CHAPTER- II:

MATERIAL AND METHOD

2.1. NATURE OF SUBJECTS AND AREA

The present study has been undertaken among rural Bengali Muslim children and their mothers residing in the Phansidewa block of Darjeeling district of North Bengal, West Bengal, India. Ethnically, the Bengali Muslim Population is a Bengali-speaking ethnic community and by religion faithful to Islam (Das Chaudhuri et al. 1993) and constitutes 20.20 million individuals or 25.30% of the total population of the state of West Bengal. The proposed study area is located under Siliguri, sub-division of Darjeeling district. The community block (Latitude 26º 34´59´´ N, Longitude 88º 22´00´´ E) covers an area of 308.65 km^2. and has a total population of 204,522 individuals (males: 103,719; females: 100,803) with the literacy rate of 41.59% (males: 51.85%; females: 30.80%)(Census 2011).The Phansidewa block has a Muslim population of 48,202 (males: 24,640; females: 23,562) (23%) individuals (Census, 2011). The region is situated near the Indo Bangladesh border region and ~35– 40 km from the sub-divisional town of Siliguri. The residents of the block have access to all the basic amenities, such as hospitals, schools, post office, markets and government offices (Mondal and Sen 2010; Sen and Mondal 2013; Debnath et al. 2018).

2.1.1. The Bengali Muslims

The Bengali Muslim constitute the largest religious minority population in West Bengal and comprises a considerable percentage of the state's population. According to the census of 2011, the Muslim population has 14.2% contribution to the total population and is the second largest religious group in India. Muslims constitute 27.10% of West Bengal's total population. West Bengal occupies the second top most position in terms of percentage of Muslim population among all the states and about 12.16% are Muslim women (Census 2011). Ethnically, the Bengali Muslim Population (BMP) is a Bengali-speaking ethnic community and by religion faithful to the Islam. They contribute a large share to the social and economic well-being of the state and of the country as a whole. In 2011, religion wise sex ratio for

Muslims in India and West Bengal was 951 females for 1000 males (Census 2011). The growth rate of population in the decade 2001-2011 was 24.6%. Work participation rate of Muslims in India was 31.3%, 47.5% and 14.1% for overall, male and female work participation (Census 2011). Forty-seven percent of Indian Muslims were aged below 20 years which was the highest among all the religious communities (Census 2011). The literacy rate in West Bengal Muslims was 57.47% (male: 64.61% and female: 49.75%). In rural areas Muslim literacy rate was about 56% compared to urban Muslims 66% (Census 2001).

Women Empowerment among Muslims

The two of the most important reform movements which have been witnessed by the nineteenth century Muslim society are the revival to Islam and the education for menand women. The most prominent Muslim social reformers of Muslim women education, girls school education and rigidity of Parda system were Sir Syed Ahmed Khan, Badru Tayabji, Haji Mohhamad Mohsin and Syed Imam. In Bengal there were many eminent women literate reformers like Sush Sundari Thakur, Sarala Devi Chowdhurani, Begum Roquiah, Khujista Akhtar Banu, Ashalata Sen, Nalini Das, SushamaSengupta, Amina Tyabji, and Begum Abdullah who improved the social status of women and made significant contribution in empowerment for the Muslim women (Roy 2020). Only after independence the socio-economic situation of Muslim women has come to light of the development authorities, academicians, and policy makers of India. It has been observed that the Muslim women are the most deprived group of the Indian population (Roy 2020). Due to various reasons the gender disparity and marginalization still exist within the Muslim society (Roy 2020).

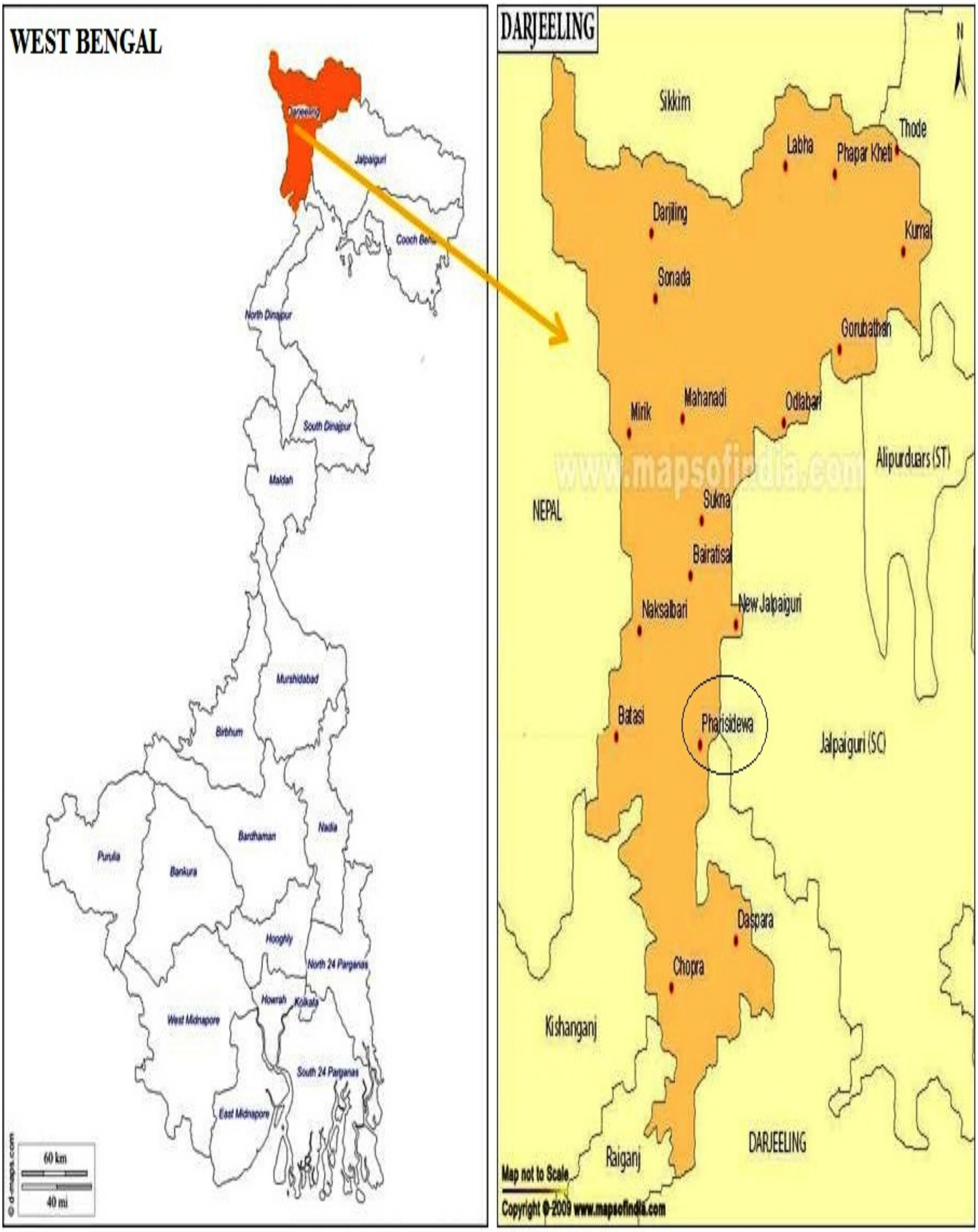

Figure 2.1. Map showing the location of study area Phansidewa Block in Darjeeling district of West Bengal, India

2.2. SAMPLING

The present cross-sectional study was carried out among 612 Bengali Muslim children (boys: 325; girls: 287) aged 1-5 years and their mothers (N=612) living in Phansidewa Block of the Darjeeling district of West Bengal, India. The minimum number of individuals required for reliably estimating the prevalence of undernutrition has calculated following the standard sample size estimation method of Lwanga and Lemeshow (1991). In this method, the anticipated population proportion of 50%, absolute precision of 5% and confidence interval of 95% are taken into consideration. The minimum sample size thus estimated was 384 children and their mothers. Subsequently the individuals were selected using a stratified random sampling method.

The children were selected using the stratified random sampling method. The study was based on the representative sample of children across the Phansidewa block. Initially 750 children (boys: 325; girls: 287) in the age group of 1–5 years were identified so as to participate in the study. Initially, 12 Bengali Muslim dominated villages were identified and listed from the official records of the respective Block and Gram Panchayets. These villages were physically visited to ascertain the actual existence of Muslim individuals. The villages were surveyed to explore the number of Bengali Muslim families' in each village. Special attention was given to those villages which were convenient for data collection, subjects' availability and easy accessibility, so that the actual sample size of the present study could be met. Finally the 10 villages mentioned above were selected for the study. The villages were situated at a distance of about 15 km to 20 km from the Phansidewa Block office.

Parents of the children were informed about the objectives of the study prior to data collection. An informed consent was obtained from them and participation in the study was purely voluntary. The study was conducted in accordance with the ethical guidelines for human experiments, as laid down in the Helsinki Declaration of 2000 (Touitou et al. 2004).

The selected villages were surveyed to collect the data on anthropometric, demographic, socio-economic and lifestyle related factors. The selections of the Bengali Muslim children were done based on the surnames and cultural and religious practices. The ethnicity was subsequently verified from the official records of the block and Gram Panchayets. The ICDS centers were also surveyed for identifying the children and their mothers. Verbal consent of the mothers has been taken for the collection of anthropometric measurements of the children and the mothers. Age of the children and mothers was collected from available official records, birth certificates, polio cards and voter identity cards.

2.3. DEMOGRAPHIC AND SOCIO-ECONOMIC PROFILE

Demographic and socio-economic data were collected from mothers using a pre-structured schedule. The data to be recorded are age of the child, birth orderof the child, number of sibsof the child, family size, age of mother, age at marriage and age at menarche of mother, marital status of mother, education of mother, education of father, occupational of mother, occupation of father, number of children of the mother, family type, water supply, electricity facility, toilet facility, number of rooms, monthly income, monthly expenditure and disease prevalence of children and mothers. These data were be collected by interviewing the mothers and guardians of the children by the household visits. The socio-economic status of the subjects was assessed by utilizing the modified scale of Kuppuswami (Singh et al., 2007). Relevant data on family income, education and nature of occupation were used to determine the socio-economic status of the children. The different variables used for measuring the SES include family income, education, and nature of occupation. These socio-economic variables were classified arbitrarily into different groups or categories with a view to understanding their influence on demographic characteristics i.e. growth, health, and nutritional status of the studied population. The scale has been used in a number of studies dealing with assessment of nutritional status (e.g., Sen and Mondal 2012; Tigga et al. 2015; Debnath et al. 2018).

Table 2.1: Kuppuswami socio-economic scale proposed by Mishra and Singh (2003) and Kumar et al. (2007)

(A) Education	Score
1. Professional or Honours	7
2. Graduate or post graduate	6
3. Intermediate or post high school diploma	5
4. High school certificate	4
5. Middle school certificate	3
6. Primary school certificate	2
7. Illiterate	1
(B) Occupation	**Score**
1. Professional	10
2. Semi-professional	6
3. Clerical,shop owner and farmer	5
4. Skilled worker	4
5. Semi-skilled worker	3
6. Unskilled worker	2
7. Unemployment	1
(C) Income per month (in Rs.) (as modified by Kumar et al. 2007)	**Score**
1. 19,575>	12
2. 9,788-19,574	10
3. 7,323-9,787	6

4. 4,894-7,322	4
5. 2,936-4,893	3
6. 980-2,935	2
7. <979	1
Socio-economic status	**Total score**
Upper (I)	**26-29**
Upper-middle (II)	**16-25**
Lower-middle (III) (Middle)	**11-15**
Upper lower (Lower)	**5-10**
Lower	**<5**

2.4. ANTHROPOMETRIC MEASUREMENTS RECORDED

Anthropometric measurements were collected using the standard procedures of anthropometric data collection (Weiner and Lourie 1981; Hall et al. 2007). The anthropometric measurements of children of weight, height, mid-upper arm circumference (MUAC), head circumference (HdC), triceps skinfold (TSF) and Sub-scapular skinfold (SSF) were collected to assess the body composition and nutritional status of children. Collected anthropometric measurements of mothers were weight, height, mid-upper arm circumference (MUAC), hip circumference (HC), waist circumference (WC), biceps skinfold (BSF), triceps skinfold (TSF), sub-scapular skinfold (SSF) and supra-iliac skinfold (SISF) thickness to assess the body composition and nutritional status of mothers. The skinfold measurements were taken using Holtain skinfold caliper.

2.5. COLLECTION OF ANTHROPOMETRIC DATA

1. Height

Height was taken with the help of the anthropometer rod to the nearest 0.1 cm. The subjects were made to stand on a horizontal platform with both heels together. The head was hold stretched upward to the fullest extent in the Frankfurt horizontal plane. The horizontal arm of the anthropometer was brought down lightly to touch the vertex and the measurement was recorded in linear distance from floor to vertex.

2. Weight

Body weight of the subjects was recorded using a portable weighing scale. The children/individuals were barefooted and wearing minimum clothing at the time of measurement. Body weight was recorded to the nearest 0.5 kg. The weighing scale was cross-checked with known weight after regular interval and the scale needle was set zero before obtaining the data.

3. Mid-Upper Arm Circumference (MUAC)

The mid-upper arm circumference (MUAC) was measured on the left arm of each individual with the arm hanging relaxed. It was measured midway between tip of the acromion and the olecranon process. The measurement points were marked by a marker and the measurements taken with the help of a non-stretchable plastic coated measuring tape to the nearest 1mm.The measurement were recorded in such a way that the tape was touching the skin but not compressing the tissue. The sometime repeated measurements were taken using the same procedures to validate/check the values obtained in first measurement.

4. Head Circumference (HdC)

Brain size and head circumference can be affected with under-nutrition, especially in case of protein energy malnutrition. The greatest circumference is to be measured for head circumference.

5. Hip circumference (HC)

HC was measured as the maximum circumference or elevation of the buttocksie, at the level of the greater trochanters with the individual standing erect with his feet placed together. Two consecutive readings were recorded to the nearest of 0.1 cm using a non-stretchable measuring tape without compressing the skin.

6. Waist circumference (WC)

Waist measurement can be used to assess central obesity. Waist circumference was measured at the level halfway between the iliac crest and the coastal margin in the mid-axillary line after exhaling with the subject in the standing position. Two consecutive readings were recorded to the nearest of 0.1 cm using a non-stretchable measuring tape without compressing the skin.

7. Biceps skin fold (BSF)

BSF was recorded in the middle of the upper arm between the acromian and the olecranon process at the level of nipple line. The elbow was placed at right angles to the middle of upper arm and marked. The skinfold was pinched vertically and lifted off the muscle about 1 cm above the marked line. The measurement was then recorded.

8. Triceps Skin Fold (TSF)

The triceps skinfold (TSF) site is on the posterior aspect of the right arm, over the TSF muscles midway between the lateral projection of the acromion process of the scapula and inferior margin of the Olecranon process of the ulna. The midpoint between the acromion and olecranon processes is marked along the lateral side of the arm with the elbow flexed 90 degrees. The subject's arm is now hanging loosely at the side with the palm of the hand facing anterior to posteriors determine the posterior midline of the upper arm at the same level as the previously marked midpoint. The skinfold is now grasped with the thumb and index finger of the left hand about 1cm proximal to the skinfold site. The caliper is placed on the site where the sides of the skinfold are approximately parallel and 1cm distal to where the skinfold is grasped. The caliper is positioned so that it can be read easily. The measurement is obtained about 4 seconds after placing the caliper tips on the skinfold.

9. Sub-Scapular Skinfold (SSF)

The sub-scapular skinfold (SSF) is 1cm below the lowest or inferior angle of the scapula. The long axis of the skinfold is on a 45 degree angle directed down and to the right side. The site can be located by gently feeling for the inferior angle of the scapula or by having the subject place his or her right arm behind the back sides. The skin is grasped 1cm above and medial to the site along the axis. The caliper is held in the right hand, perpendicular to the long axis of the skinfold and with the caliper’s dial facing up and easily readable. The dial is read approximately 4 seconds after the pressure from the measurer’s hand has been released on the lever arm of the caliper. The skinfolds measurements were taken with great care and special care was given to identify the landmarks of the measurements. The skinfolds measurements were measured very carefully by separating the muscle and fat folds among children. Two repeated measurements were taken on each subject and mean of the measurements were recorded in order avoid any measurement errors.

10. Supra-Iliac Skinfold (SISF)

SISF was recorded on the superiority portion of the iliac crest directly on the mid-auxiliary line slanting and directly on top of the iliac crest. The skinfold was pinched vertically and the measurement taken about l cm above the marked point.

2.6. CALCULATION OF TECHNICAL ERROR MEASUREMENT (TEM) AND CALCULATION OF SYSTEMATIC ERROR MEASUREMENT

The technical error measurement (TEM) was calculated following the method of Ulijaszek and Kerr (1999) to determine the accuracy of the measurements. The intra-observer TEM were observed to be within the cut-offs values of 0.95 as suggested by Ulijaszek and

Kerr (1999), hence the measurements recorded in the present study was considered to be reliable and reproducible. The TEM was calculated using the following equations:

TEM=$\sqrt{(\sum D2/2N)}$, D=Difference between the measurements, N=number of individuals. The co-efficient of reliability (R) was subsequently calculated from TEM using the following equation: R=$\{1-(TEM)^2/SD^2\}$, SD=Standard deviation of the measurements.

For calculating TEM, height, weight, MUAC, HdC, TSF and SSF were recorded from 50 children aged 1-5 years other than those selected for the investigation. High values of R (>0.95) were recorded for height and weight. The values were observed being within the acceptable limits of 0.95 as recommended by Ulijaszek and Kerr (1999). Hence, the measurements recorded were reliable and reproducible. Systematic errors are errors that affect the accuracy of measurements. Systematic errors are 'one-sided' errors, because, in the absence of other types of errors, repeated measurements yield results that differ from the true or accepted value by the same amount. The accuracy of measurements subject to systematic errors cannot be improved by repeating those measurements. The systematic errors cannot easily be analyzed by statistical analysis. Systematic errors can be difficult to detect, but once detected can be reduced only by refining the measurement method or technique. Common sources of systematic errors are faulty calibration of measuring instruments, poorly maintained instruments or faulty reading of instruments (Harris and Smith 2008).

Table 2.2: Table showing the results of Technical Errors of measurement of the anthropometric measurements recorded in the present study

Name of the Measurement	Intra--observer	
	TEM	Coefficient of Reliability
Height	**0.070**	**0.995**

Weight	**0.107**	**0.995**
MUAC	**0.077**	**0.997**
HdC	**0.129**	**0.998**
TSF	**0.125**	**0.999**
SSF	**0.015**	**0.997**

2.7. CALCULATION OF ANTHROPOMETRIC INDICES FOR ASSESSMENT OF NUTRITIONAL STATUS AND BODY COMPOSITION OF CHILDREN AND MOTHERS

1. Body Mass Index (BMI)

The body mass index (BMI) was calculated using the standard equation of WHOM (1995). The BMI is widely used index to study the physical growth pattern and nutritional status as recommended by WHO (1995; 2007).

BMI (kg/m^2) =Weight (kg)/Height^2 (m^2)

2. Percent of Body Fat (PBF)

The percent of body fat following equations of Slaughter et al. (1988) were used to estimate the percent of body fat (PBF) of children:

Boys = 1.21 (TSF +SSF) − 0.008 (TSF +SSF)^2 − 1.7

Girls =1.33 (TSF + SSF) − 0.013 (TSF+ SSF)^2 − 2.5

The present study evaluated PBF content in order to evaluate the body composition characteristics of rural school-going children using the equation of Slaughter et al. (1988). Furthermore, several studies have assessed body composition characteristics in children utilizing these equations for estimation of PBF among children from both non-Indian

(Musaiger and Gregory 2000; Gültekin et al. 2005; Ghosh et al. 2009; Laurson et al. 2011; Aguirre et al. 2015; Noradilah et al. 2016; González-Agüero et al. 2017) and Indian ethnic populations (Mukhopadhyay et al. 2005; Chowdhury et al. 2007; Sen and Mondal 2013; Debnath et al. 2018; Sharma and Mondal2018).

The following standard equation of Siri (1956) was used to assess PBF for Bengali Muslim Mothers in the present study.

PBF = (4.95/ Body density - 4.50) x 100

The body density values of mothers after calculating them from the Durnin and Womersely equations (1974) were used in the PBF equations. Several researchers have utilized Siri 's equation in order to estimate the bodv fat content in different Indian ethnic populations (Dudeja et al. 2001; Das and Bose 2006; Chakrabarty and Bharati 2010).

3. Body Density

The body density of the Bengali Muslim Mothers was calculated in order to assess PBF. The sum of four skinfold thickness (e.g ., BSF, TSF, SSF, SISF) were also utilized for calculation of body density. Sex specific standard equations of Durnin and Womersely(1974) were utilized for the purpose. These equations have been validated in different Indian populations by Dudeja et al. (2001), Das and Bose (2006) and Chakraborty and Bharati (2010). The following equation of Dumin and Womersely (1974) were utilized to assess the body density of mothers:

Female body density = 1.1567-0.0717 X $\log_{10}$ (BSF+TSF+SSF+SISF)

4. Fat Mass (FM) and Fat Free Mass (FFM)

The body mass consists of both fat mass (FM) and fat free mass (FFM). The standard equations of Van Itallie (1990) and Eckhardt et al. (2003) have been utilized to assess the amount of FM and FFM among children and mothers. Several researchers have utilized these equations to assess the FM and FFM among different Indian populations (Bhadra et al. 2005a;

Choudhury et al. 2007; Das and Bose. 2006; Debnath et al. 2018). The equations are as follows:

Fat Mass (FM) (kg)= (PBF/100) X Weight (kg)

Fat Free Mass (FFM) (kg)= Weight (kg)/ FM (kg)

5. Fat Mass Index (FMI) and Fat Free Mass Index (FFMI)

The indices of fat mass index (FMI) and fat free mass index (FFMI) were calculated from the equations of Van Itallie et al. (1990). The indices are given below:

Fat Mass Index (FM) (kg/m^2) = FM/ $Height^2$ (m^2)

Fat Free Mass Index (FFMI) (kg/m^2) = FFMI/ $Height^2$ (m^2)

6. Upper Arm Composition

The upper arm compositions of the children were evaluated using the anthropometric measure of TSF and MUAC by following the standard equations (Frisancho 1974, 1989): The upper arm composition of the individuals was evaluated in terms of total Upper Arm Area (TUA), Upper Arm Muscle Area (UMA), Upper Arm Fat Area (UFA) and Arm Fat Index (AFI).

Following upper-arm composition variables were calculated:

Total upper arm area (TUA cm^2) = $(MUAC)^2/4\,\pi$

Upper arm muscle area (UMA cm^2) = $[MUAC-(TSF\times\pi)^2]/(4\pi)$

Upper arm fat area (UFA) (cm^2) = $\{(MUAC)^2/(4\pi)\}-UMA$

Arm Fat Index (AFI) = $UFA/\{(MUAC)^2/(4\times\pi)\}\times 100$

7. Waist circumference (WC)

Waist circumference cut-offs were taken as >90 for males and >80 for females to define overweight (WHO 2000).

Table 2.3: World Health Organization cut-off points and risk of metabolic complications

Indicator	Cut-off points	Risk of metabolic complications
Waist circumference	>94 cm (M); >80 cm (W)	Increased
Waist circumference	>102 cm (M); >88 cm (W)	Substantially increased
Waist–hip ratio	≥0.90 cm (M); ≥0.85 cm (W)	Substantially increased

M, men; W, women

8. Waist-Hip Ratio (WHR)

The WHR has been calculated using the measurements of WC and HC using the following equation:

WHR = Waist circumference (cm) / Hip circumference (cm).

A high WHR is defined as >0.9 in males and >0.8 in females by Webb (2002) and Huxley et al. (2008). These cutoffs are used to assess the amount or' higher regional adiposity among the individuals.

9. Waist-height ratio (WHtR)

The WHtR has been calculated using the measurements of WC and height using the following equation:

WHR = Waist circumference (cm) / height (cm).

For WHtR, the cut-offs used was 0.5 (<0.5; ≥0.50) for both sexes (Hsieh and Muto 2004).

10. Sum of four skinfold (Σ4SKF)

The skinfold measurement can be utilized to assess of fat proportion and fat distribution in an individual or population so as to assess body composition. The sum of four skinfold thicknesses (Σ4SKF) has been calculated to assess the fat proportion among Bengali Muslim mothers.

Sum of four skinfold (Σ4SKF)= BSF+ TSF+ SSF+ SISF

For **Σ**4SKF cut off is>50 nm for both sexes (Dudeja et al. 2001)

11. BODY ADIPOSITY INDEX (BAI)

The body adiposity index (BAI) is used as a tool to evaluate body adiposity. BAI can be calculated from the hip circumference and height and it can be used to assess the body fat percentage in adults (Bergman et al. 2011). The following formula has been used to calculate BAI among Bengali Muslim mothers.

BAI= {(hip circumference)/[(height^1.5)- 18]}

2.8. CALCULATION OF ANTHROPOMETRIC VARIABLES FOR PHYSICAL GROWTH ASSESSMENT AND NUTRITIONAL STATUS OF CHILDREN

Growth references are very important tools for determining the nutritional status in a population and are valuable indicators of attained size and physical growth in children at each specific age. A variety of growth references were developed and used in the United States since the early 1900s. Most of the earlier references have considerable limitations, including lack of coverage for infants and pre-school children with limited representation of ethnic, genetic, socio-economic, environmental, and geographic variability. The Centre for Disease Control and Prevention (CDC 2000) Growth Charts released in 2000 is the updated and revised version of the National Centre for Health Statistics (NCHS) growth charts (WHO, 1995).The 2000 CDC growth charts consists of a set of charts for infants, births to 36 months of age and a set of charts for children and adolescents from ages 2 to 20 years. The charts for infants includes sex-specific smoothed percentile curves for weight-for-age, recumbent length-for-age, head circumference-for-age and weight-for-recumbent length, the charts for children and adolescents include weight-for-age, stature-for-age and body mass index (BMI)-for-age charts represents a new tool that can be used by health care providers for the early identification of children who are at risk for becoming overweight at older ages. The CDC (2000) growth charts also include weight-for-stature charts for statures ranging from 77 to 121 cm, primarily intended for use among children from ages 2 to 5 years (CDC 2000). There are three widely known and used versions of the 1978 WHO/NCHS Growth references (for children upto age 10), WHO Growth References (for children and adolescents upto age 19), and the 2006 WHO Growth standards (for pre-school children, under 6 years of age. Most of the earlier versions are based on the national survey data collected in the 1960s and 1970s.These NCHS Growth Charts included anthropometric measurements such as weight –for-height, weight-for-age, height-for-age, and head circumference –for-age. They were developed based on several national surveys (namely NHAES II, NHAES III, and NHANES I) and a local study for infants. In 1978, the WHO/CDC produced a normalized version of the US CDC/NCHS growth curves, showing Z-scores instead of absolute anthropometric values. It was called the 1978 WHO/NCHS Growth References, and has been widely used all over the world since then. In 1995, a WHO Expert Committee reviewed existing growth references and research findings, and then re-endorsed the use of the 1978 WHO/NCHS Growth Charts. The 2006 WHO Growth Standards include anthropometric indicators such as length/height –for-age, weight –for-age, weight-for-length/height, BMI-for-age, head circumference-for-age, arm circumference –for-age, Sub scapular skin fold-for-age, and triceps skin fold-for-age. Recumbent length-for-age was used for indicators of stature from birth to age of 24 months, while standing height –for-age from 2 to 5 years old. Due to differential measurements of body length and body height, a 0.7cm in length at 24 –month –old was observed. To address this issue, weight-for-length for 0-2 year –old children and weight-for-height for 2-5 year –

old children were presented on separate charts. The WHO provides growth charts and tables of percentiles and Z-Scores, separately for girls and boys.

2.9. CALCULATION OF PHYSICAL GROWTH ASSESSMENT VARIABLES OF CHILDREN

The anthropometric measures of height, weight and BMI was used to respect to age were used to calculate the Z-score values in order to assess the physical growth. A Z-score is a measure of how many standard deviations below or above the population mean a raw score is. A Z-score is also known as standard score and it can be placed on a normal distribution curve. Z-score range from -3 standard deviation (which would fall to the far left of the normal distribution curve) to +3 standard deviation (which would fall to the right of the normal distribution curve). WHO (2006, 2007) recently proposed growth references was used to calculate the age-sex specific z-score values. L, M and S method was used to calculate the age-sex specific Z-score values among children. A child with Z-score of <-2SD was considered to be undernourished in any nutritional status indicators as described below:

1. Height-For-Age Z-Score (HAZ)

A height-for-age Z-score (HAZ) is the number of standard deviation of the actual height of a child from the median height of the children of his/her age as determined from the standard sample. This is prefixed by a positive sign (+) or a negative sign (-) depending on whether the child's actual height is more than the median height or less than the median weight. When actual height of a child is exactly equal to the median, the resultant HAZ is 0 (zero).

2. Weight-For-Age Z-Score (WAZ)

It is the number of standard deviations of the actual weight of a child from the median weight of the child of his/her age as determined from the standard sample. This is prefixed by a positive sign (+) or a negative sign (-) depending on whether the child's actual weight is more than the median weight or less than the median weight. When the actual weight of a child is exactly equal to the median, the resultant WAZ is 0 (zero).

3. Weight-For-Height Z-Score (WHZ)

A weight-for-height Z-score (WHZ) is the number of standard deviation of the actual weight of a child from the median weight of the children of his/her age as determined from the standard sample. This is prefixed by a positive sign (+) or a negative sign (-) depending on whether the child's actual weight is more than the median weight or less than the median weight. When actual weight of a child is exactly equal to the median, the resultant HAZ is 0 (zero).

4. BMI-For-Age Z-Score (BMIAZ)

A BMI-for-age Z-score (BMIAZ) is the number of standard deviation of the actual height of a child from the median BMI of the children of his/her age as determined from the standard sample. This is prefixed by a positive (+) sign or a negative sign (+) depending on whether the child's actual BMI is more than the median BMI or less than the median BMI. When actual BMI of a child is exactly equal to the median, the resultant BMI is zero.

5. Head Circumference-For-Age Z-Score (HdCAZ)

A head circumference-for-age Z-score (HdCAZ) is the number of standard deviation of the actual height of a child from the median height of the children of his/her age as determined from the standard sample. This is prefixed by a positive sign (+) or a negative sign (-) depending on whether the child's actual height is more than the median height or less than the median weight. When actual height of a child is exactly equal to the median, the resultant HdCAZ is 0 (zero).

2.10. Assessment of Nutritional Status of Children

The anthropometric indices of stunting, underweight, wasting and thinness were widely used to assess the undernutrition in children and adolescents. The anthropometric indices reflect certain distinct biological process and their use is necessary for determining appropriate nutritional interventions (WHO 1995, 2006, 2007). The indices of low height-for-age (i.e., stunting) and low weight-for-height (i.e., wasting) reflects long-term chronic and short-term acute undernutrition among children, respectively. The low weight-for age (i.e., underweight) or low BMI-for-age (i.e., thinness) were used to assess the magnitude in terms of composite measure to assess the both the chronic and acute undernutrition. The interpretation of the four indices involves a comparison with an international reference population to determine undernutrition as recommended by the WHO (WHO, 1995, 2006, 2007). The justification for the use of a reference population is the empirical finding that well-nourished children in all communities follow very similar growth patterns (de Onis et al., 2006). The Nutrition Foundation of India had also advocated the use of the WHO standard to be applied among Indian children. Hence, the reference values from the WHO (WHO 1995, 2006, 2007) will be used in the course to calculate the magnitude of undernutrition among children. Recently, WHO (2006, 2007) has recommended low BMI-for-age (Thinness) to assess the nutritional status of children. To determine the nutritional status of children, the WHO has recommended the use of Z-score indicators. Children with a Z-score value below –2 for any indices are considered to be undernourished (WHO, 2006, 2007). Thus, boys and girls with Z-score values of <–2 of HAZ, WAZ, BMIAZ, WHZ were classified as suffering from stunting, underweight, thinness, wasting, respectively. The nutritional status of the children was assessed using the conventional anthropometric nutritional status of stunting (low height-for-age), underweight (low height-for-age), thinness (low BMI-for-age), wasting (low weight-for-height) and low Head circumference-for-age (low HdC-for-age) as recommended by the WHO (1995, 2007).

Furthermore, the severity of undernutrition was assessed among children by three conventional anthropometric measures of stunting, underweight and wasting was classified according to the proposed classifications of public health problem (WHO 1995). The proposed classification to assess the severity of public health problem of undernutrition based on the percentages among the children is depicted in Table 2.2.

Table 2.4: Classification of assessing severity of public health problem of undernutrition based on the percentages among the children.

Index	Low (%)	Medium (%)	High (%)	Very High (%)
Stunting	< 20	20-29	30-39	≥ 40
Underweight	<10	10-19	20-29	≥30
Wasting	< 5	5-9	10-14	≥15

Source: WHO (1995)

The different nutritional indices used to assess the undernutrition among children are depicted in Table 2.3.

Table 2.5: Recommended anthropometric measures/indices used to assess the prevalence of undernutrition status

Children	Anthropometric/ Nutritional variables	Cut-off/ Reference	Undernutrition categories/measures
Children (0-5 years)	**Height-for-age**	<−2SD	Stunting
	Weight-for-age	<−2SD	Underweight
	BMI-for-age	<−2SD	Thinness
	Weight-for-height	<−2SD	Wasting
	Head circumference-for-age	<−2SD	Low-Hdc-for-age

Source: WHO (1995, 2006, 2007)

2.11. Assessment of Nutritional Status of Mothers

Nutritional status has been assessed in terms of BMI. The BMI was calculated using the following standard equation of WHO (WHO 1995):

BMI= Weight/Height² (kg/m²)

The BMI cut-off points proposed by WHO (2004) for Asian Indians have been utilized for the assessment of under-nutrition, overweight and obesity (Table 2.5).

2.6: Proposed classification of BMI in Asian Adults (WHO 2004)

Classification		BMI (kg/m^2)	Risk of co-morbidities
Underweight		< 18.5	Low (but increased risk of other clinical problems)
Normal range		18.5-22.9	Average
Overweight		23-24.9	Increased
Obese	**Obese I**	25-29.9	Moderate
	Obese II	≥ 30	Severe

Nutritional status of mothers has also been assessed using sex specific MUAC cut-off for females. Value of MUAC<22 cm indicates undernutrition as proposed by James et al. (1994).

2.12. Statistical Analysis

The data of the present study were statistically analyzed utilizing the Statistical Package for Social Sciences (SPSS, Chicago IL, version 16.0). The statistical constants include descriptive statistics (mean and standard deviation), Homogeneity of variance (i.e., Levene statistics), One-way analysis of variance (ANOVA) and chi-square analysis was done to analyze data and test the study hypothesis. The descriptive statistics (mean and standard deviation) was used to describe the anthropometric measurements of height, weight, MUAC, TSF, SSF, PBF, FM, FFM, FMI, FFMI, TUA, UMA, UFA, AFI, UME, UFE, BMI, PBF-BMI Ratio among children. The sex specific mean difference in anthropometric measures and variables was assessed using ANOVA between boys and girls. The overall and age-sex specific homogeneity of variance (Levene statistics) was used to determine the probability distribution of the continuous anthropometric data. The one-way ANOVA was done to determine the age specific mean different in anthropometric measures measure among boys and girls. Two-way ANOVA was performed for the continuous anthropometric variables to assess the combined effect of age and sexes. Pearson correlation coefficient analysis was done to ascertain the relationships between the anthropometric variables among boys and girls, separately. The derived nutritional indices of HAZ, WAZ, WHZ, BMIAZ and HdCAZ were also presented using the descriptive statistics among children. Similarly, age-sex specific mean differences were assessed using ANOVA among children. The prevalence of undernutrition status in different nutritional indices was depicted in terms of frequency and percentages among boys and girls. Chi-square (X^2) analysis was utilized to assess the differences in the nutritional indices between and within communities and between sexes in the different nutritional categories of stunting, underweight, thinness and wasting. The Yates correction term was taken into consideration in the case of chi-square tests where the cells possessed less than five individuals. This correction term adds to the accuracy of X^2 determinations when the numbers of classes are small. Binary logistic regression and multinomial logistic regression analysis have been performed for assessing the association of socio-economic demographic and lifestyle variables with the nutritional status of children and mothers. All the differences were considered to be statistically significant at $p < 0.05$ and $p < 0.01$ level.