CHAPTER- IV:

DISCUSSION

4.1. OVERVIEW

Assessments of body composition and nutritional status among individuals and/or populations bear significant importance in developing countries such as India where the vast majority of the populations are malnourished and underprivileged. Studies among different Indian populations have reported that major segments are malnourished (undernourished or overnourished) and it is the major public health concern with the central attention being given to children less than 5 years, adolescents and women. The coexistence of undernutrition, overweight and obesity in a population is known as "double burden of malnutrition" (DBM). Therefore, the assessment of DBM in populations is important for the improvement of overall health and development of country and its citizens. The occurrence of childhood undernutrition in terms of stunting, thinness, wasting, underweight and low HdC-for-age among children have detrimental effects on their life and is a major concern in public health and continues to be a cause of ill-health and premature mortality among children (Nandy et al. 2005). Physical growth, development and body composition assessment can play an important role in nutritional status for the effect of age, sex, ethnic, geographic, environmental, socio-economic conditions, sedentary behaviour, physical activity, disease and genotype or genetic factors and provides a useful sign of the health and nutritional status (Eveleth and Tanner 1990; Rolland-Cachera 1993; Rogol et al. 2002; Hall et al. 2007; Rogol 2010; Wells 2010; Sen and Mondal 2013; Xue et al. 2016; Griffiths et al. 2016; Rengma et al. 2016; Debnath et al. 2017; Debnath et al. 2018). The presence of undernutrition and overweight and obesity in adult population has been observed by several studies. Maternal malnutrition is a major factor for morbidity and mortality among women of the developing countries. The contributing factors include inadequate food intake, poor nutritional quality of diets, frequent infections, and short inter pregnancy intervals. The consequences of poor maternal nutritional status contribute to the low pregnancy weight gain and high infant and maternal morbidity and mortality. Studies also have observed the prevalence of overweight and obesity simultaneously in one population. Several studies have observed that South Asian populations have 3%-5% of greater body-adiposity levels than Caucasians at any given BMI including low adipokine production and lower levels lean body mass and it is called the "Asian Indian Phenotype" (Little et al. 2016; Debnath et al. 2019). Obesity is observed as the 'first wave of a defined cluster of non-communicable diseases' called "New World Syndrome" creating an enormous socio-economic and public health burden in low and middle income developing countries (WHO 2000; Bharati et al. 2008).

The WHO has described overweight-obesity as one of the most neglected public health issue (Bharati et al. 2008). Several internal and external factors e.g., ethnic or genetic environment, socio-cultural, socioeconomic and demographic factors are potential contributors to the occurrence of overweight and obesity in populations. Overweight and obesity are associated with increased risk of non-communicable diseases such as metabolic syndrome, high cholesterol, type-2 diabetes mellitus, high blood pressure, and cardiovascular disease; conditions that are already serious public health concerns in rural and urban India alike (Misra et al. 2011; Zaman et al. 2012). The co-occurrence of undernutrition and overnutrition in rural villages and households, termed the 'double burden' of disease is much more troubling which worsen poverty and limit overall economic growth (Doak et al. 2005; Little et al. 2016).

For assessing the nutritional status of children the conventional anthropometric measures (e.g., stunting, thinness, wasting and underweight) are generally recommended for (WHO 1995; 2007). These reflect a failure to reach linear growth optimal potential, as a result of achieving a sub-optimal health and nutritional condition. The assessment of body composition is of interest to human biologists because of the impact of nutritional status, specific diet, exercise, disease and genetic factors. It reflects nutritional intakes, losses and needs over time (i.e., FFM and FFMI loss) and the prevalence of undernutrition. It is also associated with decreased survival, worse clinical outcome, quality of life and disease prevalence in individuals or populations (Thibault and Pichard 2012; Thibault et al. 2012). Therefore, body composition evaluations should be integrated into routine clinical practice for the initial assessment and sequential follow-up of nutritional status (e.g., undernutrition or excess weight gain) (Wells 2010; Weber et al. 2012; Sen and Mondal 2013). Assessment of nutritional status and body composition of mothers is done using the BMI cut offs for undernutrition and overnutrition (overweight and obesity) and WC, WHR, WHtR, MUAC, PBF and sum of four skinfolds.

4.2. ANTHROPOMETRIC ASSESSMENT AND BODY COMPOSITION VARIATION AMONG THE CHILDREN

Measurement of body composition is proving increasingly important in epidemiological and clinical investigations, where skin-fold thicknesses (e.g., TSF and SSF) and MUAC are preferably used to estimate the body composition in children and adolescents (Reilly et al. 1995; Gerver and de Bruin 1996; Gibson 2005; Wells 2010; Sen and Mondal 2013; Debnath et al. 2017). The results of the present study showed significant age and sex specific differences among the children ($p<0.05$). Several studies validated different skin-fold equations and recommended usage of the equations of Slaughter et al. (1988) for evaluation of body fat among pre-pubertal children (Reilly et al. 1995; Goran et al. 1996; Boot et al. 1997; Rodrı´guez et al. 2005; Sala et al. 2007). More accurate estimates of PBF can be calculated by the equations of Slaughter et al. (1988), than most currently available methods that considered the use of a multi-component approach to body composition. It has been shown from previous reliable data that skin-fold thickness equations, such as those proposed by Slaughter et al. (1988) predicted fatness with negligible bias in groups of children (Rodrı´guez et al. 2005). Hence, the present study evaluated PBF content among the children in order to evaluate their body composition characteristics using the equation of Slaughter et al. (1988). Several researchers have assessed body composition characteristics in children utilizing these equations for estimation of body fat percentages among children from both non-Indian (Musaiger and Gregory 2000; Gültekin et al. 2005; Al-Hazzaa et al. 2007; Aguirre et al. 2015; Gutiérrez et al. 2017; Teo et al. 2019) and Indian populations (Bhadra et al. 2005; Mukhopadhyay et al. 2005; Chowdhury et al. 2007; Ghosh et al. 2009; Debnath et al. 2018). Significant sexual dimorphisms have been observed among the Bengali Muslim children in MUAC, HdC, TSF, SSF, PBF, FM, FFM, FMI, TUA, UMA, UFA, AFI, UME, UFE, PBF-BMI Ratio ($p<0.01$) (Table 3.1, Table 3.2, Table 3.3 and Table 3.4). Similar trends of body composition and adiposity indicators have also been reported in other studies. (Gerver et al. 2000; Webster-Gandy et al. 2003; Gültekin et al. 2005; Wang et al. 2007; Sen and Mondal 2013; Debnath et al. 2017, 2018a,b). Wells (2007) advocated that sexual dimorphism of body composition is evident from foetal life and it mainly emerges during puberty and such differences in body composition are primarily attributed to the action of steroidal hormones. Sex differences appear in body composition prior to the onset of sexual maturation and several studies have reported that fatness showed stability between early infancy and childhood (Weststrate et al. 1989; Gerver et al. 2000; Webster-Gandy et al. 2003; Wells 2010; Kromeyer-Hauschild et al. 2012; Xiong et al. 2012).

The differences in adiposity measures (e.g., TSF, SSF, PBF, UFA, AFI, UME, BMI, PBF-BMI Ratio) were also observed to be more prominent with advancement of age. The sex-specific mean values were greater in girls than boys (Table 3.2 and Table 3.4). Similar trends in the adiposity and body composition characteristics have been reported among children by several researches (Gültekin et al. 2005; Kromeyer-Hauschild et al. 2012; Xiong et al. 2012; Sen and Mondal 2013; Debnath et al. 2018). It has also been reported that the Tanner stages had a significant relationship with body composition in both sexes and were significantly positively related to lean tissue mass and bone mineral content among boys and girls and to PBF and FM in girls in the higher age groups (Boot et al. 1997; Leonard et al. 2010).

Body composition evaluation should be integrated into a routine clinical practice for initial assessment and sequential follow-up of nutritional status. Several studies have already reported that the conventional anthropometric measure such as BMI is commonly used as a simple surrogate anthropometric measure to excess adiposity and body composition in relation to excess weight gain, but nevertheless, there are well-known limitations regarding the use of BMI as it is unable to distinguish FFM and FM, and is not sensitive to changes in adiposity during childhood (Gallagher et al. 1996; Horlick 2001; Weber et al. 2012). BMI is not able to distinguish whether it is an increase in FM or a decrease in FFM that causes increase in body mass of a child, but it can be partitioned into the fat and lean components of FMI (FM index= FM/height^2) and FFMI (FFM index= FFM/height^2) (Wells 2010; Weber et al. 2012). It is therefore desirable to investigate the relationship of both compartments lean mass (e.g., FFM and FFMI) and fat mass (FM and FMI) when analyzing the body composition data.

Moreover, FM and FFM have the advantage that they can provide discrete measures for these two components of weight, each adjusted for an independent component of size, although in some cases a more complex approach is required (VanItallie et al. 1990; Wells 2007, 2010). This could allow for a systematic and early screening of undernutrition and promote rational, early initiation of optimal nutritional support, thereby contributing to reducing malnutrition-induced morbidity, mortality, worsening of the quality-of-life and global healthcare costs (Thibault and Pichard 2012; Thibault et al. 2012). Therefore the indices of FFMI and FMI offer a powerful framework for evaluating within and between-population variability in body composition and address physique (e.g., FFMI) as well as relative adiposity (e.g., FMI). The results also showed that the body composition of school children exhibited higher values compared to the available data. The present study showed that the girls had higher body fat contents than their male counterparts in connection with adiposity indicators such as TSF, SSF, PBF, UFA, AFI , UME, BMI , PBF-BMI Ratio ($p<0.01$). Such differences in adiposity patterns have been reported among Dutch (Weststrate et al. 1989), Indian (Gerver et al. 2000), Chinese (Wang et al. 2007), Santhal (Chowdhury et al. 2007), Nepalese (Ghosh et al. 2009) and Bengalee Muslim (Sen and Mondal 2013), Indian (Debnath et al. 2013) children.

Age sex-specific FM values as observed in the present study were lower than those obtained from Bahraini (Musaiger and Gregory 2000), Turkish (Gültekin et al. 2005), Nepalese (Ghosh et al. 2009), ICDS children (Biswas and Bose 2011) and Bengalee Muslim (Sen and Mondal 2013), Bengalee pre-school children (Giri et al. 2017) children. The age and sex specific mean FFM values were lower than those reported for Bahraini (Musaiger and Gregory 2000), Turkish (Gültekin et al. 2005), Santhal children (Chowdhury et al. 2006), Nepalese (Ghosh et al. 2009), Bengalee Muslim children (Sen and Mondal 2013), Indian children (Debnath et al. 2018). The age and sex specific mean FFM values were higher than those reported for Bengalee pre-school children (Giri et al. 2017), ICDS children (Biswas and Bose 2011) and Santhal (Chowdhury et al. 2007) children. The age-specific mean values of FMI among the children were higher than the values for Nepalese (Ghosh et al. 2009), Bengalee Muslim children (Sen and Mondal 2013) and Indian children (Debnath et al. 2018). The age-specific mean values of FMI among the children were lower than the values for Bengalee pre-school children (Giri et al. 2017) and ICDS children (Biswas and Bose 2011). The age-specific mean values of FFMI among the children were higher than the values for Bengalee pre-school children (Giri et al. 2017), ICDS children (Biswas and Bose 2011), Bengalee Muslim children (Sen and Mondal 2013), Indian children (Debnath et al. 2018) and almost equal with the Nepalese (Ghosh et al. 2009) children.

Several studies have already validated different skinfold equations with alternate methods of estimation and recommended the use of the equations of Slaughter et al. (1988) for the evaluation of body fat among pre-pubertal children (Goran et al. 1996; Boot et al. 1997; Laurson et al. 2011; Sen and Mondal 2013; Almeida et al. 2016; González-Agüero et al. 2017). 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; Sharma and Mondal 2018). The results indicated pronounced sexual differences in adiposity and body composition measures (e.g., PBF, FM, FM, FMI and FFMI) between boys and girls ($p<0.01$). Similar trends of body composition and adiposity indicators were reported among Indian (Gerver et al. 2000; Sen and Mondal 2013) and rural Chinese (Wang et al. 2007) children. The differences in adiposity measures (PBF, FM and FFM) were also observed to be more prominent with the advancement of age (Table 1). The sex-specific mean values were greater in girls than boys but were distinctly higher in older age groups (e.g. 9–12 years) ($p<0.05$).

Due to the limitation of expressing body composition data as kilograms (e.g. kg of FM and FFM) and as percentages (e.g. PBF), the FMI (kg of FM/ height^2) and FFMI (kg of FFM/ height^2) appear to be better indicators of body composition (Freedman et al. 2005; Wells 2010; Debnath et al. 2018). The FMI estimates fat mass related to height and the FFMI estimates muscle mass related to height. Such variation in the body compositions might be due to genetic adaptations to ancestral environments and exposure to more contemporary, as it has been reported that variations in FM, FFM, FMI and FFMI between populations can be attributed to their ethnic elements (Musaiger and Gregory 2000; Wells 2010; Sen and Mondal 2013;

Debnath et al. 2018). The present study indicated sexual dimorphism in terms of FM, FMI and PBF. Higher amount of body fat has been observed among the girls counter parts of the sample. Several studies have observed a similar trend in fat accumulation (Reddy and Rao 1995; Mesa et al. 1996; Ghosh et al. 2009; Sen and Mondal 2013; Debnath et al. 2018). In the present study values of FFM have been observed to higher among boys than girls as observed in other studies (Ghosh et al. 2009; Sen and Mondal 2013; Debnath et al. 2018).

The occurrence of sexual dimorphism in fat patterning and body composition is primarily attributed to the effect of sex steroid hormones (He et al. 2004; Wells 2007, 2010; Sen and Mondal 2013; Debnath et al. 2017, 2018a,b). Presence of estrogen increases fat deposition and in contrary presence of testosterone increases fat metabolism, therefore, among females fat storage increases whereas among males fat storage decreases. The accumulation of body fat is important in determining the time of onset of puberty among children. Several studies have proved that gonadotropins and sex steroid hormones gradually increase among pre-pubertal children, which implies that their effects may be more prominent among older group of children than among younger pre-pubertal children (Mitamura et al. 1999, 2000; He et al. 2004; Wells et al. 2007; Debnath et al. 2017, 2018a,b). Such differences can be attributed to the tempo of adipose tissue accumulation which is likely to be greater in girls than boys, and to the onset of pubertal maturation (Wells 2007, 2010). The onset of puberty among children appears to be regulated by a number of complementary mechanisms which include intrauterine conditions, genotype, sex-specific mechanisms, nutritional status and also demographic and environmental conditions (He et al. 2002; Parent et al. 2003; Wells 2007).

Upper arm composition includes the indices of upper arm muscle area (UMA), total upper arm area (TUA), upper arm fat area (UFA), arm fat index (AFI), upper arm fat area estimate (UFE) and upper arm muscle area estimate (UME) for the assessment of body composition of children and adults. Several studies during the last few decades have established the usefulness of upper arm composition in the assessment of body composition of children and adults (e.g. Bolzan et al. 1999; Chowdhury and Ghosh 2009; Sen et al. 2011; Senbanjo et al. 2014; Singh and Mondal 2014; Sen et al. 2015; Debnath et al. 2017), although not adopted for routine assessment of body composition and nutritional status. Several studies have been conducted among children using UMA and UFA as reliable indicator of body composition and nutritional status (e.g., Erfan et al. 2003; Chowdhury and Ghosh 2009; Çiçek et al. 2009; Basu et al. 2010; Sen et al. 2011, 2015; Sikdar 2012; Singh and Mondal 2014; Debnath et al. 2017).

In present study it has been observed that muscularity related to UMA and UME was higher among boys in most of age groups than girls ($p<0.01$). Several studies have reported similar trends Indian (Chowdhury and Ghosh 2009; Basu et al. 2010; Sen et al. 2011; Sen and Mondal 2013; Singh and Mondal 2014; Debnath et al. 2017), Argentinean (Bolzan et al. 1999), South Korean (Kim et al. 1999), Kenyan (Semproli and Gualdi-Russo 2007), Zimbabwean (Olivieri et al. 2008), Turkish (Ozturk et al. 2009) and Nigerian (Senbanjo et al. 2014) children. Sex differences in body composition existed prior to puberty among boys and girls have been reported by several studies and the same trend has been observed in the present study (in UFA, AFI and UFE). Studies that have reported sex specific differences in adiposity measures (i.e., UFA and AFI) and body fat percentages among children are by He et al. (2002), Basu et al. (2010), Sen et al. (2011), Singh and Mondal (2014), Debnath et al. (2017) and Debnath et al. 2018(a,b).

4.3. PREVALENCE OF UNDERNUTRITION AMONG THE BENGALI MUSLIM CHILDREN

The prevalence of undernutrition continues to be major public health issue and principal cause of ill-health, premature mortality and morbidity by increasing the disease burden in the developing countries like India (Pelletier 1998; Nandy et al. 2005; Uthman and Aremu 2008; Akhtar 2015; Debnath et al. 2018c). Reduced cognitive performance, low productivity and non-attainment of physical and psychological growth are observed to be associated with prevalence of undernutrition among children (WHO 1995; Pelletier 1998; Bogale et al. 2013; Sandjaja et al. 2013; Akhtar 2015).

The prevalence of undernutrition was estimated to be cause of death of 45.0 percent of all deaths among children <5 years (Black et al. 2013) and India is accounted for 38.0 percent of the global burden of stunting (low height-for-age) (nearly 62 million children) (UNICEF 2013). Approximately two-thirds of the world's malnourished (undernourished and overnourished) children live in Asia which gives this region the highest concentration of worldwide childhood undernutrition (Ramachandran 2014; UNICEF/WHO 2016; Debnath et al. 2018c). India has unacceptably high rates of undernutrition (Ramachandran 2014) and has the highest prevalence of childhood undernutrition in the world with more than half of Indian children remaining undernourished. The prevalence of childhood undernutrition remains persistently high in India (Khor 2008; Ramachandran 2014; Corsi et al. 2015; Smith and Haddad 2015; Aguayo et al. 2016; Ali et al. 2016; Dhok and Thakre 2016; Saxton et al. 2016; Mandal 2017; Patil et al. 2017).

In India, the large population size, large social and economic disparities and widespread poverty are the main causes of the prevalence of undernutrition (Vella et al. 1992; Sachs and McArthur 2005; Ramachandran 2007; Antony and Laxmaiah 2008; Mondal and Sen 2010; Gopalan 2013; Varadharajan et al. 2013; Akhtar 2015). Moreover, it has been estimated that more than half of Indian children are undernourished which is the highest occurrence of childhood undernutrition in the world (Measham and Chatterjee 1999; Bamji 2003; Bhutia 2014).

The present study assessed prevalence of undernutrition among Bengali Muslim children (aged 1–5 years) of West Bengal, India. The assessment of undernutrition has been done by using low height-for-age (stunting), low BMI-for-age (thinness), low weight-for-height (wasting), low weight-for-age (underweight) and low head circumference-for-age (low HdC-for-age). In the present study the magnitude of stunting, underweight, thinness, wasting and low HdC-for-age was observed to be 44.61% (boys: 45.54%; girls: 43.55%), 40.03% (boys: 40.00%; girls: 40.07%), 26.31% (boys: 32.92%; boys: 18.82%), 26.96% (boys: 33.54%; girls: 19.51%) and 33.66% (boys: 45.23%; girls: 20.56%), respectively. The sex-specific undernutrition showed that the severity of undernourishment was observed to higher among boys than girls in stunting (45.54% vs. 43.55%) ($p>0.05$), underweight (40.00% vs. 40.07%) ($p>0.05$), thinness (32.92% vs. 18.82%) ($p<0.01$), wasting (3.54% vs. 19.51%) ($p<0.01$) and low HdC-for-age (45.23 vs. 20.56%)($p<0.01$) (Table 3.8). However, the age-sex specific prevalence of undernutrition was observed to be statistically not significant in most of the cases ($p>0.05$) (Table 3.11).

High prevalence of undernutrition has been reported from the children of West Bengal (stunting: 45.80%, underweight: 38.89% and wasting: 13.94%), Assam (stunting: 36.17%, underweight: 57.54% and wasting: 14.42%) (Som et al. 2006), Dibrugarh district of Assam (stunting: 30.40%, underweight: 29.00% and wasting: 21.60%) (Islam et al. 2014). Mandal et al., (2008) reported the prevalence of undernutrition was 48.79% (stunting), 58.83% (underweight) and 19.08% (wasting), and 50.82% (stunting), 62.52% (underweight) and 26.87% (wasting) among the boys and girls, respectively of Hooghly district, West Bengal. Moreover, several studies have reported the magnitude of undernutrition was observed to very high among children of North-east India (Som et al. 2006; Islam et al. 2014; Singh and Mondal 2014; Debnath and Bhattacharjee 2016; Sarkar and Sil 2016; Kramsapi et al. 2018). The proposed classification of WHO (1995, 2007) was used to assess the severity of the public health problem of undernutrition based on percentages of conventional nutritional indices. It was observed that high undernutritiion existed among the Bengali Muslim children (1-5 years) of Phansidewa block, Darjeeling, West Bengal. There is an urgent need of nutritional intervention programme is necessary to combat/ameliorate this serious public health problem of undernutrition. It was well established that in India, children from the economically low tribal groups were found to poorer in nutritional status as compared to the general caste children (Radhakrishna and Ravi 2004; Mondal and Sen 2010; Tigga et al. 2015a,b; Debnath et al. 2018).

The decreased availability of food and resources due to increase in population and low production may lead to lowered intake of food in individuals of a population. Lack of proper dietary knowledge also leads to wrong infant feeding practices which in turn cause undernutrition in the population. Moreover, several others factors like low socio-economic status which means lower purchasing power also causes the lack of desired nutrients importanet for the good nutritional and health condition. Poor nutritional status among children triggers the poor cognitive developments and abilities and decreases the productive efficiency of individuals. Illness in childhood, short birth interval, maternal age, weight and anemia has significant contribution to the child's nutritional status (Mittal et al. 2007; Kumar et al. 2010; Tigga et al. 2015a,b; Ansuya et al. 2018).). Poverty is a major cause of the undernutrition among the children in India (Svedberg, 2000; Nandy et al. 2005; Khor 2008; Varadharajan et al. 2013; Ramachandran 2014; Smith and Haddad 2015).

The prevalence of undernutrition leads to a critical nutritional situation for public health among Indian children (Bose et al. 2007; Mondal and Sen 2010; Singh and Mondal 2014; Sharma and Mondal 2014; Gaiha et al. 2012; Islam et al. 2014; Tigga et al. 2015a,b; Asim and Nawaz 2018; Huda et al. 2018; Debnath et al. 2018). In spite of various nutritonal intervention programmes and socio-economic development, the prevalence of undernutrition continues to be a persisting problem which causes widespread mortality and morbidity among Indian children (Nandy et al. 2005; Som et al. 2006; Bose et al. 2007; Bharatati et al. 2008; Black et al. 2013; Ramachandran 2014; Smith and Haddad 2015; Joshi et al. 2016). This prevalence of undernutrition can lead to a vicious cycle of undernourishment which can be inherited to the next generation in the population (WHO 1995; Smith and Haddad 2015).

Studies have observed that children suffering from high undernutrition during their early age are at a higher risk of infectious/communicable diseases, low levels of physical strength, lower working capacity and poor reproductive outcomes during adulthood (e.g., LBW) (WHO 1995; Nandy et al. 2005; Svedberg 2000; Black et al. 2013). Family planning methods have significant role to play in reducing childhood undernutrition (Rana and Goli 2018). Severe Acute Malnutrition in infants hampers the neural development status in the age group of 6 to 30 months (Dwivedi et al. 2018). Dietary diversity is an important factor to be considered as a significant predictor of stunting (Borkotoky et al. 2018; Ahmed et al. 2018). Maternal dietary pattern and nutritional condition are significantly associated with the birth of LBW babies and growth and nutritional condition of children (Tigga et al. 2015a,b; Rammohan et al. 2018). Availability of safe drinking water, adequate water supply and hygiene sanitation are very important factors for the eradication of the infectious disease among the children which can in turn eradicate undernutrition (Gera et al. 2018).

4.3.1. Prevalence of stunting (Low height-for-age)

Comparisons of prevalence of undernutrition among children in terms of stunting, thinness, underweight and wasting have been depicted in Table 4.1 and Table 4.2.

The prevalence of stunting obtained in the present study was observed to be distinctively lower than the prevalence observed in children in Ludhiana, Punjab (74.00%) (Sengupta et al. 2010), Saharia children of Rajasthan (67.80%) (Rao et al. 2006), Kamar children of Chattisgarh (67.40%) (Mitra et al. 2007b), tribal children of Melghat (66.40%) (Talapalliwar and Garg 2014), pre-school tribal children of Maharashtra (61.00%) (Meshram et al. 2011), tribal children of Thane (60.40%) (Khandare et al. 2008), tribal children of 17 tribal districts Bihar (60.00%) (Yadav and Singh 1999), children in urban slums of Pune

(58.70%) (Mamulwar et al. 2014) and tribal children of West Bengal (58.60%) (IIPS and Macro International 2008). The prevalence of stunting was also observed to be lower than the children infected with HIV in South India (58.00%) (Padmapriyadarsini et al. 2009), children residing in slum areas of Bhubaneswar (57.40%) (Panigrahi and Das 2014), Gond children of Chattisgarh (55.60%) (Mitra et al. 2007a), children of Kadukuruba tribes of Mysore district (55.40%) (Manjunath et al. 2014), Santal pre-school children (54.20%) (Bisai 2014), Oraon of North Bengal and tribal children of Bihar (54.00%) (Mittal and Srivastava 2006), and rural adolescents in West Bengal (54.00%) (Pal et al. 2016). Several other studies have observed higher prevalence of stunting among Indian children than in the present study, eg., among tribal children in India (53.90%) (IIPS and Macro International 2007), children of Rajasthan (53.00%) (Singh et al. 2006), children in National Capital Territory of Delhi (53.00%) (Saxena et al. 1997), tribal children of Madhya Pradesh (51.60%) (Rao et al. 2005), Gond children of Madhya Pradesh (51.60%) (Rao et al. 2005), children from urban Allahabad (51.60%) (Kumar et al. 2006), Kora-Mudi children (2-5 years) of Paschim Medinipur, West Bengal (51.10%) (Bisai and Mallick 2011), Kamar tribe of Chhattisgarh (50.00%) (Mitra et al. 2007b) and among the Kora-Mudi children (2-13 years) of Paschim Medinipur, West Bengal (49.60%) (Bisai and Mallick 2011) (Table 4.1).

The prevalence of stunting in present study (44.61%) was observed to be higher than the prevalence of stunting observed among Baiga children of Madhya Pradesh (44.30) (Chakma et al. 2009), children from Bareilly, UP (43.22%) (Singh et al. 2013), Kodaku children in Madhya Pradesh (43.00%) (Dolla et al. 2005), children belonging to tea-labourer community in West Bengal (41.70%) (Mondal and Sen 2010a), children in Maharashtra (40.46%) (Purohit et al. 2017), Bengalee rural pre-school children of ICDS (39.2%) (Biswas and Bose2010), Bengalee Muslim school children of North Bengal (38.5%) (Sen et al. 2011b), Rajbanshi children of North Bengal (35.80%) (Mondal and Sen 2010a), Lodha children of Paschim

Medinipur in West Bengal (35.10%) (Bisai et al. 2008), early adolescent school girls of Paschim Medinipur in West Bengal (34.20%) (Maiti et al. 2011) (Table 4.1).

The prevalence of stunting in present study (44.61%) was observed to be distinctively higher than the prevalence of stunting observed among Bengali Muslim children, W.B (33.70%) (Mondal and Sen 2010a), early adolescent school girls of West Bengal (32.50%) Maiti et al. (2011), rural school-going children of West Bengal (31.80%) (Debnath et al. 2018c), tribal children in riverine areas of Dibrugarh in Assam (30.40%) (Islam et al. 2014), Infants in rural areas of Madhya Pradesh (29.00%) (Meshram et al. 2015), children in a slum area of Kolkata (28.80%) (Mandal et al. 2014), rural pre-school children of Hoogly (26.60%) (Mandal and Bose 2009), ICDS children from West Bengal (26.60%) (Mandal et al. 2008), Santal children from Purulia district West Bengal (26.30%) (Das and Bose 2011a), ICDS children of Nadia District, West Bengal (23.90%) (Bose et al. 2007a), children in orphanages of Odisha (22.90%) (Routray et al. 2015), Santal children of Puruliya district, West Bengal (17.90%) (Chowdhury et al. 2008), rural school children of Onda, Bankura District, West Bengal (17.20%) (Bose et al. 2007b), school children in Army School, Pune (13.81%) (Mukherjee et al. 2008), tribal children, Bankura, West Bengal (12.80%) (Mukhopadhyay and Biswas 2011), school children in Uttar Pradesh (12.50%) (Srivastav et al. 2013), children of Karnataka (9.40%) (Joseph et al. 2002) and among rural school children in Bangalore (7.00%) (Rashmi et al. 2015) (Table 4.1).

In case of non-Indian studies several studies among children from Zambia (69.20%) (Gernaat et al. 1996), children in a rural district of Kelantan in Malaysia (69.00%) (Whye Lian et al. 2012), pre-school children of Terengganu in Malaysia (62.00%) (Wong et al. 2014), children from Central Africa Republic (61.50%) (Wanga et al. 2009), children in North-eastern of Peninsular Malaysia (61.40%) (Ali Naser et al. 2014), children in Ethiopia (58.10%) (Derso et al. 2017), children of Bangladesh (50·70%) (Semba et al. 2008), Indonesian school children

(55.00%) (Hadju et al. 1995), children from Laos (54.00%) (Phengxay et al. 2007), pre-school children of Swabi district, Pakistan (53.00%) (Khan Khattak and Ali 2010), children in Kenya (51.00%) (Adeladza 2009), children of Western Kenya (47.00%) (Bloss et al. 2004), children and adolescents in rural area of Bangladesh (46.60%) (Rahman and Karim 2014) have observed higher prevalence of stunting than it is observed in present study (44.61%). The prevalence of stunting in present study (44.61%) was observed to be higher than the prevalence of stunting observed among children from Vietnam (44.30%) (Hien and Kam 2008), children of Bangladesh (44.00%) (Rahman and Chowdhury 2007), pre-school children in Bangladesh (44.00%) (Rahman and Chowdhury 2006), rural children of Fogera and Libo Kemkem Districts in Ethiopia (42.70%) (Herrador et al. 2014), school-age children in Southern Ethiopia (41.90%) (Tariku et al. 2018), Tibetan children (41.40%) (Dang et al. 2004), pre-school children in Bangladesh (39.50%) (Jesmin et al. 2011), school children in Ethiopia (35.00%) (Mahmud et al. 2013), children of Indonesia (33.20%) (Semba et al. 2008), pre-school age children in Peru (32.10%) (Casapia et al. 2007) and among Kenyan children (30.20%) (Chesire et al. 2008).

The prevalence of stunting in present study (44.61%) was observed to be distinctively higher than the prevalence of stunting observed among children in Nicaragua (30.10%) (Sakisaka et al. 2005), children of Mugu district in Nepal (29.40%) (Thapa et al. 2013), urban children of Fogera and Libo Kemkem Districts in Ethiopia (29.20%) (Herrador et al. 2014), Malaysian children (29.20%) (Marjan et al. 1998), students in Northern Ethiopia (28.50%) (Melaku et al. 2015), rural school going children in Kavre District of Nepal (24.54%) (Mansur et al. 2015), children of Humla district of Nepal (22.40%) (Thapa et al. 2013), pre-school children in Egypt (20.30%) (Seedhom et al. 2014), children in Thailand (19.90%) (Firestone et al. 2011), primary school children in Sub-urban region in Tanzania (16.30%) (Teblick et al. 2017), Chinese children (14.59%) (Zhang et al. 2011), semi-urban Nigerian school children (14.20%) (Fetuga et al. 2011), Chinese children and adolescents (13.80%) (Yan-Ping et al.

2009), adolescent school girls in North Ethiopia (12.20%) (Gebregyorgis et al. 2016), pre-school children in Gaza strip (11.90%) (Kanoa et al. 2011), children in Iran (11.50%) (Mahyar et al. 2010), children from Turkey (10.90%) (Ergin et al. 2007), children from Oman (10.60%) (Alasfoor et al. 2007), children of Nairobi, Kenya (10.60%) (Muchina and Waithaka 2010), children in Brazil (9.90%) (de Souza et al. 2012), children in Iran (9.53%) (Kavosi et al. 2014), school children in Burkina Faso (8.80%) (Daboné et al. 2011), Pakistani primary school children (8.00%) (Mushtaq et al. 2011), Rural school-aged Sudanese children (7.10%) (Mohamed and Hussein 2015), children from Pakistan (6.00%) (Badruddin et al. 2008), Cameroon urban children and adolescents (5.70%) (Wamba et al. 2013), school children in an urban area of Sri Lanka (5.15%) (Wickramasinghe et al. 2004), children in Malaysia (3.90%) (Poh et al. 2012) and among school children from Iran (2.85%) (Rezaeian et al. 2014).

4.3.2. Prevalence of thinness (Low BMI-for-age)

The prevalence of thinness in present study (26.31%) was observed to be distinctively lower than the prevalence of thinness observed among rural children of ICDS scheme (85.21%), Hooghly, West Bengal (Mandal et al. 2009), rural Bengalee pre-school children of ICDS Scheme of Sagar Island, South 24 Parganas, West Bengal (81.25%) (Giri et al. 2017b), rural primary school in Paschim Medinipur, West Bengal (77.00%) (Das et al. 2012), Santal school children Hooghly District, West Bengal (75.95%) (Mandal and Bose 2014), rural primary school-going children residing in Darjeeling, West Bengal (69.40%) (Mondal and Sen 2010b), children of Purba Medinipur, West Bengal (67.74%) (Khanra et al. 2020), Kora-Mudi tribal children of Paschim Medinipur, West Bengal (67.20%) (Bisai et al. 2010), pre-school children of North Bengal, West Bengal (62.00%) (Tigga et al. 2015b), rural pre-school children in Karnataka (61.70%) (Nayak et al. 2015), early adolescent rural school girls of Paschim Medinipur, West Bengal (58.30%) (Maiti et al. 2011), rural children of Darjeeling district, West Bengal (57.36%) (Debnath et al. 2018d), Bhaina tribal girls in Chhattisgarh (57.10)

(Singh et al. 2014), Bengalee Muslim school children in Eastern India (56.70%) (Mondal et al. 2011), Santal Pre-school Children (56.17%) (Das and Bose 2011c), school age children of tea garden worker of Assam (53.90%) (Medhi et al. 2006), Hill Kharia tribal children (52.90) (Das and Bose 2011d), Shabar children in forest habitat, Orissa (52.42%) (Chakrabarty and Bharati 2010), children in Central India (51.10%) (Gupta et al. 2015), rural adolescents in West Bengal (49.00%) (Pal et al. 2016), rural primary school children in Hooghly, West Bengal (48.50%) (Pal and Bose 2020), children of Central Odisha (48.00%) (Mishra and Mishra 2007), Nepali speaking pre-school children of Darjeeling, West Bengal (45.22%) (Das and Datta Banik 2011), Santal tribal children and adolescents of Purulia district, West Bengal (41.30%) (Das and Bose 2011b), early adolescent school girls of Paschim Medinipur, West Bengal (40.94%) (Maiti et al. 2011), Bengalee children of Darjeeling district, West Bengal (40.19%) (Dorjee 2015), Sunni Muslim school girls Delhi (38.37%) (Bansal and Joshi 2013), school going children in Surathkal, Karnataka (37.50%) (Aroor et al. 2014) and among rural school children in Bangalore (34.00%) (Rashmi et al. 2015). The prevalence of thinness in present study (26.31%) was also observed to be lower than the prevalence of thinness observed among Ao Naga tribal children in Nagaland (30.12%) (Longkumar 2013), Santal children of Birbhum district, West Bengal (29.60%) (Ghosh and Sarkar 2013), among the children in a slum area of Kolkata, West Bengal (28.80%) (Mandal et al. 2014) and rural school-going children of West Bengal (27.70%) (Debnath et al. 2018c). The prevalence of thinness in present study (26.31%) was observed to be higher than the prevalence of thinness observed among the Sonowal Kachari tribal children in Assam (25.99%) (Singh and Mondal 2013), school children in Uttar Pradesh (23.20%) (Srivastav et al. 2013), rural school children of Onda, Bankura District, West Bengal (23.10%) (Bose et al. 2007b), children residing in slum areas of Bhubaneswar (22.9) (Panigrahi and Das 2014), urban adolescents of North 24 Parganas and Howrah, West Bengal (21.75%) (Ghosh and Bandyopadhyay 2009), early adolescent school girls of West Bengal

(20.20%) (Maiti et al. 2011), Mising tribal children of North-east India (18.19%) (Sikdar 2012b), school children in South India (12.20%) (Kumaravel et al. 2014), tribal Bodo children of Assam (11.50%) (Mondal et al. 2015) and among urban affluent school children in Gujrat (3.30%) (Chudasama et al. 2017).

In case of non-Indian studies several studies among Children and adolescents North-western Nigeria (60.60%) (Mijinyawa et al. 2014), school children in Nigeria (42.90%) (Akinpelu et al. 2014), children and adolescents in rural area of Bangladesh (42.40%) (Rahman and Karim 2014), children and adolescents in the Seychelles (35.60%) (Bovet et al. 2011), school children in Ethiopia (34.00%) (Mahmud et al. 2013), Garo tribal children in Bangladesh (30.88) (Rana et al. 2012), children in Tamale in Northern Ghana (29.80%) (Mogre et al. 2013) have observed higher prevalence of thinness than it is observed in present study (26.31%).

The prevalence of thinness in present study (26.31%) was observed to be higher than the prevalence of thinness observed among students in Northern Ethiopia (26.10%) (Melaku et al. 2015), adolescent girls in rural Bangladesh (26.00%) (Alam et al. 2010), pre-school children in Norway of South Asian origin (26.00%) (Toftemo et al. 2018), school children in an urban area of Sri Lanka 23.86%) (Wickramasinghe et al. 2004), rural school-aged Sudanese children (23.10%) (Mohamed and Hussein 2015), semi-urban Nigerian school children (22.20%) (Fetuga et al. 2011), Nigerian children and adolescents (21.61%) (Ejike et al. 2013), rural children in Fogera and Libo Kemkem Districts in Ethiopia (21.60%) (Herrador et al. 2014), adolescent school girls in North Ethiopia (21.40%) (Gebregyorgis et al. 2016), children of Humla district in Nepal (21.13%) (Thapa et al. 2013), urban children of Fogera and Libo Kemkem districts in Ethiopia (20.80%) (Herrador et al. 2014), children of Mugu district in Nepal (20.12%) (Thapa et al. 2013), children in China (16.04%) (Chen et al. 2016), school children in Burkina Faso (13.70%) (Daboné et al. 2011), children in Malaysia (13.10%) (Partap et al. 2017), urban school children and adolescents in southern Nigeria (13.00%) (Ene-Obong et al. 2012), children in Mauritius (12.70%) (Caleyachettyet al. 2012), children and adolescents in China (12.42%) (Zhang et al. 2015), Polish school-aged children and adolescents (11.70%) (Gurzkowska et al. 2017), primary school children in rural Sri Lanka (11.51%) (Naotunna et al. 2017), primary school children in Sub-urban region in Tanzania (11.30%) (Teblick et al. 2017), early adolescents in Malaysia (11.10%) (Woon et al. 2014), children in Italian school in Rome (10.9%) (Rosati et al. 2013), pre-school children of European origin in Norway (10.40%)

(Toftemo et al. 2018), rural school going children in Nepal (10.05%) (Mansur et al. 2015), Pakistani primary school children (10.00%) (Mushtaq et al. 2011).

The prevalence of thinness in present study (26.31%) was observed to be distinctively higher than the prevalence of thinness observed among Cameroon urban children and adolescents (9.50%) (Wamba et al. 2013), Malaysian children (5·40%) (Poh et al. 2013), school children and adolescents from Democratic Republic of Congo (8.93%) (Buhendwa et al. 2017), school-age children in Southern Ethiopia (8.00%) (Tariku et al. 2018), Greek children and adolescents (7.43%) (Tambalis et al. 2019), Chinese children and adolescents (7.40%) (Yan-Ping et al. 2009), children in Southwest China (6.30%) (Li et al. 2012), French children (6.00%) (Rolland-Cachera et al. 2002), children in Malaysia (5.80%) (Poh et al. 2012), children and adolescents in England (5.70%) (Whitaker et al. 2011), Portuguese children and adolescents (4.75%) (Marques-Vidal et al. 2008), pre-school children in Gaza strip (4.20%) (Kanoa et al. 2011), children and adolescents from Brazil (4.10%) (Guedes et al. 2013), Brazilian school children (3.20%) (de Assis et al. 2005) and among Portuguese children (1.00%) (Rito et al. 2012).

4.3.3. Prevalence of wasting (Low weight-for-height)

The prevalence of wasting in present study (26.96%) was observed to be distinctively lower than the prevalence of wasting observed among Kamar children in Chattisgarh (85.60%) (Mitra et al. 2007b), children in Uttar Pradesh (60.67%) (Singh et al. 2013), Gond children in

Korba in Chattisgarh (55.00%) (Mitra et al. 2007a), rural pre-school children of Hoogly in West Bengal (50.00%) (Mandal and Bose 2009), Kawar children in Chattisgarh (48.20%) (Mitra et al. 2007a), children of Kadukuruba tribes of Mysore district (43.00%) (Manjunath et al. 2014), children of urban slum in Punjab (42.00%) (Sengupta et al. 2010), Raj Gond children in Madhya Pradesh (41.50%) (Sharma et al. 2006), Baiga children in Madhya Pradesh (37.20%) (Chakma et al. 2009), Kodaku children in Madhya Pradesh (35.00%) (Dolla et al. 2005), Bharia children in Madhya Pradesh (33.90%) (Dolla et al. 2006), Infants in Rural Areas of Madhya Pradesh (33.00%) (Meshram et al. 2015), Gond children in Madhya Pradesh (32.90%) (Rao et al. 2005), slum children of Midnapore in West Bengal (32.70%) (Bisai et al. 2009), tribal children of Maharastra (30.20%) (Khandare et al. 2008), Santal children of Puruliya district in West Bengal (29.40%) (Chowdhury et al. 2008), pre-school tribal children of Maharashtra (29.00%) (Meshram et al. 2011), children in a slum area of Kolkata (28.80%) (Mandal et al. 2014), children of Rajasthan (28.00%) (Singh et al. 2006), Kora-Mudi children of Paschim Medinipur in West Bengal (27.70%) (Bisai and Mallick 2011), tribal children in India (27.60%) (IIPS and Macro International 2007).

The prevalence of wasting in present study (26.96%) was observed to be higher than the prevalence of wasting observed among Bengali Muslim children in West Bengal (26.60%) (Mondal and Sen 2010a), tribal children of 17 tribal districts Bihar (25.00%) (Yadav and Singh 1999), children of Tea-labourer community in W.B (23.50%) (Mondal and Sen 2010a), children Residing in Slum Areas of Bhubaneswar (23.30%) (Panigrahi and Das 2014), Kora-Mudi children of Paschim Medinipur in West Bengal (22.70%) (Bisai and Mallick 2011), National Capital Territory of Delhi (22.50%) (Saxena et al. 1997), tribal children in riverine areas of Dibrugarh in Assam (21.60%) (Islam et al. 2014), tribal children of Khammam in Andhra Pradesh (21.30%) (Laxmaiah et al. 2007), school age children of tea garden workers of Assam (21.20%) (Medhi et al. 2006), tribal children in West Bengal (20.70%) (IIPS and

Macro International 2008), Lodha children of Paschim Medinipur in West Bengal (20.30%) (Bisai et al. 2008), Santal pre-school children (20.10%) (Bisai 2014), tribal children of Melghat in central India (18.80%) (Talapalliwar and Garg 2014), Bengalee Muslim school children of North Bengal (17.40%) (Sen et al. 2011b), children in urban slums of Pune (16.90%) (Mamulwar et al. 2014), children Infected with HIV in South India (16.00%) (Padmapriyadarsini et al. 2009), children in Maharashtra (16.00%) (Purohit et al. 2017), children of Assam (14.42%) (Som et al. 2006), children of West Bengal (13.94%) (Som et al. 2006), Rajbanshi children of North Bengal, West Bengal (13.60%) (Mondal and Sen 2010a), Saharia children in Rajasthan (13.40%) (Rao et al. 2006), children of Punjab (13.00%) (Gupta 2014), Santal Children Purulia District, West Bengal (12.70%) (Das and Bose 2011a), Shabar children in forest habitat in Orissa (12.10%) (Chakrabarty and Bharati 2010), children from urban Allahabad (10.60%) (Kumar et al. 2006), children in Orphanages of Odisha (9.80%) (Routray et al. 2015), ICDS children of Nadia District, W.B (9.40%) (Bose et al. 2007a), school children in Army School in Pune (6.71%) (Mukherjee et al. 2008) and the tribal children of Bankura in West Bengal (3.20) (Mukhopadhyay and Biswas 2011).

Studies non-Indian several studies among children of Western Kenya (70.00%) (Bloss et al. 2004), children from Pakistan (45.00%) (Badruddin et al. 2008), children in a rural district of Kelantan, Malaysia (40.00%) (Whye Lian et al. 2012), pre-school children in Terengganu, Malaysia (38.00%) (Wong et al. 2014), children in North-eastern of Peninsular Malaysia (30.60%) (Ali Naser et al. 2014) have observed higher prevalence of wasting than that in present study (26.96%).

The prevalence of wasting in present study (26.96%) was observed to be higher than the prevalence of wasting observed among pre-school children in Peru (26.60%) (Casapia et al. 2007), children from Burkina Faso (26.00%) (Beiersmann et al. 2013), children in Central Africa Republic (20.20%) (Wanga et al. 2009), children in Sri Lanka (17.10%) (Ubeysekara et al. 2015), children in Ethiopia (17.00%) (Derso et al. 2017), children in Nghean, Vietnam (11.90%) (Hien and Kam 2008), children in rural Cambodia (10.00%) (Reinbott et al. 2015), children of Mugu district, Nepal (9.40%) (Thapa et al. 2013), children of Humla district, Nepal (8.80%) (Thapa et al. 2013), children from Turkey (8.20%) (Ergin et al. 2007), children in Iran (8.19%) (Kavosi et al. 2014), children from Oman (7.00%) (Alasfoor et al. 2007), children from Laos (6.00%) (Phengxay et al. 2007), Cameroon urban children and adolescents (5.20%) (Wamba et al. 2013), children in Granada province, Nicaragua (5.00%) (Sakisaka et al. 2005), Kenyan children (4.50%) (Chesire et al. 2008), children from Zambia (4.40%) (Gernaat et al. 1996), children in Brazil (4.10%) (de Souza et al. 2012), school children from Iran (3.10) (Rezaeian et al. 2014), Chinese children (3.07) (Zhang et al. 2011), children of Nairobi in Kenya (2.10%) (Muchina and Waithaka 2010), children in Iran (0.70%) (Mahyar et al. 2010).

4.3.4. Prevalence of underweight (Low weight-for-age)

The prevalence of underweight in present study (40.03%) was observed to be distinctively lower than the prevalence of underweight observed among Kamar children in Chattisgarh (93.90%) (Mitra et al. 2007b), Gond tribal children of Kalahandi district of Orissa (89.30%) (Balgir et al. 2002), Saharia children, Baran, Rajasthan (72.10%) (Rao et al. 2006), tribal children of Maharastra (68.70%) (Khandare et al. 2008), tribal children of Khammam, Andhra Pradesh (65.40%) (Laxmaiah et al. 2007), Santal pre-school children (65.20%) (Bisai 2014), pre-school tribal children of Maharashtra (64.00%) (Meshram et al. 2011), slum children in Midnapore, West Bengal (63.70%) (Bisai et al. 2009), rural pre-school children of Arambag, Hoogly, West Bengal (63.30%) (Mandal and Bose 2009), children Infected with HIV in South India (63.00%) (Padmapriyadarsini et al. 2009), Kora-Mudi children of Paschim Medinipur, West Bengal (61.70%) (Bisai and Mallick 2011), Gond children in Madhya Pradesh (61.60%) (Rao et al. 2005), Baiga children in Madhya Pradesh (61.00%) (Chakma et al. 2009), tribal children of Melghat in central India (60.90%) (Talapalliwar and Garg 2014), children of

Kadukuruba tribes of Mysore district (60.40%) (Manjunath et al. 2014), Gond children in Korba, Chattisgarh (60.00%) (Mitra et al. 2007a), children of Rajasthan (60.00%) (Singh et al. 2006), Kodaku children in Madhya Pradesh (59.80%) (Dolla et al. 2005), tribal children, West Bengal (59.70%) (IIPS and Macro International 2008), National Capital Territory of Delhi (57.60%) (Saxena et al. 1997), tribal children of 17 tribal districts Bihar (55.00%) (Yadav and Singh 1999), tribal children, India (54.50%) (IIPS and Macro International 2007) children in Uttar Pradesh (53.86%) (Singh et al. 2013), Kora-Mudi children of Paschim Medinipur in West Bengal (52.90%) (Bisai and Mallick 2011), Bharia children in Madhya Pradesh (52.50%) (Dolla et al. 2006), school age children of tea garden workers of Assam (51.70%) (Medhi et al. 2006), children of Tea-labourer community in West Bengal (50.80%) (Mondal and Sen 2010a), Kawar children in Chattisgarh (48.20%) (Mitra et al. 2007a) and Lodha children, Paschim Medinipur, West Bengal (47.30%) (Bisai et al. 2008).

The prevalence of underweight in present study (40.03%) was observed to be slightly lower than the prevalence of underweight observed among Bengalee Muslim school children of North Bengal (47.00%) (Sen et al. 2011b), children residing in slum areas of Bhubaneswar (45.40%) (Panigrahi and Das 2014), Bengali Muslim children, West Bengal (43.80%) (Mondal and Sen 2010a), slum children of Bankura in West Bengal (41.60%) (Shit et al. 2012) and infants in rural areas of Madhya Pradesh (41.00%) (Meshram et al. 2015).

The prevalence of underweight in present study (40.03%) was observed to be higher than the prevalence of underweight observed among Santal Children Purulia District, West Bengal (38.20%) (Das and Bose 2011a), children in Maharashtra (38.15%) (Purohit et al. 2017), Raj Gond children in Madhya Pradesh (37.40%) (Sharma et al. 2006), Rajbanshi children of North Bengal, West Bengal (37.40%) (Mondal and Sen 2010a), children from urban Allahabad (36.40%) (Kumar et al. 2006), children in urban slums of Pune (34.30%) (Mamulwar et al. 2014), Shabar children in forest habitat in Orissa (33.87%) (Chakrabarty and

Bharati 2010), Santal children of Puruliya district, West Bengal (33.70%) (Chowdhury et al. 2008), children of Karnataka (31.20%) (Joseph et al. 2002), Santal children of Birbhum district, W.B (31.10%) (Ghosh and Sarkar 2013), ICDS children of Nadia District, West Bengal (31.00%) (Bose et al. 2007a), children in a slum area of Kolkata, West Bengal (30.50%) (Mandal et al. 2014), children of urban slum in Punjab (29.50%) (Sengupta et al. 2010), tribal children in riverine areas of Dibrugarh in Assam (29.00%) (Islam et al. 2014), early adolescent school girls of West Bengal (27.90%) (Maiti et al. 2011), children in orphanages of Odisha (21.30%) (Routray et al. 2015), rural school children of Bankura in West Bengal (16.90%) (Bose et al. 2007b), school children in army school in Pune (9.87%) (Mukherjee et al. 2008) and among tribal children of Bankura in West Bengal (7.40%) (Mukhopadhyay and Biswas 2011).

In case of non-Indian studies several studies e.g., among pre-school age children in Belen in Peru (28.60%) (Casapia et al. 2007), pre-school children in Terenggan in Malaysia (71.00%) (Wong et al. 2014), children in a rural district of Kelantan in Malaysia (63.40%) (Whye Lian et al. 2012), children in North-eastern of Peninsular in Malaysia (61.00%) (Ali Naser et al. 2014) and pre-school children of Swabi district in Pakistan (49.00%) (Khan Khattak and Ali 2010) have observed higher prevalence of underweight than that in present study (40.03%).

The prevalence of underweight in present study (40.03%) was observed to be higher than the prevalence of underweight observed among children from Laos (35.00%) (Phengxay et al. 2007), children Vietnam (31.80%) (Hien and Kam 2008), rural school going children in Nepal (30.85%) (Mansur et al. 2015), children from Zambia (30.00%) (Gernaat et al. 1996), children of Western Kenya (30.00%) (Bloss et al. 2004), Pakistani children (29.50%) (Mian et al. 2002), children in Thailand (27.80%) (Firestone et al. 2011), Malaysian children (26.10%) (Marjan et al. 1998), semi-urban Nigerian school children (25.50%) (Fetuga et al. 2011), Tibetan children (24.70%) (Dang et al. 2004), children from Pakistan (22.00%) (Badruddin et al. 2008), children from Oman (17.90%) (Alasfoor et al. 2007), Kenyan children (14.90%) (Chesire et al. 2008), children in Qazvin, Iran (11.70%) (Mahyar et al. 2010), children in Granada province, Nicaragua (10.30%) (Sakisaka et al. 2005), children in Iran (9.66%) (Kavosi et al. 2014), school children from Iran (9.48%) (Rezaeian et al. 2014), Chinese children (7.19%) (Zhang et al. 2011), school children in an urban area of Sri Lanka (6.90%) (Wickramasinghe et al. 2004), children of Nairobi, Kenya (6.20%) (Muchina and Waithaka 2010), children from Turkey (4.80%) (Ergin et al. 2007) and Cameroon urban children and adolescents (2.20%) (Wambaetal. 2013).

Table 4.1: Comparison of prevalence of undernutrition among the Bengali Muslim children with the other Indian studies

Population	Age group (Years)	Prevalence (%)				Reference
		Stunting	Thinness	Wasting	Underweight	
National Capital Territory of Delhi	Under 6	53	-	22.50	57.60	Saxena et al. 1997
Tribal children of 17 tribal districts Bihar	0-6	60.0	-	25.00	55.00	Yadav and Singh 1999
Gond tribal children of Kalahandi district of Orissa	6-14	-	-	-	89.30	Balgir et al. 2002
children of Karnataka	1-5	9.40	-	-	31.20	Joseph et al. 2002
Kodaku children, Sarguja, Madhya Pradesh	1-5	43.00	-	35.00	59.80	Dolla et al. 2005
Gond children, Jabalpur, Madhya Pradesh	0-5	51.6	-	32.90	61.60	Rao et al. 2005
Bharia children, Chhindwara, Madhya Pradesh	1-5	48.1	-	33.90	52.50	Dolla et al. 2006
Children from urban Allahabad	Under 5	51.6	-	10.60	36.40	Kumar et al. 2006
School age children of tea garden worker of Assam	6-8	47.4	-	21.20	51.70	Medhi et al. 2006
School age children of tea garden worker of Assam	9-14	-	53.9	-	-	Medhi et al. 2006
Oraon of North Bengal and tribal children of Bihar	6-12	54.00	-	-	-	Mittal and Srivastava 2006
Raj Gond children, Balaghat, Madhya Pradesh	1-5	46.3	-	41.50	37.40	Sharma et al. 2006

Saharia children, Baran, Rajasthan	1-5	67.8	-	13.40	72.10	Rao et al. 2006
Children of W.B	0-5	45.80	-	13.94	-	Som et al. 2006
Children of Assam	0-5	-	-	14.42	-	Som et al. 2006
Children of Rajasthan	0–5	53.00	-	28.00	60.00	Singh et al. 2006
ICDS children of Nadia District, W.B	3-5	23.90	-	9.40	31.00	Bose et al. 2007a
Tribal children, India	Under 5	53.9	-	27.60	54.50	IIPS and Macro International 2007
Tribal children of Khammam, Andhra Pradesh	1-5	46.4	-	21.30	65.40	Laxmaiah et al. 2007
the Kamar tribe of Chhattisgarh	4-12	50.00	-	-	-	Mitra et al. 2007b
Santal children of Puruliya district, W.B	5-12	17.90	-	29.40	33.70	Chowdhury et al. 2008
Tribal children, W.B	Under 5	58.6	-	20.70	59.70	IIPS and Macro International 2008
Tribal children of Thane, Maharastra	0-6	60.4	-	30.20	68.70	Khandare et al. 2008
ICDS children from W.B	2-6	26.60	-	-	-	Mandal et al. 2008
Slum children in Midnapore, W.B	3-6	47.8	-	32.70	63.70	Bisai et al. 2009
Baiga children, Dindori, Madhya Pradesh	1-5	44.30	-	37.20	61.00	Chakma et al. 2009

Urban adolescents of North 24 Parganas and Howrah, W.B	-	-	21.75	-	-	Ghosh and Bandyopadhyay 2009
Rural children of ICDS scheme, Hooghly, W.B	2-6	-	85.21	-	-	Mandal et al. 2009
Rural pre-school children of Arambag, Hoogly, W.B	2-6	26.60	-	50.00	63.30	Mandal and Bose 2009
Children Infected with HIV in South India	0-15	58	-	16.00	63.00	Padmapriyadarsini et al. 2009
Kora-Mudi tribal children of Paschim Medinipur, W.B	2-13	-	67.2	-	-	Bisai et al. 2010
Bengalee rural pre-school children of ICDS	1–5	39.20	-	-	-	Biswas and Bose2010
Shabar children in forest habitat, Orissa	5-19	45.16	52.42	12.10	33.87	Chakrabarty and Bharati 2010
Children of Tea-labourer community, W.B	5–12	41.70	-	23.50	50.80	Mondal and Sen 2010a
Bengali Muslim children, W.B	5–12	33.70	-	26.60	43.80	Mondal and Sen 2010a
Rajbanshi children of North Bengal, W.B	5–12	35.80	-	13.60	37.40	Mondal and Sen 2010a
Rural primary school-going children residing in Darjeeling, W.B	5–12	-	69.40	-	-	Mondal and Sen 2010b
Children of urban slum in Ludhiana, Punjab	0-5	74	-	42.00	29.50	Sengupta et al. 2010

Kora-Mudi children of Paschim Medinipur, W.B	2-5	51.1	-	27.70	61.70	Bisai and Mallick 2011
Kora-Mudi children, Paschim Medinipur, W.B	2-13	49.6	-	22.70	52.90	Bisai and Mallick 2011
Santal Children Purulia District, W.B	2-6	26.30	-	12.70	38.20	Das and Bose 2011a
Santal tribal children and adolescents of Purulia district, W.B	7-18	-	41.3	-	-	Das and Bose 2011b
Santal Preschool Children	2–6	-	56.17	-	-	Das and Bose 2011c
Hill Kharia tribal children	4-18	-	52.9	-	-	Das and Bose 2011d
Nepali speaking pre-school children of Darjeeling, W.B	2-6	-	45.22	-	-	Das and Datta Banik 2011
Early adolescent school girls of W.B	10-14	32.50	20.2	-	27.90	Maiti et al. 2011
Early adolescent rural school girls of Paschim Medinipur, W.B	10–14	-	58.30	-	-	Maiti et al. 2011
Early adolescent school girls of Paschim Medinipur, W.B	10-14	34.20	40.94	-	-	Maiti et al. 2011
Pre-school tribal children of Maharashtra, India	1-5	61	-	29.00	64.00	Meshram et al. 2011
Bengalee Muslim school children in Eastern India	6-16	-	56.70	-	-	Mondal et al. 2011
Tribal children, Bankura, W.B	0.5-5	12.80	-	3.20	7.40	Mukhopadhyay and Biswas 2011

Rural primary school in Paschim Medinipur, W.B	6-12	-	77.0	-	-	Das et al. 2012
Slum children in Bankura, West Bengal	Under 5		-		41.60	Shit et al. 2012
Mising tribal children of North-east India	6-10	-	18.19	-	-	Sikdar 2012b
Sunni Muslim school girls Delhi	6-12	-	38.37	-	-	Bansal and Joshi 2013
Ao Naga tribal children, Nagaland	8-15	-	30.12	-	-	Longkumar 2013
Santal children of Birbhum district, W.B	2-16	47.8	29.6	-	31.10	Ghosh and Sarkar 2013
Sonowal Kachari tribal children in Assam	6-18	-	25.99	-	-	Singh and Mondal 2013
Children in Bareilly, UP	0-5	43.22	-	60.67	53.86	Singh et al. 2013
School children in UP	10-19	12.50	23.20	-	-	Srivastav et al. 2013
School going children in Surathkal, Karnataka	4-16	-	37.5	-	-	Aroor et al. 2014
Santal pre-school children	0-5	54.2	-	20.10	65.20	Bisai 2014
Children of Punjab	0-5	-	-	13.00	-	Gupta 2014
Tribal children in riverine areas of Dibrugarh, Assam	Under 5	30.40	-	21.60	29.00	Islam et al. 2014
School children in South India	5-18	-	12.2	-	-	Kumaravel et al. 2014
Santal school children Hooghly District, W.B	6-10	-	75.95	-	-	Mandal and Bose 2014
Children Residing in Slum Areas of Bhubaneswar	3–9	57.4	22.9	23.30	45.40	Panigrahi and Das 2014

Bhaina tribal girls in Chhattisgarh	6-12	-	57.1	-	-	Singh et al. 2014
Tribal children of Melghat in central India	0–6	66.4	-	18.80	60.90	Talapalliwar and Garg 2014
Children in Central India	6-15	-	51.1	-	-	Gupta et al. 2015
Infants in Rural Areas of Madhya Pradesh	Under 1	29.00	-	33.00	41.00	Meshram et al. 2015
Tribal Bodo children of Assam	5-11	-	11.50	-	-	Mondal et al. 2015
Rural pre-school children in Karnataka	2-5	-	61.7	-	-	Nayak et al. 2015
Rural school children in Bangalore	5-14	7.00	34.00	-	-	Rashmi et al. 2015
Children in Orphanages of Odisha	Under 6	22.90	-	9.80	21.30	Routray et al. 2015
Pre-school children of North Bengal, W.B	2-5	-	62.00	-	-	Tigga et al. 2015b
Rural adolescents in W.B	10-17	54	49	-	-	Pal et al. 2016
Bhaina tribal children in Bilaspur, Chattisgarh	7-12	-	53.8	-	-	Das et al. 2016
Urban affluent school children in Gujrat	8-18	-	3.3	-	-	Chudasama et al. 2017
Rural Bengalee pre-school children of ICDS Scheme of Sagar Island, South 24 Parganas, W.B	3-5.5	-	81.25	-	-	Giri et al. 2017b
Children in Maharashtra	Under 5	40.46	-	16.00	38.15	Purohit et al. 2017
Rural school-going children of W.B	5-12	31.80	27.7	-	-	Debnath et al. 2018c

Rural primary school children in Hooghly, W.B	6-10	-	48.5	-	-	Pal and Bose 2020
Children of Purba Medinipur, W.B	-	-	67.74	-	-	Khanra et al. 2020
Bengali Muslim children	1-5	44.61	26.31	26.96	40.03	Present Study

Table 4.2: Comparison of prevalence of undernutrition among the Bengali Muslim children with non-Indian studies

Population	Age group (Years)	Prevalence (%)				Reference
		Stunting	Thinness	Wasting	Underweight	
Indonesian school children	5-12	55.00	-	-	-	Hadju et al. 1995
Children from Zambia	Under 5	69.2	-	4.40	30.00	Gernaat et al. 1996
Malaysian children	Under 9	29.20	-	-	26.10	Marjan et al. 1998
Pakistani children	5-10	-	-	-	29.50	Mian et al. 2002
French children	7 – 9	-	6.0	-	-	Rolland-Cachera et al. 2002
Children of Western Kenya	Under 5	47	-	70.00	30.00	Bloss et al. 2004
Tibetan children	Under 3	41.40	-	-	24.70	Dang et al. 2004
School children in an urban area of Sri Lanka	8-12	5.15	23.86	-	6.90	Wickramasinghe et al. 2004
Brazilian school children	7–10	-	3.2	-	-	de Assis et al. 2005
Children in Granada province, Nicaragua	0–2	30.1	-	5.0	10.3	Sakisaka et al. 2005
Pre-school children in Bangladesh	Under 5	44	-	-	-	Rahman and Chowdhury 2006

Children from Oman	0-5	10.6	-	7.00	17.90	Alasfoor et al. 2007
Pre-school age children in Belen, Peru	Under 5	32·1	-	26.60	28·60	Casapia et al. 2007
Children from Turkey	Under 5	10.9	-	8.20	4.80	Ergin et al. 2007
Children from Laos	Under 5	54	-	6.00	35.00	Phengxay et al. 2007
Children of Bangladesh	Under 5	44.00	-	-	-	Rahman and Chowdhury 2007
Children from Pakistan	5-12	6	-	45.00	22.00	Badruddin et al. 2008
Kenyan children	6-12	30.20	-	4.50	14.90	Chesire et al. 2008
Children in Nghean, Vietnam	Under 5	44.3	-	11.9	31.8	Hien and Kam 2008
Children of Bangladesh	0–1	50·7	-	-	-	Semba et al. 2008
Children of Indonesia	0–1	33·2	-	-	-	Semba et al. 2008
Children in Kenya	1-2	51	-	-	-	Adeladza 2009
Children in Central Africa Republic	0.5–2	61.5	-	20.2		Wanga et al. 2009
Chinese children and adolescents	5-19	13.80	7.40	-	-	Yan-Ping et al. 2009
Adolescent girls in rural Bangladesh	13-18	-	26	-	-	Alam et al. 2010

Pre-school children of Swabi district, Pakistan	2-5	53	-	-	49	Khan Khattak and Ali 2010
Children in Qazvin, Iran	Under 2	11.5	-	0.70	11.70	Mahyar et al. 2010
Children of Nairobi, Kenya	0-2	10.60	-	2.10	6.20	Muchina and Waithaka 2010
Children and adolescents in the Seychelles	5-16	-	35.6	-	-	Bovet et al. 2011
Semi-urban Nigerian school children	6-10	14.2	22.2	-	25.5	Fetuga et al. 2011
Chinese children	Under 5	14.59	-	3.07	7.19	Zhang et al. 2011
Pre-school children in Gaza strip	5-6	11.9	4.2	-	-	Kanoa et al. 2011
Children and adolescents in England	2-5		5.7	-	-	Whitaker et al. 2011
Children in Mauritius	9–10	-	12.7	-	-	Caleyachettyet al. 2012
Children in Brazil	Under 5	9.9	-	4.10		de Souza et al. 2012
Urban school children and adolescents in southern Nigeria	5-18	-	13.0	-	-	Ene-Obong et al. 2012
Children of Chengdu, Southwest China	9–15	-	6.3	-	-	Li et al. 2012
Children in Klang valley, Malaysia	5-6	3.9	5.8	-	-	Poh et al. 2012
Garo tribal children in Bangladesh	5-10	-	30.88			Rana et al. 2012
Portuguese children	6–8	-	1.0	-	-	Rito et al. 2012

Children from Burkina Faso	0.5–2.5		-	26		Beiersmann et al. 2013
Nigerian children and adolescents	7-17	-	21.61	-	-	Ejike et al. 2013
Children and adolescents from Brazil	7-17		4.1	-	-	Guedes et al. 2013
Children in Tamale, Northern Ghana	5-14	-	29.8	-	-	Mogre et al. 2013
Malaysian children	0.5-12	-	5·4	-	-	Poh et al. 2013
Children in Italian school in Rome	6-19	-	10.9	-	-	Rosati et al. 2013
Children of Mugu district, Nepal	0-5	-	20.12	9.4	-	Thapa et al. 2013
Children of Humla district, Nepal	0-5	-	21.13	8.8	-	Thapa et al. 2013
Cameroon urban children and adolescents	8-15	5.7	9.5	5.2	2.2	Wamba et al. 2013
Children in Iran	0–6	9.53	-	8.19	9.66	Kavosi et al. 2014
Pre-school children in Egypt	0.5-2	20.3	-	-	-	Seedhom et al. 2014
Rural school going children in Kavre District, Nepal	4-16	24.54	10.05	-	30.85	Mansur et al. 2015
Students in Northern Ethiopia	10–19	28.5	26.1	-	-	Melaku et al. 2015
Rural school-aged Sudanese children	6–14	7.1	23.1	-	-	Mohamed and Hussein 2015
Children and adolescents in Shandong, China	7–18	-	12.42	-	-	Zhang et al. 2015
Children in Shanghai, China	3–12	-	16.04	-	-	Chen et al. 2016

Adolescent school girls in North Ethiopia	10–19	12.2	21.4	-	-	Gebregyorgis et al. 2016
School children and adolescents from Democratic Republic of Congo	6-18	-	8.93	-	-	Buhendwa et al. 2017
Children in Ethiopia	0.5–2	58.1	-	17.0		Derso et al. 2017
Polish school-aged children and adolescents	7–18	-	11.7	-	-	Gurzkowska et al. 2017
Primary school children in rural Sri Lanka	5-10	-	11.51	-	-	Naotunna et al. 2017
Children in Johor State, Malaysia	6-18	-	13.1	-	-	Partap et al. 2017
Primary school Children in Sub-urban region in Tanzania	5-19	16.3	11.3	-	-	Teblick et al. 2017
School-age children in Southern Ethiopia	6-14	41.9	8.0	-	-	Tariku et al. 2018
Bengali Muslim children	1-5	44.61	26.31	26.96	40.03	Present Study

4.4. ASSESSMENT OF MATERNAL BODY COMPOSITION AMONG THE BENGALI MUSLIM MOTHERS

Human body is composed of water, protein, minerals and can be divided into two major components i.e., fat component and fat-free component (Kravitz and Heyward 1992). The total fat can be divided into essential fat and storage fat. Fat in muscles, bone marrows, in heart, lungs, liver, spleen, kidneys, intestines and tissues throughout the central nervous system is called the essential fat, on the other hand the fat which accumulates in adipose tissue is called the storage fat. The presence of essential fat is necessary for normal body functioning and it has been found to be higher among women than in men because it includes gender related characteristics which is also related to child-bearing (Kravitz and Heyward, 1992; Das et al. 2012; Mallick and Roy 2019). Overall physical health and health of specific organs are influenced by distribution in body. In terms of location body fat can be divided into two categories ie., subcutaneous fat (under the skin) and visceral fat (around the organs). Excess visceral fat around the vital organs can interfere with proper functioning of them. Fat around the middle body portion is associated with visceral fat and the presence of excess abdominal fat possesses serious health risk in individuals. Body size of adults and status of body composition have important functional implications mainly in developing countries e.g., the lean body mass is an important factor of physical work capacity which can impact productivity in physically demanding works (Haas et al. 1995; Martorell 1995).

Height of mothers can be used to identify the risk of having a difficult delivery, obstructed or prolonged labor because short stature is often related to small pelvic size among women (Howsen et al. 1996; Rush 2000; Sokal et al. 1991). Moreover, the risk of having babies with low birth weight is another problem observed among short statured women (NFHS-3 2007). The presence of short maternal stature and maternal body size and composition is also related to the birth size and survival of infants (Martorell et al. 1996; UNICEF 1998).

The present study have observed that the mean values of all the anthropometric and body composition e.g., height, weight, MUAC, WC, HC, BSF, TSF, SSF, SISF, PBF, FM, FFM, FMI, FFMI, TUA, UMA, UFA, AFI, UME, UFE, BMI, WHR, BAI and WHtR variables showed an increasing trend with age. Although several studies have observed a decreasing trend in body composition variables among adults (Strickland and Ulijaszek 1993; Chilima and Ismail 1998; Pieterse et al. 1998; Kuozmarski et al. 2000; Oguntona and Kuku 2000; Ghosh et al. 2001; Pirlich and Lochs 2001; Bose 2002; Bose and Das Chaudhuri 2003; Ghosh 2004; Santos et al. 2004; Bose et al. 2007b; Bisai et al. 2008; Sarkar and Mukhopadhyay 2008, Bisai et al. 2009; Das et al. 2012). However, some studies also have demonstrated positive age specific trend in anthropometric and body composition measures such as Reddy (1998) and Sadhukan et al. (2007). Several studies have been reported on Body composition and BMI among various populations which have indicated ethnic differences (Misra et al. 2011; Zaman et al. 2012). Such differences depeding on ethnicity may be attributed to genetic factors and many other environmental factors (e.g., obesogenic environment). Several recent studies have investigated the relationship of BMI and body composition. The BMI assesses the entire body mass and not FM or FFM body composition of an individual. Therefore, same BMI levels among individuals does not imply that body composition status (ie., FM, FFM, FMI, FFMI etc.) of those individuals will also be similar. There are several studies on available in India on FMI, FFMI (Bhat et al., 2005; Bose et al., 2008; Khongsdier, 2005; Rao et al., 2012; Bose et al., 2006; Verma et al., 2016) and MUAC (Bose et al., 2007; Bose et al., 2006; Bisai et al., 2009; Chakraborty et al., 2009; Das et al. 2012; Mallick and Roy 2019).

Studies on West Bengal have also been reported (Das and Bose, 2006; Bisai et al., 2008; Das and Bose, 2012; Das et al., 2013; Ghosh et al., 2001; Banik, 2007; Das et al. 2012; Kuiti and Bose, 2015; Mallick and Roy 2019). The present study observed statistically significant correlations between the anthropometric and body composition variables among the Bengali

Muslim mothers. Statistically significant effect of age and BMI on the anthropometric and body composition variables are also observed in the present study.

In ideal conditions the increase in body mass during adulthood and progressive decrease of body mass with old age at a rate of approximately 1 kg per decade has been observed in several researches. It has also been observed in the present study that the younger mothers have lower BMI values than the elder ones ie., mean BMI values have increased with age among the Bengali Muslim mothers. The BMI is a measure of overall adiposity, whereas WC, WHR and WHtR reliable proxy measures of abdominal fat (Bose and Mascie-Taylor 1998; Kopelman 2000).

Sexual dimorphism in age trends in anthropometric and body composition variables have been observed in many research works from India (Singal and Sidhu 1983; Singal et al. 1988; Ghosh et al. 2001; Bose and Chaudhuri 2003; Bisai et al. 2008; Das et al. 2012; Mallick and Roy 2019). The possible causes for this sex difference may be because of the factors like, levels of physical activity and sex hormones (Bowen et al. 2011; Edwards and Sackett 2016; Sood and Bharmoria 2016; Bisai et al. 2008; Das et al. 2012; Ghosh and Bose 2018; Samuel et a. 2015; Corella et al. 2019; Mallick and Roy 2019).

The four skinfold measurements (BSF, TSF, SSF and SISF) and WHR were observed to be statistically significantly correlated correlated with height and weight ($p<0.01$). Also, height and weight were positively correlated with WC and HC which is also statistically significant. Several Indian and non-Indian studies have been done on the assessment of body composition using these above mentioned indicator to assess the health condition of individuals and populations (Khatoon et al. 2008; Bose and Das Chaudhuri 2003; Singh et al. 2014).

Statistically significant effects of age and BMI on PBF and WHtR has been observed among the mothers ($p<0.01$). Statiscally significant correlations of BMI and MUAC, WC, HC, PBF, BAI and WHtR have been observed as observed in other studies (Ghosh and

Bandypadhyay 2007; Singh et al. 2014; Banik et al. 2016; Ghosh and Bose 2018). The WC can predict health status as well as body composition accurately without any involving any other indicator as recommended by severl researches (Ghosh and Bandypadhyay 2007; Singh et al. 2014; Banik et al. 2016; Ghosh and Bose 2018). Moreover, studies have observed that WC has a better association with body fat than any other anthropometric indicator (Chakraborty and Bose 2009; Singh et al. 2014; Singh et al. 2014; Banik et al. 2016; Ghosh and Bose 2018). Several studies have used the waist-to-height ratio (WHtR) as the screening indicator among the individuals who need an assessment of visceral obesity rather than the assessment of body weight as it has been observed to be more useful than other indicators (DeNino et al. 2001; Despres and Lemieux 2006; Abdelaal et al. 2017). Human physical variation in body dimension exists between populations which is also effected by geography and environment (Saha 1985; Gite and Singh 1997; Dewangan et al. 2005; Singh et al. 2014; Banik et al. 2016; Ghosh and Bose 2018). Individuals from the same population group or even members of the same household may differ in their fatness although they are in a similar lifestyle pattern. Obesity is a chronic condition characterized by an excess amount of body fat (Arterburn and Noel 2001) which can be a major risk factor for survival.

4.5. PREVALENCE OF UNDERNUTRITION (BMI< 18.50 kg/m^2) AMONG BENGALI MUSLIM MOTHERS

Several research studies have reported a high amount of undernourishment present among Indian women (Bose and Chakraborty 2005; Subramanium and Smith 2006; Griffiths and Bentley 2005; Mahanta et al. 2012; Kshatriya and Acharya 2016). Prevalence of undernutrition ie., chronic energy deficiency (CED) will increase the disease burden and morbidity in population. Less physical productivity, poor reproductive performances (e.g., low birth weight of children) and per-capita economic development in population are the results of the presence of maternal undernutrition in populations. The prevalence of undernutrition was observed to be higher in the Hinduized Mongoloid groups like Ahom (52.00%), Koch (50.00%) and Rajbanshi (42.00%) (Khongsider 2002). The present study have observed prevalence of undernutrition ie., CED 10.29% which is observed to be lowest as observed by other research studies among women in India.

The prevalence of undernutrition (i.e., CED) is a serious problem among the adult population of Northeast India (Khongsider 2002; Gogoi and Sengupta 2002; Mungreipy and Kapoor 2010; Mahanta et al. 2012). It has also been observed that the prevalence of undernutrition i.e., CED was observed to be significantly lower in the tribal populations than in the Hinduized and caste populations (Khongsider 2001; Gogoi and Sengupta 2002). When the population specific comparison of prevalence of undernutrition (e.g. CED) among Indian and non-Indian women was taken into consideration, the prevalence of maternal undernutrition in the present study showed significantly lower prevalence. Prevalence of maternal undernutrition in the present study is observed to be significantly lower than among the Bathudi women in Odisha, India (64.50%) (Bose and Chakraborty 2005), Oraon tribal women in West Bengal (62.90%) (Kshatriya and Acharya 2016), Bathudi tribal women in Odisha (62.80%) (Kshatriya and Acharya 2016), Orang tribal women Jharkhand (62.50%) (Dutta Banik 2011), Kora tribal women in West Bengal (62.00%) (Kshatriya and Acharya 2016), Kora-Mudi tribal women West Bengal (56.40%) (Bose et al. 2006a), Savar tribal women in Orissa (49.00%) (Bose et al. 2006b), Chaudhari tribal women in Gujarat (48.80%) (Kshatriya and Acharya 2016), rural women Assam (48.00%) (Mahanta et al. 2012), rural women in Karnataka (48.00%) (Griffiths and Bentley 2005), Indian tribes (47.40%) (Kshatriya and Acharya 2016), Sarak women Jharkhand (46.36%) (Dutta Banik 2011), Dhimal tribal women in West Bengal (46.20%) (Banik et al. 2007), Santal tribal women in West Bengal (45.10%) (Kshatriya and Acharya 2016), women from Andhra Pradesh (45.00%) (Griffiths and Bentley 2001), ever-married women in Jharkhand (41.50%) (NFHS-3), ever-married women in Bihar

(41.10) (NFHS-3), Kukna tribal women in Gujarat (40.00%) (Kshatriya and Acharya 2016), ever-married women in Chhattisgarh (39.70%) (NFHS-3), ever-married women in Odisha (39.50%) (NFHS-3), ever-married women in Karnataka (38.80%)(NFHS-3), ever-married women in Madhya Pradesh (38.60%) (NFHS-3), ever-married women in West Bengal (37.10%) (NFHS-3), Bhumij tribal women in Odisha (37.00%) (Kshatriya and Acharya 2016), ever-married women in Assam (35.80%) (NFHS-3), ever-married women in Rajasthan (32.70%) (NFHS-3), ever-married women in Uttar Pradesh (32.60%) (NFHS-3), ever-married women in India (32.20%) (NFHS-3), Indian women (32.10%) (Subramanium and Smith 2006), ever-married women in Maharashtra (32.10%) (NFHS-3), Indian women from 26 states (32.00%) (Ackerson et al. 2008), Indian women in 26 Indian states (31.20%) (Bharati et al. 2007), Santal tribal women in Odisha (31.10%) (Kshatriya and Acharya 2016), ever-married women in Andhra Pradesh (30.30%) (NFHS-3), Dhodia tribal women in Gujarat (29.20%) (Kshatriya and Acharya 2016), ever-married women in Haryana (26.90%) (NFHS-3), ever-married women in Uttaranchal (25.00%) (NFHS-3), ever-married women in Himachal Pradesh (24.20%) (NFHS-3), ever-married women in Tamil Nadu (23.20%) (NFHS-3), ever-married women in Jammu and Kashmir (20.60%) (NFHS-3), women in Kerala (19.00%) (Ramesh and Jareena 2009) and among Punjabi women in Punjab (18.50%) (Singh and Kirchengast 2011) (Table 4.3).

Several non-Indian studies also observed higher prevalence of undernutrition among women (Table 4.4) e.g., among rural Bangladeshi women (38.80%) (Shafique et al. 2007), Bangladeshi women in Bangladesh Demographic and Health Survey (36.00%) (Biswas et al. 2017), urban poor Bangladeshi women (29.70%) (Shafique et al. 2007), women in South/Southeast Asia (29.00%) (Nube and Boom 2003), ever-married women in Bangladesh (24.10%) (Kamal et al. 2015), women in Sub-Saharan Africa (22.99%) (Nube and Boom 2003), women in Dakar (15.70%) (Macia et al. 2010), Colombian pregnant women (14.50%)

(Sarmiento et al. 2012) and among women in Myanmar (14.10%) (Hong et al. 2018) than it is been observed among the Bengali Muslim mothers in present study.

Prevalence of undernutrition among Bengali Muslim mothers has been observed to be higher than it is among the women in northern Nigeria (10.00%) (Bakari et al. 2007), women in Indonesia (9.10%) (Pengpid and Peltzer 2017), women in rural China (7.80%) (He et al. 2016), women in rural Tanzania (7.00%) (Keding et al. 2013), women in eastern Uganda (5.90%) (Kirunda et al. 2015), women in Latin America (5.17%) (Nube and Boom 2003), women of childbearing age in Morocco (4.70%) (Belahsen et al. 2004) and among adult females in Iran (1.00%) (Mohammadi et al. 2013).

Table 4.3: Comparison of the prevalence of undernutrition among the Bengali Muslim mothers in present study with other Indian studies

Population	Age group (Years)	Prevalence of Undernutrition (BMI< 18.50 kg/m^2)	Reference
Indian Women Andhra Pradesh	15-49	45.00	Griffiths and Bentley 2001
Bathudi women in Orissa, India	18 and above	64.5	Bose and Chakraborty 2005
Rural women in Karnataka	15–49	48	Griffiths and Bentley 2005
Ever-married women in Jharkhand	15–49	41.5	NFHS-3
Ever-married women in Bihar	15–49	41.1	NFHS-3
Ever-married women in Chhattisgarh	15–49	39.7	NFHS-3
Ever-married women in Orissa	15–49	39.5	NFHS-3
Ever-married women in Karnataka	15–49	38.8	NFHS-3
Ever-married women in Madhya Pradesh	15–49	38.6	NFHS-3
Ever-married women in West Bengal	15–49	37.1	NFHS-3
Ever-married women in Assam	15–49	35.8	NFHS-3
Ever-married women in Rajasthan	15–49	32.7	NFHS-3

Ever-married women in Uttar Pradesh	15–49	32.6	NFHS-3
Ever-married women in India	15–49	32.2	NFHS-3
Ever-married women in Maharashtra	15–49	32.1	NFHS-3
Ever-married women in Haryana	15–49	26.9	NFHS-3
Ever-married women in Uttaranchal	15–49	25	NFHS-3
Ever-married women in Himachal Pradesh	15–49	24.2	NFHS-3
Ever-married women in Tamil Nadu	15–49	23.2	NFHS-3
Ever-married women in Andhra Pradesh	15–49	30.3	NFHS-3
Ever-married women in Jammu and Kashmir	15–49	20.6	NFHS-3
Ever-married women in Punjab	15–49	13.3	NFHS-3
Ever-married women in Kerala	15–49	12.4	NFHS-3
Ever-married women in Gujarat	15–49	11.1	NFHS-3
Ever-married women in Delhi	15–49	10.7	NFHS-3
Indian Women India	15-49	32.10	Subramanium and Smith 2006
Dhimal tribal women in West Bengal	18 and above	46.20	Banik et al. 2007
Indian women in 26 Indian states	15-49	31.20	Bharati et al. 2007

Kora-Mudi tribal women West Bengal	18-65	56.40	Bose et al. 2006a
Savar tribal women in Orissa	18 and above	49.00	Bose et al. 2006b
Indian women in 26 states	15–49	32	Ackerson et al. 2008
Women in Kerala	15–49	19	Ramesh and Jareena 2009
Tangkhul Naga tribal women in Manipur	20-70	16.20	Mungreiphy and Kapoor 2010
Orang tribal women Jharkhand	39-60	62.50	Dutta Banik 2011
Sarak women Jharkhand	39-60	46.36	Dutta Banik 2011
Punjabi women Punjab	17-80	18.50	Singh and Kirchengast, 2011
Rural women Assam	18 and above	48.00	Mahanta et al. 2012
Oraon tribal women in West Bengal	20–60	62.9	Kshatriya and Acharya 2016
Bathudi tribal women in Odisha	20–60	62.8	Kshatriya and Acharya 2016
Kora tribal women in West Bengal	20–60	62.0	Kshatriya and Acharya 2016
Chaudhari tribal women in Gujarat	20–60	48.8	Kshatriya and Acharya 2016
Indian Tribes	20-60	47.40	Kshatriya and Acharya 2016
Santal tribal women in West Bengal	20–60	45.1	Kshatriya and Acharya 2016
Kukna tribal women in Gujarat	20–60	40.00	Kshatriya and Acharya 2016

Bhumij tribal women in Odisha	20–60	37	Kshatriya and Acharya 2016
Santal tribal women in Odisha	20–60	31.1	Kshatriya and Acharya 2016
Dhodia tribal women in Gujarat	20–60	29.2	Kshatriya and Acharya 2016
Nyishi tribal women of Arunachal Pradesh	15-44	10.50	Bharali et al. 2017
Karbi women residing in rural areas of Diphu, Karbi Anglong, Assam	20-49	10.67	Sharma and Mondal 2020
Bengali Muslim Mothers in West Bengal	20-34	10.29	Present Study

Table 4.4: Comparison of the prevalence of undernutrition among the Bengali Muslim mothers in present study with other non-Indian studies

Population	**Age group (Years)**	**Prevalence of Undernutrition (BMI< 18.50 kg/m^2)**	**Reference**
Women in South/Southeast Asia	15–50	29.00	Nube and Boom 2003
Women in Sub-Saharan Africa	15–50	22.99	Nube and Boom 2003
Women in Latin America	15–50	5.17	Nube and Boom 2003
Women of childbearing age in Morocco	15–49	4.7	Belahsen et al. 2004
Women in northern Nigeria	18 and above	10	Bakari et al. 2007
Rural Bangladeshi women	15–45	38.8	Shafique et al. 2007
Urban poor Bangladeshi women	15–45	29.7	Shafique et al. 2007
Women in Dakar	20 and above	15.7	Macia et al. 2010
Colombian pregnant women	20–49	14.5	Sarmiento et al. 2012
Women in rural Tanzania	17–45	7	Keding et al. 2013
Adult females in Iran	18-49	1.0	Mohammadi et al. 2013

Ever-married women in Bangladesh	15-49	24.1	Kamal et al. 2015
Women in eastern Uganda	18 and above	5.9	Kirunda et al. 2015
Women in rural China	20 to 49	7.8	He et al. 2016
Bangladeshi women in Bangladesh Demographic and Health Survey	35 and above	36.0	Biswas et al. 2017
Women in Indonesia	15–103	9.1	Pengpid and Peltzer 2017
Women in women in Myanmar	18–49	14.1	Hong et al. 2018
Bengali Muslim Mothers in West Bengal	20-34	10.29	Present Study

4.6. PREVALENCE OF UNDERNUTRITION IN TERMS OF MUAC AS AN INDICATOR

MUAC is a useful indicator for the assessment of acute adult undernutrition and is useful for both screening acute adult undernutrition at individual as well as population levels (Collins et al. 2000). Several researchers prefer to use MUAC as a reasonable alternative measure for the detection of undernutrition among adults instead of BMI and subsequently to identify individuals with morbidity risk and mortality (Vella et al. 1994; Das et al. 2012; Bose et al. 2019).

Several studies have observed high prevalence of undernutrition in India using MUAC as a measure. The prevalence of undernutrition in terms of MUAC was 51.2% among 60.4% among Santals of Purulia (Das and Bose 2012), Kora Mudis of Paschim Medinipur (Basu and Banik 2009), 43.5% among slum dwellers of Paschim Medinipur (Bose et al. 2007c), 33.4% among Santals of Bankura (Bose et al. 2006c) and 32.7% among Telegas of Paschim Medinipur (Datta Banik 2007) and 57.73% among Mahalis of Bankura (Bose et al. 2019). In the present study, the prevalence of relative risk of low MUAC with low BMI was 2.12% which was lower prevalence than that observed in other Indian opulations (Bose et al. 2006c; Bose et al. 2007; Datta Banik 2007; Basu and Banik 2009; Bose et al. 2019).

4.7. PREVALENCE OF OVERWEIGHT AND OBESITY AMONG THE BENGALI MUSLIM MOTHERS

Recent studies on the assessment of nutritional status have clearly indicated that a sizable proportion of the population is observed to be affected by overweight and obesity in India (Griffith and Bentley 2001; Subramanian and Smith 2006; Bharati et al. 2007; Subramanian et al. 2007; Mungreipy and Kpoor 2010; Sen et al. 2013; Majumder et al. 2014 Sengupta et al. 2015; Rengma et al. 2015; Giridhar et al. 2016). Prevalence of overweigtht, obesity and overall prevalence of overweight obesity in the present study is observed to be 21.08%, 15.36% and 36.44%, respectively.

Rapid socio-economic and demographic transition are currently undergoing in several developing countries which is leading to the acceleration of several non-communicable diseases and higher prevalence of overweight-obesity and slightly lower prevalence of undernutrition in population (Wang et al. 2009; Popkin et al. 2012; Subramanian et al. 2013; Varadharajan et al. 2013; Mondal and Sen 2014; Bharali et al. 2017).

A comparison of the overweight, obesity and overall overweight-obesity of Bengali Muslim mothers is depicted in Table 4.5. Several Indian studies have observed high prevalence of overall overweight and obseidy (BMI≥ 23.00 kg/m²) among Indian women e.g., Bengali Kayastha women of North Bengal (overweight: 13.33%, obesity: 78.67%, overweight-obesity: 92.00%) (Sarkar et al. 2009), Tangkhul Naga tribal women in Manipur (overweight: 25.10%, obesity: 27.10%, overweight-obesity: 52.20%) (Mungreiphy and Kapoor 2010), Indian Women in Puducherry (overweight: 19.10%, Obesity: 31.80%, overweight-obesity: 50.90%) (Majumdar et al. 2014), Bangalee Hindu caste West Bengal (overweight: 20.33%, obesity: 29.33%, overweight-obesity: 49.66 %) (Sen et al. 2013), urban women in Panjab (overweight: 12.70%, Obesity: 29.60%, overweight-obesity: 42.30%) (Girdhar et al. 2016) and among Regma Naga tribal women Assam (overweight: 25.50%, obesity: 11.63%, overweight-obesity: 37.13%) (Rengma et al. 2015) than it has been observed among Bengali Muslim mothers in the present study (overweight: 21.08%, obesity: 15.36%, overweight-obesity: 36.44%).

Several Indian studies have observed lower prevalence of overall overweight-obesity (BMI≥ 23.00 kg/m²) among women e.g., Punjabi Women Punjab (overweight: 9.20%, obesity: 24.60%, Overweight-obesity: 33.80%) (Singh and Kirchengast 2011), Dhodia tribal women (overweight-obesity: 23.3%) (Kshatriya and Acharya 2016), Nyishi tribal women of Arunachal Pradesh (overweight: 9.94%, Obesity: 9.57%, overweight-obesity: 19.57%)

(Bharali et al. 2017), Young women in Kashmir Valley (overweight: 16.50%, obesity: 2.90%, overweight-obesity: 19.40%) (Masoodi et al. 2010), Santal tribal women in Odisha (overweight-obesity: 15.10%) (Kshatriya and Acharya 2016), Kukna tribal women (overweight-obesity: 15.00%) (Kshatriya and Acharya 2016), Indian Women Andhra Pradesh (overweight: 12.00%, Obesity: 2.00%, overweight-obesity: 14.00 %) (Griffiths and Bentley 2001), Indian Tribes (overweight: 10.90%, obesity: 1.50%, overweight-obesity: 12.40%) (Kshatriya and Acharya 2016), Indian women (overweight: 9.60%, obesity: 2.70%, overweight-obesity: 12.30%) (Subramanium and Smith 2006), Santal women in West Bengal (overweight-obesity: 12.30%) (Kshatriya and Acharya 2016), Indian women in 26 Indian states (overweight: 9.40%, obesity: 2.60%, Overweight-obesity: 12.00%) (Bharati et al. 2007), Bhumij tribal women (overweight-obesity: 10.70%) (Kshatriya and Acharya 2016), Chaudhari tribal women (overweight-obesity: 10.70%) (Kshatriya and Acharya 2016), Oraon tribal women(overweight-obesity: 5.60%) (Kshatriya and Acharya 2016) and among Bathudi tribal women (overweight-obesity: 4.10%) (Kshatriya and Acharya 2016), Kora tribal women (overweight-obesity: 1.70%) (Kshatriya and Acharya 2016) than it has been observed among Bengali Muslim mothers in the present study (overweight: 21.08%, obesity: 15.36%, overweight-obesity: 36.44%).

Several Indian studies have observed high prevalence of overall overweight-obesity using the WHO (2000) cut off (BMI$\geq$ 25.00 kg/m^2) among women e.g., Bengalee Hindu women of Kolkata (54.69%) (Bhadra et al. 2005), ever-married women in Punjab (51.60%) (NFHS-3), ever-married women in Kerala (50.60%) (NFHS-3), ever-married women in Delhi (47.70%) (NFHS-3), urban women in Karnataka (44.00%) (Griffiths and Bentley 2005), ever-married women in Tamil Nadu (37.00%) (NFHS-3), ever-married women in Jammu and Kashmir (35.30%) (NFHS-3), ever-married women in Gujarat (30.90) (NFHS-3), adult women in Punjab (30.80%) (Dewan 2008), ever-married women in Haryana (30.80%) (NFHS-

3), ever-married women in Himachal Pradesh (30.00) (NFHS-3), ever-married women in Karnataka (28.00%) (NFHS-3), ever-married women in Uttaranchal (28.00%) (NFHS-3), ever-married women in Andhra Pradesh (27.90%) (NFHS-3), ever-married women in Maharashtra (27.40%) (NFHS-3), ever-married women in India (24.10%) (NFHS-3), ever-married women in West Bengal (21.60%) (NFHS-3), women in Kerala (21.00%) (Ramesh and Jareena 2009), ever-married women in Uttar Pradesh (20.10%) (NFHS-3), ever-married women in Rajasthan (18.70%) (NFHS-3), ever-married women in Assam (16.70%) (NFHS-3), ever-married women in Madhya Pradesh (15.00%) (NFHS-3), ever-married women in Orissa (14.90%) (NFHS-3), Dhodia tribal women in Gujarat (12.50%) (Kshatriya and Acharya 2016), Indian women in 26 states (12.30%) (Ackerson et al. 2008), ever-married women in Chhattisgarh (12.20%) (NFHS-3), ever-married women in Bihar (11.90%) (NFHS-3), ever-married women in Jharkhand (11.80%) (NFHS-3), Santal tribal women in Odisha (9.20%) (Kshatriya and Acharya 2016), Santal tribal women in West Bengal (7.40%) (Kshatriya and Acharya 2016), Bhumij tribal women in Odisha (5.70%) (Kshatriya and Acharya 2016), Kukna tribal women in Guajarat (4.20%) (Kshatriya and Acharya 2016), Chaudhari tribal women in Guajarat (4.10%) (Kshatriya and Acharya 2016), Oraon tribal women in Jharkhand (3.20%) (Kshatriya and Acharya 2016), Bathudi tribal women in Odisha (2.50%) (Kshatriya and Acharya 2016).

Several non-Indian studies have observed higher overall prevalence of overweight-obesity (BMI$\geq$ 23.00 kg/m^2) e.g., adult females in Iran (overweight: 40.30%, obesity: 33.00%, overweight-obesity: 73.30%) (Mohammadi et al. 2013), women in Pakistan (overweight: 27.90%, obesity: 38.80%, overweight-obesity: 66.70%) (Jafar et al. 2006), women in Myanmar (overweight-obesity: 41.20%) (Hong et al. 2018), women in Bangladesh (39.50%) (Bishwajit 2017), women of reproductive age in Bangladesh (overweight: 28.37%, obesity: 10.77%, overweight-obesity: 39.14%) (Chowdhury et al. 2018) than it has been observe in the present study among Bengali Muslim mothers. Some of the non-Indian studies have observed lower prevalence of overweight-obesity (BMI≥23.00 kg/m²) among women e.g., Bangladeshi women of reproductive age (overweight: 25.20%, obesity: 11.20%, overweight-obesity: 36.40%) (Biswas et al. 2017), ever-married women in Bangladesh (overweight: 12.80%, obesity: 16.40%, overweight-obesity: 29.20%) (Kamal et al. 2015), women in Nepal (overweight-obesity: 27.50%) (Bishwajit 2017), Bangladeshi women in BDHS (24.40%) (Biswas et al. 2017) and among women in Nigeria (20.90%) (Kandala and Stranges 2014) than it has been observed in the present study. The presence of excess adiposity levels is considered to increase the risk of non-communicable diseases (e.g., hypertension, diabetes, cardio-metabolic and cardiovascular disorders) (WHO 2000; WHO Expert Consultation 2004). Therefore, the prevalence of overweight-obesity among women in reproductive ages certainly contributes to the mortality and morbidity among women/ mothers in the near future. There are substantial evidences which suggest socioeconomic, demographic, diet and increasing sedentary lifestyle ,subsequent decrease in physical activity, increase in reliance upon processed foods, increased use of edible oils and sugar-sweetened beverages have triggered such prevalence in populations(Subramanian et al. 2007; Mungreiphy and Kapoor 2010; Popkin et al. 2012; Mondal et al. 2015).

Several non-Indian studies have observed high prevalence of overall overweight-obesity using the WHO (2000) cut off (BMI≥ 25.00 kg/m^2) among women e.g., Non-pregnant adult women in Egypt (77.30%) (Eckhardt et al. 2008), Mexican women (72.10%) (Gómez et al. 2009), Malay women in Singapore (65.10%) (Sabanayagam et al. 2009), Peruvian women (63.00%) (Jacoby et al. 2003), Mexican women (62.00%) (Jones et al. 2017), women in Ecuador (61.00%) (Weigel et al. 2016), non-pregnant adult women in Mexico (59.30%) (Eckhardt et al. 2008), Western Sahara refugee women (53.70) (Grijalva-Eternod et al. 2012), non-pregnant adult women in Peru (52.30%) (Eckhardt et al. 2008), Ghana women (49.70%) (Ofori-Asenso et al. 2016), women in Indonesia (48.80%) (Roemling and Qaim 2012), Tz'utujil Maya women in Guatemala (46.90%) (Nagata et al. 2009), women in a slum area in Brazil (46.00%) (Alves et al. 2011), Colombian women of reproductive age (42.30%) (Kordas et al. 2013), women in northern Nigeria (40.40%) (Bakari et al. 2007), women living along the Bolivia (40.30%) (Benefice et al. 2007), Colombian pregnant women (37.30%) (Sarmiento et al. 2012), women in Indonesia (36.20%) (Sohn 2014), women in eastern Uganda (35.80%) (Kirunda et al. 2015), women of childbearing age in Morocco (35.20%) (Belahsen et al. 2004), women in Dakar (34.80%) (Macia et al. 2010), adult Chinese women in Singapore (34.00%) (Sabanayagam et al. 2007), women in low and middle income countries (31.20%) (Popkin and Slining 2013), Kenyan women (29.60%) (Mkuu et al. 2018), women in Indonesia (28.70%) (Sari and Amaliah 2014), women in Bangladesh, India, Indonesia, Thailand and Vietnam (27.90%) (Razzaque et al. 2009), non-pregnant women in Bangladesh (24.50%) (Ghose 2017), women in rural Tanzania (22.00%) (Keding et al. 2013), women in the USA (20.70%) (Martorell et al. 2000).

Table 4.5: Comparison of the prevalence of overweight, obesity and overall overweight-obesity among the Bengali Muslim mothers in present study with other Indian studies

Population	Age group (Years)	Prevalence (%)				Reference
		Overweight (BMI= 23.00-24.99 kg/m²)*	Obese (BMI≥ 25.00 kg/m²)#	Overweight -Obesity (BMI≥ 23.00 kg/m²)*	Overweight-Obesity (BMI≥ 25.00 kg/m²)#	
Indian Women Andhra Pradesh	15-49	12.00	2.00	14.00	-	Griffiths and Bentley 2001
Bengalee Hindu women of Kolkata	20-50	-	-	-	54.69	Bhadra et al. 2005
urban women in Karnataka	15–49	-	-	-	44.00	Griffiths and Bentley 2005
Ever-married women in Punjab	15–49	-	-	-	51.60	NFHS-3
Ever-married women in Kerala	15–49	-	-	-	50.60	NFHS-3
Ever-married women in Delhi	15–49	-	-	-	47.70	NFHS-3
Ever-married women in Tamil Nadu	15–49	-	-	-	37.00	NFHS-3
Ever-married women in Jammu and Kashmir	15–49	-	-	-	35.30	NFHS-3

Ever-married women in Gujarat	15–49	-	-	-	30.90	NFHS-3
Ever-married women in Haryana	15–49	-	-	-	30.80	NFHS-3
Ever-married women in Himachal Pradesh	15–49	-	-	-	30.00	NFHS-3
Ever-married women in Karnataka	15–49	-	-	-	28.00	NFHS-3
Ever-married women in Uttaranchal	15–49	-	-	-	28.00	NFHS-3
Ever-married women in Andhra Pradesh	15–49	-	-	-	27.90	NFHS-3
Ever-married women in Maharashtra	15–49	-	-	-	27.40	NFHS-3
Ever-married women in India	15–49	-	-	-	24.10	NFHS-3
Ever-married women in West Bengal	15–49	-	-	-	21.60	NFHS-3
Ever-married women in Uttar Pradesh	15–49	-	-	-	20.10	NFHS-3
Ever-married women in Rajasthan	15–49	-	-	-	18.70	NFHS-3
Ever-married women in Assam	15–49	-	-	-	16.70	NFHS-3
Ever-married women in Madhya Pradesh	15–49	-	-	-	15.00	NFHS-3
Ever-married women in Orissa	15–49	-	-	-	14.90	NFHS-3
Ever-married women in Chhattisgarh	15–49	-	-	-	12.20	NFHS-3
Ever-married women in Bihar	15–49	-	-	-	11.90	NFHS-3

Ever-married women in Jharkhand	15–49	-	-	-	11.80	NFHS-3
Indian women	15-49	9.60	2.70	12.30	-	Subramanium and Smith 2006
Indian women in 26 Indian states	15-49	9.40	2.60	12.00	-	Bharati et al. 2007
Indian women in 26 states	15–49	-	-	-	12.30	Ackerson et al. 2008
Adult women in Punjab	-	-	-	-	30.80	Dewan 2008
Women in Kerala	15–49	-	-	-	21.00	Ramesh and Jareena 2009
Bengali Kayastha women of North Bengal	30-50	13.33	78.67	92.00	-	Sarkar et al. 2009
Young women in Kashmir Valley	20–40	16.50	2.90	19.40	-	Masoodi et al. 2010
Tangkhul Naga tribal women in Manipur	20-70	25.10	27.10	52.20	-	Mungreiphy and Kapoor 2010
Punjabi Women Punjab	17-80	9.20	24.60	33.80	-	Singh and Kirchengast, 2011
Bangalee Hindu caste West Bengal	20-60	20.33	29.33	49.66	-	Sen et al. 2013
Indian Women in Puducherry	30 and above	19.10	31.80	50.90	-	Majumdar et al. 2014
Regma Naga tribal women Assam	20-49	25.50	11.63	37.13	-	Rengma et al. 2015

Urban women in Panjab	20-60	12.70	29.60	42.30	-	Girdhar et al. 2016
Dhodia tribal women in Gujarat	20–60	-	-	23.30	12.50	Kshatriya and Acharya 2016
Santal tribal women in Odisha	20–60	-	-	-	9.20	Kshatriya and Acharya 2016
Santal tribal women in West Bengal	20–60	-	-	-	7.40	Kshatriya and Acharya 2016
Bhumij tribal women in Odisha	20–60	-	-	10.70	5.70	Kshatriya and Acharya 2016
Kukna tribal women in Guajarat	20–60	-	-	15.00	4.20	Kshatriya and Acharya 2016
Chaudhari tribal women in Guajarat	20–60	-	-	10.70	4.10	Kshatriya and Acharya 2016
Oraon tribal women in Jharkhand	20–60	-	-	5.60	3.20	Kshatriya and Acharya 2016

Bathudi tribal women in Odisha	20–60	-	-	4.10	2.50	Kshatriya and Acharya 2016
Indian Tribes	20-60	10.90	1.50	12.40	-	Kshatriya and Acharya 2016
Kora tribal women in West Bengal	20–60	-	-	1.70	-	Kshatriya and Acharya 2016
Santal tribal women in Odisha	20–60	-	-	15.10	-	Kshatriya and Acharya 2016
Santal women in West Bengal	20–60	-	-	12.30	-	Kshatriya and Acharya 2016
Nyishi tribal women of Arunachal Pradesh	15-44	9.94	9.57	19.57	-	Bharali et al. 2017
Karbi women residing in rural areas of Diphu, Karbi Anglong, Assam	20-49	16.67	34.00	50.67		Sharma and Mondal 2020
Bengali Muslim Mothers in West Bengal	20-34	21.08	15.36	36.44	-	Present Study

* WHO (2004) (WHO cut off for Asian Indians); $^{\#}$ WHO (2000)

Table 4.6: Comparison of the prevalence of overweight, obesity and overall overweight-obesity among the Bengali Muslim mothers in present study with other non-Indian studies

Population	Age group (Years)	Prevalence (%)				Reference
		Overweight (BMI= 23.00-24.99 kg/m²)*	Obese (BMI≥ 25.00 kg/m²)#	Overweight-Obesity (BMI≥ 23.00 kg/m²)*	Overweight-Obesity (BMI≥ 25.00 kg/m²)#	
Women in the USA	15–49	-	-	-	20.70	Martorell et al. 2000
Women in the Middle East and North Africa	15–49	-	-	-	17.20	Martorell et al. 2000
Women in Central Eastern Europe	15–49	-	-	-	15.40	Martorell et al. 2000
Women in Latin America and the Caribbean	15–49	-	-	-	9.60	Martorell et al. 2000
Women in Sub-Saharan Africa	15–49	-	-	-	2.50	Martorell et al. 2000
Women in South Asia	15–49	-	-	-	0.10	Martorell et al. 2000
Women in NHSP	25-44	-	14.00	-	-	Nanan 2002
Peruvian women	30-60	-	-	-	63.00	Jacoby et al. 2003
Women of childbearing age in Morocco	15–49	-	-	-	35.20	Belahsen et al. 2004

Women in Pakistan	15 and above	27.90	38.80	66.70	-	Jafar et al. 2006
Women in northern Nigeria	18 and above	-	-	-	40.40	Bakari et al. 2007
Women living along the Bolivia	20-49	-	-	-	40.30	Benefice et al. 2007
Urban poor Bangladeshi women	15–45	-	-	-	9.10	Shafique et al. 2007
Rural Bangladeshi women	15–45	-	-	-	4.10	Shafique et al. 2007
Adult Chinese women in Singapore	40-81	-	-	-	34.00	Sabanayagam et al. 2007
Non-pregnant adult women in Mexico	18–49	-	-	-	59.30	Eckhardt et al. 2008
Non-pregnant adult women in Egypt	18–49	-	-	-	77.30	Eckhardt et al. 2008
Non-pregnant adult women in Peru	18–49	-	-	-	52.30	Eckhardt et al. 2008
Mexican women	20-69	-	-	-	72.10	Gómez et al. 2009
Tz'utujil Maya women in Guatemala	18–82	-	-	-	46.90	Nagata et al. 2009
Women in Bangladesh, India, Indonesia, Thailand and Vietnam	25-64	-	-	-	27.90	Razzaque et al. 2009
Malay women in Singapore	40-80	-	-	-	65.10	Sabanayagam et al. 2009

Adult women in Malaysia	20-49	-	-	-	15.30	Sidik and Rampal 2009
Women in Dakar	20 and above	-	-	-	34.80	Macia et al. 2010
Women in a slum area in Brazil	20-60	-	-	-	46.00	Alves et al. 2011
Western Sahara refugee women	15-49	-	-	-	53.70	Grijalva-Eternod et al. 2012
Women in Indonesia	20-75	-	-	-	48.80	Roemling and Qaim 2012
Colombian pregnant women	20–49	-	-	-	37.30	Sarmiento et al. 2012
African immigrant women in Oslo	25 and above	-	66.00	-	-	Gele and Mbalilaki 2013
Women in rural Tanzania	17–45	-	-	-	22.00	Keding et al. 2013
Colombian women of reproductive age	18–49	-	-	-	42.30	Kordas et al. 2013
Adult females in Iran	18-49	40.30	33.00	73.30	-	Mohammadi et al. 2013
Women in low and middle income countries	40 and above	-	-	-	31.20	Popkin and Slining 2013
Ever-married women in Bangladesh	15-49	12.80	16.40	29.20	-	Kamal et al. 2015

Women in Nigeria	15–49	-	-	20.90	-	Kandala and Stranges 2014
Women in Indonesia	19-55	-	-	-	28.70	Sari and Amaliah 2014
Women in Indonesia	40 and above	-	-	-	36.20	Sohn 2014
Women in eastern Uganda	18 and above	-	-	-	35.80	Kirunda et al. 2015
Women in rural China	20-49	-	-	-	16.50	He et al. 2016
Ghana women	18 and above	-	-	-	49.70	Ofori-Asenso et al. 2016
Women in Ecuador	15–49	-	-	-	61.00	Weigel et al. 2016
Women in Bangladesh	15–49	-	-	39.50	-	Bishwajit 2017
Women in Nepal	15–49	-	-	27.50	-	Bishwajit 2017
Bangladeshi women in BDHS	35 and above	-	-	24.40	-	Biswas et al. 2017
Bangladeshi women of reproductive age	15–49	25.20	11.20	36.40	-	Biswas et al. 2017
non-pregnant women in Bangladesh	15-49	-	-	-	24.50	Ghose 2017
Mexican women	15-49	-	-	-	62.00	Jones et al. 2017
Women of reproductive age in Bangladesh	15–49	28.37	10.77	39.14	-	Chowdhury et al. 2018
Women in Myanmar	18–49	-	-	41.2	-	Hong et al. 2018

Kenyan women	15–49	-	-	-	29.60	Mkuu et al. 2018
Bengali Muslim Mothers in West Bengal	20-34	21.08	15.36	36.44	-	Present Study

[*] WHO (2004) (WHO cut off for Asian Indians); [#] WHO (2000)

4.8. PREVALENCE OF DOUBLE BURDEN OF MALNUTRITION AMONG THE BENGALI MUSLIM CHILDREN AND THEIR MOTHERS

In the present study it has been observed that there is a prevalence of undernutrition among the Bengali Muslim children and their mothers. The present study also showed that Bengali Muslim mothers are also suffering with the prevalence of overweight and obesity. This co-existence of double burden of malnutrition (DBM) (ie., both undernutriton and overnutrition) represents the opposite sides of energy balance equation which is a unique difficulty for public health policy makers in population. The coexistence of undernutrition and overweight-obesity is being considered as a common problem in low and middle-income countries (LMICs) which is due to the lack of proper distribution of social resources and economic resources. The prevalence of DBM contributes to the burden of non-communicable diseases in LMICs. When the prevalence of DBM affects the biological, social and economic development of people then it also hampers the overall growth of a developing nation like India. The problem of DBM rotates in a cyclic process with the economic growth of a country when it is not properly monitored due to its large scale distribution in the population. Several studies have observed the high prevalence of DBM in Indian populations specially among children and women of the country as observed among the Bengali Muslim children and mothers in the present study. The combined prevalence of undernutrition and overweight-obesity is considered as a proxy measure for the total burden of nutritional diseases (Delisle 2008). Chronic energy deficiency (CED) or underweight (BMI < 18.5 kg/m^2) is a major nutritional problem among women of low-income countries and the prevalence of double burden of underweight and overweight-obesity (BMI ≥ 23 kg/m^2) is emerging as a critical health situation in South Asia and sub-Saharan Africa (Delisle 2008). Studies in Bangladesh have observed among the women of reproductive age the prevalence of undernutrition was 38.8% and 29.7% among among rural and urban poor women, respectively. On the other hand there were also the occurrence of overweight-obese of 4.1% and 9.1% among rural and urban poor women, respectively (Shafique et al. 2007; Delisle 2008). Over the period of 5 years the prevalence of CED has declined and overweight-obesity has increased in both rural and urban settings in Bangladesh, but the trend of high BMI among women was more significant in rural settings than in urban areas (Delisle 2008). The adverse effect of inequality in per capita is the occurrence of DBM in populations because children and women belonging to low SES experience the greatest risk of undernutrition, whereas the high SES ones are exposed to higher risk of overweight and obesity. Therefore, the economic transitions focusing on reducing the economic inequalities can address the DBM problem in population.

There are several studies depicting the dual burden of child undernutrition (mainly stunting) and maternal overnutrition in a single household, which implies to the fact that although maternal overweight-obesity and child undernutrition looks like two different problems but they occur from single cause that is the socio-economic inequality or the improper distribution of social and economic resources among populations/households/individuals. That is, the occurrence of undernutrition and overnutrition do not have opposite causes but they appear as responses to the same situations in the country. Several published studies conducted in nutrition-transitioning countries have observed that the occurrence of double burden of malnutrition is more common among women than in men may be due to the gender inequalities that women face from childhood in most of the patriarchal societies/countries (Sawaya et al. 2003; Delisle 2008). Moreover, low birth weight and stunting also occurs as a result of maternal constraint or poor nutrition.

4.9. ASSOCIATION BETWEEN NUTRITIONAL STATUS OF MOTHERS AND CHILDREN AMONG BENGALI MUSLIMS

The present cross-sectional study has shown direct associations between maternal anthropometric characteristics, nutritional status (e.g., BMI) and nutritional status of children (e.g., WAZ, HAZ and BMIAZ) among the Bengali Muslim population of West Bengal, India. The results of the linear regression analysis showed that maternal BMI, MUAC and physical growth/nutritional variables of children ($p<0.05$) are significantly associated (Table 3.24, Table 3.25, Table 3.26, Table 3.27, Table 3.28 and Table 3.29). Several studies have shown a positive association with the maternal anthropometric parameters/body composition (e.g., height, weight or BMI) with physical growth and nutritional variables in children (Subramanian et al. 2009; Mitra et al. 2012; Addo et al. 2013; Felisbino-Mende et al. 2014; Girma and Genebo 2015; Tigga and Sen 2016; Tayade et al. 2018). The results of the linear regression model analysis revealed that maternal BMI and MUAC was the most predictive variable of anthropometric growth parameters (e.g., HAZ, WAZ, and BMIAZ) were proved as statistically significant variations in these three dependent variables in children (Table 3.24, Table 3.25 and Table 3.26). Results showed that correlations between maternal and children anthropometric variables (BMI and MUAC) were observed to be significant with the all the child anthropometric variables WHZ, WAZ, HAZ, BMIAZ of variations in the Z-score among children ($p<0.05$) (Table 3.24, Table 3.25, Table 3.26). The associations of combined maternal anthropometric measures therefore, showed a strong genetic component between maternal and anthropometric physical growth variables among school children. Santos et al. (2009) have reported the direct significant association ($p<0.01$) between maternal BMI and child BMI Z-scores. The results of the present study showed that maternal anthropometric measures and nutritional status has significant effect on children physical growth patterns among Bengali Muslim children (<5 years). Several researchers have reported an increase in maternal body composition (i.e., BMI or MUAC) and/or nutritional status was associated with a lower prevalence of undernutrition in children (<5 years) (Subramaniam et al. 2009; Addo et al. 2013; Felisbino-Mende et al. 2014; Tigga and Sen 2016; Tayade et al. 2018). Several research studies have confirmed the direct association between maternal body composition/nutritional status with physical growth attainments or nutritional status using conventional anthropometric measurements among children. Rahman et al. (1993) reported in a study from Bangladesh that physical growth variables (i.e., WAZ) of children were associated with maternal BMI in ($p<0.001$). In Bangladesh Islam et al. (1994) observed that mothers who were underweight were two times more likely to give birth to an underweight child. Women with poor nutritional status (e.g., BMI) had registered the higher risk of severe stunting (HAZ) and severe underweight (WAZ) (27.10% and 23.30%, respectively) among children as observed in a recent study by Kulasekaran (2012). Positive associations between maternal BMI with BMI of children have been observed by several recent studies (Ajslev et al. 2014; Tigga and Sen 2016). Present investigation also showed similar incidence of maternal undernutrition with lower physical growth attainments among the Bengali Muslim children. Some others investigations also observed the relationship between maternal BMI and child stunting, wasting and thinness (Mitra et al. 2012; Khan and Mohanty 2018).The present study among the Bengali Muslims has confirmed that the anthropometric measurements (e.g., BMI or MUAC) were significantly associated with the child nutritional status (Table 3.24, Table 3.25, Table 3.26).

The prevalence of undernutrition among children will manifest as a long-term effect on the physical growth attainments or reducing growth potentials, health and survivals, cognitive developments, lower attained schooling, decreased economic potential, reproductive performance, and onset of chronic illness in adulthood (Shrimpton et al. 2001; Pelletier and Frongillo 2003; Black et al. 2008, 2013; WHO 2013). Therefore, implementations of appropriate intervention programme and nutrition sensitive approaches are necessary to improve maternal and child nutritional status in the studied population.

4.10. SOCIO-ECONOMIC, DEMOGRAPHIC CORRELATES OF NUTRITIONAL STATUS AMONG THE BENGALI MUSLIM CHILDREN AND MOTHERS

The major underlying factors for the prevalence of double burden of malnutrition (overnutriton and undernutrition) in the developing countries are the disparities in socio-economic and demographic conditions, environmental factors, ethnic and variations (Mahgoub et al. 2006; Mondal and Sen 2010; Ahmed et al. 2012). Studies have reported that in most of the Indian populations gender differences are significant and boys have better access to food and basic amenities than girls and there is a pronounced preference for the male child (Mondal and Sen 2010; Sen and Mondal 2012). Studies also have documented that girls are more affected by chronic undernutrition (e.g., stunting and wasting) whereas boys are more affected by acute undernutrition (e.g., thinness and underweight) (Bose et al. 2007; Mondal and Sen 2010; Sen and Mondal 2012; Som et al. 2006). The present study has observed a higher prevalence of stunting (45.54% vs. 43.55%), wasting (33.54% vs. 19.51%), thinness (32.92% vs. 18.82%) and low HdC-for-age (45.23% vs. 20.56%) among boys than girls and the prevalence of underweight (40.00% vs. 40.07%) was almost similar among both the groups.

The odds were significantly greater among boys than girls in case of stunting ($p>0.05$), thinness ($p<0.01$), wasting ($p<0.01$) and low HdC-for-age ($p<0.01$). Odds in case of underweight were higher among girls. Therefore, the results of BLR analysis showed that boys were in higher risk of of stunting, thinness, wasting and low HdC-for-age and girls were in higher risk of underweight. Studies have reported that rural girls were more likely to be severely undernourished than rural boys (Choudhury et al. 2000; Mondal and Sen 2010). Results of BLR analysis have shown that children of lower age groups (1-2 years) were in higher risk of wasting ($p<0.01$) and underweight whereas children of higher age groups were in higher risk of stunting, thinness and low HdC-for-age ($p<0.01$).

Thus, the present study is in concordance with the other studies among children where prevalence of undernutrition was higher in higher age groups (Biswas et al. 2009; Mandal et al. 2009; Tigga et al. 2015a; Mondal et al. 2015). The significant effects of some other socioeconomic and demographic correlates (i.e., birth order, no. of sibs, mothers' occupation) on prevalence of stunting and thinness among the children can be attributed to the fact that better access to food and amenities may have significant effect on the nutritional status of the children of growing ages. Child birth order, period of breastfeeding initiation, toilet facility, drinking water and mother's education are associated with the prevalence of undernutrition (e.g., stunting and wasting) in children (Panigarhi and Das 2014; Tigga et al. 2015a,b; Mesharam et al. 2012; Dera et al. 2018; Hossain and Khan 2018). Studies have observed that undernutrition is an independent risk factor as the outcome of childhood malignancies (Trehan et al. 2015). Few studies have showed the effect of ethnicity on nutritional status (Choudhury et al. 2000; Som et al. 2007; Mondal and Sen 2010a; Bhargava et al. 2015; Sen and Mondal 2012; Tigga et al. 2015a; Poh et al. 2016; Pal and Bose 2017; Sinha et al. 2017; Venkatraman et al. 2017 Seshadri and Ramakrishna 2018). Researchers have observed that the nutrition levels are not only dependent on the access of nutrition rich foods, but several other factors e.g., clean drinking water, a proper sanitary conditions and appropriate caring practices mainly in case of children are equally impactfull and play major roles in the nutritional levels of children (Ramachandran 2014; Tigga et al. 2015a,b; Venkatraman et al. 2017). Therefore, the proper dissemination of knowledge and awareness related to nutritional requirement, improvement of economic conditions, use of nutrient rich food, improvement of feeding practices among nutritionally vulnerable segments would be helpful to reduced such prevalence. Studies have also observed that rural children are more vulnerable to undernourishment than their urban counterparts (Ramachandran 2014; Tigga et al. 2015a,b; Debnath et al. 2018).

Mothers suffering from undernutrition may give birth to infants with growth retardations which may further lead to ill health condition of the children (WHO 1995; Black et al. 2013). Also overweight-obese mothers tend to give birth to stunted child as observed in some studies. The present study have observed that children of higher mothers age category were in higher risk of stunting ($p<0.01$), underweight ($p<0.01$) and low HdC-for –age ($p<0.05$). Children of mothers with lower age at menarche were in higher risk of stunting ($p<0.01$), wasting, underweight ($p<0.01$).

Children of mothers with higher age at marriage have showed higher risk of stunting, thinness, wasting and low HdC for-age than the children whose mothers have lower age at marriage. Risk of underweight was higher among the children whose mothers have a lower age at marriage. Children with higher family size (5 and above) were in higher risk of thinness, wasting and low HdC-for-age than children of lower family size. A number of studies have observed significant relationship between larger households and occurrence of childhood undernutrition. A large household size suggests an increased competition for availables resources therefore leads to inadequate nutrition among the family members (Greene and Merrick 2005; Cleland et al. 2006; Engebretsen et al. 2008; Darteh et al. 2014; Melaku et al. 2015; Liu and Raine 2016; Debnath et al. 2018c). Children of nuclear families were observed to be in higher risk of stunting and underweight than the children of the extended, joint and broken families. Children of extended, joint and broken families were in higher risk of thinness, wasting and low HdC-for-age than the children of nuclear families. Children of families with lower number of earning head (earning head- 1) were in higher risk of stunting and underweight. Lesser number of earning heads means somehow lower economic condition therefore leading to the prevalence of undernutrition. Children with lower monthly family income were in higher risk of stunting, thinness, wasting than the children with higher monthly income of family. Also children with lower monthly family expenditure were in higher risk of stunting (p<0.01), thinness, wasting (p<0.01) and underweight (p<0.01) than the children with higher monthly family expenditure. Children using tube well and supply water were in higher risk of stunting and underweight than the children using well water. Children using well water were in higher risk of thinness, wasting and low HdC-for-age. Children who do not have toilet facility were in higher risk of stunting, thinness, wasting and underweight. Children who do not have electricity in their houses were in higher risk of thinness (p<0.01) and wasting. Children having kaccha house were in higher risk of stunting and underweight. These results of the present study were in concordance with several ther studies done in this research field (Ramachandran 2014; Tigga et al. 2015a,b; Debnath et al. 2018). It is further evident from the results that children belonging to poor socio-economic and adverse environments, including low income, were more affected by undernutrition, thereby agreeing with the results of other existing studies (Choudhury et al. 2000; Mahgoub et al. 2006). Some household hygienic practices such as access to safe water, hand washing using soap, and other sanitation practices have major role on morbidity related risks, which have a considerable effect on child growth (Checkley et al. 2004; Fink et al. 2011; García et al. 2017; Tigga et al. 2015a,b; Debnath et al. 2018). Children with lower number of rooms one or two were in higher risk of stunting, underweight and low HdC-for-age. Children with low birth weight (<2.5 kg) were in higher risk of thinness, wasting, underweight and low HdC-for-age than the children with higher birth weight. Therefore, it implies to the fact that birth weight has significant impact on a child's growth in later ages. Children with lesser number of years of breast feeding were observed to be in higher risk of stunting, thinness, underweight and low HdC-for-age. Therefore, breast feeding duration is an important factor among Bengali Muslim childrens in the present study. Children whose mothers were without education were in higher risk of stunting, wasting, underweight and low HdC-for-age than the educated mothers and Children of uneducated fathers were in higher risk of stunting, wasting, underweight and low HdC-for-age. Therefore, parent's educational status is significantly impacting the nutritional status of the children. This has also been observed by other research studies (e.g., Tigga et al. 2015a,b; Debnath et al. 2018). Mainly low educational status of mothers is a major determinant of child undernutrition (Tigga et al. 2015a,b; Debnath et al. 2018). Children whose mothers were working outside were in higher risk of stunting, thinness and wasting than the children of housewife mothers may be due to the fact that children of working mothers are left with their higher coborn and therefore not getting proper care in terms of food and nutrition. Father's occupation has been observed to be severely impacting the nutritional and health condition of children as observed in several studies. The present study also have observed similar trend and children of labourer and farmers were in higher risk of stunting, thinness ($p<0.01$), wasting and underweight as observed in other studies.

The various determinants of the maternal malnutrition are per capita income among families, family size, socio-economic disparities, gender inequality, poor feeding practices, healthcare facilities and lack of adequate care during childhood (Manu and Paul 2006; Bharati et al. 2008; Mondal and Sen 2010a; Subramaniyam et al. 2010; Cowling et al. 2014; Tigga et al. 2015; Mondal et al. 2016; Debnath et al. 2018). Age at menarche, age at marriage, place of residence, education levels, household wealth, womens occupational status, husbands occupation, awareness regarding infectious diseases, source of drinking water facilities are other strong predictors of maternal malnutrition in India (Mittal et al. 2007; Bharati et al. 2008; Subramanian et al. 2009; Tigga et al. 2015; Chowdhury et al. 2017; Chowdhury et al. 2018; Mkuu et al. 2018).

Studies have proven the fact that different ethnic groups show variation with respect to the nutritional status of populations in India. However, it is not clear if there is a casual relationship between them. Several studies have attributed to the fact that socio-economic status and economic development has little or no impact on reducing/controlling child undernutrition in developing countries as in India (Varadharajan et al. 2013; Ramachandran 2014; Subramanian and Subramaniyam 2015; Vollmer et al. 2017; Ruia et al. 2018). There is significant occurrence of gender bias among the Indian populations mainly among the marginalized sections of the society which is leading to the poor health/nutritional status of women and young girls in India (Bose et al. 2007; Mondal and Sen 2010a; Tigga et al. 2015; Kshatriya and Acharya 2016; Chowdhury et al. 2018).

Maternal nutritional status among the Bengali Muslim mothers are observed to be also associated with their socio-economic, demographic and lifestyle profile as observed in several other studies among other groups of Indian and non-Indian women. Association of socio-economic, demographic and life style related variables with the indicator of undernutrition, overweight and obesity has been analysed using multinomial logistic regression analysis and is depicted in Table 3.24. Bengali Muslim mothers of higher age group (28-34 years) were in higher risk of undernutrition, lower age groups (20-27 years) were in higher risk of overweight and obesity. Risk of prevalence of undernutrition and obesity were observed to be higher among the mothers who had a lower age at menarche. Studies have observed that prevalence of overweight and obesity among women tends to increase with age and several studies from low-income countries showed that older women are at a greater risk of overweight and obesity (Subramanian et al. 2009; Chowdhury et al. 2018). Studies also have observed that there is an increasing rate of overweight and obesity in rural areas whereas a declining rate of undernutrition in urban areas (Chowdhury et al. 2018).

This disparity between rural and urban areas may be the influence of multiple factors e.g., reduction in poverty and increase in per capita income. Risk of being overweight was higher among the mothers with higher age at menarche. Mothers with lower age at marriage were in higher risk of undernutrition and obesity and mothers with higher age at marriage were in higher risk of overweight. Mothers with higher age at first pregnancy were in higher risk of undernutrition and overweight and mothers with lower age at first pregnancy were in higher risk of obesity. Mothers with higher education level were in higher risk of undernutrition and overweight. Mothers in the category of no education were in higher risk of obesity. Mothers with earning head two or more were observed to be in higher risk of undernutrition and overweight. Mothers of the families with higher family income were in higher risk of overweight. Mothers of the families with higher family expenditure were in higher risk of overweight than the mothers with lower family expenditure. Mothers with lesser number of living children were in higher risk of undernutrition and overweight and mothers with higher number of living children were in higher risk obesity. Mothers of extended, joint and broken families were in higher risk of undernutrition ($p<0.01$) and overweight and mothers of nuclear families were in higher risk of obesity. Mothers using well water were in higher risk of undernutrition ($p>0.05$) and mothers using tube-well and supply water were in higher risk of overweight and obesity. Mothers using toilets were in higher risk of undernutrition and mothers without toilet facility were in higher risk of overweight ($p<0.01$) and obesity. Mothers of the house type category semi pucca and pucca were in higher risk of undernutrition and overweight. Mothers having higher number of rooms were in higher risk of overweight and mothers having lesser number of rooms were in higher risk of obesity. Women whose husbands were in the category of no education and with education upto class V were in higher risk of undernutrition. Women whose husbands were in the categories of education level class I to class V and class VI and above were in higher risk of overweight. Women whose husbands were in the category of no education were also in higher risk of obesity. Women whose husbands were farmers were in higher risk of undernutrition and whose husbands were businessmen were in higher risk of overweight. Mothers having higher number of children were in higher risk of undernutrition and mothers having lower number of children were in higher risk of overweight. Mothers with number of living children 2 were in higher risk of obesity. Mothers with duration of breast feeding upto 2 years 11 months i.e., lesser duration of breast feeding were in higher risk of obesity. Mothers with longer duration of breast feeding were in higher risk of undernutrition and overweight.

Studies have observed that women's marital status, women's educational status as well as their husband's educational status, employment status and employment status of their husbands also have significant impact on the nutritional status of women as observed in the present study (Subramanian et al. 2009; Chowdhury et al. 2017; Chowdhury et al. 2018; Mkuu et al. 2018) . present study also have found out that wealthier women are more likely to be overweight or obese which is consistent with studies done in other low and middle income countries (Dinsa Et al. 2012; Mkuu et al. 2018). This is may be due to the fact that increasing wealth in low and middle income countries are resulting in greater access to food and an escape from physical activity (Chowdhury et al. 2018).

13.	National Journal	Development of Dermatoglyphics in India	**South Asian Anthropologist**	**2020**	20	77-86	0257-7348	First author
14.	International Journal	Socio-economic and demographic correlates of composite index of anthropometric failure among rural children in West Bengal, India	**Man In India**	**2020**	100	73-90	0025-1569	Second author