. This method permits combining global patterns of human growth with specific local information.<sup>29</sup> It also helps in providing quick growth charts.<sup>30</sup>

## CONCLUSION

The median birth weights of both sexes and OFC in males were significantly lower than the WHO MGRS standards. Similar studies in multiple centres could be conducted to evaluate the appropriateness of using WHO MGRS standards to assess Sri Lankan babies and to ultimately develop country-specific standards.

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**Contributors** IAA: design of the study, drafting the proposal, applying for ethical approval, data collection and analysis, drafting, reviewing and approving the final paper. AA: design of the study, drafting the proposal, applying for ethical approval, data collection and analysis, drafting, reviewing and approving the final paper. TA: design of the study, drafting the proposal, applying for ethical approval, data collection and analysis, drafting, reviewing and approving the final paper. KA: design of the study, drafting the proposal, applying for ethical approval, data collection and analysis, drafting, reviewing and approving the final paper. SA: design of the study, drafting the proposal, applying for ethical approval, data collection, drafting, reviewing and approving the final paper. VA: design of the

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