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Growth Parameters and Nutrition status of Bahraini Children: Towards Establishing National Growth Charts in Bahrain

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of M.Sc. in Nutrition and Dietetics

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DEFENSE COMMITTEE APPROVAL PAGE

ABSTRACT

Aim: This study was performed to evaluate the suitability, adequacy and accuracy of the 2006-WHO growth charts to assess the nutritional status of Bahraini infants and young children.

Methods: This is a cross-sectional study of the growth parameters among healthy Bahraini children, based on data obtained from the official records of the Ministry of Health. Children were selected using a multi-stage probability sampling from 5 health regions. Data on weight, length and feeding practices were gathered by systematic random selection, growth charts for these anthropometric measures were then constructed using Cole's LMS method. This data was compared with the WHO Multicenter Growth Reference Study (MGRS) data. Underweight, stunting, wasting, overweight and obesity (Weight-for-age, height-for-age, BMI-for-age) were determined using the z-scores of the 2006- WHO reference sample.

Results: A total of 403 children (210 males and 193 females) of the targeted age were recruited in this study. The mean weight, length, and BMI of newborns was 3.2 ± 0.4 kg, 3.1 ± 0.4 kg, 49.7 ± 2.3 cm, 48.8 ± 2.1 cm, 13.2 ± 1.6 kg/m², and 12.8 ± 1.5 kg/m² among males and females, respectively. Means of weight, length, and BMI of males, were slightly but statistically significant higher than those of females in all ages. Length and weight of children were slightly higher but statistically significant than those of MGRS children. Variations in growth pattern was found between Bahraini children when compared with Saudi cohorts. Highest prevalence of wasting was found in the age of 9 months (1.7%). Only 3% were stunted at 9 months, and around 2.5% at 2 and 6 months. Very few cases of severely stunting and very tall were found 2.3% were underweight at birth, of which 1.5% were males and 3.1% females. A higher prevalence of possible risk of overweight were found among children at 12 months of age (14.5%). Obesity was the highest at the ages of 6 and 18 months (1.2%), the majority of whom were males, (1.9%) at 6 months, and at 18 months (1.4%) were males and (1%) were females. The Bahraini infants/ children (0-2) years were higher, and heavier than their cohorts in MGRS reference charts.

Conclusion: This study provides a baseline to establish reference growth charts, to ensure a correct follow up for children in Bahrain. Therefore, using national charts are more appropriate than the MGRS data. According to the MGRS measurements, some children may be considered malnourished for no clear reason.

DEDICATION

This thesis is whole-heartedly dedicated to my beloved parents, who had been my source of inspiration and gave me strength, to my dearest husband who continually provides his moral, spiritual, emotional, and endless support. To my brothers, sisters, relatives, mentor, friends who shared their words of advice and encouragement to finish this study.

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ABBREVIATIONS

ANOVA: Analysis of variance

BMI: Body Mass Index.

BMIZ: BMI Z score

CDC: Center for Disease Control of the United States.

LMS: The (lambda-mu-sigma) parameters.

LSCS: Lower segment caesarian section.

MCH: Child Health Department.

MGRS: The WHO Multicenter Growth Reference Study.

MNAR: Missing not at random.

MOH: Ministry of Health.

NCHS: National Center for Health Statistics.

PSU: primary sampling units.

RTST: Research Technical Support Team.

SD: Standard Deviation.

UNECIF: United Nations Children's Emergency Fund.

UOB: University of Bahrain.

VLBW: Very low birth weight.

WHO: World Health Organization.

CHAPTER 1

INTRODUCTION TO THE STUDY

- 1.1 Introduction
- 1.2 Research problem
- 1.3 Research questions
- 1.4 Research objectives
- 1.5 Research significance
- 1.6 The study's setting
- 1.7 Research Terminolog

CHAPTER 1: INTRODUCTION TO THE STUDY

1.1 Introduction:

The nutritional status of children has an important impact on their general health and development. Therefore, several characteristics, including the physical, mental, social and nutritional status of children as well as other characteristics related to malnutrition, should be evaluated periodically in order to monitor malnourished children (Taguri et al., 2008).

The term malnutrition “describes dietary imbalances; it consists of a broad group of conditions including undernutrition (wasting, stunting, and underweight), inadequate micronutrients, overweight, obesity, and diet-related non-communicable diseases” (WHO, 2018). According to a recent joint report of the United Nations Children’s Emergency Fund (UNICEF), World Health Organization (WHO), and World Bank group (2018), the rates of different forms of malnutrition remain alarming. Where, the prevalence of stunting, wasting, and overweight among under-five children were (22.2%), (7.5%), and (5.6%), respectively. Hence, It is considered one of the most challenging and serious problems in public health worldwide (WHO, 2010).

Relevant parameters, such as growth, development pattern, general health and/or nutritional status are usually assessed by anthropometric measurements (Frisard et al., 2005). The term “Anthropometry” is a collective expression for all body measurements, including height and weight and indices like body mass index (BMI) (Cole, 2012). Growth charts are used to provide an objective evaluation of the child’s growth and health status in clinical assessment and epidemiology (WHO, 2006; CDC,

2009). Furthermore, they are also used as standards or references to screen inadequate growth and malnutrition (De Onis et al., 2003).

The history of growth charts goes back to more than 100 years ago (Cole, 2012). Currently, there are two widely used sets of growth charts. The first one was developed by the Center for Disease Control of the United States (CDC) and was released in 2000 (Kuczmarski et al., 2002). The second set is the 2006-WHO growth charts which was published by the WHO (De Onis, 2007).

Despite that the International Growth Charts are being available and readily used (WHO, 2006a; Davies, 2007), they do not take into consideration variations in patterns of growth among different populations. These variations are attributable to genetic, nutritional, environmental, cultural, economic or other differences. (Parent et al., 2003; Freedman et al., 2006).

Many recent studies have found that growth patterns of children differ from the international mean standards (Al-Mazrou et al., 2003; Abdulrazzaq et al., 2008; El Mouzan et al., 2009; Natale and Rajagopalan, 2014). Natale and Rajagopalan (2014) have found that significant variations exist between ethnic and national groups among 11 million multi-ethnic children worldwide regarding many growth parameters. In the same context, Al-Mazrou et al., (2003) and El Mouzan et al., (2009) concluded that using non-population-specific growth charts may have various consequences such as the misclassification of perfectly healthy and developing Saudi children as malnourished. In contrast, Abdulrazzaq et al., (2008) found that children in UAE follow the CDC growth standards in terms of weight for age and length/height for age.

Accordingly, the 2006-WHO growth charts may not be the ideal reference for screening Bahraini children and they may follow a somewhat different growth pattern due to many variations, since no proper substitute for a country than having its own growth standards based on a representative sample of the population.

1.2 Research problem

Currently, the Department of Mother and Child Health (MCH) at the Primary Health Care of the Ministry of Health (MOH) in the Kingdom of Bahrain, is using the 2006-WHO growth charts for assessing growth development of children in Bahrain. The MCH started to use this version since 2009.

According to the 2014- MOH annual health statistics report, the Department of the Primary Health Care reported that the combined prevalence of wasting and severe wasting, among children under 5 year old for the year 2012 was around 2.1%. In addition, around 2.4% were stunted and severely stunted, and 2.4% were overweight and obese among children under 5 years in Bahrain (MOH, 2014a).

In particular, these statistics require further investigation, since children maybe inappropriately classified as stunted, wasted, and/or overweight and obese using the International Growth Charts. However, it is very probable that the growth of these children may be deemed “normal” within the characteristics of the local population. When children are misclassified, they may, sometimes be subjected to unnecessary medical referrals combined with parental anxiety. Hence, the importance of establishing national growth charts which takes into consideration the specific physical differences/variability of a Bahraini child, is justified.

1.3 Research questions

- Are the 2006-WHO growth charts suitable, adequate and accurate to assess a section of the nutritional status of Bahraini infants and young children?
- Are the growth pattern of Bahraini infants and young children similar to or different from the growth patterns used to develop the 2006-WHO charts, which may justify establishing national growth standards?
- Does the use of the 2006-WHO growth charts have any predictive nutritional and health implications?
- What is the current prevalence of wasting, stunting, and underweight among Bahraini infants and young children?
- What is the current prevalence of overweight and obesity among Bahraini infants and young children?
- Are there any differences in means of weight (kg), length (cm), and BMI between the Health Centers?
- Are there any differences in weight (kg), length (cm), and BMI between males and females?
- Are there any relationships between breast-feeding of children and their weight from 2 -24 months, and their Hb level at 9 months?
- Are there relationships between children BMI and Hb level at 9 months?

1.4 Research objectives

This study is undertaken with the following main aim:

- To evaluate the suitability, adequacy and accuracy of the 2006-WHO growth charts to assess the nutritional status of Bahraini infants and young children.

Other specific objectives of the study include:

- To generate growth charts that could be used to establish national growth charts in Bahrain.
- To assess the current prevalence of wasting, stunting and underweight among Bahraini infants and young children;
- To assess the current prevalence of overweight and obesity among Bahraini infants and young children.
- To investigate the differences in means of weight (kg), length (cm), and BMI between the Health Centers.
- To identify any differences in weight (kg), length (cm), and BMI between males and females.
- To investigate the relationship between breast feeding of children and their weight from 2 -24 months, and their Hb level at 9 months.
- To investigate the relationship between children BMI and their Hb level at 9 months.

1.5 Research Significance

Several regional countries started to establish their national growth charts including Saudi Arabia (Al-Mazrou et al., 2003; El-Mouzan et al, 2007) and United Arab Emirates (Abdulrazzaq et al., 2008). Unfortunately, no such initiatives have been undertaken previously in Bahrain. Therefore,

more research on the growth parameters and nutritional status among Bahraini children is required. The finding of this study could be used as a baseline for establishing national growth charts, as well as, for promoting further studies in similar fields.

The realization of the importance of the results of this study can be seen more clearly; when this study may conclude that there is a significant difference between the studied growth parameters among children in Bahrain and the International Growth Charts of the WHO. In this situation, establishing a more appropriate national growth chart and valid method for assessing the nutritional status of Bahraini children becomes a national necessity.

1.6 The study's setting

In this cross-sectional study, infants and young children were recruited from the MCH clinics in the Primary Health Care in NBB-Arad Health Center, Bilad Alqadeem Health Center, A'Ali Health Center, Sitra Health Center, and Budayia Health Center and was conducted at April 2018.

The age of the selected population of this study was from birth to 2 years. The study population included both genders who were born in 2014 and had completed 2 years prior to the commencement of the study..

The official record of each selected infant/child was surveyed. Usually, each child is brought to the health center at specific age intervals, every 2 months for the first half year of life, and every 3 months at the second half. During the second year, the interval is extended to 6 months. Hence, the normal scheduled visits for a typical child are at 2, 4, 6, 9, 12,

18 and 24 months. During each visit, a child is typically examined by the attendant health professionals.

Physiological, growth development, clinical history and the type of feeding information which are officially recorded in the child booklets by the MCH in the primary care were extracted, collected and tabulated.

The following information was extracted for each selected subject:

- Child's and their parent's demographic information (child's gender, date of birth, gestational age, type of delivery, child's history, child rank in his family) and data related to (parent's age, education level, occupation and living status)
- Child's gestational age; preterm children (born before 37 weeks of pregnancy) were excluded.
- History of clinical examinations, children with certain conditions that could affect growth were excluded (children with diabetes mellitus and had congenital malformations and debilitating chronic diseases like asthma, hereditary diseases like thalassemia and sickle cell disease).
- Weight of children, recorded at each visit from birth to 24 months to the nearest 0.1 grams.
- Recumbent length/ Standing height, recorded at birth, 2, 4, 6, 9, 12, 18, 24 months to the nearest 0.1 centimeters.
- Body mass index = weight (kg) / high or length (m²)
- Type of feeding; breastfeeding for at least 4 months accompanied with a complementary feeding after 4 months and/or bottle-fed children were included.

- Hemoglobin level (mg/dl), which usually recorded at 9 months.

1.7 Research Terminology

- **Malnutrition:** Refers to “deficiencies, excesses or imbalances in a person’s intake of energy and/or nutrients. The term malnutrition covers two broad groups of conditions. One is ‘under nutrition ‘which includes stunting (low height for age), wasting (low weight for height), underweight (low weight for age) and micronutrient deficiencies or insufficiencies (a lack of important vitamins and minerals). The other is overweight, obesity and diet-related non-communicable diseases, such as heart disease, stroke, diabetes and cancer)” (WHO, 2017).
- **Underweight:** “children with low weight-for-age are known as underweight. A child who is underweight may be stunted, wasted, or both. The weight for age SD is below -2 of the WHO Child Growth Standards median” (WHO, 2017).
- **Stunting:** Refers to “a child who is too short for his or her age. Stunting is the failure to grow both physically and cognitively and is the result of chronic or recurrent malnutrition. The devastating effects of stunting can last a lifetime. The height for age SD is below -2 of the WHO Child Growth Standards median” (UNICIF, 2017).
- **Wasting:** Refers to “a child who is too thin for his or her height. Wasting, or acute malnutrition, is the result of recent rapid weight loss or the failure to gain weight. A child who is moderately or severely wasted has an increased risk of death, but treatment is possible. The weight for height SD is below -2 of the WHO Child Growth Standards median” (UNICIF, 2017).

- **Overweight:** Refers to “a child who is too heavy for his or her height, this form of malnutrition results from expending too few calories for the amount consumed from food, drinks, and increases the risk of non-communicable diseases later in life. The weight for height SD is above +2 of the WHO Child Growth Standards median” (UNICIF, 2017).
- **Z-scores:** Are defined as “The number of standard deviation (SD) away from the mean, when the distribution is normal (WHO, 2006).
- **Percentiles:** Are defined as “the percentage of observations (or population) falls below the value of a variable (WHO, 2006).
- **Anthropometry:** Is a universally applicable, non-invasive, and inexpensive method to assess the size, proportions, composition of the human body (Frisard et al., 2005).
- **ANOVA:** “One-way ANOVA is an appropriate statistical test to compare the groups given that the outcome variable is continuous and that there are more than two groups” (Kao and Green, 2007)

CHAPTER 2

THEIORITICAL FRAMEWORK AND LITERATURE REVIEW

2.1 Growth assessment

2.2 Influences on growth parameters

2.3 Historical background of growth charts

2.4 Variations in child's growth patterns

CHAPTER 2: THEIORITICAL FRAMEWORK AND LITERATURE REVIEW

Child's growth is considered a very critical, complex, and variable process in the human lifespan (Veldhuis et al., 2006; Gillman 2010). The interaction of growth and several integral factors including physical, mental, social, and nutrition status considered good indicators of children's health and nutrition status (De Onis et al., 2003).

2.1 Growth assessment

One of the methods used to assess a child's growth, size, proportions, and body composition is "Anthropometry" (Frisard et al., 2005). Assessment of growth based on anthropometric measurements is a reliable method in the monitoring of child's growth and health (Neyzi et al., 2015), when compared with more sophisticated methodologies (dilution techniques, hydrodensitometry, electronic bioimpedance, and measuring K-40 by whole body counting), the use of which is restricted by cost and complexity and in population based studies (Kyle et al., 2002). The main elements of anthropometry are weight, height, body mass index (BMI), body circumferences (head, hip, waist, and limbs), and skinfold thickness (Casadei and Kiel, 2019). Although, the most frequently used indices to evaluate the nutritional state of the community are height and weight measurements (Neyzi et al., 2015).

In general, the term "Anthropometry" is a term used to express all the body measurements appears in the growth chart (Cole 2012). The percentiles distributions (or z-scores) of anthropometric measurements in a reference group of children can be summarized graphically by constructing of growth Charts (Cole, 2012). A growth chart is a graphical

tool, which displays the relation between anthropometrics and demographic variables (Khadilkar and Khadilkar, 2011; Cole, 2012). In practice, at least, collecting four variables is fair enough for determining the growth of an individual. For instance, gender, age, weight and length or height, when using two of these variables together, they are referred to as an index. There are also four indexes commonly used to assess the growth and development: weight-for-age, height/length-for-age, weight-for-height/length, and BMI-for-age (WHO, 2006a).

Different healthcare professionals use growth charts to provide an objective evaluation of the child's growth and health status particularly in clinical and/ public healthcare services and epidemiology (WHO, 2006; CDC, 2009). As well, they also can be used as standards or references to screen inadequate growth and malnutrition at both collective and individual levels (De Onis et al., 2003).

2.2 Influences on growth parameters

Growth parameters are affected by complex interactions of several factors, including genes, ethnicity, hormone, birth weight, environment, and nutrition (Risnes et al., 2011). The most important basic factors that indirectly influencing child growth are the general socioeconomic, cultural, and political circumstances. These are fundamental for establishing all determinants for living conditions (Nguyen et al., 2013).

The underlying factors are primarily characteristics of persons and households. At the person's level, the traditional demographic characteristics like the parent's age, occupation, and educational level (Alom et al., 2012; Lakshman et al., 2013). Particularly important are of the mothers, children of highly educated mothers have shown better growth (lower rates of underweight, stunting, overweight and obesity) (Lakshman

et al., 2013). At the household level, economy, housing status, family size, numbers of adults and children, are considered key factors (Janevic et al., 2010).

The Immediate factors are the directly influencing factors on child growth; the child's birth weight is the result of maternal growth as well as the gestational age at birth and nutritional conditions. It is also reflecting the health, nutritional status of mothers and the antenatal care during pregnancy (Demerath et al., 2007; Webb Girard and Olude, 2012). Data from developing countries have shown slight improvements in birthweight and length in a result of higher intake of omega-3 fatty acid or by supplementation during pregnancy. However, Limited data suggested that omega-3 supplementation during lactation and in infancy may be beneficial on the growth and development of young children 6-24 months. These benefits are more prominent in malnourished children. (Hffman et al., 2011)

Furthermore, birth weight is the initial point for the growth in childhood. After birth, the child's health, illness, infection, and nutritional practices, primarily breastfeeding, are likely to influence growth (Barker, 2002; Demerath et al., 2007). In a systematic review by Ong et al., (2015) included 49 observational studies. Positive associations were found between birth weight and neurocognitive outcomes. As well, studies reported a poor postnatal growth is associated with adverse neurocognitive outcomes in preterm infants.

2.3 Historical background of growth charts

Growth charts construction passed through several phases over the past 100 years (Cole, 2012). Historically, their first appearance was in the late 18th century by Count Philibert de Montbeillard (1720-1785), who

started to plot his son's height on a chart to track his growth pattern from birth and every six months until the age of 18 (Cole, 2012).

Currently, there are two widely used sets of growth charts. The first one was developed by the CDC-USA and released in 2000. This set is a revised version of the National Center for Health Statistics (NCHS) growth charts that have been in use since 1977 (Kuczmarski et al., 2002). It is known as 2000 growth charts, and considered as a reference to describe the growth standards of the American children and adolescents and recommended for use in research and clinical practice (Kuczmarski et al., 2000).

In fact, the 2000 growth charts describe how typical USA children grow during a specific period. However, the typical growth patterns may not be the ideal (CDC, 2009). Furthermore, these charts do not consider the breastfed infant as the norm for growth. Moreover, the weight data were not available for the first months of age, besides that the sample sizes during the first 6 months of age were very small for age group and gender (CDC, 2009). This situation promoted the WHO to examine and reevaluate the accuracy of the NCHS curves-CDC growth charts and their appropriateness for the applications in communities from different genetic backgrounds (Heydari et al., 2008).

The second set of growth charts is the 2006-WHO charts. This set describes the growth standards of children based on the WHO Multicenter Growth Reference Study (MGRS), which was conducted between 1997 and 2003 (de Onis et al., 2004a). In particular, it included children from a diverse set of countries: Brazil, India, Ghana, Norway, Oman and the USA (WHO, 2006b). Besides the inclusion of children from different countries, the 2006-WHO growth charts have several other strengths. The set was based on healthy breastfed children who were living under conditions

likely to achieve full growth potential (WHO, 2006b). Moreover, the mothers of the selected children used for developing the standards were engaged in health-promoting practices, namely breastfeeding and being non-smokers (de Onis et al., 2004b).

2.4 Differences in child's growth pattern

Despite that, the International Growth Charts are being available and readily used as the benchmark standards for the anthropometric measurements of children (WHO, 2006a; Davies, 2007). Some researchers advocated construction of local charts based on national references for certain groups of a population instead of using international growth charts, due to an influence of genetic and ethnic factors on the children's growth and development in the first years of life (Guedes et al., 2010; Gleiss et al., 2013). In contrast, others claimed that until the fifth year of life, these factors are less important than the environmental factors to which the child was exposed (Schell et al., 2009). Therefore, growth pattern would be universal for any healthy population at this certain age.

Variations in growth patterns among different healthy populations have been a matter of concern of the diverse areas in public health research over the years. Many studies showed some deviations from the international mean standards (Indorf et al., 2001; Wikland et al., 2002). These deviations may be attribute to genetic, nutritional, environmental, cultural, economic or other differences (Parent et al., 2003; Freedman et al., 2006).

Some studies reported that significant differences in growth patterns existed even in the same county; these differences in growth patterns were obvious between different regions of Iran when compared with NCHS

curves. Studies carried out in Shiraz in 1996 showed that all corresponding centiles were lower than NCHS (Ayatollahi and Ahmadi, 2001). In contrast, another study conducted in Isfahan in 2003 showed that NCHS curve was well fit for children evaluation (Aminorroaya et al., 2003).

On the other hand, some other population-based studies found that the growth patterns among children are very similar to the CDC or 2006-WHO growth charts. For instance, Abdulrazzaq et al., (2008) found that children in UAE of the age 0-36 months follow the CDC growth standards in terms of weight for age and length/height for age. In comparison to the growth patterns of some countries involved in the 2006- WHO, these authors also found that the heights of UAE children in the first three years of life apparently mirrored those achieved by Brazilian children.

Furthermore, Kamal et al., (2008) compared the growth pattern of Qatari children from birth to 5 years old with 2006-WHO and CDC growth reference charts. These authors found that the nutritional status of a large proportion of Qatari children was normal or slightly above normal. Moreover, around 11%, 4.4%, of children were stunted, underweight, respectively. While 5.4% of the children were taller for their age.

Other studies concluded that the use of 2006-WHO or CDC growth charts might lead to misclassification of perfectly healthy and developing children as malnourished. For instance, Al-Mazrou et al., (2003) and El Mouzan et al., (2009) reported that the use of WHO or CDC growth charts for Saudi children led to overestimate the prevalence of nutritional disorders like underweight and stunting. Norris et al. (2009) reported that the 2006-WHO standards identified children from urban South Africa as being generally more stunted. Although, the 2006-WHO standards provided a good fit for length/height, they were more likely to misdiagnose

a large number of apparently normal children in developing countries as being stunted (Khadilkar 2010).

Moreover, a study conducted by Hof et al., (2011) found a difference in the birth weights of immigrant children compared to native Dutch. In addition, a study among Norwegian and Belgian children recommended that in terms of the growth contradictions, the locally developed growth standards were more preferable rather than the 2006-WHO growth standards (Juliussen et al., 2011).

Further, Bong et al., (2014) observed that by using the 2006-WHO standards, an additional 6.1% of Malaysian children were defined as stunted, with 7.1% as underweight, as compared to 2.2% for both underweight and stunting using their locally developed reference data. As well, about half of the Malaysian children exceeded the 50th percentile cut-offs of the 2006-WHO standards for height, while around one third for weight (Bong et al., 2014).

Around the same time, a large-scale recent meta-analysis study had examined the growth in healthy children around the world. Natale and Rajagopalan (2014) analyzed published studies from 55 countries using the 2006-WHO standards among approximately 11 million children. The study showed that weight and height curves may not be optimum and could not fit all cases. In addition, the differences between the national or ethnic group in terms of head circumference means were large enough to ensure that using the WHO charts would increase the risk of misdiagnosis for many children.

Something that is strongly recognized throughout the literature on growth charts that currently, there are no optimum growth charts can be applied across different ethnic and genetically diverse populations. Most

researchers, however, share the view that, there may be some differences between different population's growth patterns particularly children under 5 year and the CDC growth standards as well as 2006-WHO (Ayatollahi and Ahmadi, 2001; Al-Mazrou et al., 2003; El Mouzan et al., 2009; Hof et al., 2011; Juliusson et al., 2011; Bong et al., 2014; Natale and Rajagopalan (2014).

Historically, the Kingdom of Bahrain has often adopted and used many international guidelines, recommendations and standards. Such adaptation is, mainly due to practical reasons. The local implementation of the WHO growth charts comes in this context. Due to the different growth patterns associated with many variations in the kingdom of Bahrain, using others growth chart is not appropriate for screening Bahraini children and since no proper substitute for a country than having its own growth standards based on a representative sample of the population. Therefore, this study will evaluate the currently available data from the official records of the MOH and compare them in order to explore any deviation from the 2006-WHO.

CHAPTER 3

METHODS AND PROCEDURES

- 3.1 Target and study population
- 3.2 Source of data and ethical considerations
- 3.3 Sample size calculation
- 3.4 Sampling criteria
- 3.5 Inclusion and exclusion criteria
- 3.6 Practice of filling child's record
- 3.7 Setting of data collection
- 3.8 Data cleaning
- 3.9 Statistical analysis
- 3.10 Sources of dataset used for comparison

CHAPTER 3: METHODS AND PROCEDURES

3.1 Target and study population

The present cross-sectional study was carried out in Bahrain in 2018 among infants and young children. The targeted population included healthy (37-42 gestational weeks) children which are Bahrainis from both genders, among whom born in 2014 and had completed 2 years prior to commencing the study. Hence, children from zero to 2 years served as the target population for this study.

3.2 Source of data and ethical considerations

The present cross-sectional study was carried out using records of the Mother and Child Health Department (MCH) of the Ministry of Health (MOH), the Kingdom of Bahrain, as the primary source of data from five (5) health centers. Upon approval of the research project proposal by the University of Bahrain (Appendex-3), an ethical approval from the MOH was sought from and granted by the Research Technical Support Team (RTST, MOH). Subsequently, an official permission was obtained from the MCH to access the required data from the child and student health record of the MOH (Appendix-4).

The child's records were used as the primary source of information for this study in order to follow the growth pattern for children. It includes information which is recorded by the MCH in the primary care, related to growth and physiological development, clinical history, and the type of feeding as well as other related information.

Some data were missing specifically at 18 months and 2 years, due to the administrative transition from the manual procedures to using (I-SEHA) electronic system for child screening in 2016. Hence, certain information's were obtained from the system to fulfill the missing data and it was considered as the supplemental source of information.

3.3 Sample size calculation

Sample size of the targeted population was determined by using the following equation (Lindell and Whitney, 2001):

$$\text{Sample size} = \frac{Z_{1-\alpha/2}^2 p (1-p)}{d^2}$$

Where:

$Z_{1-\alpha/2}$ = is a standard normal varieties (at 5% type 1 error ($P < 0.05$) it is 1.96 and at 1% type, 1 error ($P < 0.01$) it is 2.58. As in a majority of studies, P values are considered significant below 0.05 hence 1.96 is used in formula.

P = Expected proportion of event of interest for the study.

D = Absolute error or precision – Has to be decided by a researcher.

According to the available numbers, it was anticipated to have a sample of ~ 400 subjects. However, 50 additional subjects were considered to compensate for incomplete records and cases with missing information.

3.4 Sampling tanique

The sample was selected by using multistage stratified random sampling technique of a representative sample from each of the five health regions of Bahrain (MOH, 2015). Where, the catchment area of the health

regions covers the four governorates (Capital, Northern, Southern, and Muharraq). There are 28 governmental Health Centers distributed around the country (MOH, 2015). Based on this, one Health Center from each health region was selected conveniently and treated as the primary sampling unit (PSU); hence, there was five PSUs or strata.

Each PSU was sampled with a probability proportional to its population size based on the registered live births by Health Region / Health Center, sex and nationality as reported by information of Ministry of Health's statistics 2014 (Appendix-2). The sample size selected from each designated Health

Center was determined according to the following formula:

$$\frac{N_{HC}}{N_T} \times n$$

Where;

N_{HC} = is the population size in the Health Center.

N_T = is the total population of all selected Health Center.

n = is the required sample size.

Thus, the distribution of sample size according to the selected Health Centers was:

- 55 subject from NBB Arad Health Center (Health Region 1)
- 53 subjects from Bilad Alqadeem Health Center (Health Region 2)
- 82 subjects from A-Ali Health Center (Health Region 3)
- 81 subjects from Sitra Health Center (Health Region 4)
- 134 subjects from Budayia Health Center (Health Region 5)

Further, the selected sample from each health center was stratified according to the child's gender (second-stage sampling), the sample size of each gender was determined according to the following formula:

$$\frac{N_i}{N_{HC}} \times n_{HC}$$

Where;

N_i = is population size of males or females in the Health Center.

N_{HC} = is the population size in the Health Center.

n_{HC} = is the sample size selected from the Health Center.

Accordingly, the distribution of sample size according to the gender was:

- 27 males and 28 females from NBB Arad Health Center.
- 28 males and 25 females from Bilad Alqadeem Health Center.
- 45 males and 38 females from A-Ali Health Center.
- 41 males and 40 females s from Sitra Health Center.
- 67 males and 66 females from Budayia Health.

The child's booklets used to be kept on shelves inside the MCH Department and splitted by year of birth and gender. A systematic random sample, proportional to the size of each gender, was withdrawn from each health center (third-stage sampling).

3.5 Inclusion and exclusion criteria

Selection of subjects was based on the following inclusion criteria:

- Bahraini nationality of Bahraini parents (to prevent growth variations which attributed to genetic factors)

- Healthy (without any serious health conditions)
- Gestational age (Kirby, 2019):
 - Between 37 weeks, 0 days and 38 weeks, 6 days (Early term).
 - Between 39 weeks, 0 days and 40 weeks, 6 days-42 (Full term).
 - Between 41 weeks, 0 days and 41 weeks, 6 days (Late term)
- Born in 2014

Each child record was observed tentatively, and several exclusions were made before the selection of the subjects. Initially, any record with at least one-visit defaulter and have many missing data were excluded. Thereafter, pre-term infants who born prior 37 weeks of pregnancy and considered as very low birth-weight (VLBW) infants (<1,500 grams) were excluded. Primarily because the growth pattern of VLBW infants is known to be markedly different compared to full-term infants with a higher birth-weight.

The child diseases history was surveyed, if had any disease and/ or health complications after delivery that could affect their growth pattern such as anemia other than iron-deficiency anemia for instance sickle-cell anemia, diabetes mellitus, congenital malformations, debilitating chronic diseases like asthma, any hereditary disease like different types of thalassemia, and severe jaundice which required phototherapy were excluded.

3.6 Practice of filling child's record

Administratively, each HC is considered as an independent unit responsible for keeping and maintaining health records belonging to

infants and children resides in their officially recognized and specified areas.

A health record is opened for each newly born child. During a typical visit, each child is physically examined, weighed and measured by well-trained health professionals (MCH nurses and physicians). Vaccinations are also given according to a schedule. These visits are scheduled at specific age intervals, every 2 months for the first half year of life, and every 3 months in the second half. During the second year, the interval is extended to 6 months. Hence, the normally scheduled visits for a typical child are at 2, 4, 6, 9, 12, 18 and 24 months.

Data on socio-demographic characteristics of each child and parents, child's weight to the nearest 0.1 grams and recumbent length/ standing height to the nearest 0.1 centimeters, which was recorded at 0, 2, 4, 6, 9, 12, 18, 24 months, and the calculated body mass index = $\text{weight (kg)} / \text{height (m)}^2$ were collected.

The infant's weight was measured in supine position by electronic infant scales. Recumbent length was measured by a special headboard with other movable board for more accuracy. Once child can stand, the weight and height were measured by special digital scale with stadiometer.

In addition to hemoglobin level (Hb g/dl) at 9 months, and feeding practices especially from birth to 6 months; breastfed children for at least 4 months exclusively accompanied with a complementary feeding after 4 months and/ bottle-fed children with a complementary feeding after 4 months.

3.7 Setting of data collection

Data were personally collected by the researcher from each of the designated health centers during a period of one month (April 2018). A prior arrangement with the administration of each HC was sought, and dates were scheduled for visits.

A pre-designed Excel sheet (Microsoft) was used to collect information from the randomly selected children (see Appendix-5). The excel sheet was designed as a table consisting of two major parts. The first part was dedicated to collect the demographic characteristics of both child and their parents including, date of birth, child's history, gestational age, type of delivery, and weight at birth, child's rank in their families, mother's age, and mothers and father's occupation and educational level.

The second part was dedicated for collecting the anthropometric data (weight, height and BMI), and feeding practices (breastfeeding/ bottle feeding/both types, and complementary feeding) at each specified age (2, 4, 6, 9, 12, 18, and 24 months), and hemoglobin level at the age of 18 months.

Usually, each child is typically examined, weighed and measured by attendant health professionals (MCH nurses and physicians) during the scheduled visits for child screening and vaccinations.

For each selected subject, the required information that were registered in the child booklets, were extracted from child booklets, collected and tabulated in the Excel spreadsheet.

Data on socio-demographic characteristics of each child and parents, child's weight and recumbent length/ standing height for each time interval, and the calculated BMI were collected.

3.8 Data cleaning

Entered data were carefully checked for errors and invalid entries. Missing data of length at birth was observed in some of the selected subjects, most of them referred to one of the primary sampling units (PSU)/health centers. Missing values analysis was implemented for the determination of the number and the distribution of those missing values. In order to decide how to handle missing data, it was helpful to know why they are missing. In our case, missingness depends on unobserved predictors, it considered not “at random”, because it depends on information that has not been recorded (Galimard et al., 2018).

Variety of approaches are commonly used to deal with missing data. These include; for instance, replacing missing values with values, which are imputed from the observed data (mean substitution/ multiple imputations), using a missing category indicator and last value carried forward approach, which used to replace missing values with the last measured value (Carpenter and Kenward, 2008). In general, if data were MNAR, the mechanism of missingness may not be ignored (Pasteels, 2013), analysis of only available data would be biased, and missing values can be replaced by multiple imputations with estimates based on information from correlated variables (Donders et al., 2006). In addition, multiple imputations of between-study parameters may virtually improve the estimation, validation and development of prediction models of systematically missing predictors in Individual participant data in meta-analyses (Jolani et al., 2015).

Although, Sterne et al., (2009) found that none of these approaches is statistically valid, and they can be a serious source of bias. Moreover, data values that are MNAR cannot be reliably estimated from other variables, unless the missingness mechanism is known, which is

uncommon. Although multiple imputation approach can give some protection against MNAR mechanisms, identifying and controlling for such mechanism can be very challenging (Schafer and Graham, 2002; Groenwold et al., 2012).

Hence, the Pairwise Deletion approach (available-case analysis) was used to deal with missing values in this study. Pairwise deletion disregards missing values only when the particular data-point needed to test a particular assumption and available values are used in the statistical testing. (Kang, 2013). This approach attempts to minimize the loss of cases and maximizes all data available by analysis basis; it also increases the power in the analyses (Le Roux and Rouanet, 2010).

In addition, outliers were detected in weight, length, and BMI for both genders using Z-scores. According to WHO criteria, values with 3 SD (Z-score) considered outlier and was excluded. Thereafter, the clean dataset was used to calculate the LMS, centiles, and Z-score (see appendix-6 for outliers detecting details).

3.9 Statistical analysis

Data were statistically analyzed using SPSS (version 23.0, Chicago, IL, USA) accordingly to find out the outcomes. The charts were constructed by LMSchartmaker pro (version 2.54) and Microsoft excel 2016.

Frequencies and percentages were computed for the categorical variables including; gender, child's demographic characteristics like child history, gestational age, child rank, and type of delivery, parent's demographic characteristics like education level, occupation, living status, and parents living. Mean, standard deviation (SD), and the 3rd, 10th, 25th,

50th, 75th, 90th, and 97th age sex specific percentiles, and the corresponding Z-score values of (-3), (-2), (-1), (+1), (+2), and (+3) Z-scores were computed for the quantitative variables including weight, length/height, and BMI.

The L, M, and S method was applied for developing of smoothed charts (Flegal and Cole, 2013). It is a comprehensive method for an efficient calculation of z scores (Flegal and Cole, 2013). At each age, the distribution is characterized by *L* (the skewness) as well as by *M* (the median of the data) and *S* (the generalized coefficient of variation). Curves were smoothed and constructed by using LMSchartmaker (Appendix-6). Given these parameters, any percentile value can be calculated by the following equations:

$$X = M (1 + LSZ)^{1/L}; L \neq 0,$$

or

$$X = M \exp(SZ); L = 0$$

Where;

X = is the value of the anthropometric variable.

Z = is the required percentile in standard deviation units.

In contrast, for any given value of percentiles (*X*), the corresponding z-score (*Z*) can be calculated as:

$$Z = [(X/M)^L - 1]/LS; L \neq 0,$$

or

$$Z = \ln(X/M)/S; L =$$

Collected anthropometric measurements was assessed based on the WHO reference data in order to determine the prevalence of malnutrition

(WHO, 2007). For the purpose of description, data were analyzed accordingly using means $\pm$ standard deviations and percentages. For interpretation purpose, Z-scores were used for the classification of under and over nutrition. The odd ratio (OR) $p \leq 0.05$ was used to determine the statistical significant differences in each class. As well, Pearson chi-square test $p \leq 0.05$ was used to find statistical difference with child's and parents demographic characteristics.

For interpretation purpose, undernourished children (those below -2 standard deviations of the median reference of length/ height for-age, weight-for-age, and weight-for-length/height) were defined as stunted, underweight, and wasted, respectively. Z-scores of larger negative indicates higher levels of under-nutrition. In contrast, over-nourished children (those above 2 standard deviations of the median reference of weight-for-length/ height and BMI-for-age (BMIZ) were defined as overweight and obese (De Onis et al., 2007). The Z-scores cutoffs according to WHO as are shown in Table (1). Prevalence of anemia was determined by the definition, which set forth by the WHO (Hb < 11 g/dl) (Joo et al., 2016).

Student t-test was used to determine whether there is a significant difference in means of two groups if sample size in each group is more than 30. The test statistic is calculated as (Kim, 2015):

$$t = d / \sqrt{s^2/n}$$

Where:

$\bar{d}$ is the mean difference,

s^2 is the sample variance,

n = is the sample size and t is a Student t quantile with n-1 degrees of freedom.

ANOVA test was used to determine whether there is a significant difference in means of more than two groups if sample size in each group is more than 30. Below mentioned formula represents one way ANOVA test statistics (Kim, 2014):

$$F = \frac{MST}{MSE}$$

Where;

F = Anova Coefficient

MST = Mean sum of squares due to treatment

MSE = Mean sum of squares due to error.

Formula for MST is given below:

$$MST = \frac{SST}{p-1}$$

$$SST = \sum n(x - \bar{x})^2$$

Where;

SST = Sum of squares due to treatment

p = Total number of populations

n = The total number of samples in a population. Formula for MSE is given below:

$$MSE = \frac{SSE}{N - p}$$

$$SSE = \sum (n - 1) S^2$$

Where;

SSE = Sum of squares due to error

S = Standard deviation of the samples

N = Total number of observations.

To determine whether there is a significant difference in means of two groups if sample size in at least one group is less than 30, Mann Whitney U test was used. Calculation of the Mann-Whitney U by the following formula (Hart 2001):

$$U = n_1 n_2 + \frac{n_2 (n_2 + 1)}{2} - \sum_{i=n_1+1}^{n_2} R_i$$

Where;

U=Mann-Whitney U test

N₁ = sample size one

N₂= Sample size two

R_i = Rank of the sample size

The Kruskal-Wallis test was used to determine whether there is a significant difference in means of more than two groups if sample size in at least one group is less than 30. This test can be calculated by the following formula (Bewick et. al., 2004) after sorting data by descending order and ranking the sorted data and the third step is to add up the different ranks for each group/sample:

$$H = \left[\frac{12}{n(n+1)} \sum_{j=1}^c \frac{T_j^2}{n_j} \right] - 3(n+1)$$

Where;

n = sum of sample sizes for all samples,

c = number of samples,

T_j = sum of ranks in the j^{th} sample,

n_j = size of the j^{th} sample.

Thereafter, we can find the critical chi-square value, and finally compare the H value from with the critical chi-square value.

To compare and determine whether there is a significant relationship between two categorical variables, the Chi-Square test was used. The formula for the chi-square statistic used in the chi square test is (McHugh, 2013):

$$\chi^2 = \sum \frac{(O_i - E_i)^2}{E_i}$$

Where;

χ^2 = is the Chi Square,

O_i = is the Observed (actual) value

E_i = the Expected value.

Pearson's Correlation Coefficient was used to measure the correlation between two quantitative variables. In all statistical tests, it can be calculated by the following formula (Mukaka, 2012):

$$r = \frac{\sum_i (x_i - \bar{x})(y_i - \bar{y})}{\sqrt{\sum_i (x_i - \bar{x})^2} \sqrt{\sum_i (y_i - \bar{y})^2}}$$

Where;

r = is the Pearson r correlation coefficient

N = number of observations

$\sum xy$ = sum of the products of paired scores

$\sum x$ = sum of x scores

$\sum y$ = sum of y scores

$\sum x^2$ = sum of squared x scores

$\sum y^2$ = sum of squared y scores

The p -value < 0.05 was considered significant.

Significant differences in linear growth between MGRS and Bahrain study's populations was examined by adopting the WHO cut-off, which consider (> 0.5 SD) as a benchmark for clinical significance (WHO, 1995; WHO, 2006). However, smaller and consistent differences that was 0.25–0.49 SD from the MGRS mean could be considered, because less than 0.5 SD could not be an optimal definition for not significance.

Table (1): A Summary of definitions of growth problems in terms of Z-scores

Z-score (SD)	Growth Indicators			
	Length/Height for –age	Weight-for-age	Weight –for- length/height	BMI-for-age
Above 3	Very tall		Obese	Obese
Above 2			Overweight	Overweight

Above 1			Possible risk of overweight	Possible risk of overweight
0 (median)				
Below -1				
Below -2	Stunted	Underweight	Wasted	Wasted
Below -3	Severely Stunted	Severely underweight	Severely wasted	Severely wasted

*World Health Organization,
2017

3.10 Sources of datasets used for comparison

Two sets of data were used for comparison purpose(s); the first is the WHO data of growth charts for the age of 0-2 years (https://www.cdc.gov/growthcharts/who_charts.htm), and the Saudi Arabia set of data was obtained from Prof. El-Mouzan by personal communication (with Dr. A. Ameer Allaith).

CHAPTER 4

RESULTS

- 4.1 Sample size
- 4.2 Demographic characteristics
- 4.3 Growth parameters
- 4.4 LMS curves
- 4.5 Weight, length, BMI centiles of Bahraini males and females
- 4.6 Comparison between Bahraini and MGRS measurements
- 4.7 Comparison between Bahraini and Saudi measurements
- 4.8 Percentiles and z-scores tables
- 4.9 Relationships between gestational age, birth weight, and Hb
- 4.10 Feeding practices
- 4.11 Nutritional status
- 4.12 Discussion
- 4.13 Recommendations

CHAPTER 4: RESULTS

4.1 Sample size

This study included 428 children aged between zero to 2 years selected from 5 governmental health centers representing the targeted population of the study. Twenty-five of the originally selected subjects were excluded due to non-compliance with the inclusion criteria. Of which, 23 subjects were preterm (gestational age < 37 weeks) and two had a hereditary disease (B-Thalassemia). A total of 403 subjects (210 males and 193 females) remained and included in the analysis as shown in Figure (1).

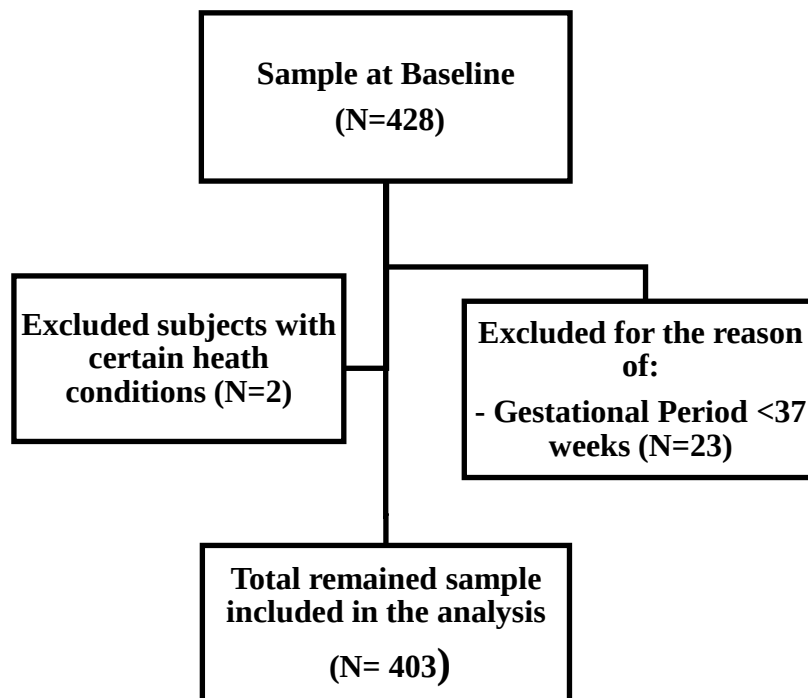


Figure 1: A flow chart, representing the selection of the study samples.

4.2 Demographic characteristics

Table (2) shows the distribution of sample size according to the recruited health centers. The highest proportion was recruited from Budayia health center (31.8%).

Table (2): The distribution of sample size according to health centers

Health Center	N	%
A ‘Ali	82	20.3
Arad (NBB)	56	13.9
Bilad Al-Qadeem	55	13.6
Budayia	128	31.8
Sitra	82	20.3
Total	403	100

Table (3) shows are the demographic characteristics of the subjects. Gender within the sample size was roughly equally distributed between males (52.1%) and females (47.9%). Most of the subjects were a single child (97.4%) of which, 97.6% of males and 99.0% of females, while only 2.6% were twins. The majority were normally delivered “vaginal” (79.9 %). 22.5% were a first child, 28.0% were a second child, while 25.7% were a third child in their families.

Table (3): Distribution of demographical characteristics among males and females

Variable	Level	Males		Females		Total	
		N	%	n	%	n	%
Gender		210	52.1	193	47.9	403	100
Child History	Single	205	97.6	191	99.0	396	98.3
	Twin	5	2.4	2	1	7	1.7
Type of delivery	Vaginal	165	78.9	156	80.8	321	79.9
	LSCS*	44	21.1	37	19.2	81	20.2
Child rank	First	42	20.1	48	24.9	90	22.5
	Second	67	32.1	46	23.8	113	28.0
	Third	52	24.9	51	26.4	103	25.7
	Fourth	24	11.5	29	15	53	13.3
	Fifth or more	24	11.5	19	9.8	43	10.7

* Lower segment caesarian section

Data on demographic characteristics of child’s parents showed that 60.5 % and 39.3% of infant’s mothers and father, respectively; were highly educated and had achieved a university education (Table 4).

Approximately, 35.6% of mothers were employed in contrast to 78.2% of fathers. With regard to social status, most of the children's parents were living together (99.5%) as a nuclear family (72.5%) (Table 4).

Table (4): Distribution of parent's demographical characteristics according to gender

Variable	Level	Males		Females		Total		Chi-square test
		N	%	N	%	N	%	P-value
Mother occupation	Employed	62	34.8	66	36.3	128	35.6	0.356
	Unemployed	110	61.8	112	61.5	222	61.7	
	Other	3	1.7	0	0.0	3	0.9	
	Student	3	1.7	4	2.2	7	2.0	
Mother education	Primary	3	1.4	0	0.0	3	0.7	0.067
	Intermediate	5	2.4	13	6.8	18	4.6	
	Secondary	73	34.9	64	33.5	137	34.2	
	University	128	61.2	114	59.7	242	60.5	
Father occupation	Employed	152	80.4	136	76.0	288	78.2	0.576
	Unemployed	5	2.6	5	2.8	10	2.7	
	Other	32	16.9	37	20.7	69	18.8	
	Student	0	0.0	1	0.6	1	0.3	
Father education	Primary	2	1.0	3	1.6	5	1.3	0.079
	Intermediate	29	14.1	22	11.6	51	12.9	
	Secondary	92	44.9	91	48.1	183	46.5	
	University	82	40.0	73	38.6	155	39.3	
Parents living	Together	195	99.5	154	99.4	349	99.5	0.689
	Separated	1	0.5	1	0.6	2	0.6	
Housing status	Nuclear Family	121	74.2	87	70.7	208	72.5	0.299
	Expanded Family	42	25.8	36	29.3	78	27.6	

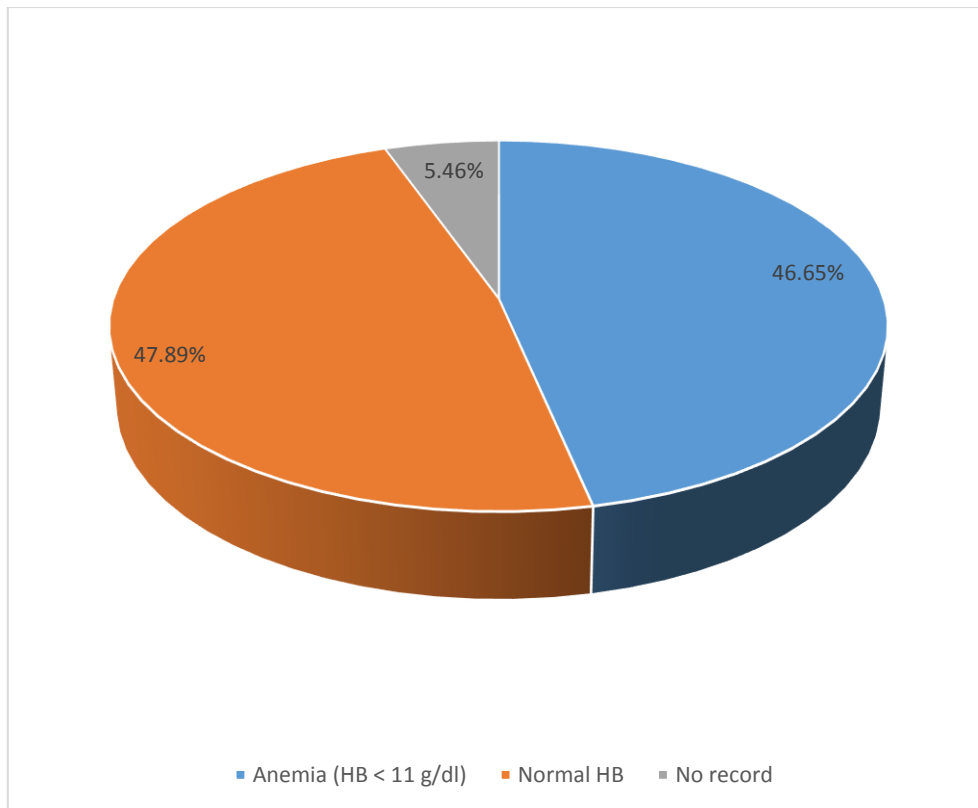


Figure 2: Percent of anemic subjects based on hemoglobin concentration (Hb) among children of both genders at 9 months.

A large proportion of the recruited sample children (46.65%) had a low Hb anemia as shown in figure (2). Less than one half the sample exhibited a normal blood Hb (47.89%).

4.3 Growth parameters

Mean weight, length, and BMI of newborn males were 3.2 ± 0.4 kg, 49.7 ± 2.3 cm, 13.2 ± 1.6 kg/m², and for females were 3.1 ± 0.4 kg, 48.8 ± 2.06 cm, and 12.8 ± 1.5 kg/m², respectively (Table 6). At 24 months, the mean weight, length, and BMI for males were 12.4 ± 1.4 kg, 88.11 ± 3.8 cm, and 16.0 ± 1.5 kg/m², respectively; for females, they were 12.0 ± 1.7 kg, 87.3 ± 4.3 cm, and 15.6 ± 1.7 kg/m² (Table 5).

Table (5): Comparison between means of weight (kg), length (cm), and BMI according to gender

Variable	Age (months)	Males			Females			t- test P-value
		n	Mean	SD	n	Mean	SD	
Weight	0	205	3.2	0.5	193	3.1	0.5	0.000
	2	210	5.5	0.6	193	5.0	0.6	0.000
	4	209	7.0	0.8	193	6.4	0.8	0.000
	6	210	8.0	0.9	192	7.4	0.9	0.000
	9	210	9.2	1.1	192	8.5	1.1	0.000
	12	208	10.0	1.2	193	9.4	1.3	0.000
	18	209	11.5	1.4	193	10.8	1.6	0.000
	24	210	12.4	1.4	193	12.0	1.8	0.004
Length	0	136	49.7	2.3	123	48.8	2.1	0.001
	2	210	57.2	2.2	193	55.8	2.0	0.000
	4	209	62.9	2.3	193	61.4	2.3	0.000
	6	209	67.2	2.3	192	65.4	2.5	0.000
	9	210	71.9	2.8	191	70.3	2.7	0.000
	12	209	76.0	2.9	193	74.4	3.2	0.000
	18	209	82.7	3.3	193	81.5	3.4	0.000
	24	210	88.1	3.9	193	87.3	4.3	0.044
BMI	0	136	13.2	1.7	123	12.9	1.5	0.078
	2	210	16.7	1.5	193	16.0	1.6	0.000
	4	209	17.6	1.8	193	16.9	1.8	0.000
	6	209	17.7	1.8	192	17.4	1.9	0.043
	9	210	17.8	1.7	191	17.2	1.8	0.001
	12	208	17.4	1.6	193	17.0	1.7	0.021
	18	209	16.8	1.7	193	16.2	1.8	0.001
	24	210	16.0	1.5	193	15.7	1.8	0.039

Overall, mean weight, length, and BMI of males were slightly higher than of females in all ages with a statistically significant difference between the means ($P \leq 0.05$), except the mean BMI at birth (Table 5).

ANOVA test showed a significant difference ($p \leq 0.05$) in terms of mean length between the health centers at the following ages: 2, 4, 6, 9, 12 months, but not at birth, 18 months, and at 24 months. For the mean BMI, there is a significant difference ($p \leq 0.05$) between health centers at birth and 24 months only. As for mean weight, there is no significant difference found between health centers except at birth (Table 6).

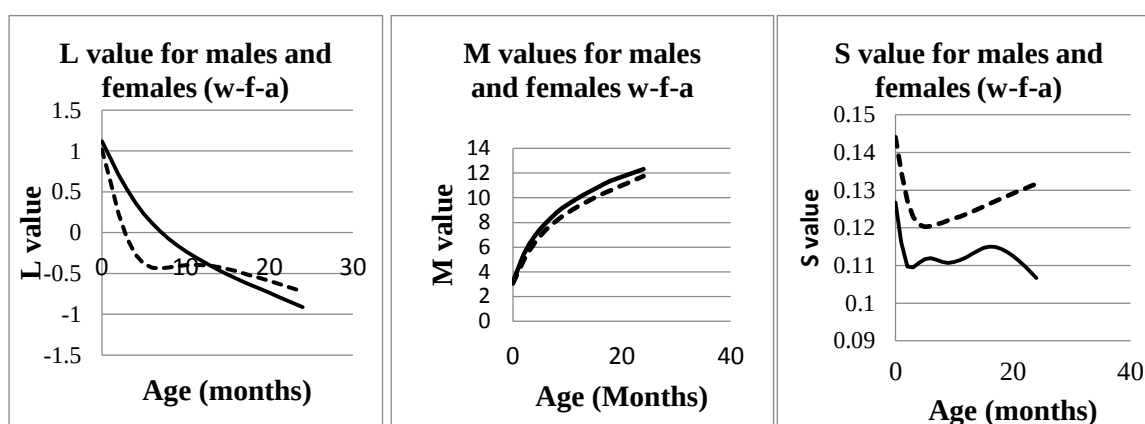
Table (6): Means of weight (kg), length (cm), and BMI according to health centers

Variable	Age (months)	A 'Ali		Arad		Bilad Alqadeem		Budayia		Sitra		ANOVA P-value
		Mean	SD	Mean	SD	Mean	SD	Mean	SD	Mean	SD	
Weight (kg)	0	3.1	0.5	2.9	0.5	3.2	0.53	3.2	0.4	3.3	0.5	0.001
	2	5.1	0.6	5.2	0.6	5.3	0.60	5.3	0.7	5.3	0.7	0.191
	4	6.5	0.9	6.8	0.9	6.7	0.76	6.7	0.8	6.8	0.9	0.380
	6	7.6	1.00	7.9	1.0	7.7	0.96	7.7	0.9	7.8	1.1	0.637
	9	8.8	1.1	9.00	1.1	8.8	1.12	8.9	1.1	8.9	1.2	0.845
	12	9.6	1.1	10.1	1.4	9.8	1.22	9.7	1.3	9.7	1.3	0.319
	18	11.1	1.3	11.6	1.7	11.3	1.73	11.1	1.5	11.1	1.5	0.326
	24	12.1	1.3	12.6	1.9	12.3	1.69	12.2	1.6	12.1	1.5	0.292
Length (cm)	0	49.3	2.9	.*	.*	49.5	2.03	48.8	2.1	49.8	1.8	0.073
	2	55.9	2.0	56.9	2.0	57.5	2.32	56.1	2.4	57.0	2.1	0.000
	4	61.4	2.4	62.8	2.4	62.8	2.15	61.8	2.5	62.8	2.3	0.000
	6	65.4	2.4	66.7	2.6	66.9	2.55	66.1	2.6	66.8	2.3	0.001
	9	70.1	2.5	71.5	2.9	71.4	2.83	71.1	3.2	71.6	2.6	0.007
	12	74.3	2.8	76.1	2.9	75.6	3.17	75.2	3.5	75.2	2.8	0.012
	18	81.8	3.5	83.1	3.5	82.1	3.55	82.4	3.5	81.5	2.7	0.062
	24	87.0	3.3	89.8	4.6	87.1	3.64	88.6	4.3	86.2	3.4	0.000
BMI (kg/cm)	0	12.6	1.5	.*	.*	13.3	1.83	13.2	1.5	13.2	1.5	0.042
	2	16.3	1.3	16.1	1.6	16.0	1.60	16.7	1.7	16.3	1.7	0.055
	4	17.3	1.9	17.1	1.6	16.9	1.67	17.6	1.8	17.1	1.8	0.131
	6	17.8	2.0	17.7	1.8	17.2	1.87	17.6	1.8	17.5	2.1	0.501
	9	17.8	1.8	17.6	1.8	17.3	1.78	17.6	1.7	17.3	1.8	0.353
	12	17.4	1.5	17.4	1.7	17.1	1.65	17.1	1.6	17.2	1.6	0.560
	18	16.5	1.6	16.7	2.0	16.7	1.94	16.4	1.7	16.6	1.7	0.656
	24	16.0	1.5	15.6	1.9	16.1	1.51	15.5	1.7	16.1	1.5	0.013

*Missing data in length at birth of 56 subject in NBB Arad health center

4.4 LMS Curves

Shown in Figures 3 to 6 are the calculated smoothed LMS values (curves) for w-f-a, l-f-a, BMI-f-a, and w-f-l of Bahraini infants and children. These values were obtained as a result of using LMSchartmaker for generating and smoothing LMS values in order to be used for producing the growth charts (percentiles) of Bahraini infant and children of both genders males and females (0-24 months) that are presented in the next



section.

Figure 3: LMS curves of weight for age among Bahraini infants and children of both genders (0-24 months). Males (—) and females (- - -).

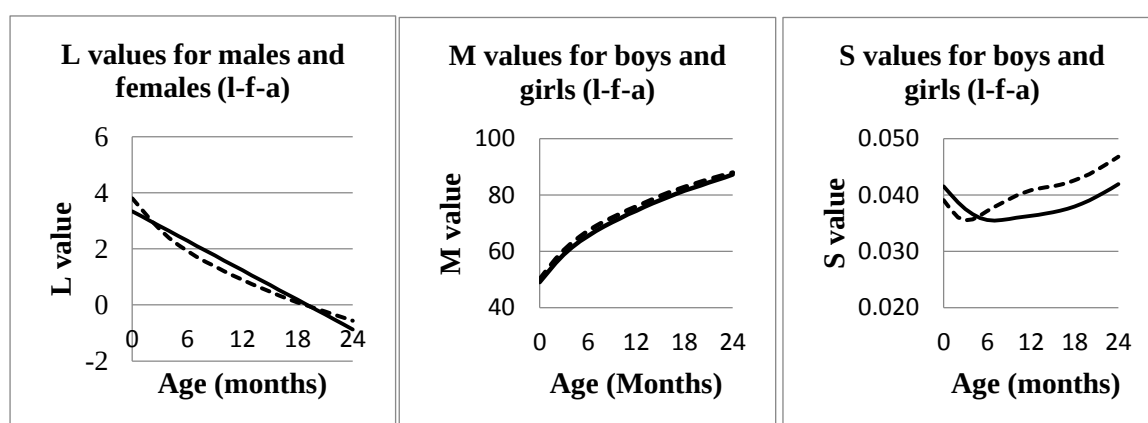


Figure 4: LMS curves of length for age among Bahraini infants and children (0-24 months). Males (—) and females (- - -).

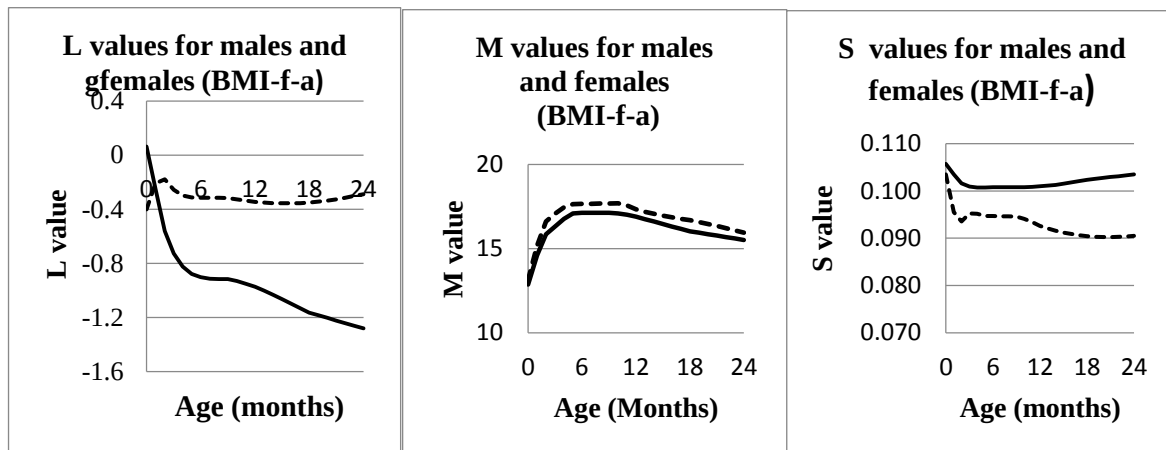


Figure 5: LMS curves of BMI for age among Bahraini females and males (0-24 months). Males (—) and females (- - -).

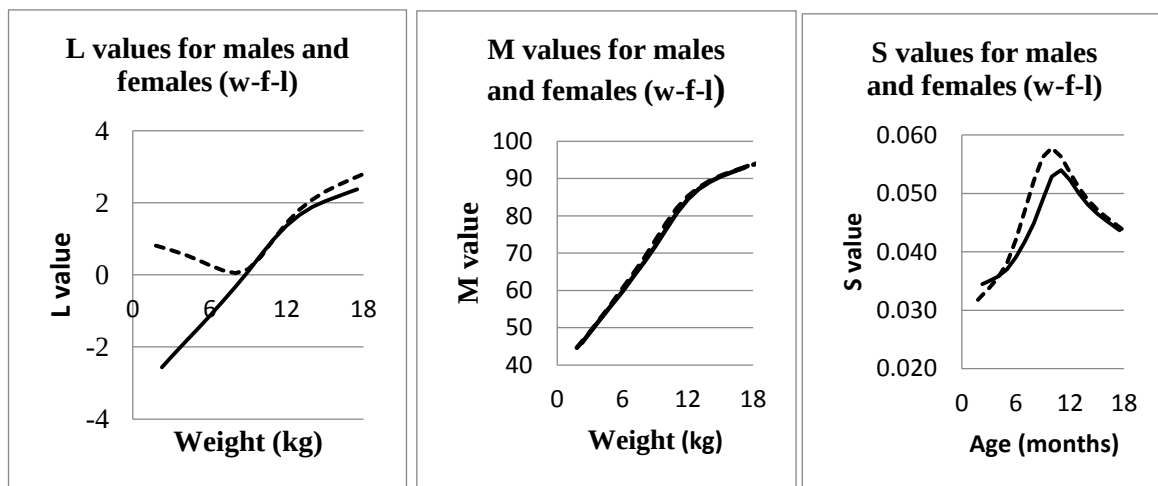


Figure 6: LMS curves of weight for length among Bahraini females and males (0-24 months). Males (—) and females (- - -).

4.5 Weight, length, BMI centiles of Bahraini males and females

The smooth centiles of weight, length, and BMI among females and males aged from (0 - 24 months) are shown in Figures (7) to (11).

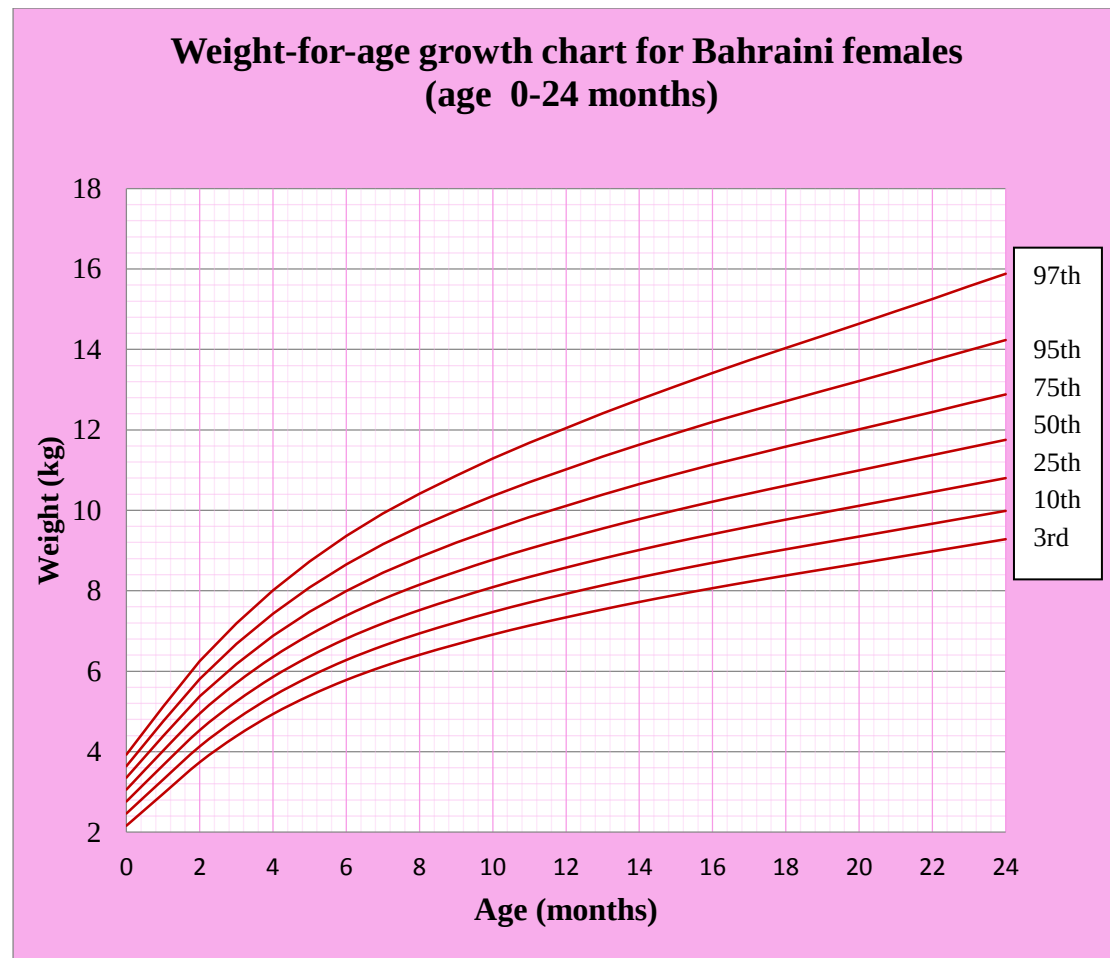


Figure 7: Weight for age percentiles among Bahraini females (0-2 years)

Figure (7) shows the weight for age percentiles of 0-24 months Bahraini females, the weight of females have shown an increase by age.

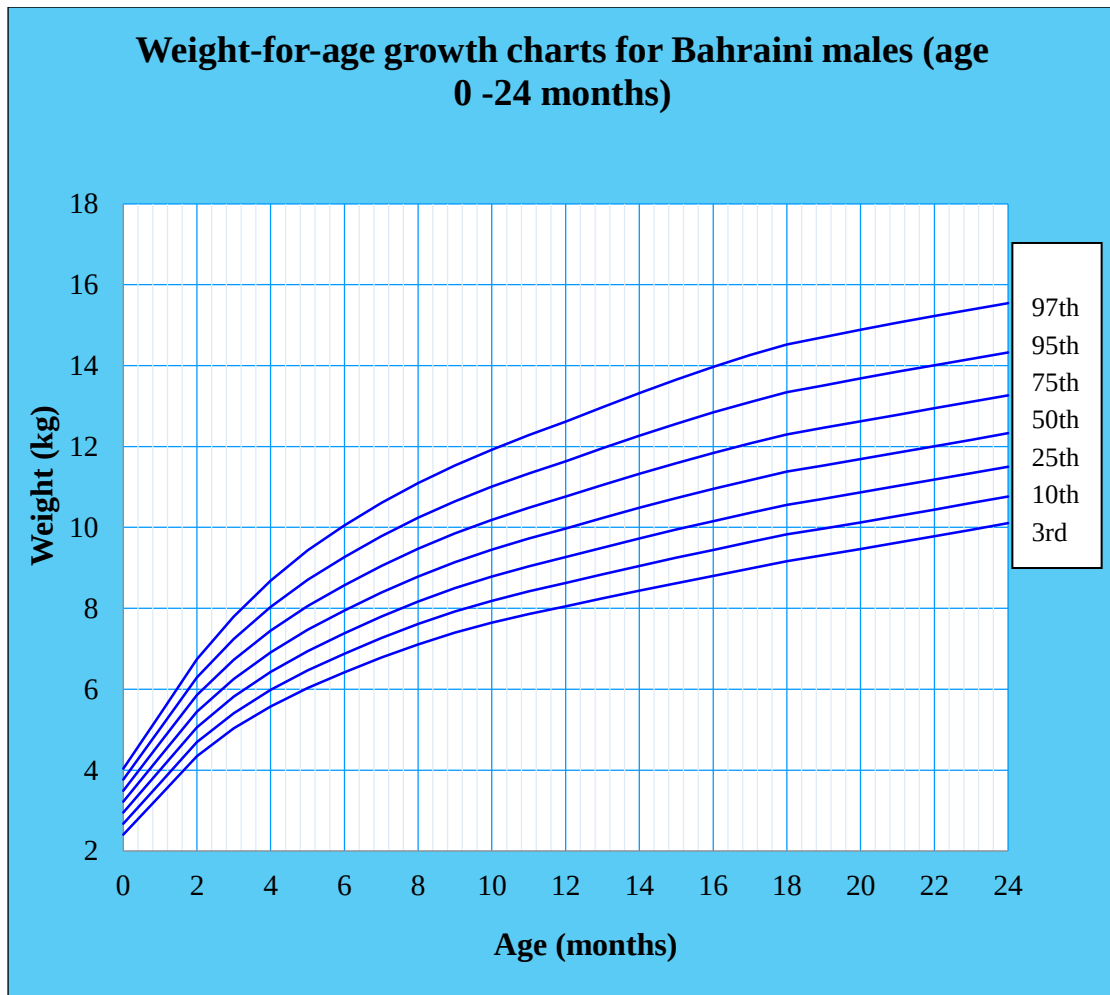


Figure 8: Weight for age percentiles among Bahraini males (0-2 years)

Figure (8) shows the weight for age percentiles of 0-24 months Bahraini males, it indicates that the weight of males have had increased by age.

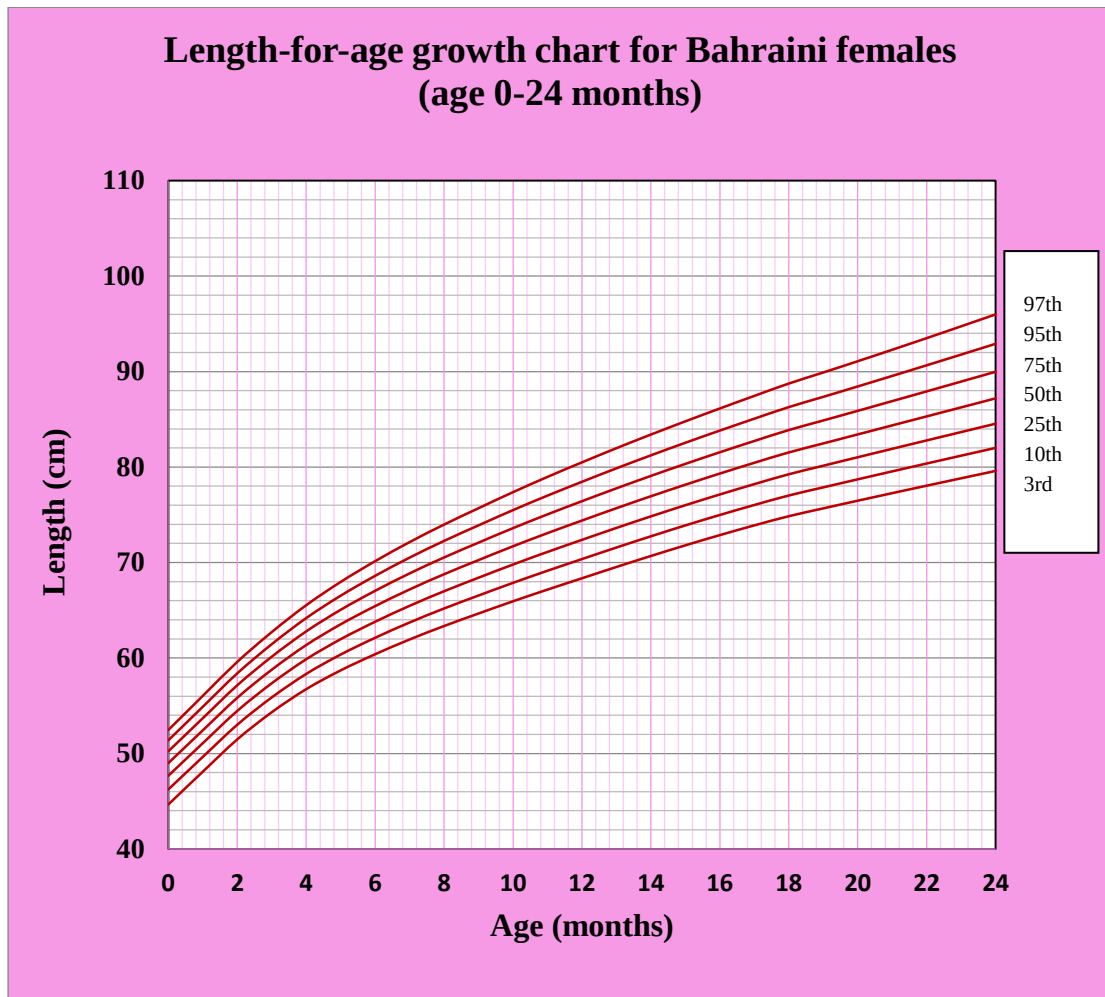


Figure 9: Length for age percentiles among Bahraini females (0-24 months)

Length for age percentiles of Bahraini females (0-24 months) is shown in Figure 9, the length of females also increased by age up to two years.

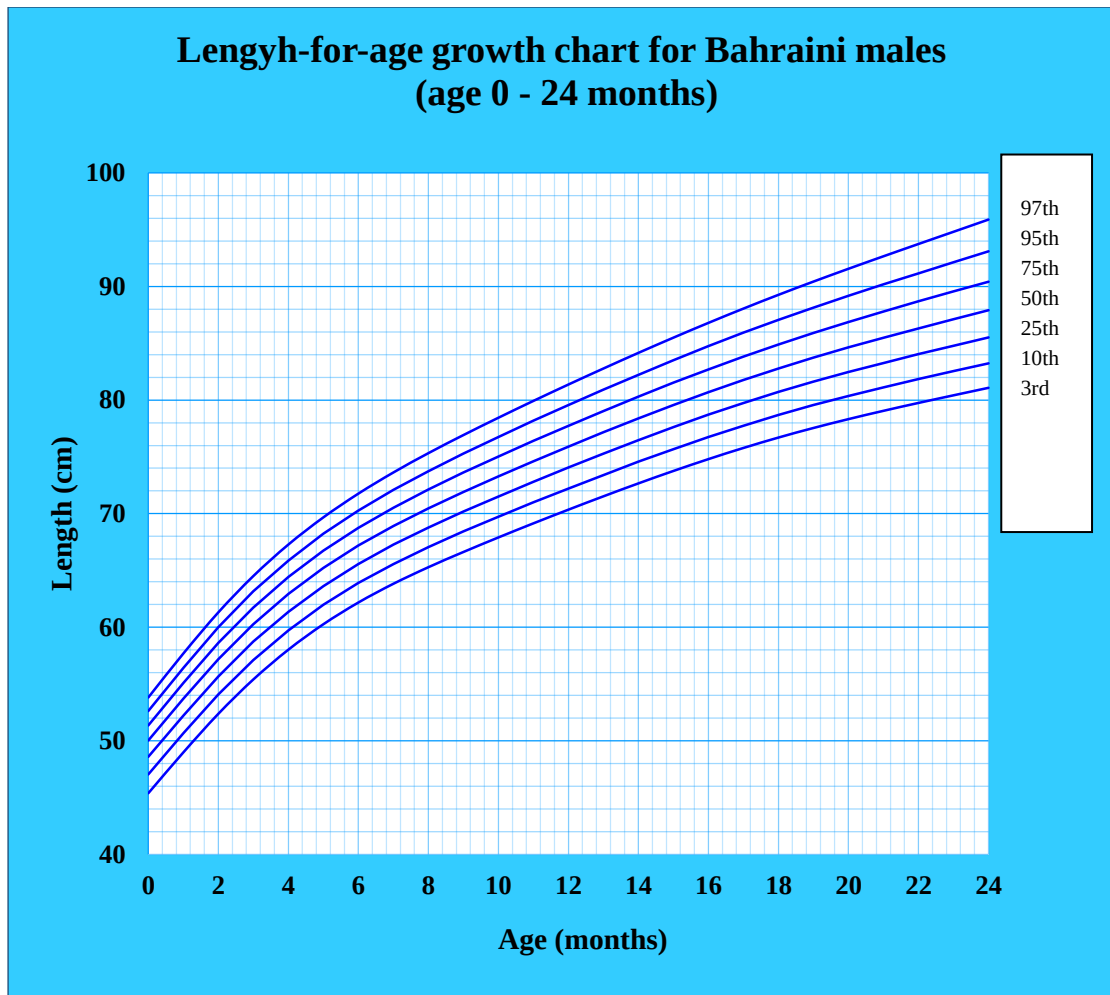


Figure 10: Length for age percentiles among Bahraini males (0-24 months)

Figure (10) shows the Length for age percentiles among Bahraini males (0-24 months), it indicates that the male's length increased also up to two years.

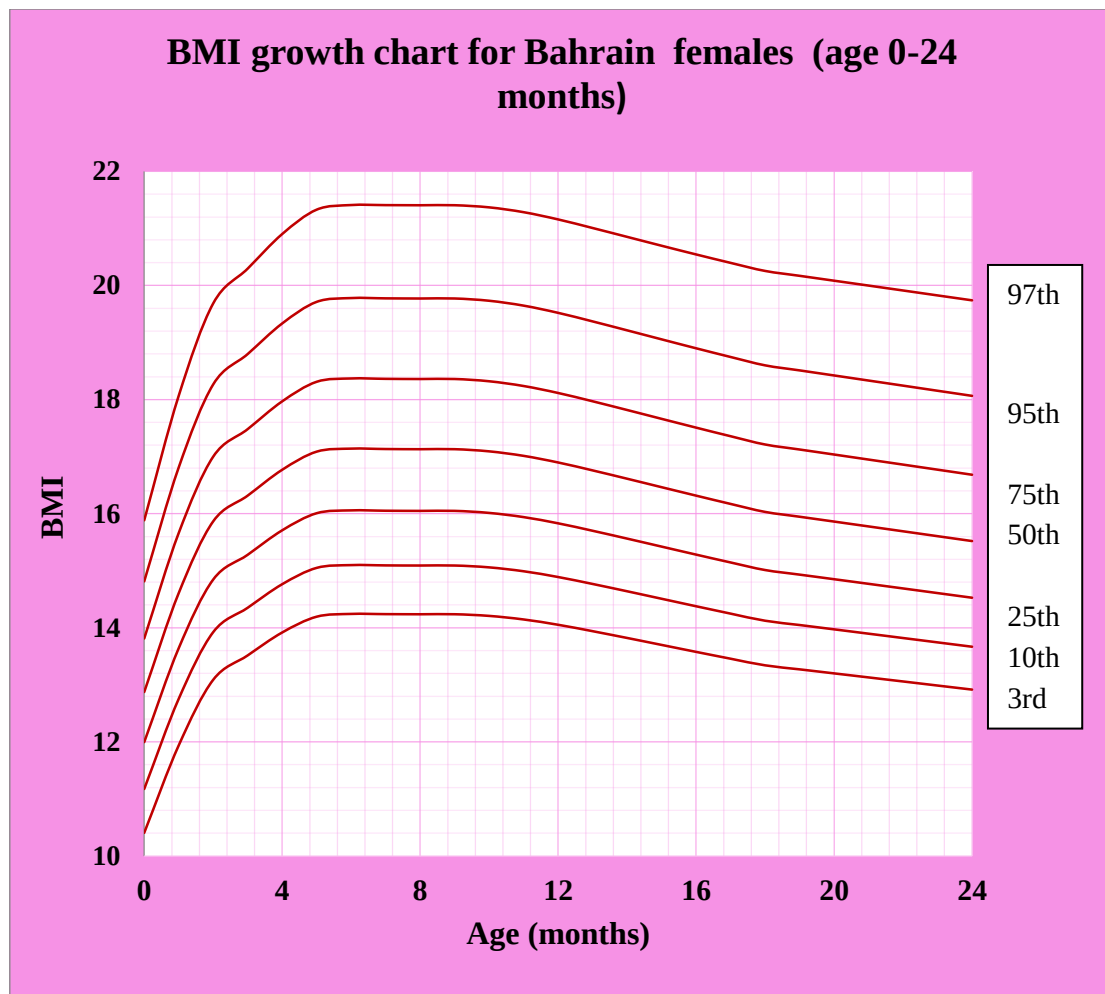


Figure 11: BMI for age percentiles among Bahraini females (0-2 years)

The BMI of females showed an increase up to around six months followed a decrease from 6 months to two years (Figure 11).

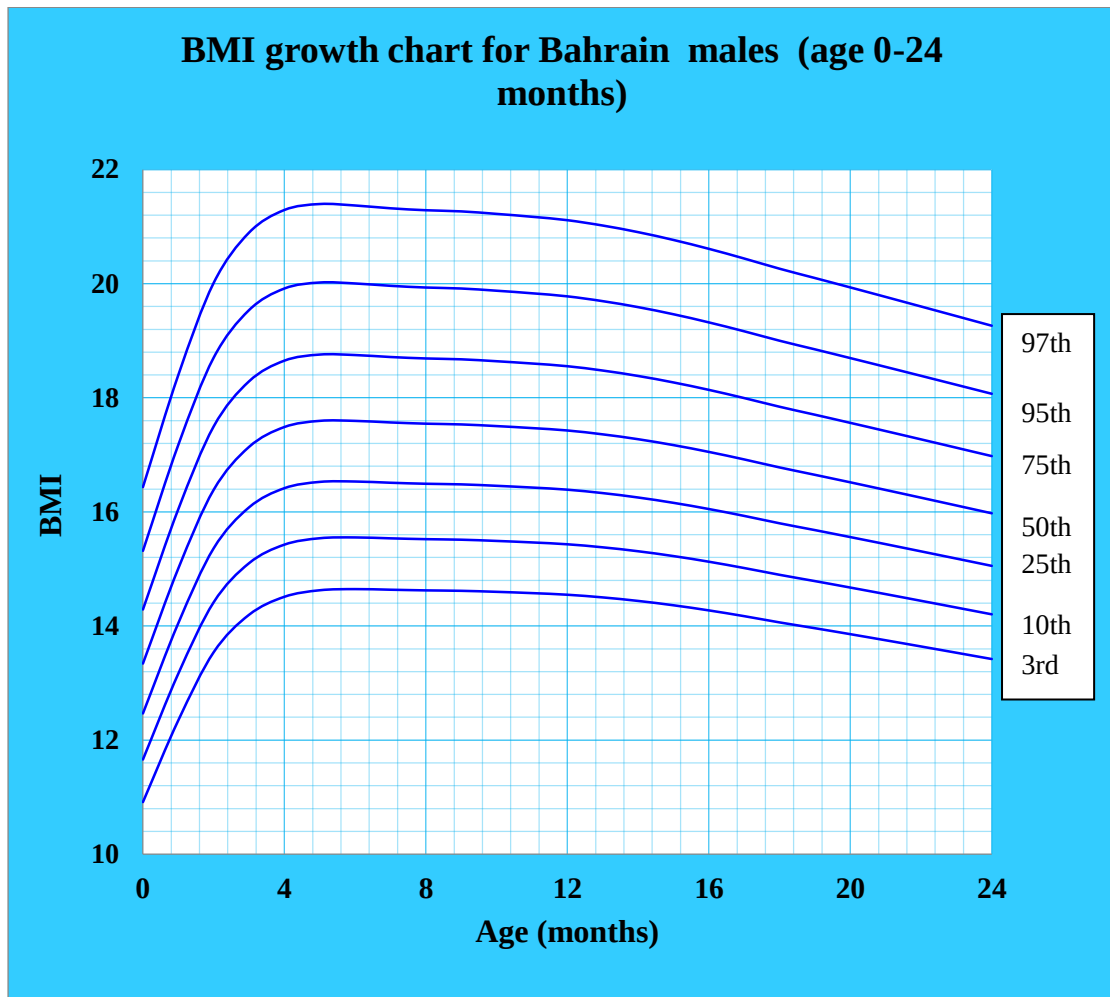


Figure 12: BMI-for-age percentiles of Bahraini males (0-24 months)

The BMI of males showed a steeped increase up to around six months followed a decrease from 6 months to two years as shown (12).

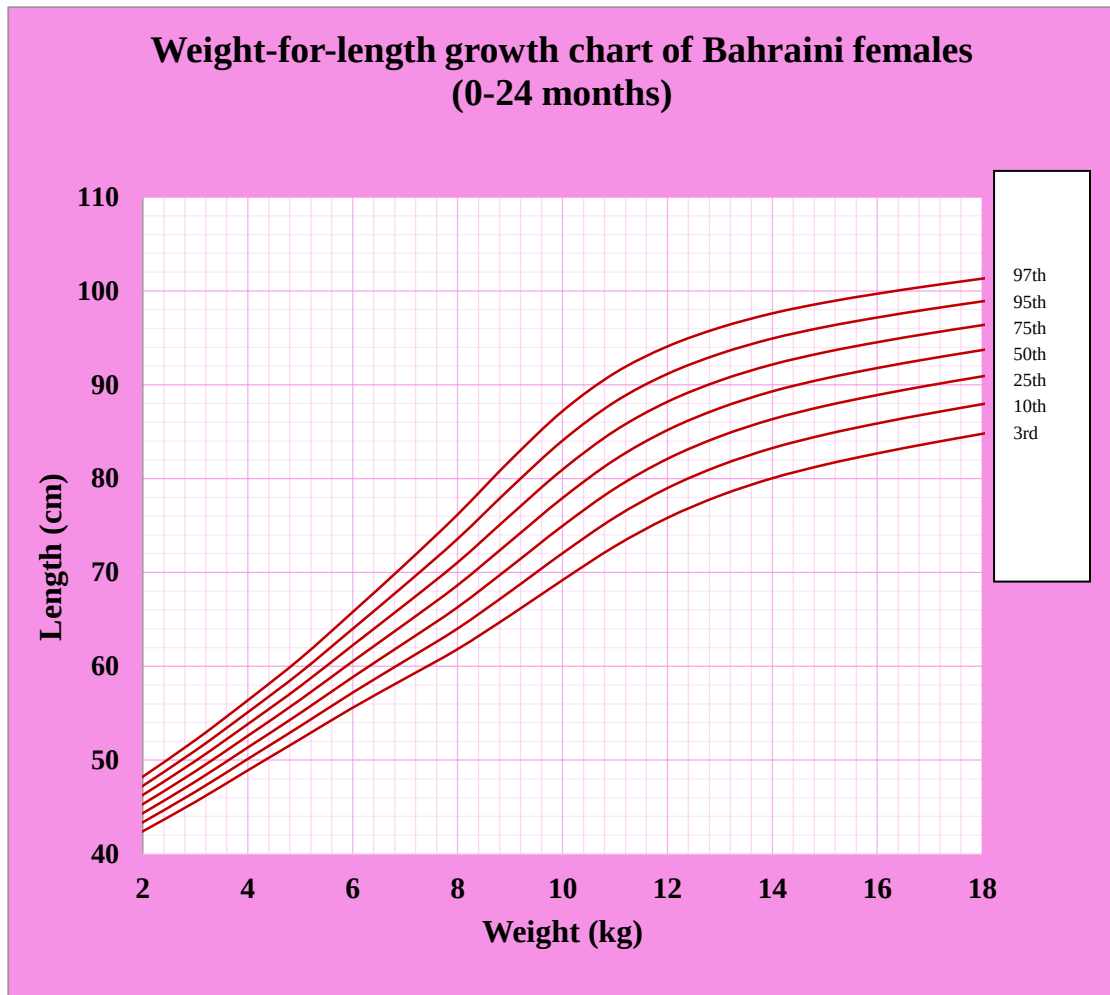


Figure 13: Weight-for-length percentiles of Bahraini females (0-24 months)

Figures (13) show the weight-for-length centiles of Bahrain females.

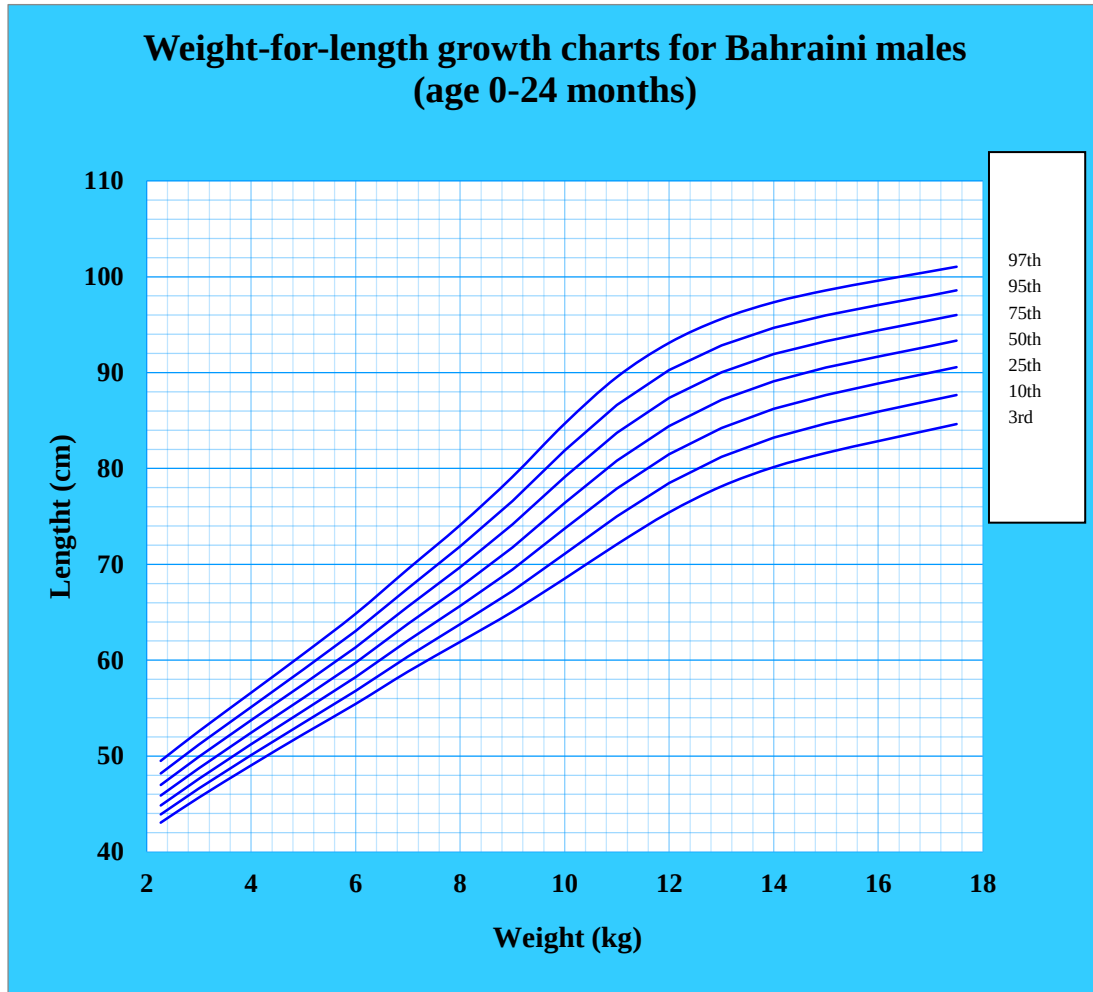


Figure 14: Weight for length percentiles of Bahraini males (0-24 months)

Figures (14) show the weight-for-length centiles of Bahrain males.

4.6 Comparison between Bahraini and MGRS measurements

Tables (7) and (8) present a comparison between the 3rd, 50th and 97th of weight centiles of Bahraini females and males recruited in this study and the MGRS standards, respectively. As seen in these tables, the female's weight was heavier than MGRS standards (> 0.5 SD), at ages from 10 to 24 months at the 97th centile (Table 7).

Amongst the male's weight, those of the age eight months to two years were heavier than MGRS standards at the 97th centile with according to WHO criteria (> 0.5 SD) (Table 8).

Table (7): Comparison of weight (kg) centiles between 0-2 years Bahraini females and MGRS.

	Age	MGRS (WHO)			Bahrain			Difference		
		Centiles			Centiles			Centiles		
		3 rd	50 th	97 th	3 rd	50 th	97 th	3 rd	50 th	97 th
Weight (kg)	0	2.4	3.2	4.2	2.4	3.4	4.5	0.0	-0.2	-0.3
	1	3.2	4.2	5.4	2.9	4.0	5.3	0.3	0.2	0.1
	2	4	5.1	6.5	3.4	4.7	6.2	0.6	0.4	0.3
	3	4.6	5.8	7.4	3.9	5.3	7.0	0.7	0.5	0.4
	4	5.1	6.4	8.1	4.3	5.9	7.8	0.8	0.5	0.3
	5	5.5	6.9	8.7	4.7	6.5	8.5	0.8	0.4	0.2
	6	5.8	7.3	9.2	5.1	7.0	9.2	0.7	0.3	0.0
	7	6.1	7.6	9.6	5.5	7.5	9.8	0.6	0.1	-0.2
	8	6.3	7.9	10	5.9	7.9	10.4	0.4	0.0	-0.4
	9	6.6	8.2	10.4	6.2	8.3	10.9	0.4	-0.1	-0.5
	10	6.8	8.5	10.7	6.5	8.7	11.4	0.3	-0.2	-0.7
	11	7	8.7	11	6.8	9.1	11.8	0.2	-0.4	-0.8
	12	7.1	8.9	11.3	7.0	9.4	12.2	0.1	-0.5	-0.9
	13	7.3	9.2	11.6	7.3	9.7	12.6	0.0	-0.5	-1.0
	14	7.5	9.4	11.9	7.5	10.0	12.9	0.0	-0.6	-1.0
	15	7.7	9.6	12.2	7.7	10.3	13.3	0.0	-0.7	-1.1
	16	7.8	9.8	12.5	7.9	10.5	13.6	-0.1	-0.7	-1.1
	17	8	10	12.7	8.1	10.8	13.9	-0.1	-0.8	-1.2
	18	8.2	10.2	13	8.3	11.0	14.1	-0.1	-0.8	-1.1
	19	8.3	10.4	13.3	8.5	11.2	14.4	-0.2	-0.8	-1.1
	20	8.5	10.6	13.5	8.7	11.5	14.7	-0.2	-0.9	-1.2
	21	8.7	10.9	13.8	8.9	11.7	14.9	-0.2	-0.8	-1.1
	22	8.8	11.1	14.1	9.1	11.9	15.2	-0.3	-0.8	-1.1
	23	9	11.3	14.3	9.2	12.1	15.4	-0.2	-0.8	-1.1
	24	9.2	11.5	14.6	9.4	12.3	15.6	-0.2	-0.8	-1.0

Table (8): Comparison of weight (kg) centiles between 0-2 years Bahraini males and MGRS.

	Age	MGRS (WHO)			Bahrain			Difference		
		Centiles			Centiles			Centiles		
		3rd	50th	97th	3rd	50th	97th	3 rd	50th	97 th
Weight (kg)	0	2.5	3.3	4.3	2.7	3.7	4.9	-0.2	-0.4	-0.6
	1	3.4	4.5	5.7	3.2	4.4	5.8	0.2	0.1	-0.1
	2	4.4	5.6	7.0	3.7	5.1	6.7	0.7	0.5	0.3
	3	5.1	6.4	7.9	4.3	5.7	7.6	0.8	0.7	0.3
	4	5.6	7	8.6	4.7	6.4	8.4	0.9	0.6	0.2
	5	6.1	7.5	9.2	5.2	7.0	9.1	0.9	0.5	0.1
	6	6.4	7.9	9.7	5.7	7.5	9.8	0.7	0.4	-0.1
	7	6.7	8.3	10.2	6.1	8.0	10.4	0.6	0.3	-0.2
	8	7	8.6	10.5	6.5	8.5	11.0	0.5	0.1	-0.5
	9	7.2	8.9	10.9	6.8	9.0	11.5	0.4	-0.1	-0.6
	10	7.5	9.2	11.2	7.2	9.4	12.0	0.3	-0.2	-0.8
	11	7.7	9.4	11.5	7.5	9.7	12.4	0.2	-0.3	-0.9
	12	7.8	9.6	11.8	7.8	10.1	12.8	0.0	-0.5	-1.0
	13	8.0	9.9	12.1	8.0	10.4	13.2	0.0	-0.5	-1.1
	14	8.2	10.1	12.4	8.3	10.7	13.5	-0.1	-0.6	-1.1
	15	8.4	10.3	12.7	8.5	10.9	13.8	-0.1	-0.6	-1.1
	16	8.5	10.5	12.9	8.8	11.2	14.1	-0.3	-0.7	-1.2
	17	8.7	10.7	13.2	9.0	11.4	14.3	-0.3	-0.7	-1.1
	18	8.9	10.9	13.5	9.2	11.6	14.5	-0.3	-0.7	-1.0
	19	9.0	11.1	13.7	9.4	11.9	14.7	-0.4	-0.8	-1.0
	20	9.2	11.3	14	9.6	12.1	14.9	-0.4	-0.8	-0.9
	21	9.3	11.5	14.3	9.8	12.2	15.1	-0.5	-0.7	-0.8
	22	9.5	11.8	14.5	10.0	12.4	15.3	-0.5	-0.6	-0.8
	23	9.7	12	14.8	10.1	12.6	15.5	-0.4	-0.6	-0.7
	24	9.8	12.2	15.1	10.3	12.8	15.6	-0.5	-0.6	-0.5

Table (9) presents a comparison of length (cm) centiles between Bahraini females and MGRS (0-24 months). It can be seen that Bahraini females were shorter than MGRS at small age (from 2 to 8 months) but become taller from 9 to 24 months at the 97th centile (Table 9). Bahraini males were shorter than MGRS children at 3rd centile in all ages except at the birth. In contrast, they become taller at the 97th centile, the exception was at ages from 3-6 months (> 0.5 SD) (Table 10).

Table (9): Comparison of length (cm) centiles between 0-2 years Bahraini females and MGRS.

	Age	MGRS (WHO)			Bahrain			Difference		
		Centiles			Centiles			Centiles		
		3rd	50th	97th	3rd	50th	97th	3rd	50th	97th
Length (cm)	0	45.6	49.1	52.7	46.6	51.2	55.5	-1.0	-2.1	-2.8
	1	50	53.7	57.4	48.7	53.5	58.0	1.3	0.2	-0.6
	2	53.2	57.1	60.9	50.7	55.8	60.4	2.5	1.3	0.5
	3	55.8	59.8	63.8	52.8	58.0	62.8	3.0	1.8	1.0
	4	58	62.1	66.2	54.7	60.2	65.2	3.3	1.9	1.0
	5	59.9	64	68.2	56.6	62.3	67.4	3.3	1.7	0.8
	6	61.5	65.7	70	58.5	64.3	69.6	3.0	1.4	0.4
	7	62.9	67.3	71.6	60.2	66.2	71.7	2.7	1.1	-0.1
	8	64.3	68.7	73.2	61.8	68.0	73.6	2.5	0.7	-0.4
	9	65.6	70.1	74.7	63.4	69.7	75.5	2.2	0.4	-0.8
	10	66.8	71.5	76.1	64.9	71.4	77.3	1.9	0.1	-1.2
	11	68	72.8	77.5	66.3	72.9	79.0	1.7	-0.1	-1.5
	12	69.2	74	78.9	67.6	74.4	80.6	1.6	-0.4	-1.7
	13	70.3	75.2	80.2	68.9	75.8	82.1	1.4	-0.6	-1.9
	14	71.3	76.4	81.4	70.1	77.1	83.5	1.2	-0.7	-2.1
	15	72.4	77.5	82.7	71.3	78.4	84.9	1.1	-0.9	-2.2
	16	73.3	78.6	83.9	72.4	79.7	86.3	0.9	-1.1	-2.4
	17	74.3	79.7	85	73.5	80.9	87.6	0.8	-1.2	-2.6
	18	75.2	80.7	86.2	74.5	82.0	88.8	0.7	-1.3	-2.6
	19	76.2	81.7	87.3	75.5	83.2	90.1	0.7	-1.5	-2.8
	20	77	82.7	88.4	76.5	84.3	91.3	0.5	-1.6	-2.9
	21	77.9	83.7	89.4	77.5	85.3	92.5	0.4	-1.6	-3.1
	22	78.7	84.6	90.5	78.5	86.4	93.7	0.2	-1.8	-3.2
	23	79.6	85.5	91.5	79.4	87.5	94.8	0.2	-2.0	-3.3
	24	80.3	86.4	92.5	80.4	88.5	96.0	-0.1	-2.1	-3.5

Table (10): Comparison of length (cm) centiles between 0-2 years Bahraini males and MGRS.

	Age	MGRS (WHO)			Bahrain			Difference		
		Centiles			Centiles			Centiles		
		3rd	50th	97th	3rd	50th	97th	3 rd	50th	97 th
Length (cm)	0	46.3	49.9	53.4	47.4	52.9	57.3	-1.1	-3.0	-3.9
	1	51.1	54.7	58.4	49.5	55.2	59.8	1.6	-0.5	-1.4
	2	54.7	58.4	62.2	51.6	57.4	62.2	3.1	1.0	0.0
	3	57.6	61.4	65.3	53.6	59.6	64.5	4.0	1.8	0.8
	4	60	63.9	67.8	55.6	61.8	66.8	4.4	2.1	1.0
	5	61.9	65.9	69.9	57.6	63.8	69.0	4.3	2.1	0.9
	6	63.6	67.6	71.6	59.4	65.8	71.1	4.2	1.8	0.5
	7	65.1	69.2	73.2	61.2	67.7	73.1	3.9	1.5	0.1
	8	66.5	70.6	74.7	62.9	69.5	75.0	3.6	1.1	-0.3
	9	67.7	72	76.2	64.5	71.2	76.8	3.2	0.8	-0.6
	10	69	73.3	77.6	66.0	72.8	78.5	3.0	0.5	-0.9
	11	70.2	74.5	78.9	67.5	74.4	80.1	2.7	0.1	-1.2
	12	71.3	75.7	80.2	68.8	75.8	81.6	2.5	-0.1	-1.4
	13	72.4	76.9	81.5	70.1	77.2	83.1	2.3	-0.3	-1.6
	14	73.4	78	82.7	71.4	78.5	84.4	2.0	-0.5	-1.7
	15	74.4	79.1	83.9	72.6	79.7	85.7	1.8	-0.6	-1.8
	16	75.4	80.2	85.1	73.7	80.9	86.9	1.7	-0.7	-1.8
	17	76.3	81.2	86.2	74.8	82.1	88.1	1.5	-0.9	-1.9
	18	77.2	82.3	87.3	75.9	83.2	89.3	1.3	-0.9	-2.0
	19	78.1	83.2	88.4	76.9	84.2	90.4	1.2	-1.0	-2.0
	20	78.9	84.2	89.5	77.9	85.3	91.4	1.0	-1.1	-1.9
	21	79.7	85.1	90.5	78.9	86.3	92.5	0.8	-1.2	-2.0
	22	80.5	86	91.6	79.9	87.3	93.5	0.6	-1.3	-1.9
	23	81.3	86.9	92.6	80.9	88.3	94.5	0.4	-1.4	-1.9
	24	82.1	87.8	93.6	81.8	89.3	95.6	0.3	-1.5	-2.0

The BMI of Bahraini females were larger than of MGRS at the 97th centiles (SD >0.5) (Tables 11). Table (12) shows that the BMI of Bahraini males at 3rd centiles was lower than of MGRS at ages from 1-5 months (SD > 0.5), and became larger than of those of MGRS at the 97th centiles at all ages (Tables 12).

Table (11): Comparison of BMI centiles between Bahraini females and MGRS (0-24 months).

	Age	MGRS (WHO)			Bahrain			Difference		
		Centiles			Centiles			Centiles		
		3 rd	50 th	97 th	3 rd	50 th	97 th	3 rd	50 th	97 th
BMI (kg/m ²)	0	11.2	13.3	15.9	11.6	14.9	19.2	-0.4	-1.6	-3.3
	1	12.1	14.6	17.3	11.9	15.2	19.6	0.2	-0.6	-2.3
	2	13.2	15.8	18.8	12.2	15.5	19.9	1.0	0.3	-1.1
	3	13.7	16.4	19.4	12.5	15.8	20.3	1.2	0.6	-0.9
	4	14	16.7	19.8	12.7	16.1	20.6	1.3	0.6	-0.8
	5	14.2	16.8	20	13.0	16.3	20.8	1.2	0.5	-0.8
	6	14.3	16.9	20.1	13.2	16.5	21.0	1.1	0.4	-0.9
	7	14.3	16.9	20.1	13.3	16.7	21.2	1.0	0.2	-1.1
	8	14.3	16.8	20	13.4	16.8	21.3	0.9	0.0	-1.3
	9	14.2	16.7	19.9	13.5	16.9	21.3	0.7	-0.2	-1.4
	10	14.1	16.6	19.7	13.6	17.0	21.3	0.5	-0.4	-1.6
	11	14	16.5	19.6	13.6	17.0	21.3	0.4	-0.5	-1.7
	12	13.9	16.4	19.4	13.7	16.9	21.2	0.2	-0.5	-1.8
	13	13.8	16.2	19.2	13.6	16.9	21.1	0.2	-0.7	-1.9
	14	13.7	16.1	19.1	13.6	16.8	21.0	0.1	-0.7	-1.9
	15	13.7	16	19	13.6	16.8	20.9	0.1	-0.8	-1.9
	16	13.6	15.9	18.8	13.5	16.7	20.7	0.1	-0.8	-1.9
	17	13.5	15.8	18.7	13.5	16.6	20.5	0.0	-0.8	-1.8
	18	13.4	15.7	18.6	13.4	16.4	20.3	0.0	-0.7	-1.7
	19	13.4	15.7	18.5	13.3	16.3	20.1	0.1	-0.6	-1.6
	20	13.3	15.6	18.5	13.3	16.2	19.9	0.0	-0.6	-1.4
	21	13.3	15.5	18.4	13.2	16.1	19.7	0.1	-0.6	-1.3
	22	13.3	15.5	18.3	13.1	15.9	19.5	0.2	-0.4	-1.2
	23	13.2	15.4	18.3	13.0	15.8	19.3	0.2	-0.4	-1.0
	24	13.2	15.4	18.2	12.9	15.7	19.1	0.3	-0.3	-0.9

Table (12): Comparison of BMI centiles between Bahraini males and MGRS (0-24 months)

	Age	MGRS (WHO)			Bahrain			Difference		
		Centiles			Centiles			Centiles		
		3 rd	50 th	97 th	3 rd	50 th	97 th	3 rd	50 th	97 th
BMI (kg/m ²)	0	11.3	13.4	16.1	12.0	15.6	19.8	-0.7	-2.2	-3.7
	1	12.6	14.9	17.6	12.2	15.9	20.1	0.4	-1.0	-2.5
	2	13.8	16.3	19.2	12.5	16.2	20.4	1.3	0.1	-1.2
	3	14.4	16.9	19.8	12.8	16.5	20.7	1.6	0.4	-0.9
	4	14.7	17.2	20.1	13.0	16.7	20.9	1.7	0.5	-0.8
	5	14.8	17.3	20.2	13.3	16.9	21.1	1.5	0.4	-0.9
	6	14.9	17.3	20.3	13.5	17.1	21.2	1.4	0.2	-0.9
	7	14.9	17.3	20.3	13.6	17.3	21.3	1.3	0.0	-1.0
	8	14.9	17.3	20.2	13.8	17.4	21.4	1.1	-0.1	-1.2
	9	14.8	17.2	20.1	13.9	17.4	21.4	0.9	-0.2	-1.3
	10	14.7	17	19.9	14.0	17.5	21.4	0.7	-0.5	-1.5
	11	14.6	16.9	19.8	14.0	17.5	21.3	0.6	-0.6	-1.5
	12	14.5	16.8	19.6	14.1	17.5	21.2	0.4	-0.7	-1.6
	13	14.4	16.7	19.5	14.1	17.4	21.1	0.3	-0.7	-1.6
	14	14.3	16.6	19.3	14.1	17.3	20.9	0.2	-0.7	-1.6
	15	14.2	16.4	19.2	14.1	17.3	20.8	0.1	-0.9	-1.6
	16	14.2	16.3	19.1	14.0	17.2	20.6	0.2	-0.9	-1.5
	17	14.1	16.2	18.9	14.0	17.0	20.4	0.1	-0.8	-1.5
	18	14	16.1	18.8	14.0	16.9	20.2	0.0	-0.8	-1.4
	19	13.9	16.1	18.7	13.9	16.8	20.0	0.0	-0.7	-1.3
	20	13.9	16	18.6	13.8	16.7	19.7	0.1	-0.7	-1.1
	21	13.8	15.9	18.6	13.8	16.5	19.5	0.0	-0.6	-0.9
	22	13.8	15.8	18.5	13.7	16.4	19.3	0.1	-0.6	-0.8
	23	13.7	15.8	18.4	13.6	16.2	19.1	0.1	-0.4	-0.7
	24	13.7	15.7	18.3	13.6	16.1	18.8	0.1	-0.4	-0.5

4.7 Comparison between Bahraini and Saudi measurements

The comparisons of weight, length, and BMI centiles of Bahraini and Saudi young children are shown in Figures (15) to (20). Variations of growth trends (pattern/rate) between Bahraini and their Saudi counterparts were indicated in both genders and at different ages. Figure (15) clearly shows that at early months Saudi females and males were heavier. Later at ages from 14 months up to two years, Bahraini females were heavier than their Saudi cohorts, As well for Bahraini males were also heavier when compared to Saudi males particularly after 22 months, as shown in Figure (16).

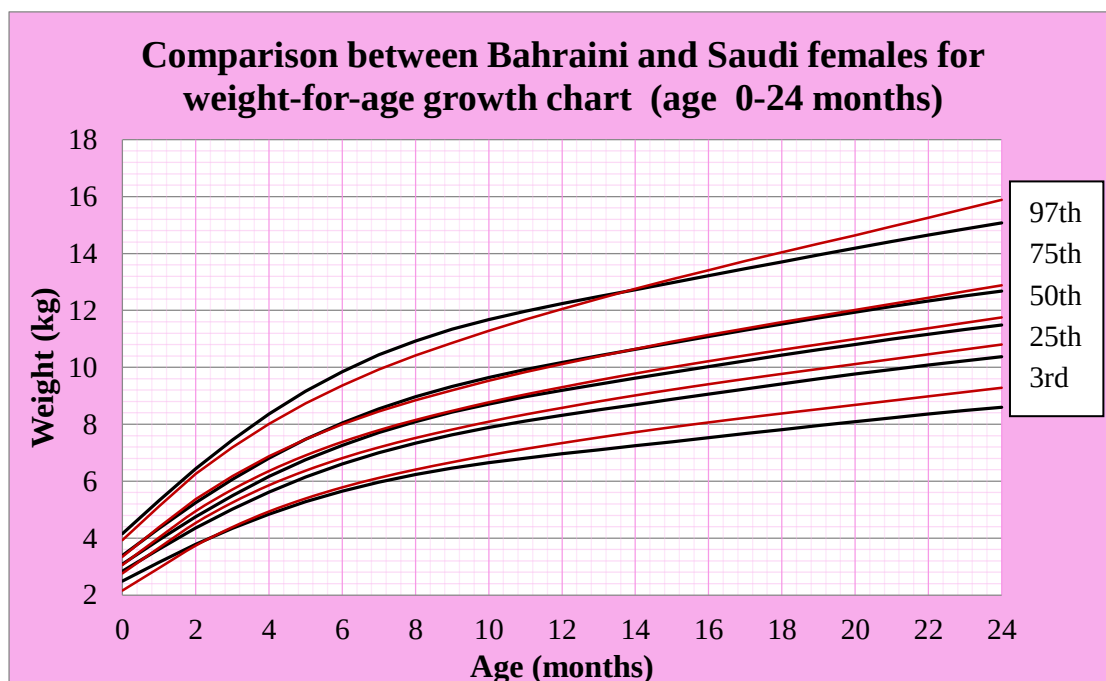


Figure 15: Comparison of weight (kg) centiles between 0-2 years Bahraini (pink) and Saudi females (black).

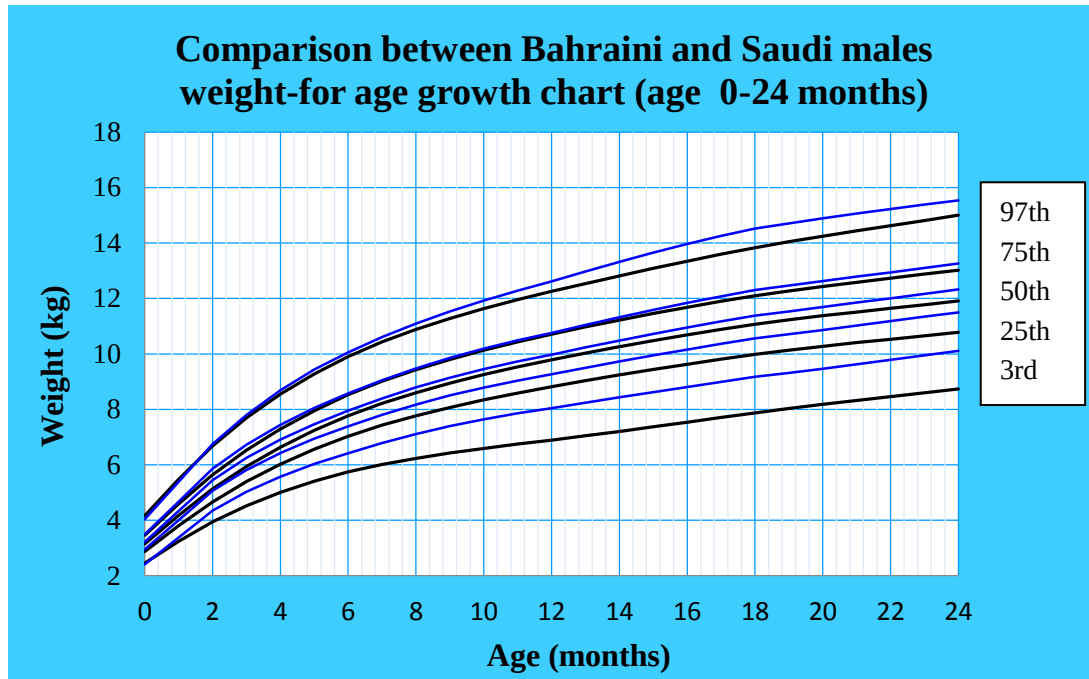


Figure 16: Comparison of weight (kg) centiles between Bahraini (blue) and Saudi (black) males (0-24 months).

In terms of length for age centiles, the comparison between Bahraini and Saudi 0-2 years females showed that their length was about to be similar and Saudis were slightly higher at the 97th centiles (Figure 17). Among males, the comparison between Bahrainis and Saudis showed that their length was very close, Saudis showed a slight increase in length compared to Bahrainis in the 97th centiles as shown in Figure (18).

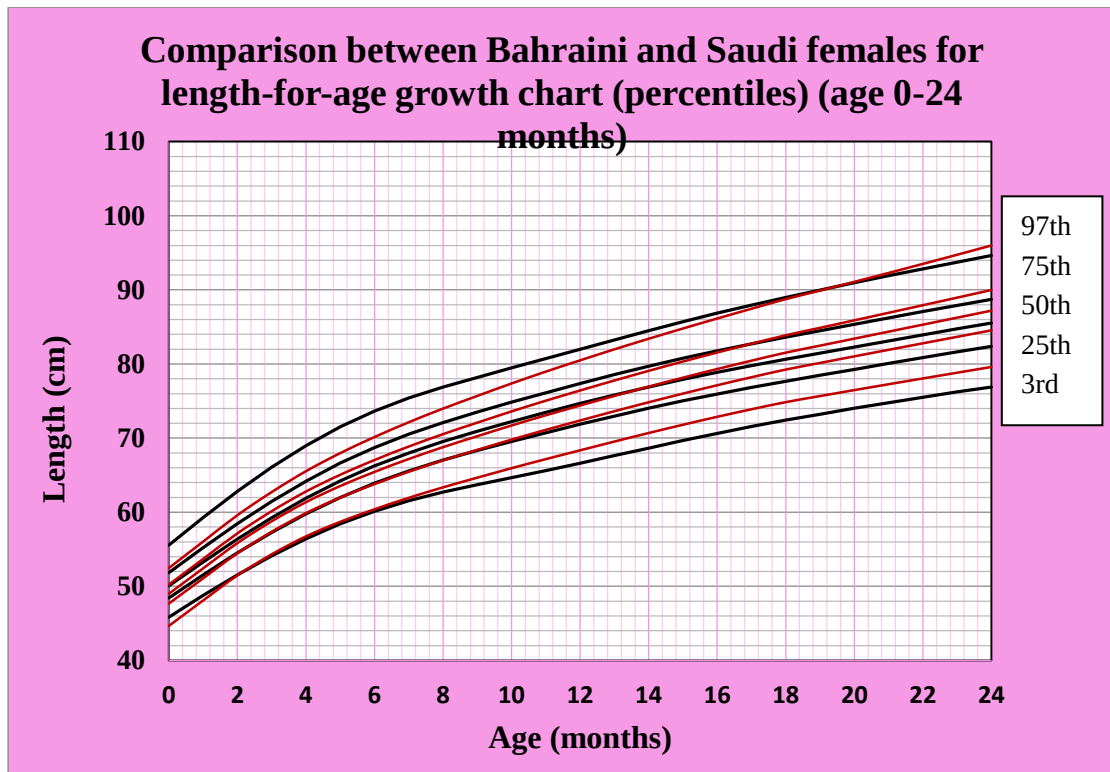


Figure 17: Comparison of length (kg) centiles between Bahraini (pink) and Saudi females (black) (0-24 months).

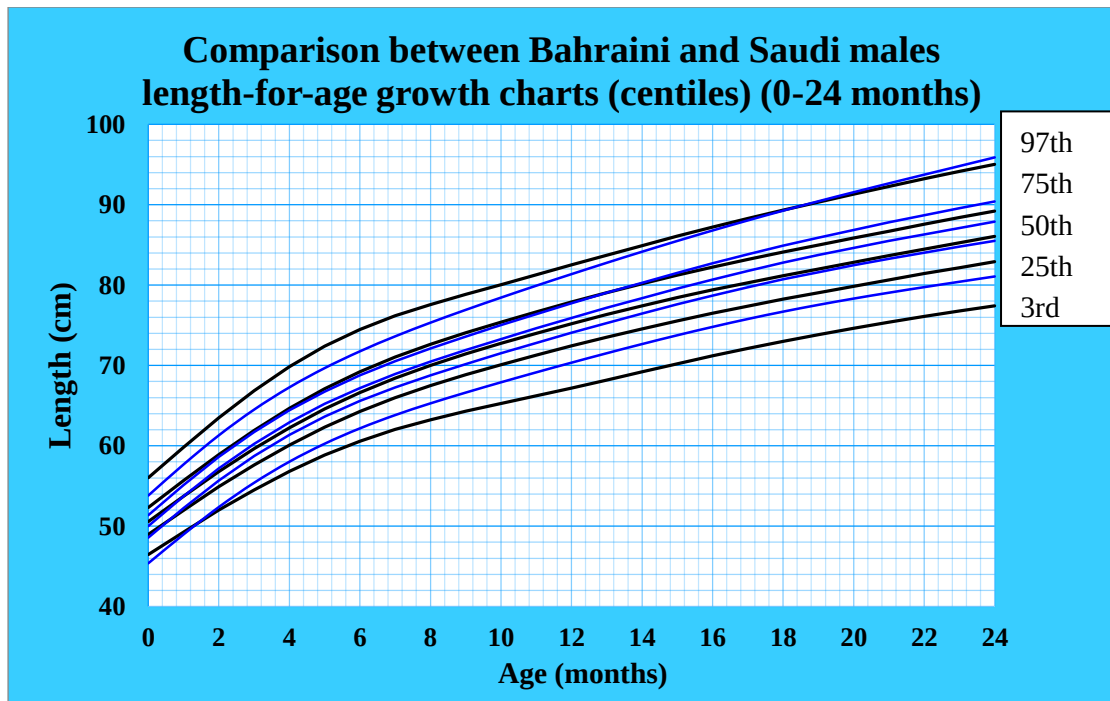


Figure 18: Comparison of length (kg) centiles between Bahraini (blue) and Saudi males (black) (0-24 months).

Figure (19) shows that variations exist between Bahraini and Saudi females in term of BMI. Bahrainis had a higher BMI from birth to 8 months and became slightly lower than Saudis up to two years. Figure (20) shows that Bahraini males have a higher BMI at the first 6 months at the 3rd and 25th centiles and became slightly lower than of Saudis up to two years in the 97th BMI centiles.

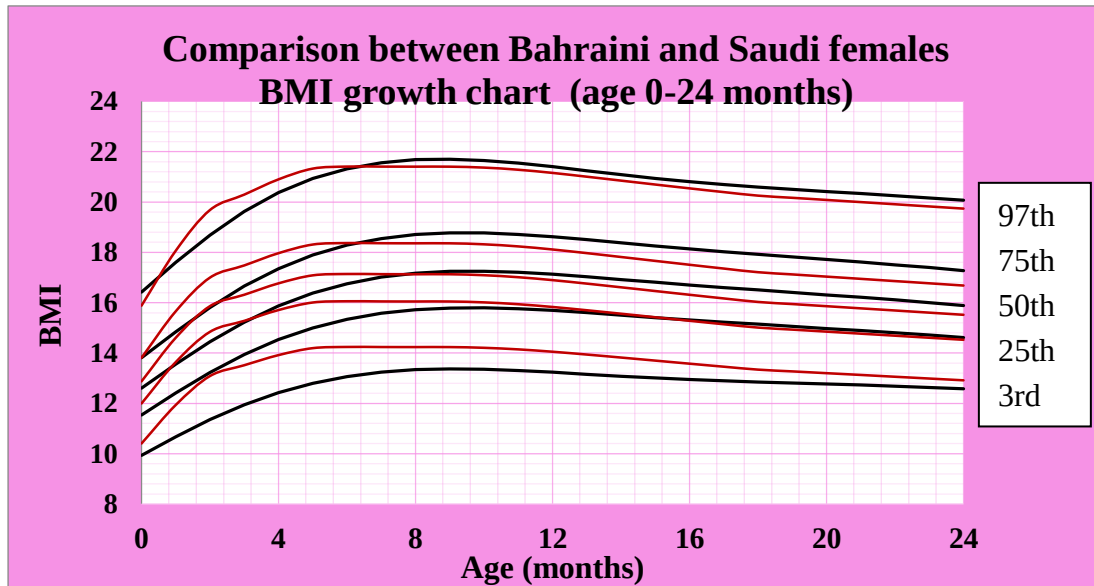


Figure 19: Comparison of BMI centiles between Bahraini (pink) and Saudi females (black) (0-24 months).

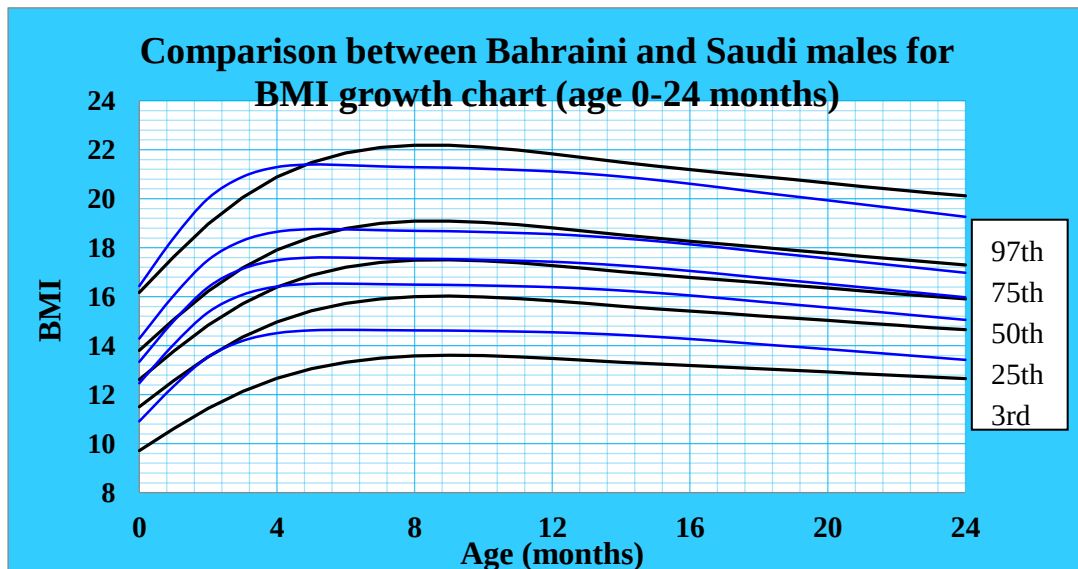


Figure 20: Comparison of BMI centiles between Bahraini (blue) and Saudi males (black) (0-24 months).

4.8 Percentiles and z-scores tables

The 3rd, 10th, 25th, 50th, 75th, 90th, and 97th centiles of weight, length, and BMI of Bahraini males and females are listed in Tables (13) to (20). In addition, Z-scores of weight, length, and BMI among males and females are shown in Tables (21), (22), and (23).

Table (13): LMS values and weight-for-age percentiles for Bahraini females (0-24 months)

Age (months)	LMS			Percentiles						
	L	M	S	3 rd	10 th	25 th	50 th	75 th	90 th	97 th
0	0.4	3.4	0.2	2.4	2.7	3.0	3.4	3.7	4.1	4.5
1	0.4	4.0	0.2	2.9	3.3	3.6	4.0	4.4	4.9	5.3
2	0.4	4.7	0.1	3.4	3.8	4.2	4.7	5.2	5.7	6.2
3	0.4	5.3	0.1	3.9	4.3	4.8	5.3	5.8	6.4	7.0
4	0.4	5.9	0.1	4.3	4.8	5.3	5.9	6.5	7.1	7.8
5	0.4	6.5	0.1	4.7	5.3	5.8	6.5	7.1	7.8	8.5
6	0.4	7.0	0.1	5.1	5.7	6.3	7.0	7.7	8.4	9.2
7	0.4	7.5	0.1	5.5	6.1	6.8	7.5	8.2	9.0	9.8
8	0.4	7.9	0.1	5.9	6.5	7.2	7.9	8.7	9.5	10.4
9	0.4	8.3	0.1	6.2	6.9	7.6	8.3	9.1	10.0	10.9
10	0.4	8.7	0.1	6.5	7.2	7.9	8.7	9.6	10.4	11.4
11	0.4	9.1	0.1	6.8	7.5	8.3	9.1	9.9	10.9	11.8
12	0.4	9.4	0.1	7.0	7.8	8.6	9.4	10.3	11.2	12.2
13	0.4	9.7	0.1	7.3	8.0	8.9	9.7	10.6	11.6	12.6
14	0.4	10.0	0.1	7.5	8.3	9.1	10.0	10.9	11.9	12.9
15	0.4	10.3	0.1	7.7	8.5	9.4	10.3	11.2	12.2	13.3
16	0.4	10.5	0.1	7.9	8.8	9.6	10.5	11.5	12.5	13.6
17	0.4	10.8	0.1	8.1	9.0	9.9	10.8	11.8	12.8	13.9
18	0.4	11.0	0.1	8.3	9.2	10.1	11.0	12.0	13.1	14.1
19	0.4	11.2	0.1	8.5	9.4	10.3	11.2	12.2	13.3	14.4
20	0.4	11.5	0.1	8.7	9.6	10.5	11.5	12.5	13.5	14.7
21	0.4	11.7	0.1	8.9	9.8	10.7	11.7	12.7	13.8	14.9
22	0.4	11.9	0.1	9.1	10.0	10.9	11.9	12.9	14.0	15.2
23	0.4	12.1	0.1	9.2	10.1	11.1	12.1	13.1	14.2	15.4
24	0.4	12.3	0.1	9.4	10.3	11.3	12.3	13.4	14.5	15.6

The weight centiles of females and males showed an increase by age, but the rate of increase in the first six months was more than of six months to two years (Table 13) (Table 14).

Table (14): LMS values and weight-for-age percentiles for Bahraini males (0-24 months)

Age (months)	LMS			Percentiles						
	L	M	S	3 rd	10 th	25 th	50 th	75 th	90 th	97 th
0	0.3	3.7	0.1	2.7	3.0	3.3	3.7	4.1	4.5	4.9
1	0.3	4.4	0.1	3.2	3.6	4.0	4.4	4.8	5.3	5.8
2	0.3	5.1	0.1	3.7	4.2	4.6	5.1	5.6	6.1	6.7
3	0.3	5.7	0.1	4.3	4.7	5.2	5.7	6.3	6.9	7.6
4	0.3	6.4	0.1	4.7	5.2	5.8	6.4	7.0	7.7	8.4
5	0.3	7.0	0.1	5.2	5.8	6.3	7.0	7.6	8.3	9.1
6	0.3	7.5	0.1	5.7	6.2	6.9	7.5	8.2	9.0	9.8
7	0.3	8.0	0.1	6.1	6.7	7.3	8.0	8.8	9.6	10.4
8	0.3	8.5	0.1	6.5	7.1	7.8	8.5	9.3	10.1	11.0
9	0.3	9.0	0.1	6.8	7.5	8.2	9.0	9.8	10.6	11.5
10	0.3	9.4	0.1	7.2	7.8	8.6	9.4	10.2	11.1	12.0
11	0.3	9.7	0.1	7.5	8.2	8.9	9.7	10.6	11.5	12.4
12	0.3	10.1	0.1	7.8	8.5	9.3	10.1	10.9	11.9	12.8
13	0.3	10.4	0.1	8.0	8.8	9.6	10.4	11.3	12.2	13.2
14	0.3	10.7	0.1	8.3	9.0	9.8	10.7	11.6	12.5	13.5
15	0.3	10.9	0.1	8.5	9.3	10.1	10.9	11.8	12.8	13.8
16	0.3	11.2	0.1	8.8	9.5	10.3	11.2	12.1	13.1	14.1
17	0.3	11.4	0.1	9.0	9.7	10.6	11.4	12.3	13.3	14.3
18	0.3	11.6	0.1	9.2	10.0	10.8	11.6	12.6	13.5	14.5
19	0.3	11.9	0.1	9.4	10.2	11.0	11.9	12.8	13.7	14.7
20	0.3	12.1	0.1	9.6	10.4	11.2	12.1	13.0	13.9	14.9
21	0.3	12.2	0.1	9.8	10.6	11.4	12.2	13.2	14.1	15.1
22	0.3	12.4	0.1	10.0	10.7	11.6	12.4	13.3	14.3	15.3
23	0.3	12.6	0.1	10.1	10.9	11.8	12.6	13.5	14.5	15.5
24	0.3	12.8	0.1	10.3	11.1	11.9	12.8	13.7	14.7	15.6

Table (15) and (16) shows that females and males length centiles increased up to two years in a steady pattern.

Table (15): LMS values and length-for-age percentiles for Bahraini females (0-24 months)

Age (months)	LMS			Percentiles						
	L	M	S	3 rd	10 th	25 th	50 th	75 th	90 th	97 th
0	2.1	51.2	0.04	46.6	48.2	49.7	51.2	52.7	54.1	55.5
1	2.1	53.5	0.04	48.7	50.4	52.0	53.5	55.1	56.5	58.0
2	2.1	55.8	0.04	50.7	52.5	54.2	55.8	57.4	58.9	60.4
3	2.1	58.0	0.04	52.8	54.6	56.3	58.0	59.7	61.3	62.8
4	2.1	60.2	0.04	54.7	56.6	58.4	60.2	61.9	63.6	65.2
5	2.1	62.3	0.04	56.6	58.6	60.5	62.3	64.1	65.8	67.4
6	2.1	64.3	0.04	58.5	60.5	62.4	64.3	66.1	67.9	69.6
7	2.1	66.2	0.04	60.2	62.3	64.3	66.2	68.1	69.9	71.7
8	2.1	68.0	0.04	61.8	64.0	66.0	68.0	69.9	71.8	73.6
9	2.1	69.7	0.04	63.4	65.6	67.7	69.7	71.7	73.6	75.5
10	2.1	71.4	0.04	64.9	67.1	69.3	71.4	73.4	75.4	77.3
11	2.1	72.9	0.04	66.3	68.6	70.8	72.9	75.0	77.0	79.0
12	2.1	74.4	0.04	67.6	70.0	72.2	74.4	76.5	78.6	80.6
13	2.1	75.8	0.04	68.9	71.3	73.6	75.8	78.0	80.0	82.1
14	2.1	77.1	0.04	70.1	72.5	74.9	77.1	79.3	81.5	83.5
15	2.1	78.4	0.04	71.3	73.7	76.1	78.4	80.7	82.8	84.9
16	2.1	79.7	0.04	72.4	74.9	77.3	79.7	81.9	84.1	86.3
17	2.1	80.9	0.04	73.5	76.0	78.5	80.9	83.2	85.4	87.6
18	2.1	82.0	0.04	74.5	77.1	79.6	82.0	84.4	86.6	88.8
19	2.1	83.2	0.04	75.5	78.2	80.7	83.2	85.5	87.8	90.1
20	2.1	84.3	0.04	76.5	79.2	81.8	84.3	86.7	89.0	91.3
21	2.1	85.3	0.04	77.5	80.2	82.8	85.3	87.8	90.2	92.5
22	2.1	86.4	0.04	78.5	81.2	83.9	86.4	88.9	91.3	93.7
23	2.1	87.5	0.04	79.4	82.2	84.9	87.5	90.0	92.4	94.8
24	2.1	88.5	0.04	80.4	83.2	85.9	88.5	91.1	93.6	96.0

Table (16): LMS values and length-for-age percentiles for Bahraini males (0-24 months)

Age (months)	LMS			Percentiles						
	L	M	S	3 rd	10 th	25 th	50 th	75 th	90 th	97 th
0	3.2	52.9	0.05	47.4	49.4	51.2	52.9	54.5	55.9	57.3
1	3.2	55.2	0.05	49.5	51.5	53.4	55.2	56.8	58.3	59.8
2	3.2	57.4	0.05	51.6	53.7	55.6	57.4	59.1	60.7	62.2
3	3.2	59.6	0.05	53.6	55.8	57.8	59.6	61.3	63.0	64.5
4	3.2	61.8	0.04	55.6	57.8	59.9	61.8	63.5	65.2	66.8
5	3.2	63.8	0.04	57.6	59.8	61.9	63.8	65.7	67.4	69.0
6	3.2	65.8	0.04	59.4	61.7	63.9	65.8	67.7	69.5	71.1
7	3.2	67.7	0.04	61.2	63.5	65.7	67.7	69.6	71.4	73.1
8	3.2	69.5	0.04	62.9	65.3	67.5	69.5	71.5	73.3	75.0
9	3.2	71.2	0.04	64.5	66.9	69.1	71.2	73.2	75.1	76.8
10	3.2	72.8	0.04	66.0	68.5	70.7	72.8	74.8	76.7	78.5
11	3.2	74.4	0.04	67.5	69.9	72.2	74.4	76.4	78.3	80.1
12	3.2	75.8	0.04	68.8	71.3	73.6	75.8	77.9	79.8	81.6
13	3.2	77.2	0.04	70.1	72.7	75.0	77.2	79.2	81.2	83.1
14	3.2	78.5	0.04	71.4	73.9	76.3	78.5	80.6	82.5	84.4
15	3.2	79.7	0.04	72.6	75.1	77.5	79.7	81.8	83.8	85.7
16	3.2	80.9	0.04	73.7	76.3	78.7	80.9	83.0	85.0	86.9
17	3.2	82.1	0.04	74.8	77.4	79.8	82.1	84.2	86.2	88.1
18	3.2	83.2	0.04	75.9	78.5	80.9	83.2	85.3	87.3	89.3
19	3.2	84.2	0.04	76.9	79.5	81.9	84.2	86.4	88.4	90.4
20	3.2	85.3	0.04	77.9	80.5	83.0	85.3	87.4	89.5	91.4
21	3.2	86.3	0.04	78.9	81.5	84.0	86.3	88.5	90.5	92.5
22	3.2	87.3	0.04	79.9	82.5	85.0	87.3	89.5	91.5	93.5
23	3.2	88.3	0.04	80.9	83.5	86.0	88.3	90.5	92.6	94.5
24	3.2	89.3	0.04	81.8	84.5	86.9	89.3	91.5	93.6	95.6

Table (17) shows an increase in females BMI centiles up to 10 months, and decrease from 11 months to 24 months.

Table (17): LMS values and BMI-for-age percentiles for Bahraini females (0-24 months)

Age (months)	LMS			Percentiles						
	L	M	S	3 rd	10 th	25 th	50 th	75 th	90 th	97 th
0	-0.2	14.9	0.1	11.6	12.6	13.7	14.9	16.2	17.6	19.2
1	-0.2	15.2	0.1	11.9	12.9	14.0	15.2	16.5	18.0	19.6
2	-0.2	15.5	0.1	12.2	13.2	14.3	15.5	16.9	18.3	19.9
3	-0.2	15.8	0.1	12.5	13.5	14.6	15.8	17.2	18.6	20.3
4	-0.2	16.1	0.1	12.7	13.8	14.9	16.1	17.5	18.9	20.6
5	-0.2	16.3	0.1	13.0	14.0	15.1	16.3	17.7	19.2	20.8
6	-0.2	16.5	0.1	13.2	14.2	15.3	16.5	17.9	19.4	21.0
7	-0.2	16.7	0.1	13.3	14.3	15.5	16.7	18.1	19.5	21.2
8	-0.2	16.8	0.1	13.4	14.5	15.6	16.8	18.2	19.7	21.3
9	-0.2	16.9	0.1	13.5	14.6	15.7	16.9	18.2	19.7	21.3
10	-0.2	17.0	0.1	13.6	14.6	15.7	17.0	18.3	19.7	21.3
11	-0.2	17.0	0.1	13.6	14.7	15.8	17.0	18.3	19.7	21.3
12	-0.2	16.9	0.1	13.7	14.7	15.8	16.9	18.3	19.7	21.2
13	-0.2	16.9	0.1	13.6	14.6	15.7	16.9	18.2	19.6	21.1
14	-0.2	16.8	0.1	13.6	14.6	15.7	16.8	18.1	19.5	21.0
15	-0.2	16.8	0.1	13.6	14.6	15.6	16.8	18.0	19.4	20.9
16	-0.2	16.7	0.1	13.5	14.5	15.5	16.7	17.9	19.2	20.7
17	-0.2	16.6	0.1	13.5	14.4	15.4	16.6	17.8	19.1	20.5
18	-0.2	16.4	0.1	13.4	14.3	15.3	16.4	17.6	18.9	20.3
19	-0.2	16.3	0.1	13.3	14.3	15.2	16.3	17.5	18.8	20.1
20	-0.2	16.2	0.1	13.3	14.2	15.1	16.2	17.3	18.6	19.9
21	-0.2	16.1	0.1	13.2	14.1	15.0	16.1	17.2	18.4	19.7
22	-0.2	15.9	0.1	13.1	14.0	14.9	15.9	17.0	18.2	19.5
23	-0.2	15.8	0.1	13.0	13.9	14.8	15.8	16.9	18.1	19.3
24	-0.2	15.7	0.1	12.9	13.8	14.7	15.7	16.7	17.9	19.1

Table (18) shows an increase in males BMI centiles up to 9 months, and decrease from 10 months to 24 months.

Table (18): LMS values and BMI-for-age percentiles for Bahraini males (0-24 months)

Age (months)	LMS			Percentiles						
	L	M	S	3 rd	10 th	25 th	50 th	75 th	90 th	97 th
0	0.5	15.6	0.1	12.0	13.1	14.4	15.6	17.0	18.4	19.8
1	0.5	15.9	0.1	12.2	13.4	14.7	15.9	17.3	18.7	20.1
2	0.5	16.2	0.1	12.5	13.7	14.9	16.2	17.6	19.0	20.4
3	0.5	16.5	0.1	12.8	14.0	15.2	16.5	17.8	19.2	20.7
4	0.5	16.7	0.1	13.0	14.2	15.5	16.7	18.1	19.5	20.9
5	0.5	16.9	0.1	13.3	14.4	15.7	16.9	18.3	19.7	21.1
6	0.5	17.1	0.1	13.5	14.6	15.9	17.1	18.4	19.8	21.2
7	0.5	17.3	0.1	13.6	14.8	16.0	17.3	18.6	19.9	21.3
8	0.5	17.4	0.1	13.8	14.9	16.1	17.4	18.7	20.0	21.4
9	0.5	17.4	0.1	13.9	15.0	16.2	17.4	18.7	20.0	21.4
10	0.5	17.5	0.1	14.0	15.1	16.3	17.5	18.7	20.0	21.4
11	0.5	17.5	0.1	14.0	15.1	16.3	17.5	18.7	20.0	21.3
12	0.5	17.5	0.1	14.1	15.1	16.3	17.5	18.7	19.9	21.2
13	0.5	17.4	0.1	14.1	15.1	16.3	17.4	18.6	19.8	21.1
14	0.5	17.3	0.1	14.1	15.1	16.2	17.3	18.5	19.7	20.9
15	0.5	17.3	0.1	14.1	15.1	16.2	17.3	18.4	19.6	20.8
16	0.5	17.2	0.1	14.0	15.0	16.1	17.2	18.3	19.4	20.6
17	0.5	17.0	0.1	14.0	15.0	16.0	17.0	18.1	19.2	20.4
18	0.5	16.9	0.1	14.0	14.9	15.9	16.9	18.0	19.1	20.2
19	0.5	16.8	0.1	13.9	14.8	15.8	16.8	17.8	18.9	20.0
20	0.5	16.7	0.1	13.8	14.8	15.7	16.7	17.7	18.7	19.7
21	0.5	16.5	0.1	13.8	14.7	15.6	16.5	17.5	18.5	19.5
22	0.5	16.4	0.1	13.7	14.6	15.5	16.4	17.3	18.3	19.3
23	0.5	16.2	0.1	13.6	14.5	15.4	16.2	17.2	18.1	19.1
24	0.5	16.1	0.1	13.6	14.4	15.2	16.1	17.0	17.9	18.8

Table (19) shows an increase of female's weight for length centiles by age up to two years.

Table (19): LMS values and weight-for-length percentiles for Bahraini females (0-24 months)

Length (cm)	LMS			Percentiles						
	L	M	S	3 rd	10 th	25 th	50 th	75 th	90 th	97 th
44	0.8	2.2	0.2	1.2	1.5	1.8	2.2	2.5	2.9	3.3
45	0.8	2.4	0.2	1.3	1.6	2.0	2.4	2.8	3.1	3.6
46	0.8	2.6	0.2	1.4	1.8	2.2	2.6	3.0	3.4	3.9
47	0.8	2.8	0.2	1.6	1.9	2.4	2.8	3.2	3.7	4.1
48	0.8	3.0	0.2	1.7	2.1	2.5	3.0	3.5	3.9	4.4
49	0.8	3.2	0.2	1.8	2.3	2.7	3.2	3.7	4.2	4.7
50	0.8	3.4	0.2	2.0	2.4	2.9	3.4	3.9	4.5	5.0
51	0.8	3.6	0.2	2.1	2.6	3.1	3.6	4.2	4.7	5.3
52	0.8	3.8	0.2	2.2	2.7	3.3	3.8	4.4	5.0	5.6
53	0.8	4.1	0.2	2.4	2.9	3.5	4.1	4.7	5.3	5.9
54	0.8	4.3	0.2	2.5	3.1	3.7	4.3	4.9	5.5	6.2
55	0.8	4.5	0.2	2.7	3.3	3.9	4.5	5.1	5.8	6.5
56	0.8	4.7	0.2	2.8	3.4	4.1	4.7	5.4	6.1	6.8
57	0.8	4.9	0.2	3.0	3.6	4.3	4.9	5.6	6.3	7.1
58	0.8	5.2	0.2	3.1	3.8	4.5	5.2	5.9	6.6	7.4
59	0.8	5.4	0.2	3.3	4.0	4.7	5.4	6.1	6.9	7.7
60	0.8	5.6	0.2	3.5	4.2	4.9	5.6	6.4	7.2	8.0
61	0.8	5.8	0.2	3.6	4.3	5.1	5.8	6.6	7.4	8.2
62	0.8	6.1	0.2	3.8	4.5	5.3	6.1	6.9	7.7	8.5
63	0.8	6.3	0.2	4.0	4.7	5.5	6.3	7.1	8.0	8.8
64	0.8	6.5	0.2	4.1	4.9	5.7	6.5	7.4	8.2	9.1
65	0.8	6.7	0.2	4.3	5.1	5.9	6.7	7.6	8.5	9.4
66	0.8	7.0	0.2	4.5	5.3	6.1	7.0	7.8	8.7	9.6
67	0.8	7.2	0.2	4.7	5.5	6.3	7.2	8.1	9.0	9.9
68	0.8	7.4	0.2	4.8	5.7	6.5	7.4	8.3	9.2	10.2
69	0.8	7.6	0.2	5.0	5.9	6.7	7.6	8.5	9.5	10.4
70	0.8	7.9	0.2	5.2	6.1	6.9	7.9	8.8	9.7	10.7
71	0.8	8.1	0.2	5.4	6.3	7.1	8.1	9.0	10.0	11.0
72	0.8	8.3	0.2	5.6	6.4	7.4	8.3	9.2	10.2	11.2
73	0.8	8.5	0.2	5.7	6.6	7.6	8.5	9.5	10.4	11.5
74	0.8	8.7	0.2	5.9	6.8	7.8	8.7	9.7	10.7	11.7
75	0.8	8.9	0.2	6.1	7.0	8.0	8.9	9.9	10.9	11.9
76	0.8	9.1	0.2	6.3	7.2	8.2	9.1	10.1	11.1	12.2

77	0.8	9.3	0.2	6.5	7.4	8.4	9.3	10.3	11.3	12.4
78	0.8	9.5	0.2	6.7	7.6	8.6	9.5	10.5	11.6	12.6
79	0.8	9.7	0.2	6.9	7.8	8.8	9.7	10.8	11.8	12.8
80	0.8	9.9	0.2	7.0	8.0	9.0	9.9	11.0	12.0	13.0
81	0.8	10.1	0.1	7.2	8.2	9.1	10.1	11.2	12.2	13.3
82	0.8	10.3	0.1	7.4	8.4	9.3	10.3	11.4	12.4	13.5
83	0.8	10.5	0.1	7.6	8.6	9.5	10.5	11.6	12.6	13.7
84	0.8	10.7	0.1	7.8	8.8	9.7	10.7	11.8	12.8	13.9
85	0.8	10.9	0.1	8.0	8.9	9.9	10.9	12.0	13.0	14.1
86	0.8	11.1	0.1	8.2	9.1	10.1	11.1	12.2	13.2	14.3
87	0.8	11.3	0.1	8.4	9.3	10.3	11.3	12.3	13.4	14.5
88	0.8	11.5	0.1	8.6	9.5	10.5	11.5	12.5	13.6	14.6
89	0.8	11.7	0.1	8.8	9.7	10.7	11.7	12.7	13.8	14.8
90	0.8	11.9	0.1	9.0	9.9	10.9	11.9	12.9	14.0	15.0
91	0.8	12.1	0.1	9.2	10.1	11.1	12.1	13.1	14.1	15.2
92	0.8	12.3	0.1	9.4	10.3	11.3	12.3	13.3	14.3	15.4
93	0.8	12.5	0.1	9.6	10.5	11.5	12.5	13.5	14.5	15.5
94	0.8	12.7	0.1	9.8	10.7	11.7	12.7	13.7	14.7	15.7
95	0.8	12.9	0.1	10.0	10.9	11.9	12.9	13.9	14.9	15.9
96	0.8	13.0	0.1	10.2	11.1	12.1	13.0	14.0	15.0	16.1
97	0.8	13.2	0.1	10.4	11.3	12.3	13.2	14.2	15.2	16.2
98	0.8	13.4	0.1	10.6	11.5	12.5	13.4	14.4	15.4	16.4

Table (20) shows an increase of male's weight for length centiles by age up to two years.

Table (20): LMS values and weight-for-length percentiles for Bahraini males (0-24 months)

Length (cm)	LMS			Percentiles						
	L	M	S	3 rd	10 th	25 th	50 th	75 th	90 th	97 th
44	0.8	2.2	0.3	1.1	1.5	1.8	2.2	2.6	3.0	3.4
45	0.8	2.4	0.3	1.2	1.6	2.0	2.4	2.9	3.3	3.7
46	0.8	2.7	0.3	1.4	1.8	2.2	2.7	3.1	3.6	4.1
47	0.8	2.9	0.3	1.5	1.9	2.4	2.9	3.4	3.9	4.4
48	0.8	3.1	0.2	1.6	2.1	2.6	3.1	3.6	4.2	4.7
49	0.8	3.3	0.2	1.8	2.3	2.8	3.3	3.9	4.5	5.0
50	0.8	3.6	0.2	1.9	2.4	3.0	3.6	4.1	4.7	5.4
51	0.8	3.8	0.2	2.1	2.6	3.2	3.8	4.4	5.0	5.7
52	0.8	4.0	0.2	2.2	2.8	3.4	4.0	4.7	5.3	6.0
53	0.8	4.3	0.2	2.3	3.0	3.6	4.3	4.9	5.6	6.3
54	0.8	4.5	0.2	2.5	3.1	3.8	4.5	5.2	5.9	6.6
55	0.8	4.7	0.2	2.7	3.3	4.0	4.7	5.4	6.2	6.9
56	0.8	4.9	0.2	2.8	3.5	4.2	4.9	5.7	6.5	7.2
57	0.8	5.2	0.2	3.0	3.7	4.4	5.2	6.0	6.7	7.5
58	0.8	5.4	0.2	3.2	3.9	4.6	5.4	6.2	7.0	7.8
59	0.8	5.7	0.2	3.3	4.1	4.9	5.7	6.5	7.3	8.2
60	0.8	5.9	0.2	3.5	4.3	5.1	5.9	6.7	7.6	8.5
61	0.8	6.1	0.2	3.7	4.5	5.3	6.1	7.0	7.9	8.8
62	0.8	6.4	0.2	3.9	4.7	5.5	6.4	7.2	8.1	9.0
63	0.8	6.6	0.2	4.0	4.9	5.7	6.6	7.5	8.4	9.3
64	0.8	6.8	0.2	4.2	5.1	5.9	6.8	7.8	8.7	9.6
65	0.8	7.1	0.2	4.4	5.3	6.2	7.1	8.0	9.0	9.9
66	0.8	7.3	0.2	4.6	5.5	6.4	7.3	8.3	9.2	10.2
67	0.8	7.5	0.2	4.8	5.7	6.6	7.5	8.5	9.5	10.5
68	0.8	7.8	0.2	5.0	5.9	6.8	7.8	8.8	9.7	10.7
69	0.8	8.0	0.2	5.2	6.1	7.0	8.0	9.0	10.0	11.0
70	0.8	8.2	0.2	5.4	6.3	7.3	8.2	9.2	10.2	11.3
71	0.8	8.5	0.2	5.6	6.5	7.5	8.5	9.5	10.5	11.5
72	0.8	8.7	0.2	5.8	6.7	7.7	8.7	9.7	10.7	11.8
73	0.8	8.9	0.2	6.0	6.9	7.9	8.9	9.9	11.0	12.0
74	0.8	9.1	0.2	6.2	7.1	8.1	9.1	10.2	11.2	12.3
75	0.8	9.3	0.2	6.4	7.3	8.3	9.3	10.4	11.4	12.5
76	0.8	9.6	0.2	6.6	7.5	8.5	9.6	10.6	11.6	12.7

77	0.8	9.8	0.2	6.8	7.8	8.8	9.8	10.8	11.9	12.9
78	0.8	10.0	0.2	7.0	8.0	9.0	10.0	11.0	12.1	13.1
79	0.8	10.2	0.2	7.2	8.2	9.2	10.2	11.2	12.3	13.3
80	0.8	10.4	0.1	7.4	8.4	9.4	10.4	11.4	12.5	13.5
81	0.8	10.6	0.1	7.6	8.6	9.6	10.6	11.6	12.7	13.7
82	0.8	10.8	0.1	7.8	8.8	9.8	10.8	11.8	12.9	13.9
83	0.8	11.0	0.1	8.0	9.0	10.0	11.0	12.0	13.1	14.1
84	0.8	11.2	0.1	8.2	9.2	10.2	11.2	12.2	13.2	14.3
85	0.8	11.4	0.1	8.4	9.4	10.4	11.4	12.4	13.4	14.5
86	0.8	11.6	0.1	8.6	9.6	10.6	11.6	12.6	13.6	14.6
87	0.8	11.7	0.1	8.8	9.8	10.8	11.7	12.7	13.8	14.8
88	0.8	11.9	0.1	9.0	10.0	10.9	11.9	12.9	13.9	14.9
89	0.8	12.1	0.1	9.2	10.2	11.1	12.1	13.1	14.1	15.1
90	0.8	12.3	0.1	9.5	10.4	11.3	12.3	13.3	14.2	15.2
91	0.8	12.5	0.1	9.7	10.6	11.5	12.5	13.4	14.4	15.4
92	0.8	12.7	0.1	9.9	10.8	11.7	12.7	13.6	14.6	15.5
93	0.8	12.8	0.1	10.1	11.0	11.9	12.8	13.8	14.7	15.7
94	0.8	13.0	0.1	10.3	11.2	12.1	13.0	13.9	14.9	15.8
95	0.8	13.2	0.1	10.5	11.4	12.3	13.2	14.1	15.0	15.9
96	0.8	13.4	0.1	10.8	11.6	12.5	13.4	14.3	15.2	16.1
97	0.8	13.6	0.1	11.0	11.8	12.7	13.6	14.4	15.3	16.2
98	0.8	13.7	0.1	11.2	12.0	12.9	13.7	14.6	15.5	16.3

Table (21) shows an increase of female's weight for age Z-scores by age up to two years.

Table (21): LMS values and weight-for-age Z-score for Bahraini females (0-24 months)

Age (months)	LMS			Z-scores						
	L	M	S	-3SD	-2 SD	-1SD	Median	1SD	2SD	3SD
0	0.4	3.4	0.2	0.4	1.4	2.4	3.4	4.4	5.4	6.4
1	0.4	4.0	0.2	1.0	2.0	3.0	4.0	5.0	6.0	7.0
2	0.4	4.7	0.1	1.7	2.7	3.7	4.7	5.7	6.7	7.7
3	0.4	5.3	0.1	2.3	3.3	4.3	5.3	6.3	7.3	8.3
4	0.4	5.9	0.1	2.9	3.9	4.9	5.9	6.9	7.9	8.9
5	0.4	6.5	0.1	3.5	4.5	5.5	6.5	7.5	8.5	9.5
6	0.4	7.0	0.1	4.0	5.0	6.0	7.0	8.0	9.0	10.0
7	0.4	7.5	0.1	4.5	5.5	6.5	7.5	8.5	9.5	10.5
8	0.4	7.9	0.1	4.9	5.9	6.9	7.9	8.9	9.9	10.9
9	0.4	8.3	0.1	5.3	6.3	7.3	8.3	9.3	10.3	11.3
10	0.4	8.7	0.1	5.7	6.7	7.7	8.7	9.7	10.7	11.7
11	0.4	9.1	0.1	6.1	7.1	8.1	9.1	10.1	11.1	12.1
12	0.4	9.4	0.1	6.4	7.4	8.4	9.4	10.4	11.4	12.4
13	0.4	9.7	0.1	6.7	7.7	8.7	9.7	10.7	11.7	12.7
14	0.4	10.0	0.1	7.0	8.0	9.0	10.0	11.0	12.0	13.0
15	0.4	10.3	0.1	7.3	8.3	9.3	10.3	11.3	12.3	13.3
16	0.4	10.5	0.1	7.5	8.5	9.5	10.5	11.5	12.5	13.5
17	0.4	10.8	0.1	7.8	8.8	9.8	10.8	11.8	12.8	13.8
18	0.4	11.0	0.1	8.0	9.0	10.0	11.0	12.0	13.0	14.0
19	0.4	11.2	0.1	8.2	9.2	10.2	11.2	12.2	13.2	14.2
20	0.4	11.5	0.1	8.5	9.5	10.5	11.5	12.5	13.5	14.5
21	0.4	11.7	0.1	8.7	9.7	10.7	11.7	12.7	13.7	14.7
22	0.4	11.9	0.1	8.9	9.9	10.9	11.9	12.9	13.9	14.9
23	0.4	12.1	0.1	9.1	10.1	11.1	12.1	13.1	14.1	15.1
24	0.4	12.3	0.1	9.3	10.3	11.3	12.3	13.3	14.3	15.3

Table (22) shows an increase of male's weight-for -age Z-scores by age up to two up to two years.

Table (22): LMS values and weight-for-age Z-score for Bahraini males (0-24 months)

Age (months)	LMS			Z-scores						
	L	M	S	-3SD	-2SD	-1SD	Median	1SD	2SD	3SD
0	0.3	3.7	0.1	0.7	1.7	2.7	3.7	4.7	5.7	6.7
1	0.3	4.4	0.1	1.4	2.4	3.4	4.4	5.4	6.4	7.4
2	0.3	5.1	0.1	2.1	3.1	4.1	5.1	6.1	7.1	8.1
3	0.3	5.7	0.1	2.7	3.7	4.7	5.7	6.7	7.7	8.7
4	0.3	6.4	0.1	3.4	4.4	5.4	6.4	7.4	8.4	9.4
5	0.3	7.0	0.1	4.0	5.0	6.0	7.0	8.0	9.0	10.0
6	0.3	7.5	0.1	4.5	5.5	6.5	7.5	8.5	9.5	10.5
7	0.3	8.0	0.1	5.0	6.0	7.0	8.0	9.0	10.0	11.0
8	0.3	8.5	0.1	5.5	6.5	7.5	8.5	9.5	10.5	11.5
9	0.3	9.0	0.1	6.0	7.0	8.0	9.0	10.0	11.0	12.0
10	0.3	9.4	0.1	6.4	7.4	8.4	9.4	10.4	11.4	12.4
11	0.3	9.7	0.1	6.7	7.7	8.7	9.7	10.7	11.7	12.7
12	0.3	10.1	0.1	7.1	8.1	9.1	10.1	11.1	12.1	13.1
13	0.3	10.4	0.1	7.4	8.4	9.4	10.4	11.4	12.4	13.4
14	0.3	10.7	0.1	7.7	8.7	9.7	10.7	11.7	12.7	13.7
15	0.3	10.9	0.1	7.9	8.9	9.9	10.9	11.9	12.9	13.9
16	0.3	11.2	0.1	8.2	9.2	10.2	11.2	12.2	13.2	14.2
17	0.3	11.4	0.1	8.4	9.4	10.4	11.4	12.4	13.4	14.4
18	0.3	11.7	0.1	8.6	9.6	10.7	11.7	12.7	13.7	14.7
19	0.3	11.9	0.1	8.9	9.9	10.9	11.9	12.9	13.9	14.9
20	0.3	12.1	0.1	9.1	10.1	11.1	12.1	13.1	14.1	15.1
21	0.3	12.3	0.1	9.2	10.3	11.3	12.3	13.3	14.3	15.3
22	0.3	12.4	0.1	9.4	10.4	11.4	12.4	13.4	14.4	15.4
23	0.3	12.6	0.1	9.6	10.6	11.6	12.6	13.6	14.6	15.6
24	0.3	12.8	0.1	9.8	10.8	11.8	12.8	13.8	14.8	15.8

Table (23) shows an increase of female's length-for -age Z-scores by age up to two up to two years.

Table (23): Length for age z-scores for Bahraini females

Age (months)	LMS			Z-scores						
	L	M	S	-3SD	-2SD	-1SD	Median	1SD	2SD	3SD
0	2.1	51.3	0.0	48.3	49.3	50.3	51.3	52.3	53.3	54.3
1	2.1	53.5	0.0	50.5	51.5	52.5	53.5	54.5	55.5	56.5
2	2.1	55.8	0.0	52.8	53.8	54.8	55.8	56.8	57.8	58.8
3	2.1	58.0	0.0	55.0	56.0	57.0	58.0	59.0	60.0	61.0
4	2.1	60.2	0.0	57.2	58.2	59.2	60.2	61.2	62.2	63.2
5	2.1	62.3	0.0	59.3	60.3	61.3	62.3	63.3	64.3	65.3
6	2.1	64.3	0.0	61.3	62.3	63.3	64.3	65.3	66.3	67.3
7	2.1	66.2	0.0	63.2	64.2	65.2	66.2	67.2	68.2	69.2
8	2.1	68.0	0.0	65.0	66.0	67.0	68.0	69.0	70.0	71.0
9	2.1	69.7	0.0	66.7	67.7	68.7	69.7	70.7	71.7	72.7
10	2.1	71.4	0.0	68.4	69.4	70.4	71.4	72.4	73.4	74.4
11	2.1	72.9	0.0	69.9	70.9	71.9	72.9	73.9	74.9	75.9
12	2.1	74.4	0.0	71.4	72.4	73.4	74.4	75.4	76.4	77.4
13	2.1	75.8	0.0	72.8	73.8	74.8	75.8	76.8	77.8	78.8
14	2.1	77.2	0.0	74.2	75.2	76.2	77.2	78.2	79.2	80.2
15	2.1	78.4	0.0	75.4	76.4	77.4	78.4	79.4	80.4	81.4
16	2.1	79.7	0.0	76.7	77.7	78.7	79.7	80.7	81.7	82.7
17	2.1	80.9	0.0	77.9	78.9	79.9	80.9	81.9	82.9	83.9
18	2.1	82.0	0.0	79.0	80.0	81.0	82.0	83.0	84.0	85.0
19	2.1	83.2	0.0	80.2	81.2	82.2	83.2	84.2	85.2	86.2
20	2.1	84.3	0.0	81.3	82.3	83.3	84.3	85.3	86.3	87.3
21	2.1	85.4	0.0	82.4	83.4	84.4	85.4	86.4	87.4	88.4
22	2.1	86.4	0.0	83.4	84.4	85.4	86.4	87.4	88.4	89.4
23	2.1	87.5	0.0	84.5	85.5	86.5	87.5	88.5	89.5	90.5
24	2.1	88.6	0.0	85.6	86.6	87.6	88.6	89.6	90.6	91.6

The male's length-for -age Z-scores showed an increase by age up to two up to two years (Table 24).

Table (24): LMS values and length-for-age Z-scores for Bahraini males (0-24 months)

Age (months)	LMS			Z-scores						
	L	M	S	-3SD	-2SD	-1SD	Median	1SD	2SD	3SD
0	3.2	52.9	0.0	49.9	50.9	51.9	52.9	53.9	54.9	55.9
1	3.2	55.2	0.0	52.2	53.2	54.2	55.2	56.2	57.2	58.2
2	3.2	57.4	0.0	54.4	55.4	56.4	57.4	58.4	59.4	60.4
3	3.2	59.6	0.0	56.6	57.6	58.6	59.6	60.6	61.6	62.6
4	3.2	61.8	0.0	58.8	59.8	60.8	61.8	62.8	63.8	64.8
5	3.2	63.9	0.0	60.9	61.9	62.9	63.9	64.9	65.9	66.9
6	3.2	65.8	0.0	62.8	63.8	64.8	65.8	66.8	67.8	68.8
7	3.2	67.7	0.0	64.7	65.7	66.7	67.7	68.7	69.7	70.7
8	3.2	69.5	0.0	66.5	67.5	68.5	69.5	70.5	71.5	72.5
9	3.2	71.2	0.0	68.2	69.2	70.2	71.2	72.2	73.2	74.2
10	3.2	72.9	0.0	69.9	70.9	71.9	72.9	73.9	74.9	75.9
11	3.2	74.4	0.0	71.4	72.4	73.4	74.4	75.4	76.4	77.4
12	3.2	75.8	0.0	72.8	73.8	74.8	75.8	76.8	77.8	78.8
13	3.2	77.2	0.0	74.2	75.2	76.2	77.2	78.2	79.2	80.2
14	3.2	78.5	0.0	75.5	76.5	77.5	78.5	79.5	80.5	81.5
15	3.2	79.7	0.0	76.7	77.7	78.7	79.7	80.7	81.7	82.7
16	3.2	80.9	0.0	77.9	78.9	79.9	80.9	81.9	82.9	83.9
17	3.2	82.1	0.0	79.1	80.1	81.1	82.1	83.1	84.1	85.1
18	3.2	83.2	0.0	80.2	81.2	82.2	83.2	84.2	85.2	86.2
19	3.2	84.2	0.0	81.2	82.2	83.2	84.2	85.2	86.2	87.2
20	3.2	85.3	0.0	82.3	83.3	84.3	85.3	86.3	87.3	88.3
21	3.2	86.3	0.0	83.3	84.3	85.3	86.3	87.3	88.3	89.3
22	3.2	87.3	0.0	84.3	85.3	86.3	87.3	88.3	89.3	90.3
23	3.2	88.3	0.0	85.3	86.3	87.3	88.3	89.3	90.3	91.3
24	3.2	89.3	0.0	86.3	87.3	88.3	89.3	90.3	91.3	92.3

The females BMI-for-age Z-scores showed an increase up to 11 months and decreased from 12 months up to two years (Table 25).

Table (25): LMS values and BMI-for-age z-scores for Bahraini females (0-24 months)

Age (months)	LMS			Z-scores						
	L	M	S	-3SD	-2SD	-1SD	Median	1SD	2SD	3SD
0	-0.2	14.9	0.1	11.9	12.9	13.9	14.9	15.9	16.9	17.9
1	-0.2	15.2	0.1	12.2	13.2	14.2	15.2	16.2	17.2	18.2
2	-0.2	15.5	0.1	12.5	13.5	14.5	15.5	16.5	17.5	18.5
3	-0.2	15.8	0.1	12.8	13.8	14.8	15.8	16.8	17.8	18.8
4	-0.2	16.1	0.1	13.1	14.1	15.1	16.1	17.1	18.1	19.1
5	-0.2	16.3	0.1	13.3	14.3	15.3	16.3	17.3	18.3	19.3
6	-0.2	16.5	0.1	13.5	14.5	15.5	16.5	17.5	18.5	19.5
7	-0.2	16.7	0.1	13.7	14.7	15.7	16.7	17.7	18.7	19.7
8	-0.2	16.8	0.1	13.8	14.8	15.8	16.8	17.8	18.8	19.8
9	-0.2	16.9	0.1	13.9	14.9	15.9	16.9	17.9	18.9	19.9
10	-0.2	17.0	0.1	14.0	15.0	16.0	17.0	18.0	19.0	20.0
11	-0.2	17.0	0.1	14.0	15.0	16.0	17.0	18.0	19.0	20.0
12	-0.2	17.0	0.1	14.0	15.0	16.0	17.0	18.0	19.0	20.0
13	-0.2	16.9	0.1	13.9	14.9	15.9	16.9	17.9	18.9	19.9
14	-0.2	16.8	0.1	13.8	14.8	15.8	16.8	17.8	18.8	19.8
15	-0.2	16.8	0.1	13.8	14.8	15.8	16.8	17.8	18.8	19.8
16	-0.2	16.7	0.1	13.7	14.7	15.7	16.7	17.7	18.7	19.7
17	-0.2	16.6	0.1	13.6	14.6	15.6	16.6	17.6	18.6	19.6
18	-0.2	16.4	0.1	13.4	14.4	15.4	16.4	17.4	18.4	19.4
19	-0.2	16.3	0.1	13.3	14.3	15.3	16.3	17.3	18.3	19.3
20	-0.2	16.2	0.1	13.2	14.2	15.2	16.2	17.2	18.2	19.2
21	-0.2	16.1	0.1	13.1	14.1	15.1	16.1	17.1	18.1	19.1
22	-0.2	15.9	0.1	12.9	13.9	14.9	15.9	16.9	17.9	18.9
23	-0.2	15.8	0.1	12.8	13.8	14.8	15.8	16.8	17.8	18.8
24	-0.2	15.7	0.1	12.7	13.7	14.7	15.7	16.7	17.7	18.7

The males BMI-for-age Z-scores as well showed an increase up to 11 months and decreased from 12 months up to two years (Table 26).

Table (26): LMS values and BMI-for-age z-scores for Bahraini males (0-24 months)

Age (months)	LMS			Z-scores						
	L	M	S	-3SD	-2SD	-1SD	Median	1SD	2SD	3SD
0	0.5	15.6	0.1	12.6	13.6	14.6	15.6	16.6	17.6	18.6
1	0.5	15.9	0.1	12.9	13.9	14.9	15.9	16.9	17.9	18.9
2	0.5	16.2	0.1	13.2	14.2	15.2	16.2	17.2	18.2	19.2
3	0.5	16.5	0.1	13.5	14.5	15.5	16.5	17.5	18.5	19.5
4	0.5	16.7	0.1	13.7	14.7	15.7	16.7	17.7	18.7	19.7
5	0.5	17.0	0.1	14.0	15.0	16.0	17.0	18.0	19.0	20.0
6	0.5	17.1	0.1	14.1	15.1	16.1	17.1	18.1	19.1	20.1
7	0.5	17.3	0.1	14.3	15.3	16.3	17.3	18.3	19.3	20.3
8	0.5	17.4	0.1	14.4	15.4	16.4	17.4	18.4	19.4	20.4
9	0.5	17.4	0.1	14.4	15.4	16.4	17.4	18.4	19.4	20.4
10	0.5	17.5	0.1	14.5	15.5	16.5	17.5	18.5	19.5	20.5
11	0.5	17.5	0.1	14.5	15.5	16.5	17.5	18.5	19.5	20.5
12	0.5	17.5	0.1	14.5	15.5	16.5	17.5	18.5	19.5	20.5
13	0.5	17.4	0.1	14.4	15.4	16.4	17.4	18.4	19.4	20.4
14	0.5	17.3	0.1	14.3	15.3	16.3	17.3	18.3	19.3	20.3
15	0.5	17.3	0.1	14.3	15.3	16.3	17.3	18.3	19.3	20.3
16	0.5	17.2	0.1	14.2	15.2	16.2	17.2	18.2	19.2	20.2
17	0.5	17.1	0.1	14.1	15.1	16.1	17.1	18.1	19.1	20.1
18	0.5	16.9	0.1	13.9	14.9	15.9	16.9	17.9	18.9	19.9
19	0.5	16.8	0.1	13.8	14.8	15.8	16.8	17.8	18.8	19.8
20	0.5	16.7	0.1	13.7	14.7	15.7	16.7	17.7	18.7	19.7
21	0.5	16.5	0.1	13.5	14.5	15.5	16.5	17.5	18.5	19.5
22	0.5	16.4	0.1	13.4	14.4	15.4	16.4	17.4	18.4	19.4
23	0.5	16.3	0.1	13.3	14.3	15.3	16.3	17.3	18.3	19.3
24	0.5	16.1	0.1	13.1	14.1	15.1	16.1	17.1	18.1	19.1

The female's weight-for-length Z-scores as showed an increase up to two years (Table 27).

Table (27): LMS values and weight-for-length Z-scores for Bahraini females (0-24 months)

Length (cm)	LMS			Z-scores						
	L	M	S	-3SD	-2SD	-1SD	Median	1SD	2SD	3SD
44	0.8	2.2	0.2	-0.8	0.2	1.2	2.2	3.2	4.2	5.2
45	0.8	2.4	0.2	-0.6	0.4	1.4	2.4	3.4	4.4	5.4
46	0.8	2.6	0.2	-0.4	0.6	1.6	2.6	3.6	4.6	5.6
47	0.8	2.8	0.2	-0.2	0.8	1.8	2.8	3.8	4.8	5.8
48	0.8	3.0	0.2	0.0	1.0	2.0	3.0	4.0	5.0	6.0
49	0.8	3.2	0.2	0.2	1.2	2.2	3.2	4.2	5.2	6.2
50	0.8	3.4	0.2	0.4	1.4	2.4	3.4	4.4	5.4	6.4
51	0.8	3.6	0.2	0.6	1.6	2.6	3.6	4.6	5.6	6.6
52	0.8	3.8	0.2	0.8	1.8	2.8	3.8	4.8	5.8	6.8
53	0.8	4.1	0.2	1.1	2.1	3.1	4.1	5.1	6.1	7.1
54	0.8	4.3	0.2	1.3	2.3	3.3	4.3	5.3	6.3	7.3
55	0.8	4.5	0.2	1.5	2.5	3.5	4.5	5.5	6.5	7.5
56	0.8	4.7	0.2	1.7	2.7	3.7	4.7	5.7	6.7	7.7
57	0.8	4.9	0.2	1.9	2.9	3.9	4.9	5.9	6.9	7.9
58	0.8	5.2	0.2	2.2	3.2	4.2	5.2	6.2	7.2	8.2
59	0.8	5.4	0.2	2.4	3.4	4.4	5.4	6.4	7.4	8.4
60	0.8	5.6	0.2	2.6	3.6	4.6	5.6	6.6	7.6	8.6
61	0.8	5.8	0.2	2.8	3.8	4.8	5.8	6.8	7.8	8.8
62	0.8	6.1	0.2	3.1	4.1	5.1	6.1	7.1	8.1	9.1
63	0.8	6.3	0.2	3.3	4.3	5.3	6.3	7.3	8.3	9.3
64	0.8	6.5	0.2	3.5	4.5	5.5	6.5	7.5	8.5	9.5
65	0.8	6.7	0.2	3.7	4.7	5.7	6.7	7.7	8.7	9.7
66	0.8	7.0	0.2	4.0	5.0	6.0	7.0	8.0	9.0	10.0
67	0.8	7.2	0.2	4.2	5.2	6.2	7.2	8.2	9.2	10.2
68	0.8	7.4	0.2	4.4	5.4	6.4	7.4	8.4	9.4	10.4
69	0.8	7.6	0.2	4.6	5.6	6.6	7.6	8.6	9.6	10.6
70	0.8	7.9	0.2	4.9	5.9	6.9	7.9	8.9	9.9	10.9
71	0.8	8.1	0.2	5.1	6.1	7.1	8.1	9.1	10.1	11.1
72	0.8	8.3	0.2	5.3	6.3	7.3	8.3	9.3	10.3	11.3
73	0.8	8.5	0.2	5.5	6.5	7.5	8.5	9.5	10.5	11.5
74	0.8	8.7	0.2	5.7	6.7	7.7	8.7	9.7	10.7	11.7
75	0.8	8.9	0.2	5.9	6.9	7.9	8.9	9.9	10.9	11.9

76	0.8	9.1	0.2	6.1	7.1	8.1	9.1	10.1	11.1	12.1
77	0.8	9.3	0.2	6.3	7.3	8.3	9.3	10.3	11.3	12.3
78	0.8	9.5	0.2	6.5	7.5	8.5	9.5	10.5	11.5	12.5
79	0.8	9.7	0.2	6.7	7.7	8.7	9.7	10.7	11.7	12.7
80	0.8	9.9	0.2	6.9	7.9	8.9	9.9	10.9	11.9	12.9
81	0.8	10.1	0.1	7.1	8.1	9.1	10.1	11.1	12.1	13.1
82	0.8	10.3	0.1	7.3	8.3	9.3	10.3	11.3	12.3	13.3
83	0.8	10.5	0.1	7.5	8.5	9.5	10.5	11.5	12.5	13.5
84	0.8	10.7	0.1	7.7	8.7	9.7	10.7	11.7	12.7	13.7
85	0.8	10.9	0.1	7.9	8.9	9.9	10.9	11.9	12.9	13.9
86	0.8	11.1	0.1	8.1	9.1	10.1	11.1	12.1	13.1	14.1
87	0.8	11.3	0.1	8.3	9.3	10.3	11.3	12.3	13.3	14.3
88	0.8	11.5	0.1	8.5	9.5	10.5	11.5	12.5	13.5	14.5
89	0.8	11.7	0.1	8.7	9.7	10.7	11.7	12.7	13.7	14.7
90	0.8	11.9	0.1	8.9	9.9	10.9	11.9	12.9	13.9	14.9
91	0.8	12.1	0.1	9.1	10.1	11.1	12.1	13.1	14.1	15.1
92	0.8	12.3	0.1	9.3	10.3	11.3	12.3	13.3	14.3	15.3
93	0.8	12.5	0.1	9.5	10.5	11.5	12.5	13.5	14.5	15.5
94	0.8	12.7	0.1	9.7	10.7	11.7	12.7	13.7	14.7	15.7
95	0.8	12.9	0.1	9.9	10.9	11.9	12.9	13.9	14.9	15.9
96	0.8	13.1	0.1	10.1	11.1	12.1	13.1	14.1	15.1	16.1
97	0.8	13.2	0.1	10.2	11.2	12.2	13.2	14.2	15.2	16.2
98	0.8	13.4	0.1	10.4	11.4	12.4	13.4	14.4	15.4	16.4

Table (28) shows that the male's weight-for-length Z-scores increased by age up to two years.

Table (28): LMS values and weight-for-length Z-scores for Bahraini males (0-24 months)

Length (cm)	LMS			Z-scores						
	L	M	S	-3SD	-2SD	-1SD	Median	1SD	2SD	3SD
44	0.8	2.2	0.3	-0.8	0.2	1.2	2.2	3.2	4.2	3.2
45	0.8	2.4	0.3	-0.6	0.4	1.4	2.4	3.4	4.4	3.4
46	0.8	2.7	0.3	-0.3	0.7	1.7	2.7	3.7	4.7	3.7
47	0.8	2.9	0.3	-0.1	0.9	1.9	2.9	3.9	4.9	3.9
48	0.8	3.1	0.2	0.1	1.1	2.1	3.1	4.1	5.1	4.1
49	0.8	3.3	0.2	0.3	1.3	2.3	3.3	4.3	5.3	4.3
50	0.8	3.6	0.2	0.6	1.6	2.6	3.6	4.6	5.6	4.6
51	0.8	3.8	0.2	0.8	1.8	2.8	3.8	4.8	5.8	4.8
52	0.8	4.0	0.2	1.0	2.0	3.0	4.0	5.0	6.0	5.0
53	0.8	4.3	0.2	1.3	2.3	3.3	4.3	5.3	6.3	5.3
54	0.8	4.5	0.2	1.5	2.5	3.5	4.5	5.5	6.5	5.5
55	0.8	4.7	0.2	1.7	2.7	3.7	4.7	5.7	6.7	5.7
56	0.8	4.9	0.2	1.9	2.9	3.9	4.9	5.9	6.9	5.9
57	0.8	5.2	0.2	2.2	3.2	4.2	5.2	6.2	7.2	6.2
58	0.8	5.4	0.2	2.4	3.4	4.4	5.4	6.4	7.4	6.4
59	0.8	5.7	0.2	2.7	3.7	4.7	5.7	6.7	7.7	6.7
60	0.8	5.9	0.2	2.9	3.9	4.9	5.9	6.9	7.9	6.9
61	0.8	6.1	0.2	3.1	4.1	5.1	6.1	7.1	8.1	7.1
62	0.8	6.4	0.2	3.4	4.4	5.4	6.4	7.4	8.4	7.4
63	0.8	6.6	0.2	3.6	4.6	5.6	6.6	7.6	8.6	7.6
64	0.8	6.8	0.2	3.8	4.8	5.8	6.8	7.8	8.8	7.8
65	0.8	7.1	0.2	4.1	5.1	6.1	7.1	8.1	9.1	8.1
66	0.8	7.3	0.2	4.3	5.3	6.3	7.3	8.3	9.3	8.3
67	0.8	7.5	0.2	4.5	5.5	6.5	7.5	8.5	9.5	8.5
68	0.8	7.8	0.2	4.8	5.8	6.8	7.8	8.8	9.8	8.8
69	0.8	8.0	0.2	5.0	6.0	7.0	8.0	9.0	10.0	9.0
70	0.8	8.2	0.2	5.2	6.2	7.2	8.2	9.2	10.2	9.2
71	0.8	8.5	0.2	5.5	6.5	7.5	8.5	9.5	10.5	9.5
72	0.8	8.7	0.2	5.7	6.7	7.7	8.7	9.7	10.7	9.7
73	0.8	8.9	0.2	5.9	6.9	7.9	8.9	9.9	10.9	9.9
74	0.8	9.1	0.2	6.1	7.1	8.1	9.1	10.1	11.1	10.1
75	0.8	9.3	0.2	6.3	7.3	8.3	9.3	10.4	11.4	10.4

76	0.8	9.6	0.2	6.6	7.6	8.6	9.6	10.6	11.6	10.6
77	0.8	9.8	0.2	6.8	7.8	8.8	9.8	10.8	11.8	10.8
78	0.8	10.0	0.2	7.0	8.0	9.0	10.0	11.0	12.0	11.0
79	0.8	10.2	0.2	7.2	8.2	9.2	10.2	11.2	12.2	11.2
80	0.8	10.4	0.1	7.4	8.4	9.4	10.4	11.4	12.4	11.4
81	0.8	10.6	0.1	7.6	8.6	9.6	10.6	11.6	12.6	11.6
82	0.8	10.8	0.1	7.8	8.8	9.8	10.8	11.8	12.8	11.8
83	0.8	11.0	0.1	8.0	9.0	10.0	11.0	12.0	13.0	12.0
84	0.8	11.2	0.1	8.2	9.2	10.2	11.2	12.2	13.2	12.2
85	0.8	11.4	0.1	8.4	9.4	10.4	11.4	12.4	13.4	12.4
86	0.8	11.6	0.1	8.6	9.6	10.6	11.6	12.6	13.6	12.6
87	0.8	11.7	0.1	8.7	9.7	10.7	11.7	12.7	13.7	12.7
88	0.8	11.9	0.1	8.9	9.9	10.9	11.9	12.9	13.9	12.9
89	0.8	12.1	0.1	9.1	10.1	11.1	12.1	13.1	14.1	13.1
90	0.8	12.3	0.1	9.3	10.3	11.3	12.3	13.3	14.3	13.3
91	0.8	12.5	0.1	9.5	10.5	11.5	12.5	13.5	14.5	13.5
92	0.8	12.7	0.1	9.7	10.7	11.7	12.7	13.7	14.7	13.7
93	0.8	12.8	0.1	9.8	10.8	11.8	12.8	13.8	14.8	13.8
94	0.8	13.0	0.1	10.0	11.0	12.0	13.0	14.0	15.0	14.0
95	0.8	13.2	0.1	10.2	11.2	12.2	13.2	14.2	15.2	14.2
96	0.8	13.4	0.1	10.4	11.4	12.4	13.4	14.4	15.4	14.4
97	0.8	13.6	0.1	10.6	11.6	12.6	13.6	14.6	15.6	14.6
98	0.8	13.7	0.1	10.7	11.7	12.7	13.7	14.7	15.7	14.7

4.9 Relationships between gestational age, birth weight and Hb

A relationship was found between gestational age and the weight at birth of males with a significant difference between the two variables ($p < 0.001$). In contrast, no relationship was found between gestational age and Hb at 9 months in both genders ($p < 0.001$) (Table 29).

Table (29): Relationship between gestational age and each of weight at birth and Hb at 9 months according to gender

		Weight at birth (kg)		Hb at 9 months	
		Males	Females	Males	Females
Gestational age (in weeks)	Pearson Correlation	0.282	0.210	0.036	0.990
	P-value	0.000	0.003	0.620	0.187
	N	202	191	194	180

4.10 Feeding Practices

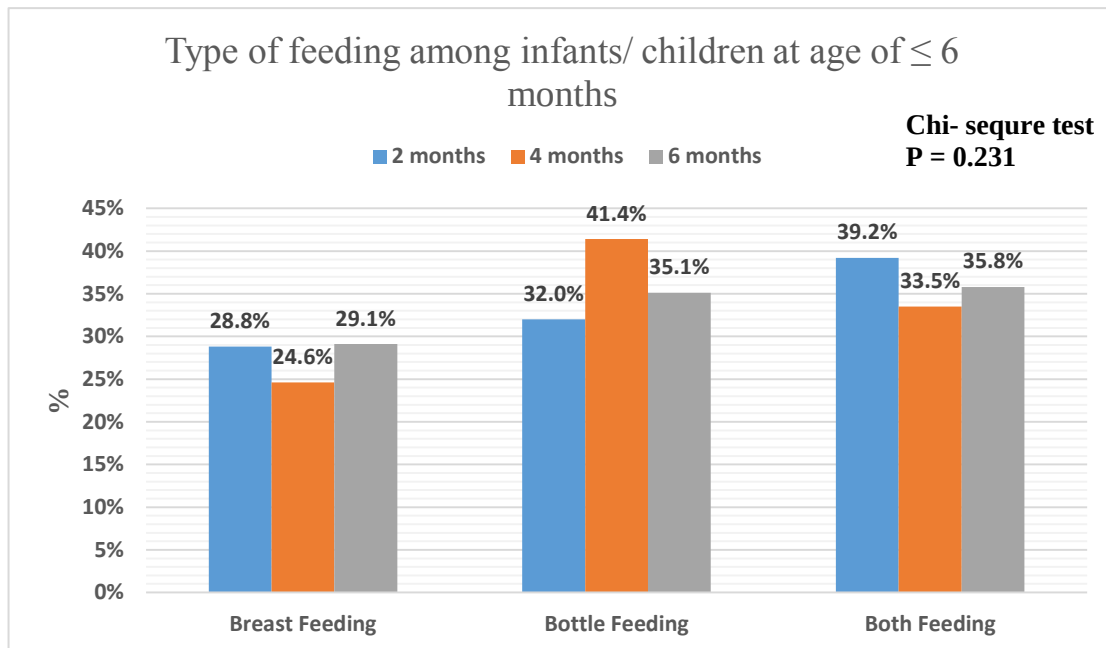


Figure 21: Type of feeding among infants/children at age of ≤ 6 months

The proportion of breastfed infants/children at 2 months was 28.8%, which slightly decreased at 4 months (24.6%) followed by slight increase at 6 month age (Figure 21). Pattern of bottle feeding showed an increase at the same age (41.4%), and increased again at 6 months (29.1%) (Figure 21). Furthermore, 39.2% of children were having both breast and bottle-feeding at 2 months, decreased to 33.5%, 35.8% at 4 and 6 months, respectively (Figure 21). However, no significance relationship found between age and type of feeding ($p < 0.05$) (Figure 21).

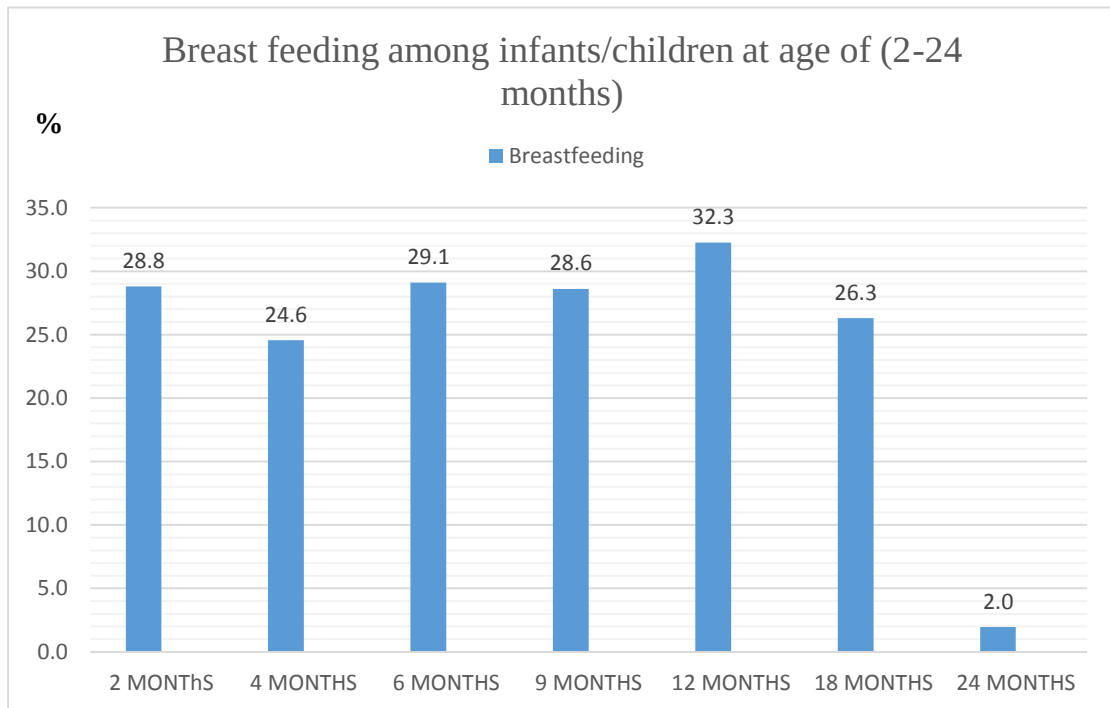


Figure 22: Breastfeeding pattern among infants/children at age of (2-24 months)

Figure (22) illustrates the rates of breastfeeding among children at the ages of 2 to 18 months; it shows an increase at 12 months (32.3%). At the age 24 months the rate of breastfeeding dropped because, mothers usually start weaning at this age.

Table (30) shows the relationship between the breastfeeding of children in 2, 4, 6, and 9 months and their Hb at 9 months. A statistically significance between the two variables was found in all ages ($P < 0.05$).

Table (30): Relation between Hb at 9 months and breastfeeding of children

Breast Feeding	Hb at 9 months		T-test P-value
		Mean SD	
2 months	Yes	10.7 1.0	0.003
	No	11.0 1.2	
4 months	Yes	10.6 .9	0.002
	No	11.0 1.2	
6 months	Yes	10.6 1.0	0.002
	No	11.0 1.2	
9 months	Yes	10.7 1.0	0.003
	No	11.0 1.2	

4.11 Nutritional status

Table (31) presents the prevalence of underweight and severely underweight that were found among the subjects of the study, according to gender. Nine cases were found at birth (2.3%), of which three were males (1.5%) and six females (3.1%). At the age of 2 months, the underweight percentage was 2.5% (n=10), five cases for each males and females. One case of severely underweight (0.2%) were found at both 4 and 12 months and both cases were among males.

Table (31): Prevalence of malnutrition among males and females according to weight-for-age z-scores

Age (months)	Status*	Males		Females		Total	
		N	%	n	%	N	%
0	Underweight	3	1.5	6	3.1	9	2.3
	Normal	202	98.5	187	96.9	389	97.7
2	Underweight	5	2.4	5	2.6	10	2.5
	Normal	205	97.6	188	97.4	393	97.5
4	Severely underweight	1	0.5	0	0.0	1	0.2
	Underweight	2	1.0	1	0.5	3	0.7
	Normal	206	98.6	192	99.5	398	99.0
6	Underweight	3	1.4	1	0.5	4	1.0
	Normal	207	98.6	191	99.5	398	99.0
9	Underweight	3	1.4	3	1.6	6	1.5
	Normal	207	98.6	189	98.4	396	98.5
12	Severely underweight	1	0.5	0	0.0	1	0.2
	Underweight	1	0.5	2	1.0	3	0.7
	Normal	206	99.0	191	99.0	397	99.0
18	Underweight	2	1.0	1	0.5	3	0.7
	Normal	207	99.0	192	99.5	399	99.3
24	Underweight	1	0.5	2	1.0	3	0.7
	Normal	209	99.5	191	99.0	400	99.3

* Status: Severely Underweight < -3SD – Underweight < -2SD -Normal = gray zone ((<-1 SD - > 3SD)
(WHO- Z-scores 2017)

Shown in Table (32) is the prevalence of stunting, severely stunting, and very tall among children in the ages from 0-24 months according to gender. The highest stunting percentages were found at 9 months (3.0%), 2.5% at 2 and 6 months, and very few cases of severely stunting and very tall were found.

Table (32): Prevalence of malnutrition among males and females according to length-for-age z-scores

Age (months)	Status*	Males		Females		Total	
		n	%	N	%	n	%
0	Severely Stunted	0	0.0	1	0.8	1	0.4
	Stunted	5	3.7	1	0.8	6	2.3
	Normal	131	96.3	121	98.4	252	97.3
2	Severely Stunted	1	0.5	0	0.0	1	0.2
	Stunted	4	1.9	6	3.1	10	2.5
	Normal	204	97.1	187	96.9	391	97.0
	Very tall	1	0.5	0	0.0	1	0.2
4	Severely Stunted	3	1.4	0	0.0	3	0.7
	Stunted	3	1.4	5	2.6	8	2.0
	Normal	202	96.7	186	96.4	388	96.5
	Very tall	1	0.5	2	1.0	3	0.7
6	Severely Stunted	1	0.5	0	0.0	1	0.2
	Stunted	7	3.3	3	1.6	10	2.5
	Normal	199	95.2	189	98.4	388	96.8
	Very tall	2	1.0	0	0.0	2	0.5
9	Stunted	7	3.3	5	2.6	12	3.0
	Normal	203	96.7	186	97.4	389	97.0
12	Stunted	3	1.4	6	3.1	9	2.2
	Normal	205	98.1	187	96.9	392	97.5
	Very tall	1	0.5	0	0.0	1	0.2
18	Severely Stunted	2	1.0	0	0.0	2	0.5
	Stunted	4	1.9	3	1.6	7	1.7
	Normal	203	97.1	189	97.9	392	97.5
	Very tall	0	0.0	1	0.5	1	0.2
24	Stunted	3	1.4	4	2.1	7	1.7
	Normal	206	98.1	189	97.9	395	98.0
	Very tall	1	0.5	0	0.0	1	0.2

* Status: Severely stunted < -3SD - stunted < -2SD – very tall > 3 SD -Normal = gray zone (< -1SD -> 2 SD) (WHO- Z-scores 2017)

The highest prevalence of wasting was found in the age of 9 months (1.7%). Possible risk of overweight varied between (10.8%) at birth, (13.4 %,) at 2 months, (12.4%) at 4 months, at 6 months (13.2%), (12%) at 9 months, (14.5%) at 12 months, and (12.2%), (10.7%) at 18 and 24 months, respectively. The prevalence percentages of possible risk of overweight, however, were very close between males and females (Table 33).

Table (33) furthermore reflects a low prevalence of overweight and obesity, with ages 4 and 18 months having the highest prevalence of overweight (4.7%), and (3%), respectively. The highest prevalence of obesity was found at the ages of 6 and 18 months (1.2%). The majority of whom were males, (1.9%) at 6 months, and at 18 months (1.4%) were males and (1%) were females.

Table (33): Prevalence of malnutrition among males and females according to BMI for-age z-scores

Age (months)	Status*	Males		Females		Total	
		N	%	n	%	n	%
0	Wasted	2	1.5	2	1.6	4	1.5
	Normal	117	86.0	102	82.9	219	84.6
	Possible risk of overweight	13	9.6	15	12.2	28	10.8
	Overweight	3	2.2	3	2.4	6	2.3
	Obese	1	0.7	1	0.8	2	0.8
2	Wasted	4	1.9	4	2.1	8	2.0
	Normal	167	79.5	162	83.9	329	81.6
	Possible risk of overweight	33	15.7	21	10.9	54	13.4
	Overweight	5	2.4	5	2.6	10	2.5
	Obese	1	0.5	1	0.5	2	0.5
4	Wasted	2	1.0	0	0.0	2	0.5
	Normal	170	81.3	159	82.4	329	81.8

	Possible risk of overweight	27	12.9	23	11.9	50	12.4
	Overweight	10	4.8	9	4.7	19	4.7
	Obese	0	0.0	2	1.0	2	0.5
6	Wasted	3	1.4	1	0.5	4	1.0
	Normal	178	85.2	150	78.1	328	81.8
	Possible risk of overweight	20	9.6	33	17.2	53	13.2
	Overweight	4	1.9	7	3.6	11	2.7
	Obese	4	1.9	1	0.5	5	1.2
	Wasted	5	2.4	2	1.0	7	1.7
	Normal	172	81.9	160	83.8	332	82.8
9	Possible risk of overweight	25	11.9	23	12.0	48	12.0
	Overweight	6	2.9	4	2.1	10	2.5
	Obese	2	1.0	2	1.0	4	1.0
	Severely wasted	1	0.5	0	0.0	1	0.2
12	Wasted	1	0.5	1	0.5	2	0.5
	Normal	167	80.3	159	82.4	326	81.3
	Possible risk of overweight	33	15.9	25	13.0	58	14.5
	Overweight	5	2.4	6	3.1	11	2.7
	Obese	1	0.5	2	1.0	3	0.7
	Wasted	1	0.5	0	0.0	1	0.2
18	Normal	175	83.7	160	82.9	335	83.3
	Possible risk of overweight	25	12.0	24	12.4	49	12.2
	Overweight	5	2.4	7	3.6	12	3.0
	Obese	3	1.4	2	1.0	5	1.2
	Wasted	4	1.9	2	1.0	6	1.5
24	Normal	174	82.9	169	87.6	343	85.1
	Possible risk of overweight	27	12.9	16	8.3	43	10.7
	Overweight	4	1.9	3	1.6	7	1.7
	Obese	1	0.5	3	1.6	4	1.0
	Wasted	1	0.5	0	0.0	1	0.2

* Status: Severely wasted < -3SD – wasted < -2SD – possible risk of overweight > 1 SD – overweight > 2 SD – Obese > 3 SD-Normal = gray zone (<-1 SD – 0 SD) (WHO- Z-scores 2017)

A relationship was found between Hb at 9 months and BMI categories at birth and 6 months with a statistically significant difference between the two variables ($p < 0.001$) (Table 34).

Table (34): Relationship between children BMI and their Hb at 9 months

		Hb at 9 months		Kruskal Wallis Test P-value
		Mean	SD	
BMI at birth	Wasted	9.6	.5	0.022
	Overweight	11.0	1.3	
BMI at 2 months	Wasted	11.0	1.1	0.308
	Overweight	11.7	1.2	
	Obese	11.6	.1	
BMI at 4 months	Wasted	11.8	.2	0.340
	Overweight	10.7	2.6	
	Obese	11.9	.	
BMI at 6 months	Wasted	11.5	.4	0.045
	Overweight	10.9	1.4	
	Obese	7.8	4.3	
BMI at 9 months	Wasted	11.8	.6	0.118
	Overweight	9.9	3.6	
	Obese	10.6	.6	

Table (35) describes the relationship between weight and breastfeeding from 2 to 24 months. Those who are breastfed had lower BMI in the following ages; 0, 6, 9, 12, 18 months with a statistically significant relationship, but not at 2, 4 and 24 months ($p<0.05$).

Table (35): Relationship between weight and breast feeding at each age from 2 -24 months*

		Weight		T-test P-value
		Mean	SD	
Breast Feeding at 2 months	Yes	5.3	0.7	0.302
	No	5.2	0.6	
Breast Feeding at 4 months	Yes	6.6	0.9	0.52
	No	6.7	0.8	
Breast Feeding at 6 months	Yes	7.6	1.0	0.048
	No	7.8	1.0	
Breast Feeding at 9 months	Yes	8.6	1.1	0.008
	No	9.0	1.1	
Breast Feeding at 12 months	Yes	9.4	1.2	<0.001
	No	9.9	1.2	
Breast Feeding at 18 months	Yes	10.8	1.4	0.002
	No	11.3	1.6	
Breast Feeding at 24 months	Yes	12.3	2.0	0.956
	No	12.2	1.6	

* Mann Whitney test

4.12 Discussion

General

Presented in this study is the first national growth reference charts in the Kingdom of Bahrain. These growth reference charts describe the growth patterns of normal and healthy of both breast- and formula-fed Bahraini infants and young children. Official MCH records of the MOH from 5 health centers representing the target population were used to construct these national growth reference charts. To construct these charts, only data of children from birth to 2 years were used. Charts were constructed using the widely cited Cole's LMS method and were used to produce centiles.

Similarities and differences between genders and health centers regarding weight, length, and BMI

The present study demonstrated that the weight, length, and BMI of body males were slightly more than females. Similar findings were reported by Abdulrazzaq et al. (2008) in UAE and Bong et al., (2014) in Malaysia. In addition, a significant difference between health centers in terms of length was found in the present study in most ages up to two years, these findings might indicate that a variation in child's growth exists between regions of Bahrain. Similarly, studies carried out in different regions in Iran found significant differences in growth patterns existed, particularly between Shiraz (Ayatollahi and Ahmadi, 2001) and Isfahan (Aminorroaya et al., 2003). Although, it could be incidental due to reasons related to sample size.

Comparison of growth parameters between Bahraini and MGRS children

The findings of this study clearly indicate the difference between the MGRS and the Bahraini growth measurements. In particular, in terms of weight female's and male's was heavier than their cohorts in MGRS; Similar findings was reported by Natale and Rajagopalan (2014) which concluded that significant variations exist between ethnic and national groups in terms of weight and height and other growth parameters worldwide. On the other hand, results for a similar study of Euro-growth references for length, weight, and body circumferences means identified only four 0.5 SD outliers and 2/15 (13%; males and females) (Haschke et al., 2000).

A comparison between MGRS length data and their correspondings of this study, showed that, at age 0-2 years, Bahraini infants/ children were statistically shorter in the first 6 months and became taller up to 2 years. This in line with large study findings that means for German males and females up to age 5 differ particularly at the 62nd and 60th MGRS centiles, respectively (Rosario et al., 2011). These authors considered these differences sufficient to warrant the use of national growth charts rather the MGRS charts in Germany (Rosario et al., 2011). In addition, a study by Atladottir et al., (2000) that measured children at birth and 12 months in Iceland, found that the average length of all children was approximately 2/3 of an SD taller than the MGRS charts at these two-time points. Furthermore, male and female infants up to age one year in Denmark were considered outliers in terms of length (Nielsen et al., 2010). This was consistent with the finding of Fredriks et al., (2004), which found that Moroccan infants among whom living in the Netherlands were also outliers at age one.

The BMI of both males and females among whom included in our study were significantly higher than MGRS standards at the 97th centiles in most age point up to two years. Similarly, the BMI of U.S. children is remarkably different from MGRS standards, partly reflecting obesity numbers in the U.S. sample, and probably as well, edge effects in the 2000 growth charts (De onis et al., 2007). Consequently, estimates of overweight and obesity increased when the MGRS standards was used for U.S. children. As well, the significant difference in the BMI-for-age between the 2000 and 2006-WHO growth charts at the -2 SD and -3 SD resulted in lower estimation of undernutrition when based on the WHO standards (De onis et al., 2007).

Based on the evidence given above, this study reveals that the MGRS growth charts of length, weight, and BMI are not optimal fits to infants/ children in Bahrain. Hence, this study recommends the using of its finding (i.e. charts) to develop and implement new national reference standards. This recommendation is justifiable and consistent with the conclusions and suggestion of Natale and Rajagopalan (2014) that the MGRS charts may not be optimal for all children worldwide.

Since the publication of the 2006-WHO charts, many studies have presented comparisons between national references and the 2006-WHO growth references. According to Rao et al., (2012) some countries had already decided to use their own population-based charts as a reference of child growth. Among these countries are China, Belgium, Denmark, Czechoslovakia, Bolivia, and Norway. The driving force for such move was the findings that the local/national children growth in these countries was significantly different from the parameters proposed by the WHO. The trend of moving away from the 2006-WHO is expected to grow in the future since more countries are finding no agreement between studies

conducted at national level and the WHO growth charts. Examples of these studies include United Arab Emirates, Iran, Poland, Hong Kong, Norway, South Africa, Germany, and United Kingdom (Abdulrazzaq et al., 2008; Norris et al., 2009; Rosario et al., 2011).

Some authors consider the regular updates of local references and comparisons with the 2006-WHO growth charts is an essential practice. Because it would provide important information on the local children's of each population, and greater specificity for the assessment of the nutritional status in certain ethnic groups (Abdulrazzaq et al., 2008; Juliusson et al., 2011). Others justify the construction of local growth charts based on the fact that, although the 2006-WHO charts based on the MGRS have representative samples from six continents, these charts could not be appropriate in certain countries. This may due to the influence of genetic factors, cultural, and socio-economic differences (Heydari et al., 2009; Kułaga et al., 2011; Rosario et al., 2011). A recent study by Hof et al., (2011) found a difference in birth weights between native Dutch and immigrant children. Another study conducted in Saudi Arabia by El Mouzan et al., (2008) also demonstrated lower centiles in Saudi children in comparison to the USA-CDC references.

Comparison of growth parameters between Bahraini and Saudi children

Growth curves generated by the present study were compared with the growth reference for Saudi school-age children (El Mouzan et al., 2016). The comparison showed that differences existed between Bahraini children from birth up to two years and their Saudi cohorts in growth pattern, particularly in weight, length, and BMI. This supports the studies that affirms the existence of growth variations in regional countries. In the same context, Bonthuis et al., (2012) found considerable variations among European populations in mean heights, where children from Southern

Europe generally being shorter than those from Northern Europe (Cavelaars et al., 2000; Larnkjaer et al., 2006; Danubio and Sanna, 2008).

Construction of growth charts

In this study, the percentiles method was used for the construction of the growth charts. However, the growth or nutritional status of a child or group of children can also be assessed by using the standardized age- and gender-specific growth references by Z-scores or percentiles, which are of equivalent units of measurement (Cole, 2012). While both approaches have strengths and limitations, the Z-scores are the more accurate and preferred approach for the assessment of individuals and populations specifically in the research setting and surveillance (WHO, 2006a). Although, due to simplicity and practical reasons, the percentile method is commonly used at the individual level during the assessment of a child's growth and nutrition in the clinical setting (WHO, 1995).

Feeding practices

Unlike the MGRS, which consider the growth of healthy breastfed children as a normative model for growth and development (WHO 2006b); in this study, both breastfed and formula-fed children were considered for setting norms. Despite the fact that the WHO and most prominent pediatric societies advocate practicing exclusive breastfeeding for infants from birth to 6 months (Binns and Lee, 2007), the prevalence of exclusive breastfeeding remains, unfortunately, low in many countries (Imdad et al., 2011). Likewise in Bahrain, the rates of exclusive and continued breastfeeding among children <6 and 20–23 months old in 2010 were 34% and 41%, respectively (IBFAN, 2010). Moreover, two-thirds of Bahraini mothers tend to start giving their infants complementary foods before six months (IBFAN, 2010). These findings are relevant to the present study

findings, which revealed a low numbers of breastfeeding among Bahraini mothers. Besides, it was difficult to confirm whether a child was exclusively breastfed or not.

The impact of breastfeeding on the linear growth of children have been examined by several studies. Although breastfed children tend to be smaller than their formula-fed cohorts (Tanaka et al., 2013), in most studies, breastfed children lengths were closer to local growth standards than to the WHO standards (Hui et al., 2008; Juliusson et al., 2011; Tinggaard et al., 2014; Tanaka et al., 2013). This was supported by Tanaka et al., (2013) who found that Japanese breastfed children was below the MGRS mean at every age measured with at least 0.5 SD difference. While the difference between formula-fed children means were either within 0.25 SD or not below 0.5 SD of the MGRS means (Tanaka et al., 2013). In contrast, no pattern was found between Greek breastfed infants when comparing the national standards with the MGRS data (Patsourou et al., 2012).

Demographics

A relationship between the children gestational age and their weight at birth with a statistically significant difference was found in the present study. Similar findings was reported by Gutbrod et al., (2000) who concluded that being very low birthweight (VLBW) with a short gestational age leads to early developmental delay, poor weight gain, and poor head growth in infancy. In addition, Deierlein et al., (2011) suggested that gestational age is a modifiable intrauterine exposure that influence infant's size, growth rate, and rapid infant weight gain within the first 6 months of life.

Nutritional assessment

An expected finding that a higher prevalence of low Hb anemia among males and females (46.56%) at 9 months was evidently revealed by this study. Dalili et al., (2015) found a high prevalence of anemia among Iranian infants from 6 to 9 months of age specifically in Guilan province which is consistent with our findings. A relationship was found between Hb at 9 months and BMI categories specifically at birth and 6 months with a statistically significant difference between the two variables. This is in-line with several studies, which found an adverse effect of obesity on iron levels (Lecube et al., 2006; Tussing-Humphreys et al., 2009). In contrast, findings of De Sá, et al., (2015) was inconsistent with the present study; they suggested that maternal iron deficiency anemia could affect the iron concentrations in newborns, without affecting the child's anthropometric parameters.

Findings of this study showed a statistically significant relationship between breastfeeding among children in 2, 4, 6, and 9 months and their Hb at 9 months. Again, this finding is consistent with Dalili et al., (2015) who demonstrated that duration of exclusive breastfeeding was significantly related to anemia in this age group. Unlike Teixeira et al., (2010) who concluded that the type of feeding had no influence on the hemoglobin concentration (Hb) among Brazilian children.

In addition, a relationship was found between weight from 2 months to 24 months and breastfeeding. There was a significant relationship between breastfeeding at each certain age and the weight at the same age, except at 2, 4 and 24 months. In addition, it was clear that non-breastfed children had higher mean weight than breastfed. These findings consistent with Carling et al., (2015) who found that breastfed infants for shorter

durations were more likely to have a rising weight gain pattern than who breastfed for longer durations.

Bahraini infants and/ children were more likely to be overweight when compared to the 2006-WHO standards. In addition, the analysis revealed an existence of stunting, wasting and underweight cases among Bahraini children below 2 years old in different age points with no clear reason. These findings agree with those of Al-Mouzan et al., (2009) who demonstrated that the use of the 2006-WHO standards for Saudi children led to an increase of the prevalence of undernutrition, stunting, and wasting. This was further supported by Khadilkar and Khadilkar (2010) who reported that the use of 2006-WHO standards was more likely to diagnose a large number of normal children in developing countries as being stunted.

Furthermore, these findings were consistent with the results of Norris et al. (2009), who found that the use of 2006-WHO standards identified children in South Africa as being generally more stunted. Furthermore, Bong et al., (2014) demonstrated that by using the 2006-WHO standards, an additional proportion of (6.1%) and (7.1%) of children in Malaysia were defined as stunted and underweight, respectively, compared to only (2.2%) for both stunting and underweight using the local growth standards. However, assessment of children growth using the 2006-WHO growth standards resulted in more children falling below the 3rd percentile lines, in addition to more children to be classified as overweight or obese (Binns and Lee, 2007). Normal children on the 2006-WHO standards is apparently shorter and heavier, while children living in low social and economic conditions would demonstrate unsurpassed growth on the 2006-WHO standards (Binns and Lee, 2007).

Limitations of the study. The results of present study, being a cross-sectional, are to some extent influenced by biases such as selection bias and information bias (Sedgwick, 2015); for instance, the selection of one Health Center of each Health rejoin could not be representative of the target population. As well, information bias related to missing data. During the designing and conducting of the study all efforts were taken to identify and minimize or eliminate these biases. In addition, this study only included children from birth until 2 years. Data of length at birth was not required to be registered in the child's record, consequently some health centers do not take it into consideration. In some health centers, hereditary blood diseases were very common. Thus, many subjects were excluded due to this reason. In addition, the information of exclusive breastfeeding was not clear in the child's records, it was difficult to distinguish whether the child was exclusively breast-fed or not. Despite these limitations, the findings are statistically valid and suggest important directions for future research field with the goal of construction of growth charts.

Conclusions. In conclusion, the results of the present study provide an evidence-based foundation that can be used to construct reference national growth charts which fit our local needs. The constructed charts showed significant differences in comparison with the WHO- MGRS reference charts. Bahraini children (0-2) years were taller, and heavier than their cohorts in MGRS reference charts. According to the MGRS measurements and 2006-WHO Z-scores, some children were at possible risk of overweight with no obvious reason. Therefore, using nationally developed and constructed children growth charts is more appropriate than relying on charts, which are, based on MGRS data.

4.13 Recommendations

In light of the findings of this study, the followings are some recommendations for consideration and further work:

1. To study the possibility of using the newly constructed charts to establish growth charts for child screening at the clinical setting in the MCH departments.
2. Further similar studies are needed considering the children and adolescents from 2 – 18 years and children with certain health conditions, which could affect the child's growth.
3. Further longitudinal studies are needed for monitoring the growth pattern of children.
4. Emphasize the inclusion of the length at birth as a requirement for the child screening system in all the MCH departments.
5. Advocate the MCH authorities to include specific and compulsory questions in the child's screening to assess the exclusive breastfeeding practices.
6. To investigate the impact of hereditary blood disease, which was common in some regions on the children growth.
7. To train relevant health staff to conduct studies on children growth and develop growth charts in a regular basis (systematic).
8. To implement newly developed statistical approaches and methodologies (such as using quantile regression approach and BCPE (Box-Cox Power Exponential), which takes into consideration the issue of kurtosis of the distribution of the parameters, LMS method does not do that) for the construction of growth charts in further.

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APPENDICES

APPENDIX 1: A copy of the child & student health record for males

KINGDOM OF BAHRAIN
MINISTRY OF HEALTH
Primary Health Care



مملكة البحرين
وزارة الصحة
الرعاية الصحية الأولية

سجل الفحص الدوري للطفل والطالب Child & Student Health Record

خدمات الأمومة والطفولة Maternal Child Health Services

سجل الطفل الدوري (صفر - ٥ سنوات)
Child health record (0 - 5 years)

خدمات الصحة المدرسية

SCHOOL HEALTH SERVICES

سجل الطالب الدوري (٦ - ١٨ سنة)
Student health record (6 - 18 years)

دائرة طب الأطفال

PAEDIATRIC DEPARTMENT

Salmaniya Medical Center

HEALTH CENTER: _____ اسم المركز:

CHILD'S NAME: _____ اسم الطفل:

CHILD CPR NO. _____ الرقم الشخصي:

DATE OF BIRTH: _____ تاريخ الميلاد:

NATIONALITY: _____ الجنسية:

Updated version 2009

To be kept in the family folder,
after completion of 5 years screening

RECORD SHEET

Child CPR No.

Place of Birth: _____

Risk Factors ☐ SCD ☐ SCT
☐ G6PD Reduced
☐ α -Thalassemia trait
☐ β -Thalassemia: ☐ Disease
☐ Trait
☐ Others (Specify)

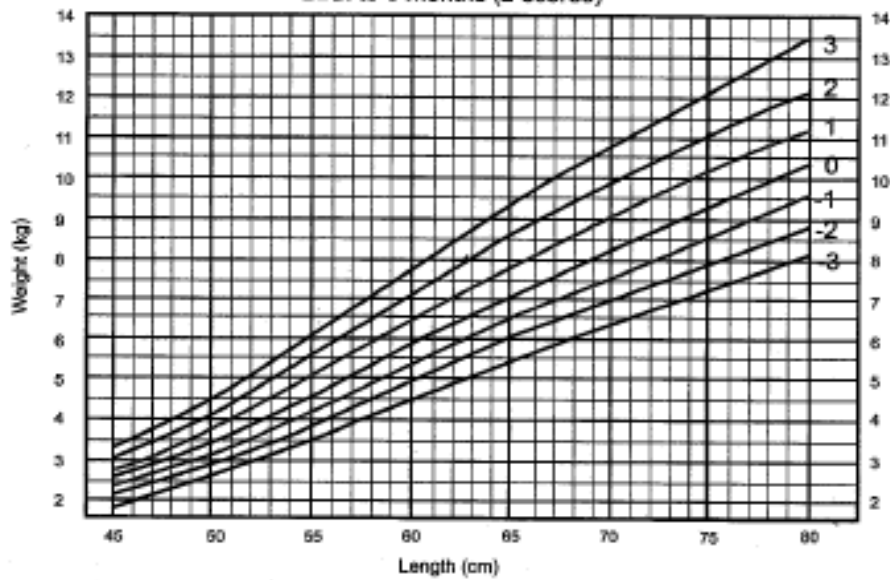
immunization ☐ Completed
☐ not completed

```
ADDITIONAL COMMENTS *****
*****
*****
*****
```

Boys (Birth - 6 months)

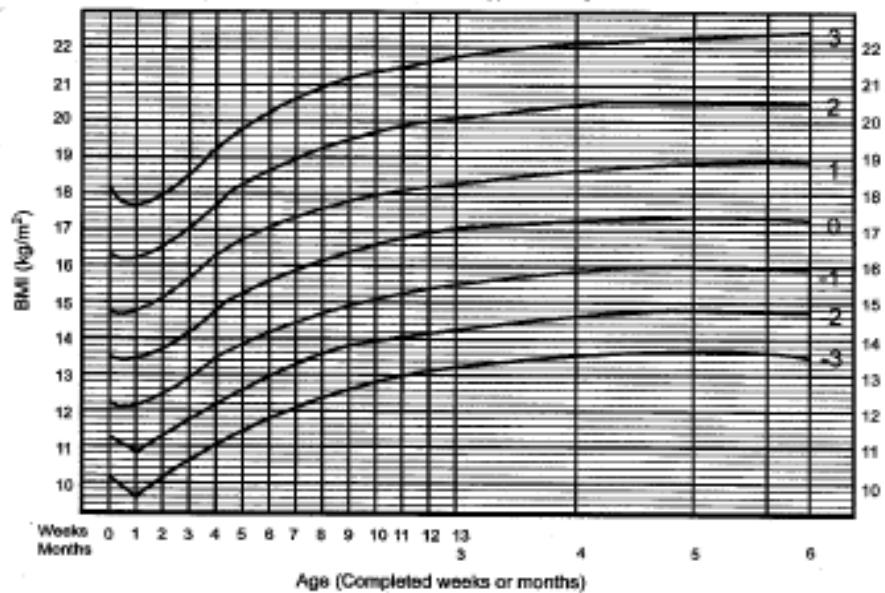
Weight-for-length BOYS

Birth to 6 months (z-scores)



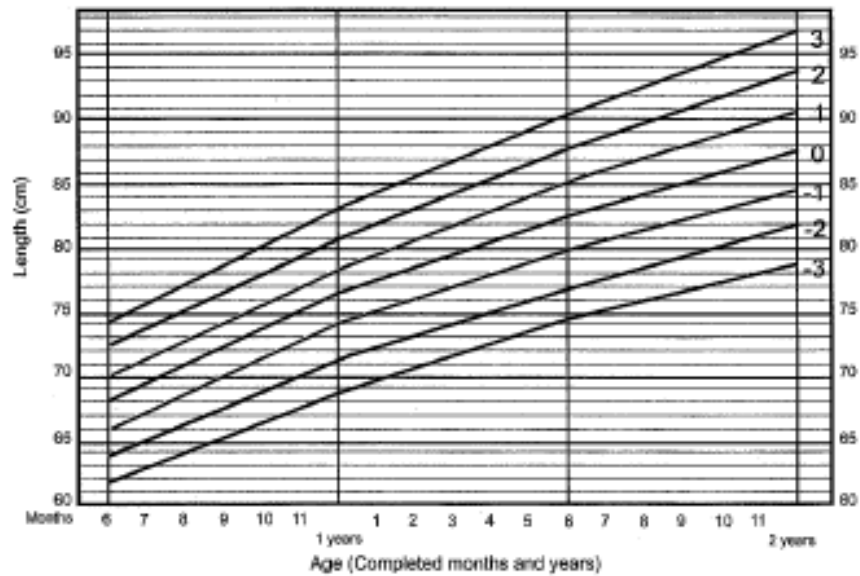
BMI-for-age BOYS

Birth to 6 months (z-scores)

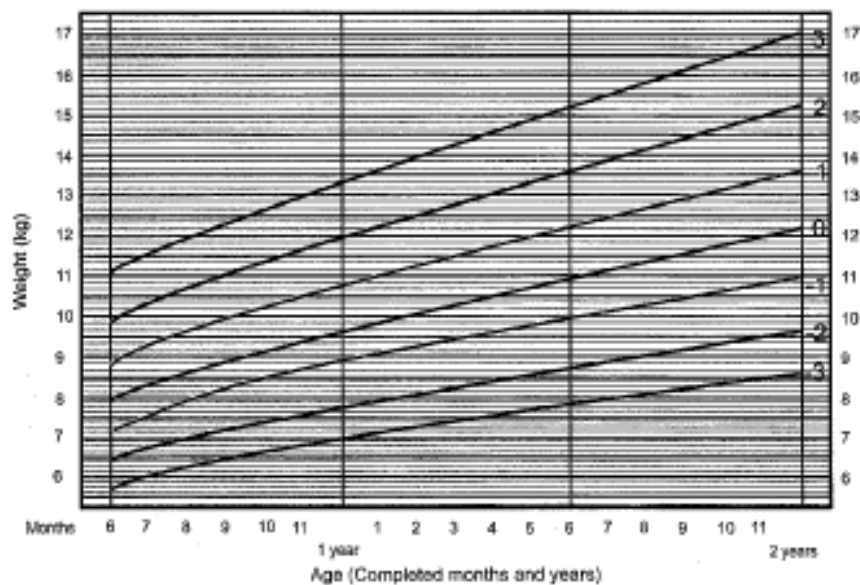


Boys (6 months - 2 years)

Length-for-age BOYS
6 months to 2 years (z-scores)

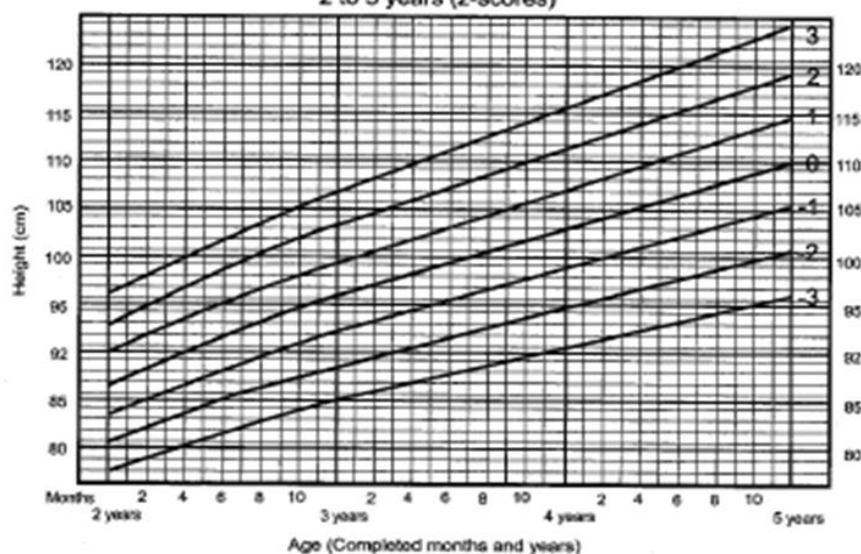


Weight-for-age BOYS
6 months to 2 years (z-scores)

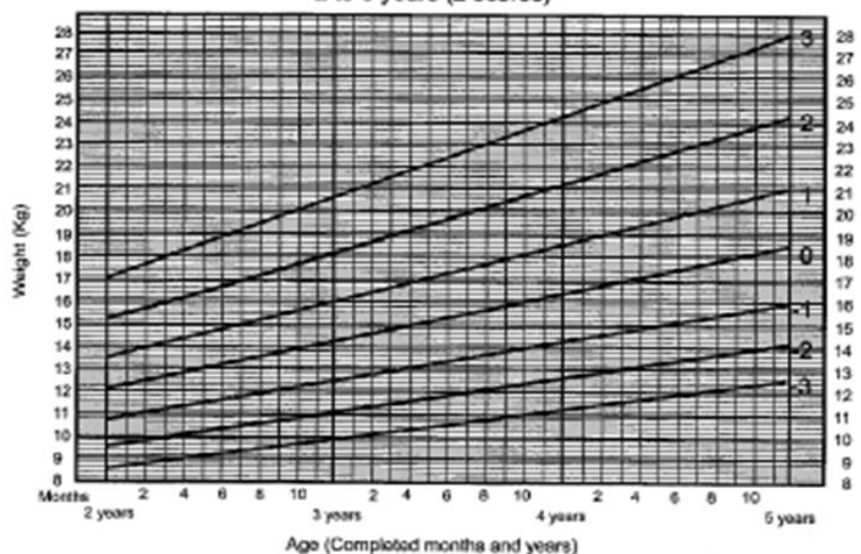


Boys (2 - 5 years)

Height-for-age BOYS
2 to 5 years (z-scores)



Weight-for-age BOYS
2 to 5 years (z-scores)



EXAMINATION AT 2 MONTHS

DATE _____ Weight _____ kg Head Circumference _____ cm
 AGE _____ Length _____ cm BMI _____ Kg/m²

1. MOTHER'S COMPLAINTS:

If problem (specify): _____

2. FEEDING HISTORY: ☐ No Problem ☐ Problem (specify)

Breast (exclusive) _____ Yes ☐ No ☐ Reason _____ Refer to breast feeding clinic ☐

Bottle _____ Type _____ Frequency _____ /day _____ amount/feed ☐ tbf/ _____ ml

Others (specify) _____

WEIGHT: Normal ☐ Abnormal ☐ Advice: _____

3. SLEEPING PATTERN: Normal ☐ Excessively Asleep ☐ Excessively Awake ☐

4. BOWELS: Normal ☐ Abnormal (specify): _____

(Tick as appropriate)

5. DEVELOPMENTAL EXAMINATION

1. GROSS MOTOR & POSTURE	YES	NO	H	O	فحص النمو	Conclusion
Pone: lifts chin off couch					- عندما يستلقي على بطنه يرفع رأسه عن السرير	N D A
Pull to sit: Considerable Head Lag					- لا يتحكم في وضع رأسه عندما يرفع للجولس	
Ventral Suspension: Head held momentarily in plane of body					- قدرته على حمل رأسه في مستوى جسمه عن حمله معلقاً من بطنه	
Active in Bath (Kicks)					- تشويش وحركي عند الاستحمام	
2. FINE MOTOR (MANIPULATION) & VISION	YES	NO	H	O		
Intact regard on Mothers or Examiners					- يحدق بنظرة إلى وجه أمه أو الطبيب	N D A
Face (Fixation)					- يتابع بنظرة الأشياء معلقة أمامه	
Following dangling object at _____ * Past 90° * Fractional					- * يبتعد 90° * يقل من 90°	
Hands closed					- مقلل اليدين	
Grasp Reflex					- رد الفعل التلقائي للشد	
3. HEARING & LANGUAGE	YES	NO	H	O		
Sound / Movement / Startle Reflex					- يستجيب بصوت أو حركة عند الازدحام	N D A
Responds Vocally					- يثرثر عند سماع الأصوات	
Vocalization other than Crying					- يصدر أصوات غير الصراخ	
Searches for sounds with eye					- يتابع مصدر الصوت بالنظر	
4. PERSONAL / SOCIAL BEHAVIOUR & SKILLS	YES	NO	H	O		
Quieted on Picking Up					- يهدأ عندما يحمل	N D A
Social Smile					- يبتسم	
Follows a Moving Person with Eye					- يتابع حركة الأشخاص بالنظر	
Visually Recognises Mother					- يميز أمه بالنظر	

6. PHYSICAL EXAMINATION 7. DIAGNOSIS (CODE)

	N	D	A
Eyes	☐	☐	☐
Red Reflex	☐	☐	☐
Light Reflex	☐	☐	☐
Pupillary Reflex	☐	☐	☐
Nose	☐	☐	☐
Oral Cavity	☐	☐	☐
Throat	☐	☐	☐
Ears	☐	☐	☐
Skin	☐	☐	☐
Muscle tone	☐	☐	☐
R.S.	☐	☐	☐
CVS	☐	☐	☐
Abdomen	☐	☐	☐
Femoral P	☐	☐	☐
Genitalia	☐	☐	☐
Hips	☐	☐	☐
Limbs	☐	☐	☐
Spine	☐	☐	☐

Note: Fill page 6 physical examination for all ages after every visit
 N = Normal, D = Doubtful, A = Abnormal
 H = History, O = Observed

8. ASSESSMENT: Normal ☐

Abnormal (specify): _____

9. MANAGEMENT/ADVICES

10. VACCINATION:

- ☐ Fit
☐ Fit but delay
☐ Unfit (specify) _____

11. Referral (specify): _____

Name of Examiner: _____

Signature: _____

EXAMINATION AT 4 MONTHS

DATE Weight kg Head Circumference cm
AGE Length cm BMI kg/m²

1. MOTHER'S COMPLAINTS:

If problem (specify):

2. FEEDING HISTORY : ☐ No Problem ☐ Problem (specify)

Breast (exclusive)..... Yes ☐ No ☐ Reason Refer to breast feeding clinic ☐

Bottle Type Frequency /day amount/feed ☐ tsf/ ml

Others (specify)
WEIGHT: Normal ☐ Abnormal ☐ Advice:

3. SLEEPING PATTERN: Normal ☐ Excessively Asleep ☐ Excessively Awake ☐

4. BOWELS: Normal ☐ Abnormal (specify):

5. DEVELOPMENTAL EXAMINATION

1. GROSS MOTOR & POSTURE	YES	NO	H	O	فحص النمو	Conclusion
Prone: * Pelvis flat on couch.....	-	-	-	-	مستلقياً على البطن : الحوض مستوي	N
* Chins & Shoulders off couch.....	-	-	-	-	يرفع الكتفين والعمود	D
* Wt. borne on forearms.....	-	-	-	-	يضع وزنه فوق يديه	A
Pull to Sit: only slight head lag.....	-	-	-	-	تحتكم إلى وضع الرأس (عند رفعه للجوف)	
Ventral suspension: Head held up for prolonged period.....	-	-	-	-	عند حمله معلق من بطنه يكون الرأس على أو في مستوى الجسم	
2. FINE MOTOR (MANIPULATION) & VISION	YES	NO	H	O		
Holds a rattle.....	-	-	-	-	يعمل الشئشأته في اليد	N
Hands loosely open.....	-	-	-	-	اليد مفتوحة	D
Follows dangling toy side to side.....	-	-	-	-	يتابع حركة لعبة معلقة أمامه	A
Hand regards.....	-	-	-	-	الاعتماد بالعين وملا حلقهم	
3. HEARING & LANGUAGE	YES	NO	H	O		
Hearing: Turns head meaningfully to sound.....	-	-	-	-	يلفتت إلى مصدر الصوت إذا كان الصوت في مستوى الأذن	N
(on level of ear: 18 inches, away & out of sight)	-	-	-	-	على بعد 18 إنش ومن دون أن يراه	D
Squalls of pleasure.....	-	-	-	-	يومي سروريه بضحكة	A
Searches for sounds with eyes.....	-	-	-	-	يبحث عن الصوت بالعين	
4. PERSONAL / SOCIAL BEHAVIOUR & SKILLS	YES	NO	H	O		
Focus contented.....	-	-	-	-	يهدق النظر	N
Purposeful gaze on mother's face.....	-	-	-	-	يهدق يتبعن إلى وجه أمه	D
Friendly handling.....	-	-	-	-	يسر لمسه	A
Friendly to strangers.....	-	-	-	-	سول التمايل مع الغرباء	
Stops crying when talked to.....	-	-	-	-	يتوقف عن البكاء عندما يتكلم معه أحد	

6. PHYSICAL EXAMINATION 7. DIAGNOSIS (Code)

	N	D	A
Eyes	☐	☐	☐
Red Reflex	☐	☐	☐
Light Reflex	☐	☐	☐
Pupillary Reflex	☐	☐	☐
Nose	☐	☐	☐
Oral Cavity	☐	☐	☐
Throat	☐	☐	☐
Ears	☐	☐	☐
Skin	☐	☐	☐
Muscle tone	☐	☐	☐
R.S.	☐	☐	☐
CVS	☐	☐	☐
Abdomen	☐	☐	☐
Genetal P	☐	☐	☐
Genitalia	☐	☐	☐
Hips	☐	☐	☐
Limbs	☐	☐	☐
Spine	☐	☐	☐
Anus/area	☐	☐	☐

Note: Fill page 6 physical examination for all ages after every visit
N = Normal, D = Doubtful, A = Abnormal
H = History, O = Observed

8. ASSESSMENT: Normal ☐

Abnormal (specify):

9. MANAGEMENT/ADVISES

10. VACCINATION:

- ☐ Fit
☐ Fit but delay
☐ Unfit (specify)

11. Referral (specify):

Name of Examiner:

Signature:

EXAMINATION AT 6 MONTHS

DATE _____ Weight _____ kg Head Circumference _____ cm
 AGE _____ Length _____ cm BMI _____ Kg/m²

1. MOTHER'S COMPLAINTS.

If problem (specify): _____

2. FEEDING HISTORY: ☐ No Problem ☐ Problem (specify): _____

Breast (exclusive) _____ Yes ☐ No ☐ Reason _____ Refer to breast feeding clinic ☐

Bottle _____ Type _____ Frequency _____ / day _____ amount/feed ☐ ml ☐ ml

Others (specify): _____

WEIGHT: Normal ☐ Abnormal ☐ Advice: _____

3. SLEEPING PATTERN: Normal ☐ Excessively Asleep ☐ Excessively Awake ☐

4. BOWELS: ☐ Normal ☐ Abnormal (Specify): _____

(Tick as appropriate)					فحص النمو	Conclusion
5. DEVELOPMENTAL EXAMINATION						
1. GROSS MOTOR & POSTURE	YES	NO	H	D		
Head erect - no bobbing					رأية مستقيمة عند حملها	
Born weight on legs					عند الوقوف يرفع وزن الجسم على الساقين	
Pull to sit - no head lag					الرائع حينئذ حملها	
Weight borne on hands when prone					في وضع الانبطاح على البطن يرتكز وزن الجسم على اليدين	N
Sits with support					يحملها ويستند عليها	D
Rolls prone to supine					يتقلب من وضع الانبطاح على البطن إلى الظهر	A
2. FINE MOTOR (MANIPULATION) & VISION	YES	NO	H	D		
Approaches & grabs near object					يقترب إلى الأشياء حوله ويأخذها	
Passes cube hand to hand					يأخذ الأشياء من يد إلى أخرى	
Hands held loosely open					يأخذ الأشياء بسهولة	N
Hand regards no longer as protruding feature					أخذها كخاصية لا تعيق باليد	D
3. HEARING & LANGUAGE	YES	NO	H	D		
Turns head towards sound of voice (above level of ear)					يقلب رأسه إلى مصدر الصوت إذا كان أعلى من مستوى الأذن	
Laughs					يضحك	
Variety of sounds in vocal response					يتجاوب مع الصوت بأصوات مختلفة	N
Shouts for attention					يصرخ عند الحاجة	D
4. PERSONAL / SOCIAL BEHAVIOUR & SKILLS	YES	NO	H	D		
Anticipates food on sight					يتوقع الطعام عند النظر إليه	
If left lying: needs entertainment					عندما يترك مستلقي يحتاج إلى منشطة	N
Turns head to person talking or singing					يقلب رأسه إلى شخص يتحدث أو يغني	D
If displaced if toy is taken away					يتراجع إذا أخذت منه لعبة	A
Knows strangers from familiar friends					يعرف الغرباء من الأهل	

6. PHYSICAL EXAMINATION 7. DIAGNOSIS (CODE)

N D A

Eyes ☐ ☐ ☐

Red Reflex ☐ ☐ ☐

Light Reflex ☐ ☐ ☐

Pupillary Reflex ☐ ☐ ☐

Nose ☐ ☐ ☐

Oral Cavity ☐ ☐ ☐

Throat ☐ ☐ ☐

Ears ☐ ☐ ☐

Skin ☐ ☐ ☐

Muscle tone ☐ ☐ ☐

R.S. ☐ ☐ ☐

CVS ☐ ☐ ☐

Abdomen ☐ ☐ ☐

Femoral P. ☐ ☐ ☐

Genitalia ☐ ☐ ☐

Hips ☐ ☐ ☐

Limbs ☐ ☐ ☐

Spine ☐ ☐ ☐

Anal area ☐ ☐ ☐

Fluoride Paste Yes ☐ No ☐

See 100 pages Physical examination
 For all ages after every visit
 N = Normal, D = Doubtful, A = Abnormal
 H = History, O = Observed

8. ASSESSMENT: Normal ☐

Abnormal (specify): _____

9. MANAGEMENT/ADVISES

10. VACCINATION:

☐ Fit

☐ Fit but delay _____

☐ Unfit (specify) _____

11. Referral (specify): _____

Name of Examiner: _____

Signature: _____

Next Visit: _____

EXAMINATION AT 9 MONTHS

DATE _____ Weight _____ kg Head Circumference _____ cm
AGE _____ Length _____ cm BMI _____ Kg/m²

1. MOTHER'S COMPLAINTS:

If problem (specify): _____

2. FEEDING HISTORY : ☐ No Problem ☐ Problem (specify): _____

Breast _____ Yes ☐ No ☐ Reason _____ Refer to breast feeding clinic ☐

Bottle _____ Type _____ Frequency _____ /day _____ amount/feed ☐ 1st/2nd _____ ml

Others: Vegetables _____ Fruits _____ Cereals _____ Proteins _____

WEIGHT: Normal ☐ Abnormal ☐ Advice: _____

3. SLEEPING PATTERN: Normal ☐ Abnormal (specify): _____

4. BOWELS: Normal ☐ Abnormal (specify): _____

(Tick as appropriate)

5. DEVELOPMENTAL EXAMINATION

1. GROSS MOTOR & POSTURE	YES	NO	H	O	فحص النمو	Conclusion
Stands briefly when hands held	☐	☐	☐	☐	يقف عندما يمسك من اليدين	N D A
Sits without support	☐	☐	☐	☐	يجلس بدون مساند	
Goes over from sitting to prone & from prone to sitting	☐	☐	☐	☐	يتسلق على ظهره ثم يرجع إلى وضع الجلوس ثانية	
Crawls _____ Shuffle _____	☐	☐	☐	☐	يحبو / يزحف	
2. FINE MOTOR (MANIPULATION) & VISION	YES	NO	H	O		
Holds cube in each hand - retains them	☐	☐	☐	☐	يحمل مكعب في يديه	N D A
Retains them	☐	☐	☐	☐	يحتفظ به	
Pick up a pellet by raking	☐	☐	☐	☐	يحبس بالكرة الصغيرة	
may use pincer grasp	☐	☐	☐	☐	مسكة التلم	
Index finger approach	☐	☐	☐	☐	يحمل بالاصابع والابهام	
3. HEARING & LANGUAGE	YES	NO	H	O		
Free and varied vocalisation	☐	☐	☐	☐	يصدر أصوات مختلفة	N D A
Understands "No"	☐	☐	☐	☐	يفهم معنى لا	
Responds to words	☐	☐	☐	☐	يتفاعل مع الكلام	
Knows own name	☐	☐	☐	☐	يعرف اسمه	
One word (mama, dada)	☐	☐	☐	☐	يقول كلمة مثل ماما ، بابا	
(define and meaning)	☐	☐	☐	☐		
4. PERSONAL / SOCIAL BEHAVIOUR & SKILLS	YES	NO	H	O		
Waves bye bye	☐	☐	☐	☐	يؤشر يديه مودعاً	N D A
Chews stodgy food with bits	☐	☐	☐	☐	يمضغ الأطعمة الصلبة	
Stretches for objects out of reach	☐	☐	☐	☐	يهدد للأشياء البعيدة عنه	
Clap hands	☐	☐	☐	☐	يمضغ باليدين	
Stretches to be taken up	☐	☐	☐	☐	يرفع جسمه لئلا	
Interested in small children (other than own sibling)	☐	☐	☐	☐	يلعب مع الأطفال الصغار (دون إخوته)	

6. PHYSICAL EXAMINATION 7. DIAGNOSIS (CODE)

	N	D	A	
Eyes	☐	☐	☐	
Red Reflex	☐	☐	☐	
Light Reflex	☐	☐	☐	
Pupillary Reflex	☐	☐	☐	
Nose	☐	☐	☐	
Oral Cavity	☐	☐	☐	
Throat	☐	☐	☐	
Ears	☐	☐	☐	
Skin	☐	☐	☐	
Muscle tone	☐	☐	☐	Hb:
R.S.	☐	☐	☐	(if low, do work up for anemia) (Page 5)
CVS	☐	☐	☐	
Abdomen	☐	☐	☐	
Femoral P	☐	☐	☐	Fluoride Paste Yes ☐
Ostealitis	☐	☐	☐	No ☐
Hips	☐	☐	☐	
Limbs	☐	☐	☐	
Scars	☐	☐	☐	

Note: Fill page 6 physical examination for all ages after every visit
N = Normal, D = Doubtful, A = Abnormal

8. ASSESSMENT: Normal ☐

Abnormal (specify): _____

9. MANAGEMENT/ADVICES

10. VACCINATION:

- ☐ Fit
☐ Fit but delay
☐ Unfit (specify): _____

11. Referral (specify): _____

Name of Examiner: _____

Signature: _____

EXAMINATION AT 1 YEAR

DATE _____

ACE

Weight	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25	26	27	28	29	30	31	32	33	34	35	36	37	38	39	40	41	42	43	44	45	46	47	48	49	50	51	52	53	54	55	56	57	58	59	60	61	62	63	64	65	66	67	68	69	70	71	72	73	74	75	76	77	78	79	80	81	82	83	84	85	86	87	88	89	90	91	92	93	94	95	96	97	98	99	100
1	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25	26	27	28	29	30	31	32	33	34	35	36	37	38	39	40	41	42	43	44	45	46	47	48	49	50	51	52	53	54	55	56	57	58	59	60	61	62	63	64	65	66	67	68	69	70	71	72	73	74	75	76	77	78	79	80	81	82	83	84	85	86	87	88	89	90	91	92	93	94	95	96	97	98	99	100

Head Circumference _____ cm

Length mm **Weight** g **Sex** **Age** **Stage** **Notes** **CD**

BMI.....Kg/m²

1. MOTHER'S COMPLAINTS:

If problem (specify):

2. **FEEDING HISTORY:** ☐ No Problem ☐ Problem (specify):

Breast Yes ☐ No ☐ Reason Refer to breast feeding clinic ☐

Bottle _____ Type _____ Frequency _____ /day _____ amount/feed _____ (oz) _____

Others: Vegetables _____ Fruits _____ Cereals _____ Protein _____

WEIGHT: Normal ☐ Abnormal ☐ Advice: _____

SLEEPING PATTERN: Normal ☐ Abnormal (specify): _____

3. **SLEEPING PATTERN:** Normal ☐ Abnormal (specify):

BOWELS: Normal ☐ Abnormal ☐

4. **BOWELS:** Normal ☐ Abnormal (specify) _____

(Tick as appropriate)

5. DEVELOPMENTAL EXAMINATION

1. GROSS MOTOR & POSTURE					YES	NO	H	O	
Prone:									
Walks on hands and feet like a bear	-	-	-	-					N
Walks: one hand held	-	-	-	-					D
May shuffle on buttocks and hand	-	-	-	-					A
2. FINE MOTOR (MANIPULATION) & VISION					YES	NO	H	O	
Mouthing virtually stopped	-	-	-	-					N
Picks up fine objects	-	-	-	-					D
Quickly finds toys hidden behind his eyes	-	-	-	-					A
3. HEARING & LANGUAGE					YES	NO	H	O	
May understand meaning of phrases "Where is your shoe?"	-	-	-	-					N
Two or three words with meaning	-	-	-	-					D
Listens with obvious pleasure to sound making toys	-	-	-	-					A
4. PERSONAL / SOCIAL BEHAVIOUR & SKILLS					YES	NO	H	O	
Drinks from cup with little assistance	-	-	-	-					N
Holds spoon and uses it by himself	-	-	-	-					D
Helps with dressing	-	-	-	-					A
Puts wooden cubes in and out of cup when shown	-	-	-	-					N
Plays "pat-a-cake" waves bye bye spontaneously	-	-	-	-					D
Gives affection	-	-	-	-					A

6. PHYSICAL EXAMINATION 7. DIAGNOSIS (CODE)

	N	D	A
Eyes	☐	☐	☐
Red Reflex	☐	☐	☐
Light Reflex	☐	☐	☐
Pupillary Reflex	☐	☐	☐
Nose	☐	☐	☐
Oral Cavity	☐	☐	☐
Throat	☐	☐	☐
Ears	☐	☐	☐
Skin	☐	☐	☐
Muscle tone	☐	☐	☐
R.S.	☐	☐	☐
CVS	☐	☐	☐
Abdomen	☐	☐	☐
Perineal P	☐	☐	☐
Genitalia	☐	☐	☐
Hips	☐	☐	☐
Limbs	☐	☐	☐
Spine	☐	☐	☐

Now: Fill page 6 physical examination for all ages after every visit
H = Normal, D = Doubtful, A = Abnormal

8. **ASSESSMENT:** Normal ☐

Abnormal (specify): _____

9. MANAGEMENT/ADVISES

10. VACCINATION:

Fit

☐ Fit but delay☐ Unfit (specify)

11. Referral (specify):

Name of Examiner: _____

Signature:

EXAMINATION AT 18 MONTHS

DATE: _____ Weight: _____ kg Head Circumference: _____ cm
AGE: _____ Length: _____ cm BMI: _____ Kg/m²

1. MOTHER'S COMPLAINTS:

If problem (specify): _____

2. FEEDING HISTORY: ☐ No Problem ☐ Problem (specify)

Breast: _____ Yes ☐ No ☐ Reason: _____ Refer to breast feeding clinic ☐
Bottle: _____ Type: _____ Frequency: _____ /day amount/feed ☐ tsf/ _____ ml
Vegetables: _____ Fruits: _____ Cereals: _____ Proteins: _____ Others: _____
WEIGHT: Normal ☐ Abnormal ☐ Advice: _____

3. SLEEPING PATTERN: Normal ☐ Abnormal (specify): _____

4. BOWELS: Normal ☐ Abnormal (specify): _____

(Tick as appropriate)

5. DEVELOPMENTAL EXAMINATION

1. GROSS MOTOR & POSTURE	YES	NO	H	O	فحص النمو	Conclusion
Walks alone					يمشي لوحده	N D A
Walks upstairs, one hand held					يمشي الدرج بمساعدة	
Still mainly crawling or hitching					ما زال يزحف	
Walks backwards pulling toy on string					يمشي للخلف ممسكاً بسلك اللعبة	
2. FINE MOTOR (MANIPULATION) & VISION	YES	NO	H	O		
Put 1-2 cubes in cup after several demonstration					يضع مكعب أو اثنين في الكوب بعد تدرية لمدة مرات	N D A
Put 5-6 cubes in cup spontaneously or after 1 cube demonstration					يضع 5-6 مكعبات في الكوب بنفسه أو بعد تدرية لكمة واحدة	
Turns 2 or 3 pages at a time					يقلب 2-3 صفحات من الكتاب في وقت واحد	
Attempts tower of 2 cubes successfully					يبنى برج بمكعبين بنجاح	
3. HEARING & LANGUAGE	YES	NO	H	O		
Claps, waves or other parlor tricks on command					يصفق ويؤشر حسب الطلب	N D A
Says 3-6 words, understands many more					يقول 3-6 كلمات / يفهم معنى كلمات أكثر من ذلك	
Jargoning					يرن	
4. PERSONAL / SOCIAL BEHAVIOUR & SKILLS	YES	NO	H	O		
Offers toys and releases them					يُعطي / يتخلي عن أعباءه للغير	N D A
Finch hidden toys					يختبئ على الألعاب المخفية	
Picks up cup with 2 hands					يحمل الكوب بيديه	
Drinks and puts cup down					يشرب بالكوب ويضع مكانه	
Plays domestic mimicry					يقلد الأصوات المنزلية	
Tries to turn door knob or handle					يحاول فتح وإغلاق الباب	
Shows sheets					يعرف عذراء	
Enjoys picture book					يمتع بصور الكتاب	

6. PHYSICAL EXAMINATION 7. DIAGNOSIS (CODE)

	N	D	A
Eyes	☐	☐	☐
Red Reflex	☐	☐	☐
Light Reflex	☐	☐	☐
Pupillary Reflex	☐	☐	☐
Nose	☐	☐	☐
Oral Cavity	☐	☐	☐
Throat	☐	☐	☐
Ears	☐	☐	☐
Skin	☐	☐	☐
Muscle tone	☐	☐	☐
R.S.	☐	☐	☐
CVS	☐	☐	☐
Abdomen	☐	☐	☐
Perineal P	☐	☐	☐
Genitalia	☐	☐	☐
Hips	☐	☐	☐
Limbs	☐	☐	☐
Spine	☐	☐	☐
Anal area	☐	☐	☐

Hb

Note: Fill page 8 physical examination for all ages after every visit
N = Normal, D = Doubtful, A = Abnormal
H = History, O = Observed

8. ASSESSMENT: Normal ☐

Abnormal (specify): _____

9. MANAGEMENT/ADVISES

10. VACCINATION:

☐ Fit

☐ Fit but delay

☐ Unfit (specify): _____

11. Referral (specify): _____

Name of Examiner: _____

Signature: _____

EXAMINATION AT 2 YEARS

DATE _____ Weight _____ kg Head Circumference _____ cm
AGE _____ Length _____ cm BMI _____ Kg/m²

1. MOTHER'S COMPLAINTS:

If problem (specify): _____

2. FEEDING HISTORY : ☐ No Problem ☐ Problem (specify): _____

Breast _____ Yes ☐ No ☐

Bottle _____ Type _____ Frequency _____ /day Protein _____

Vegetables _____ Fruits _____ Cereals _____ Others: _____

WEIGHT: Normal ☐ Abnormal ☐ Advice: _____

3. SLEEPING PATTERN: ☐ Normal ☐ Abnormal (specify): _____

4. BOWELS: ☐ Normal ☐ Abnormal (specify): _____

(Tick as appropriate)

5. DEVELOPMENTAL EXAMINATION					فحص النمو	Conclusion
1. GROSS MOTOR & POSTURE	YES	NO	H	O		
Walks and runs without falling					يمشي ويجري دون أن يسقط	N
Walks downstairs alone					ينزل الدرج بمفرده	D
Jumps both feet off floor					يقفز بالقصدين معا	A
Kicks ball forward					يركل الكرة الى الامام	
2. FINE MOTOR (MANIPULATION) & VISION	YES	NO	H	O		
Builds 6-7 cubes tower					يبنى برج ستة أو سبع مكعبات	N
Imitates circular stroke & a straight line					يقلد رسم دائري أو خط مستقيم	D
Turns pages singly					يقلب صفحات الكتاب صفحة صفحة	A
3. HEARING & LANGUAGE	YES	NO	H	O		
Joins 2-3 words					يركب جمل من كلمتين أو ثلاث	N
Names 3-5 pictures or objects					يسمي 3-5 صور أو أشياء	D
Vocalises all needs					يعبر عن احتياجاته (شرب - طعام)	A
Uses pronouns					يستخدم الضمائر (أنا - أنت)	
Listens to stories (short while)					يستمع إلى سرد القصص القصيرة	
4. PERSONAL / SOCIAL BEHAVIOUR & SKILLS	YES	NO	H	O		
Asks for toilet by day					يطلب التبول إلى الحمام نهاراً	N
Play: uses toys meaningfully					يلعب ألعاباً ذات معنى	D
Pushes toys with good steering					يحدث التصريف بالأيدي	A
Manages spoon efficiently					يستخدم المعلقة بسهولة	
Manages cup efficiently					يستخدم الكوب بسهولة	
Can open a door					يستطيع فتح الباب	
Can take-off shoes, socks					يستطيع طلع الجوارب والحقاء	
Identifies three of body parts					يعرف على ثلاث أجزاء من جسمه	
Helps actively to dress and undress					يساعد في لبس وخلع ملابسه	

6. PHYSICAL EXAMINATION 7. DIAGNOSIS (CODE)

N D A

Eyes ☐ ☐ ☐

Red Reflex ☐ ☐ ☐

Light Reflex ☐ ☐ ☐

Pupillary Reflex ☐ ☐ ☐

Nose ☐ ☐ ☐

Oral Cavity ☐ ☐ ☐

Throat ☐ ☐ ☐

Ears ☐ ☐ ☐

Skin ☐ ☐ ☐

Muscle tone ☐ ☐ ☐

R.S. ☐ ☐ ☐

CVS ☐ ☐ ☐

Abdomen ☐ ☐ ☐

Perineal P ☐ ☐ ☐

Genitals ☐ ☐ ☐

Hips ☐ ☐ ☐

Limbs ☐ ☐ ☐

Spine ☐ ☐ ☐

Anal area ☐ ☐ ☐

Notes: Fill page 6 (physical examination)
for all ages after every visit
N = Normal, D = Doubtful, A = Abnormal
H = History, O = Observed

8. ASSESSMENT: Normal ☐

Abnormal (specify): _____

9. MANAGEMENT/ADVICES

10. VACCINATION:

☐ Fit

☐ Fit but delay

☐ Unfit (specify) _____

11. Referral (specify): _____

Name of Examiner: _____

Signature: _____

APPENDIX 2 : A copy of the vital statistics of the Ministry of Health for registered live births by health region/ health center, sex and fathers nationality 2014

جدول 05 2014
Registered Live Births by Health Region / Health Center, Sex and Father's Nationality 2014

Health Region / Health Center	Total			Non-Bahraini			Bahraini			المنطقة الصحية / المركز الصحي
	الجنس		ذكر Male	الجنس		ذكر Male	الجنس		ذكر Male	
	أنثى Female	Total		أنثى Female	Total		أنثى Female	Total		
Health Region I	3946	1917	2029	1131	528	603	2815	1389	1426	المنطقة الصحية الأولى
	1159	548	611	411	194	217	748	354	394	المحرق
	942	452	490	428	201	227	514	251	263	الشيخ سلمان
	499	252	247	43	18	25	456	234	222	بنك البحرين الوطني - عراد
	407	201	206	8	4	4	399	197	202	بنك البحرين الوطني - دير
	939	464	475	241	111	130	698	353	345	بنك البحرين والكويت - الحد
	3236	1580	1656	1979	971	1008	1257	609	648	المنطقة الصحية الثانية
	757	375	382	522	269	253	235	106	129	النديم
	475	221	254	376	171	205	99	50	49	ابن سينا
	964	476	488	617	293	324	347	183	164	الشيخ صباح السالم
Health Region II	550	268	282	424	211	213	126	57	69	الهور
	490	240	250	40	27	13	450	213	237	بلاد القديم
	4231	2028	2203	482	231	251	3749	1797	1952	المنطقة الصحية الثالثة
	1208	580	628	217	99	118	991	481	510	يوسف عبد الرحمن إنجنيير
Health Region III	828	398	430	115	56	59	713	342	371	مدينة عيسى
	1459	712	747	116	58	58	1343	654	689	جذافس
	736	338	398	34	18	16	702	320	382	علي
	4606	2243	2363	984	502	482	3622	1741	1881	المنطقة الصحية الرابعة
Health Region IV	710	349	361	26	12	14	684	337	347	سitra
	1484	718	766	362	195	167	1122	523	599	حمد كنو
	1762	839	923	561	275	286	1201	564	637	الرافع الشرقي
	563	295	268	19	10	9	544	285	259	أحمد علي كنو
Health Region V	87	42	45	16	10	6	71	32	39	عيادة جو وعسكر
	4686	2258	2428	412	190	222	4274	2068	2206	المنطقة الصحية الخامسة
	1192	563	629	83	41	42	1109	522	587	مدينة حمد
	922	440	482	50	22	28	872	418	454	محمد جاسم كنو
Unknown	911	447	464	34	12	22	877	435	442	الكويت
	136	62	74	24	6	18	112	56	56	الزلاق
	1263	620	643	138	61	77	1125	559	566	البدية
	262	126	136	83	48	35	179	78	101	عيادة البدع الساحلية
Total	47	27	20	21	12	9	26	15	11	غير معين
Total	20,752	10,053	10,699	5,009	2,434	2,575	15,743	7,619	8,124	الجملة

Note: Data is based on Father's Nationality.
Source: Birth and Death Registration System database.

ملاحظة : البيانات حسب جنسية الأب .
المصدر : قاعدة بيانات نظام تسجيل المواليد والوفيات .

APPENDIX 3: Ethical approval from University of Bahrain



UNIVERSITY OF BAHRAIN

College of Science

Department of Biology

جامعة البحرين

كلية العلوم

قسم علوم الحياة



8 February 2018

Mrs. Fatema Abdulwahed ALAhmed

Assistant Undersecretary for Human Resources and Services

Ministry of Health

Subject: Evaluation of Thesis Proposal for M.Sc. Nutrition and Dietetics Program for the Academic Year 2015/2016

Dear Mrs. ALAhmed,

This to certify that the thesis proposal of Ms. Shahzlan A.Iusain (Student No. 20150043), entitled "Growth Parameters and Nutrition Status of Bahraini Children: Towards Establishing National Growth Charts in Bahrain" has been reviewed by the ethics committee and was found that it meets the basic ethical requirements for research proposals involving human subjects.

Kind regards,

Dr. Essam Mohammed Ahmed Janahi
Ethics Committee Head
Department of Biology
College of Science
University of Bahrain

Dr. Afnan Mahmood Freije
Head of Department
Department of Biology
College of Science
University of Bahrain



P.O. Box: 32038 - Kingdom of Bahrain
Tels.: (+973) 17437557 / 17437559 / 17437477
Fax: (+973) 17449158 / 17449662

صندوق بريد: ٣٢٠٣٨ - مملكة البحرين
هاتف: ١٧٤٣٧٥٥٧ / ١٧٤٣٧٥٥٩ / ١٧٤٣٧٤٧٧ (+٩٧٣)
فاكس: ١٧٤٤٩١٥٨ / ١٧٤٤٩٦٦٢ (+٩٧٣)

مكتبة دار الكتب
والمخطوطات
بمكة المكرمة
الطبعة الأولى ١٤٠٠ هـ
الطبعة الثانية ١٤٠١ هـ

$\Delta H = (-98) + 17 \times 23959 - 10 \times 26936 = 17000$ ج. كالمول، القائمة، مقلقة البعثة.

APPENDIX 5 : Samples of the excel spreadsheets used for data collection

[illegible][illegible][illegible]

APPENDIX 6 : Steps in detecting outliers and working out the l, m, s by LMSChartmaker

I- Data cleaning and handling missing values

1. The accuracy of data was checked.
2. The pairwise deletion criterion (available-case analysis) was used to handle the missing values.
3. Data were exported to the LMSChartmaker, each two variables together (age/weight-age/length- age/BMI-weight/length)

 **LMSChartmaker**
File Edit Model Graph Help Window

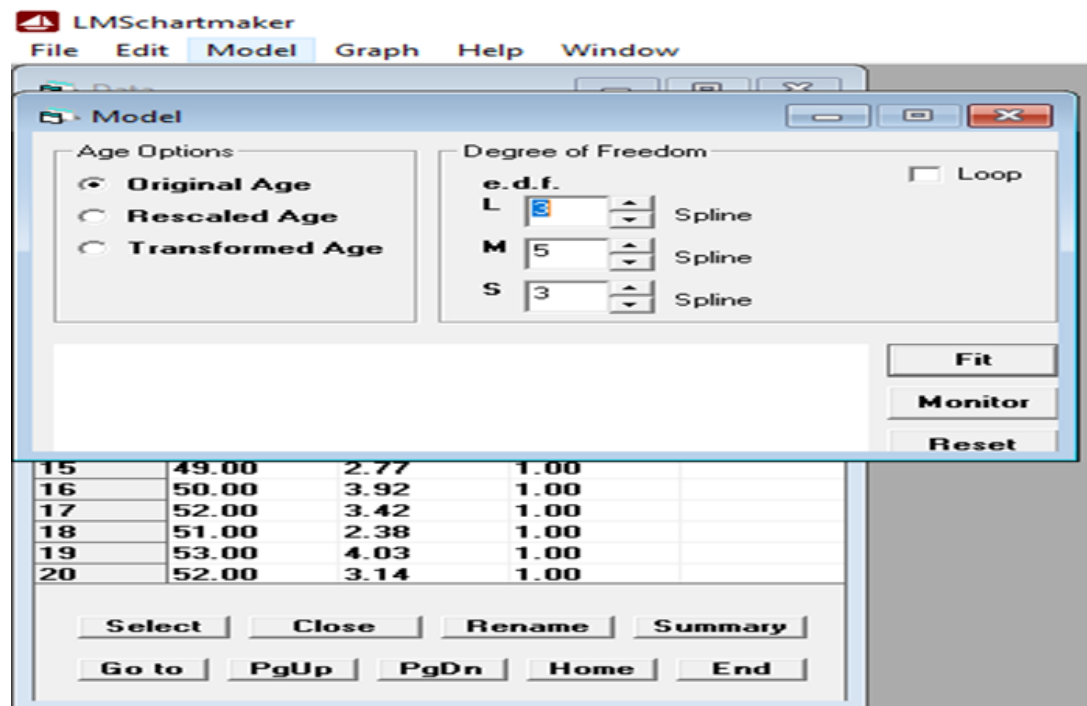
Data

No.	Age	Measure	Weighting	Selector
1	49.00	3.43	1.00	
2	49.00	2.79	1.00	
3	50.00	3.35	1.00	
4	50.00	3.24	1.00	
5	46.00	2.96	1.00	
6	49.00	3.17	1.00	
7	50.00	4.25	1.00	
8	52.00	3.60	1.00	
9	47.00	2.75	1.00	
10	47.00	3.46	1.00	
11	51.50	3.58	1.00	
12	52.00	3.10	1.00	
13	51.00	3.90	1.00	
14	49.00	3.40	1.00	
15	49.00	2.77	1.00	
16	50.00	3.92	1.00	
17	52.00	3.42	1.00	
18	51.00	2.38	1.00	
19	53.00	4.03	1.00	
20	52.00	3.14	1.00	

Select Close Rename Summary
Go to PgUp PgDn Home End

II- Fitting model

1. The original age model was selected by default.
2. LMSChartmaker was used for crude and final estimation of LMS, centiles, and Z-score.
3. The degree of freedom for LMS was modified to L=1, M=3, S=2 based on a comparison between 2 models (original and rescaled age according to the instruction given by the developer of the software (Details shown below in the same appendix).
4. Then the model was fitted and l, m, and s curves were smoothed by using the loop function and centile curves was generated.

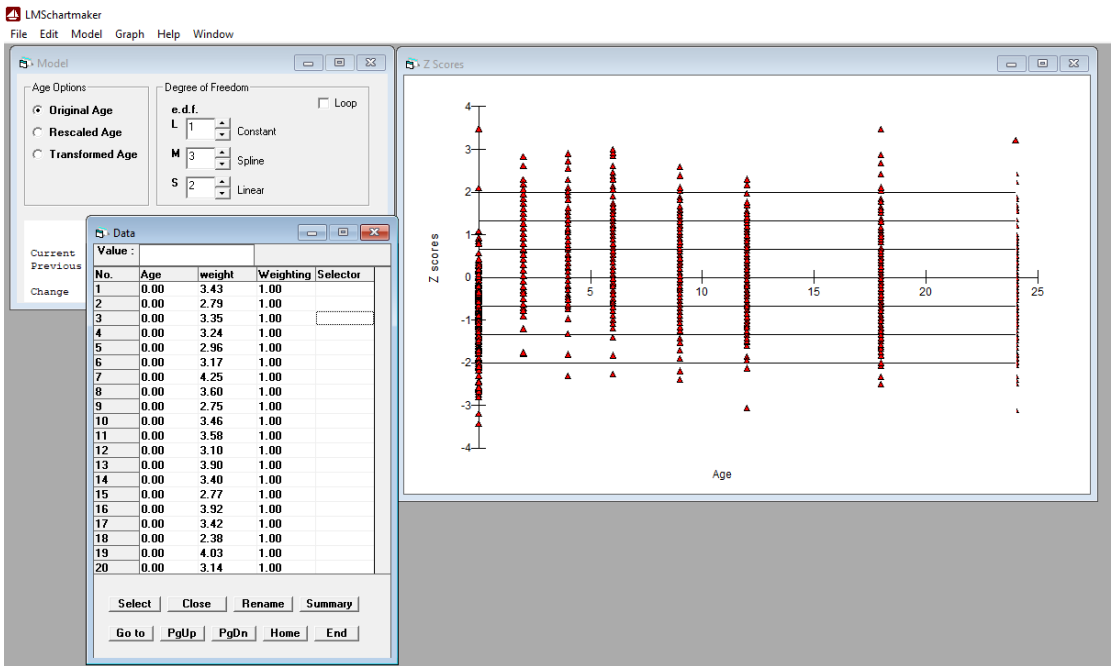


III- Detecting outliers

1. Outliers was detected using Z-scores. According to WHO criteria, values with 3 SD Z-score are considered outlier.
2. Outlier subjects were detected and removed and a clean dataset was used to calculate the LMS, centiles, and Z-scores.

Weight of males

- Z-scores Figure of males weight shown below:

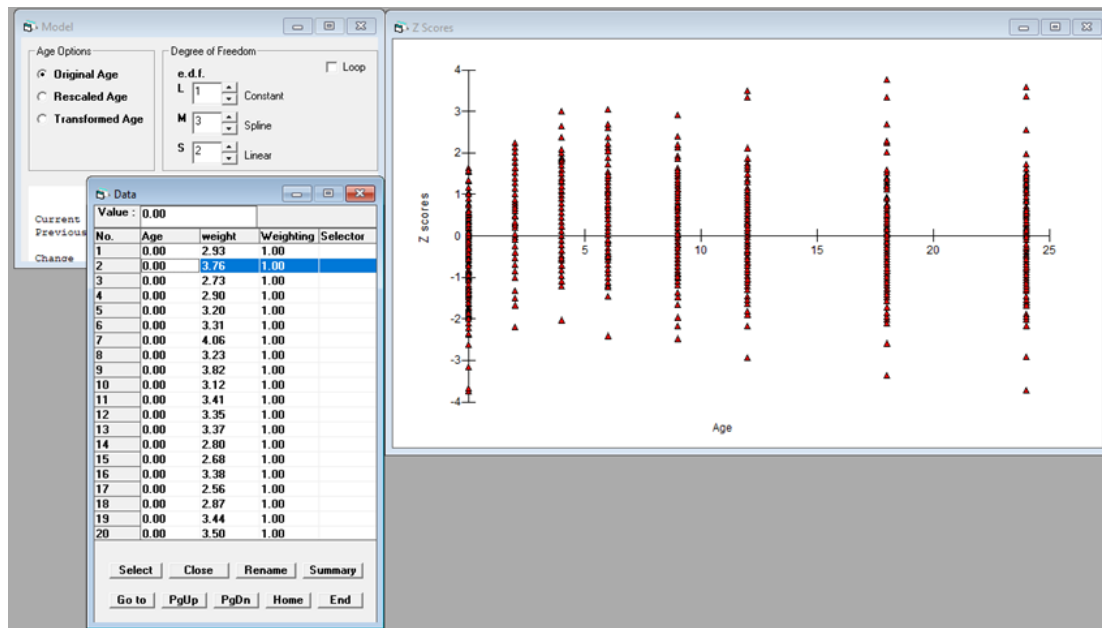


- Eleven (11) male subjects were considered outliers in terms of weight and was removed.

Month	0	0	0	0	0	4	6	9	12	18	24
Z-score	3.403	-3.175	-3.175	4.976	-3.495	-3.493	-3.382	-3.227	-3.831	3.278	-3.159
Weight -kg	5.01	2.1	2.1	6	2	4.4	5.3	6.3	6.5	16.9	9
Line #	32	114	116	161	200	562	772	982	1132	1408	1549
Case ID #	31	10	12	13	24	42	42	42	49	5	28
HC	Sitra	A'Ali	A'Ali	B.Q	Arad	A'Ali	A'Ali	A'Ali	Budayia	B.Q	Sitra

Weight of females

- Z-scores Figure of females weight shown below:

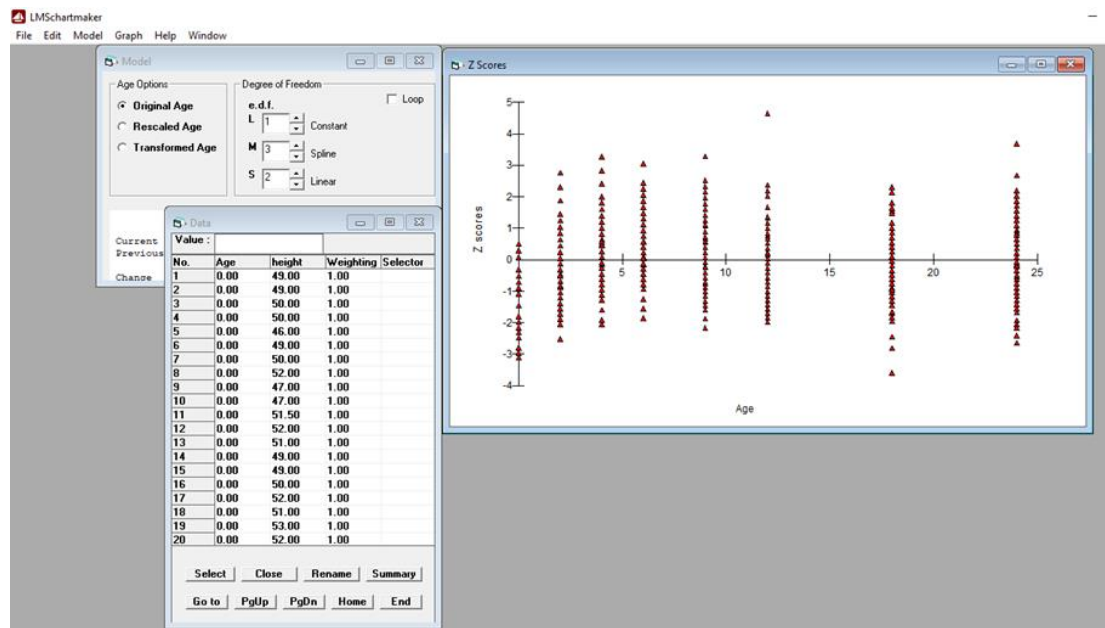


- Ten (10) female subjects were considered outliers in terms of weight and was removed.

Month	6	9	12	12	12	18	18	18	24	24
Z-score	-3.187	-3.187	3.386	-3.356	3.25	3.379	-3.379	3.082	-4.148	3.097
Weight-kg	4.8	5.7	15	6	14.7	18	6.6	17.1	7	19.5
Line #	725	917	1050	1110	1147	1243	1303	1340	1496	1523
Case ID #	7	7	53	7	20	53	7	20	7	10
HC	B.Q	B.Q	Budayia	B.Q	Arad	Budayia	B.Q	Arad	B.Q	Arad

Length of males

- Z-scores Figure of males length shown below:

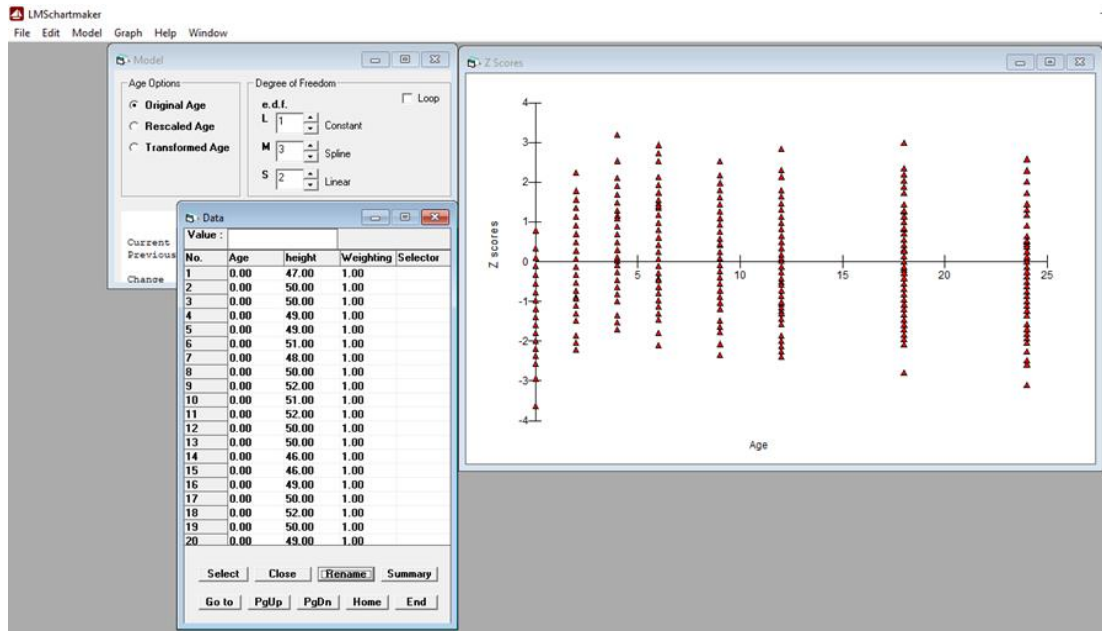


- Seven (7) male subjects were considered outliers in terms of length and was removed.

Month	2	4	9	12	18	18	24
Z-score	3.455	3.275	3.14	4.429	-4.266	-3.148	3.107
Length- cm	64	70	80.5	89	69	72.5	101
Line #	168	378	815	1069	1231	1327	1590
Case ID #	31	31	8	56	5	39	16
HC	Sitra	Sitra	Budayia	Budayia	Budayia	A'Ali	Arad

Length of females

- Z-scores Figure of females length shown below:

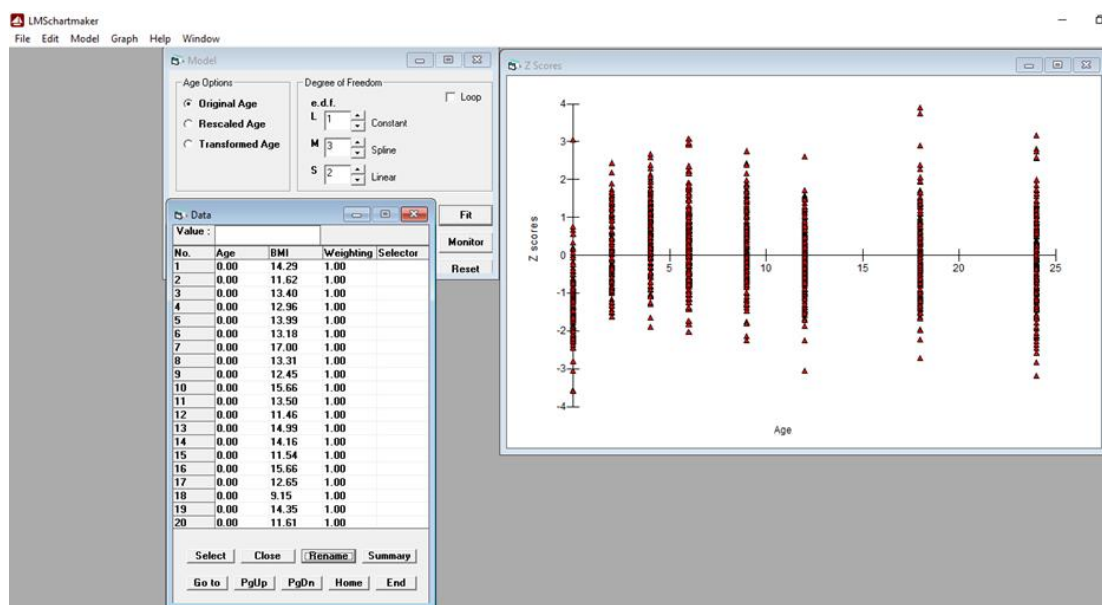


- Five (5) female subjects were considered outliers in terms of length and was removed.

Month	0	4	4	18	24
Z-score	-3.157	3.224	3.224	-3.035	-3.047
Length- cm	42	68	68	71	75
Line #	95	404	482	1232	1425
Case ID #	24	54	2	7	7
HC	A'Ali	Budayia	Arad	B.Q	B.Q

BMI of males

- Z-scores Figure of BMI males shown below:

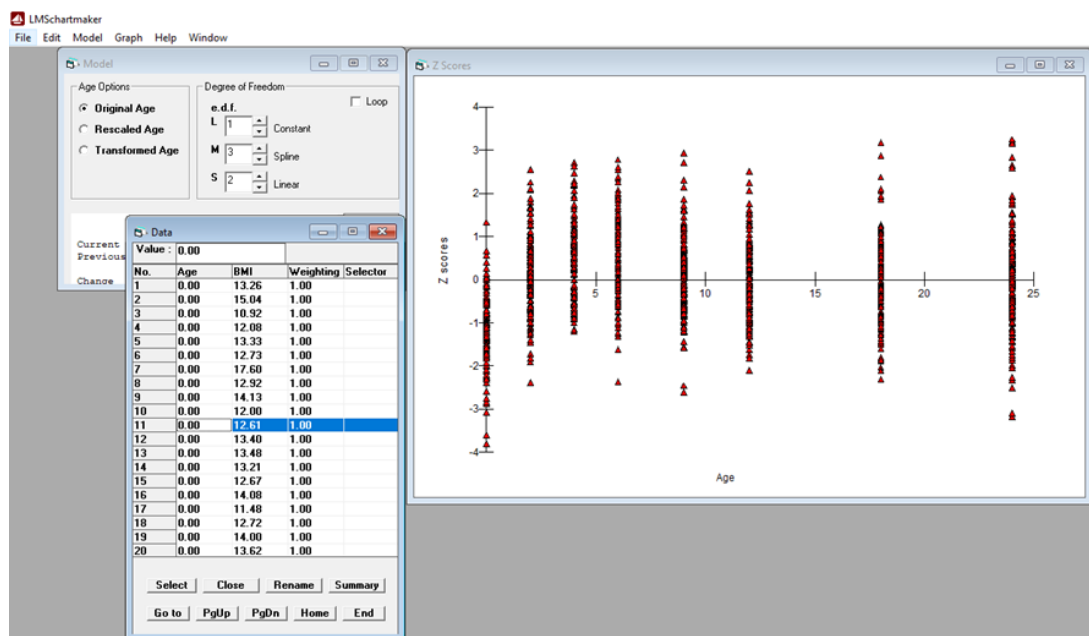


- Nine (9) male subjects were considered outliers in terms of BMI and was removed.

Month	0	0	0	9	12	18	18	18	24
Z-score	-3.459	-3.492	4.338	-3.092	-3.991	-3.059	3.4	3.503	-3.112
BMI	9.15	9.11	22.19	13.31	12.2	12.78	23.39	23.65	11.97
Line #	18	88	120	912	1062	1320	1338	1375	1454
Case ID #	17	12	13	42	49	32	5	11	21
HC	Sitra	A'Ali	B.Q	A'Ali	Budayia	A'Ali	B.Q	Arad	Budayia

BMI of females

- Z-scores Figure of BMI females shown below:

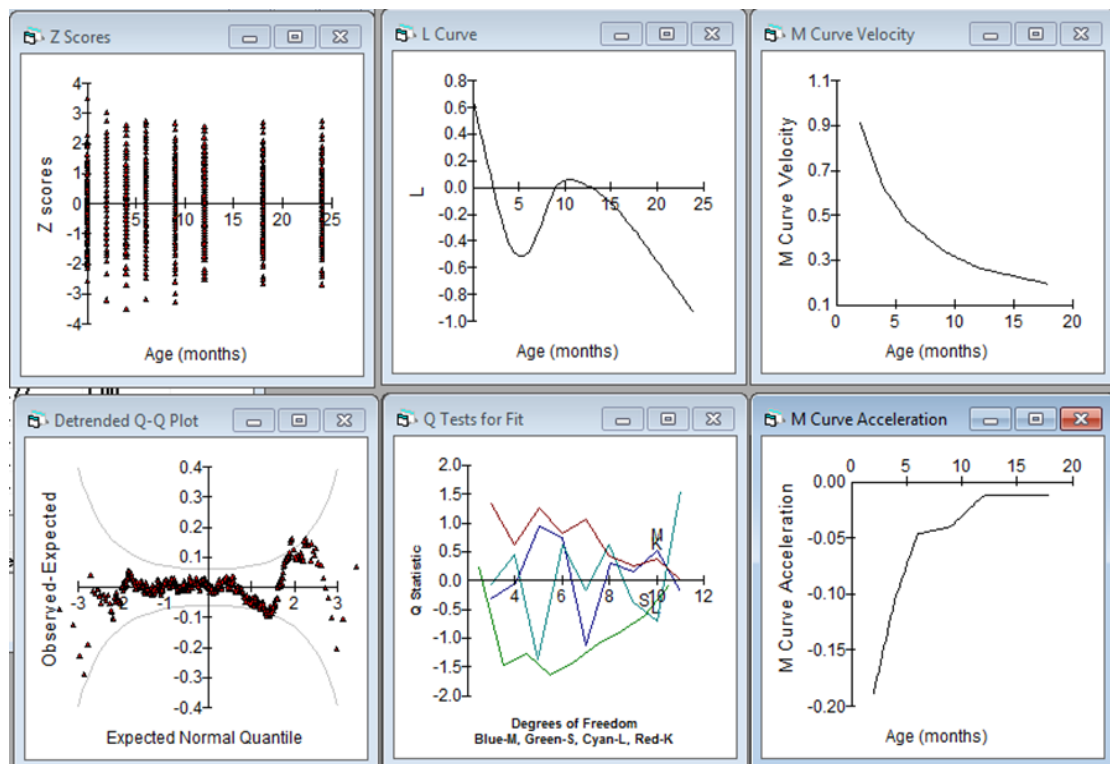


- Seven (7) female subjects were considered outliers in terms of BMI and was removed.

Month	0	0	6	9	9	24	24
Z-score	-3.23	-3.029	-3.376	-3.371	-3.585	-3.139	-3.055
BMI	9.05	9.3	12.39	12.64	12.42	11.32	11.41
Line #	80	92	534	744	882	1295	1344
Case ID #	3	20	28	8	19	19	30
HC	A'Ali	A'Ali	Sitra	Budayia	Arad	Sitra	Budayia

IV. Centiles smoothing and produce curves

1. Models with different M, S, and L values was attempted as recommended by the instruction of the program in order to smooth the centiles, the best model was selected.
2. Centiles were smoothed for each variable and for both genders and LMS and centiles curves was produced.
3. Curves of z-scores, L, M, S, degrees of freedom, and centiles for males weight shown below: (this is shown as an example, others were similarly processed)



APPENDIX 7: Additional statistical analysis

A relationship was found between the child's gestational age and the type of delivery (vaginal or LSCS) with a significant difference between the two variables ($p < 0.05$) as shown in Table (1).

Table (1): Relationship between children gestational age and type of delivery

		Gestational age (in weeks)		T-test P-value
		Mean	SD	
Type of delivery	Vaginal	39.1	1.1	0.003
	LSCS	38.7	1.2	

Table (2) depicts the relationship between the mother's age and breastfeeding their infants. However, no statistically significant difference found between the two variables ($p < 0.5$)

Table (2): Relationship between mother age and breastfeeding

Breast Feeding		Mother age		T-test P-value
		Mean	SD	
2 months	Yes	30.5	5.7	0.603
	No	30.1	5.8	
4 months	Yes	30.5	5.8	0.602
	No	30.1	5.8	
6 months	Yes	30.3	5.8	0.774
	No	30.2	5.8	
9 months	Yes	30.1	6.0	0.902
	No	30.2	5.7	
12 months	Yes	30.3	6.0	0.865
	No	30.2	5.7	
18 months	Yes	30.2	5.6	0.968
	No	30.2	5.9	
24 months	Yes	30.5	6.0	0.682 ¹

No	30.2	5.8
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1. Mann Whitney Test

Table (3) shows the relationship between the mother occupation and breastfeeding their infants. A statistically significant difference was found between the two variables in all ages ($p < 0.001$), except for the 24 months, most probably due to starting weaning practices in accordance to religious teaching.

Table (3): Relationship between mother occupation and breastfeeding of children

Breast Feeding		Mother occupation				Chi-Squared P-value
		Employed		Unemployed		
		N	%	n	%	
2 months	Yes	25	19.5	75	33.8	0.004
	No	103	80.5	147	66.2	
4 months	Yes	19	14.8	65	29.3	0.002
	No	109	85.2	157	70.7	
6 months	Yes	17	13.3	83	37.4	<0.001
	No	111	86.7	139	62.6	
9 months	Yes	16	12.5	84	38.0	<0.001
	No	112	87.5	137	62.0	
12 months	Yes	23	18.0	91	41.0	<0.001
	No	105	82.0	131	59.0	
18 months	Yes	20	15.6	71	32.0	0.001
	No	108	84.4	151	68.0	
24 months	Yes	4	3.1	4	1.8	0.471 ¹
	No	124	96.9	218	98.2	

1. Fisher's Exact Test

Table (4) shows that there was no relation between child's history (single or twin) and having breastfeeding with no statistically significant difference between the two variables in all ages due to very small number of twins.

Table (4): Relationship between Breast Feeding of children and their history

Breast Feeding		Child History				Fisher's Exact Test P-value
		Single		Twin		
		n	%	n	%	
2 months	Yes	116	29.30	0	0.00	0.200
	No	280	70.70	7	100.00	
4 months	Yes	99	25.00	0	0.00	0.202
	No	297	75.00	7	100.00	
6 months	Yes	117	29.60	0	0.00	0.112
	No	278	70.40	7	100.00	
9 months	Yes	115	29.10	0	0.00	0.199
	No	280	70.90	7	100.00	
12 months	Yes	129	32.70	1	14.30	0.436
	No	266	67.30	6	85.70	
18 months	Yes	106	26.80	0	0.00	0.197
	No	289	73.20	7	100.00	
24 months	Yes	8	2.00	0	0.0	1.000
	No	388	98.00	7	100.0	

الملخص

الهدف: أجريت هذه الدراسة لتقييم مدى ملاءمة وكفاية ودقة مخططات النمو لعام 2006 لمنظمة الصحة العالمية لتقييم الوضع الغذائي للرضع البحرينيين والأطفال الصغار.

طرق البحث: هذه الدراسة هي عبارة عن دراسة مقطعية لمؤشرات النمو للأطفال البحرينيين الأصحاء، الذين تتراوح أعمارهم بين 0-2 سنوات بناءً على البيانات التي تم الحصول عليها من السجلات الرسمية لفحص الطفل من الرعاية الصحية الأولية. تم اختيار الأطفال باستخدام طريقة الاحتمال متعدد المراحل من 5 مناطق صحية. تم جمع بيانات الوزن والطول والممارسات الغذائية للأطفال بطريقة الانتقاء العشوائي المنتظم، تم اعداد منحنيات النمو لهذه القياسات باستخدام طريق Coles LMS. تمت مقارنة هذه البيانات مع بيانات النمو المرجعية لمنظمة الصحة العالمية للدراسات المرجعية للنمو المتعدد المراكز (MGRS) وبيانات النمو المرجعة للأطفال السعوديين. كما تم تحديد نقص الوزن، التقزم، الهزال، زيادة الوزن والسمنة (الوزن مقابل العمر، الطول مقابل العمر، مؤشر كتلة الجسم مقابل العمر) باستخدام معايير منظمة الصحة العالمية المرجعية للنمو Z-scores لعام 2006.

النتائج: اشتملت هذه الدراسة على 403 طفلاً (210 فتى و193 فتاة) تتراوح أعمارهم بين صفر إلى سنتين. كان متوسط الوزن والطول ومؤشر كتلة الجسم للمواليد الجدد 3.2 ± 0.5 كجم، 3.1 ± 0.45 كجم، 2.3 ± 49.7 سم، 48.8 ± 2.1 سم، 13.2 ± 1.6 ، و 12.9 ± 1.5 بين الأولاد والبنات، على التوالي. كان متوسط الوزن، والطول، ومؤشر كتلة الجسم لدى الأولاد أعلى قليلاً مقارنة بمقاييس الفتيات في جميع الأعمار وكان الاختلاف ذي دلالة إحصائية. عند مقارنة النسب المئوية المختلفة للبيانات البحرينية وMGRS، كان طول ووزن الأطفال أقل قليلاً من أقرانهم في دراسة MGRS وكان الاختلاف ذي دلالة إحصائية. كذلك عند مقارنة النسب المئوية لبيانات الأطفال البحرينيين مع أقرانهم السعوديين فقد وجد تباين في النمو في كل من الوزن والطول ومؤشر كتلة الجسم. كان أعلى معدل انتشار للهزال في سن 9 أشهر (1.7 %). حوالي 3% فقط كانوا يعانون من التقزم في سن 9 أشهر، وحوالي 2.5% في سن 2 و6 أشهر. وجد عدد قليل جداً من حالات التقزم الشديد وطول القامة. تسع حالات فقط كانت تعاني من نقص الوزن عند الولادة 2.3 %، منها ثلاث فتيان 1.5 % وست فتيات 3.1 %. وجدت حالات ارتفاع معدل انتشار خطورة زيادة الوزن بين الأطفال في سن 12 شهراً (14.5 %). كانت السمنة هي الأعلى في سن 6 و18 شهراً (1.2 %)، معظمهم من الصبيان، (1.9 % في 6 أشهر، وفي 18 شهراً (1.4 %) كانوا من الأولاد و (1 %) كانوا من الفتيات. كان الرضع / الأطفال البحرينيين (0-2) سنوات أعلى وأثقل من مجموعاتهم في المخططات المرجعية لـ MGRS

خاتمة: توفر هذه الدراسة خط الأساس لوضع مخططات النمو المرجعية، وهي مناسبة لضمان المتابعة الصحيحة للأطفال في البحرين. حيث يعد استخدام المخططات الوطنية أكثر ملاءمة من البيانات المرجعية لمنظمة الصحة العالمية. وفقاً لقياسات MGRS، يمكن تصنيف بعض الأطفال على أنهم يعانون من سوء التغذية دون سبب واضح. **الكلمات الأساسية:** مخططات النمو، البحرين، الطول، الوزن، مؤشر كتلة الجسم.

جامعة البحرين

قسم علوم الحياة

كلية العلوم



مؤشرات النمو والحالة التغذوية للأطفال البحرينيين: نحو إنشاء منحنيات نمو وطنية في البحرين

أطروحة قدمت من أجل تحقيق جزء من متطلبات درجة الماجستير في التغذية والنظم الغذائية

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