CHAPTER-II

LITERATURE REVIEW

II

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2.1 INTERNATIONAL CONTEXT

Anthropometric studies are valuable as they provide good information on the physical growth and nutritional status of a community. These studies are also helpful for improving the health conditions of human populations. Hence, a well-designed anthropometric study can be used as a powerful tool to monitor the health and nutritional status of any population or community.

Anthropometry is widely used and well accepted in surveys as an indicator of nutritional and health status. It is especially important during adolescence as it allows evaluation of physical and maturational growth as well as health risks during this critical period of development (Al-Sendi et al. 2003). The health and nutritional status of a population is most accurately reflected in the growth of its children. Measurements of HT and WT are important factors relating to growth and development, puberty, and nutritional status of children and adolescents (Bener and Kamal 2005).

There have been numerous anthropometric studies among growing children throughout the world (Hamill et al. 1979, Eveleth and Tanner 1990, Frisancho 1990, WHO 1995). Musaiger et al. (1989) undertook a comparative investigation of school children in Bahrain to study the physical growth pattern. Mean values for HT and WT increase with age in both sexes and MUAC also increases with age. The mean TS and BS of boys decrease slightly, by age 16.5 and above, whereas in girls these thicknesses continue to increase with age. At the subscapular and suprailiac sites, girls have means which are greater than boys at every age. The differences in these sites between boys and girls are almost double.

Body fat topography and body composition are topics of importance to human biologists. There is a wide range of data on body composition and body fat patterning for the industrialized countries of the world (Mukhopadhyay et al. 2005c). On the other hand, studies from lesser developed regions are far less common (Sanjeev et al. 1991). A number of studies have been undertaken on adiposity in various countries, e.g. rural Mestizos in Colombia (Mueller and Reid 1979), Swedes (Ohlson et al. 1985), French (Ducimetiere et al. 1986), Europeans (Seidell et al. 1992). A survey was carried out among children to evaluate body mass index and subcutaneous fat of African or Indian subcontinent descent living in Trinidad and Tobago (Gulliford et al. 2001). Teramoto et al. (1999) studied age related changes in body composition among Japanese children. Lurbe et al. (2001) investigated obesity, body fat distribution and ambulatory blood pressure in children and adolescents. Savva et al. (2001) studied Reference Growth Curves for Cypriot Children 6 to 17 Years of Age.

Tthe patterns of growth in HT and WT and the prevalence of overweight among Qatari school children aged 6 to 18 years was analyzed by Bener and Kamal (2005). The mean values for HT, WT and BMI increased with the age for both boys and girls until the age of 18 years, except BMI, which stabilized at the age of 16 to 18 years at around 22.6 for boys and at 21.6 for girls.

A longitudinal study of 494 white boys and girls aged 8 to 18 years was undertaken by Demerath et al. (2006) to examine the degree to which changes in BMI percentile reflect changes in body fat and lean body mass during childhood and how age and gender affect these relationships. Results revealed that FFMI consistently increased with BMI percentile, whereas FMI and PBF had more complicated relationships with BMI percentile depending on gender, age, and whether BMI percentile was high or low. The results also suggested that BMI percentile changes might not accurately reflect changes in adiposity in children over time, particularly among male adolescents and children of lower BMI.

Bundak et al. (2006) constructed the BMI reference curves for Turkish children aged 6 to 18 years, and investigated the prevalence of overweight and obesity. The smoothed percentile values and curves for BMI in Turkish children show that there is a constant increase in BMI values towards adulthood, especially during the pubertal years, in both sexes.

Mc Carthy and Ashwell (2006) examined the influence of age and gender on the WHTR and to compare changes over time in WHTR, in British children (5-16 yr). Results exposed that WHTR decreased with age, with the mean WHTR being significantly lower in girls. They concluded that the values of WHTR during the past 10-20 years have increased greatly showing that central fatness in children has risen dramatically. WHTR is more closely linked to childhood morbidity than BMI and they suggest it should be used as an additional or alternative measure to BMI in children as well as adults.

Freedman et al. (2005) examined the relation of BMI to levels of FM and FFM among children and adolescents aged 5 to 18 years. The association of BMI to FM was markedly nonlinear, and substantial differences in FM were seen only at BMI levels >or=85th percentile. Although a high BMI-for-age is a good indicator of excess FM, BMI differences among thinner children can be largely due to FFM.

Koziel and Malina (2005) completed a longitudinal study of 136 boys (8-16 yr) and 124 girls (8-15 yr) to assess the association between maturational timing and the relative distribution of subcutaneous adipose tissue. The data suggested that early maturing subjects accumulate more subcutaneous adipose tissue on the lower trunk compared with later maturing peers of the same age and sex.

In another study (Al-Sendi et al. 2003) anthropometric (HT, WT, MUAC, WC, HC, TS, SSS, MCS), adiposity (BMI, WHR, STR) and body composition (PBF, AMC, AMA, AFA) characteristics was determined in Bahraini adolescents aged 12-17 years. A sexual dimorphism that appears to be related to differential changes in body composition during puberty was observed. The findings showed that mean BMI, skinfold thickness and PBF were all higher, indicating an increase in fat accumulation among the adolescent population.

A cross-sectional study of 394 adolescence, 11-16 years of age from Caracas, capital city of Venezuela was undertaken by Perez and Landaeta–Jimenez (2001) to assess the influence of WT and HT on WC, BMI and CI in adolescents. Results revealed that at 13-14 years, BMI showed high correlations with WT and high values of WT were associated with high values of CI.

Jackson et al. (2010) studied Waist circumference percentiles for Kuwaiti children and Adolescents. Male children had higher WC than female children. WC increased with age in bothgenders, but larger percentages of male children had WC$90th percentile. Male children aged .10 years have higher WC percentiles than do female children at the 50th, 75th, 90th and 97th percentiles. Conclusions: Male children (especially those aged .10 years) are at higher risk than female children. Few health-care professionals routinely measure WC. WC measurement should be promoted as an important tool in paediatric primary care practice. The use of these age- and gender-specific percentiles can impact public health recommendations for Kuwaiti and other Arab children from the Gulf.

Addo et al. (2010) studied the reference curves for triceps and subscapular skinfold thicknesses in US children and adolescents. The new reference curves exhibit established age- and sex-related patterns of development, including dramatic prepubescent increases in subcutaneous fatness in boys at the highest percentiles. Comparisons of smoothed medians for race-ethnicity groups confirm greater subcutaneous fatness in white children than in black age mates at the triceps site but similar median subscapular skinfold thicknesses. Median skinfold thicknesses for children considered overweight (> or =85th percentile) or obese (> or =95th percentile) on the basis of BMI cutoffs do not follow closely the skinfold percentile reference channels across age, especially in boys, which suggests a certain degree of independence between BMI and skinfold thickness at the upper extremes of the BMI distribution.

Maffeis et al. (2012) assessed dietary intake, cardiovascular risk factors, and the association between diet composition and glycemic control in 114 Italian youth aged 6-16 years with T1D. In prepubertal children, BMI, subcutaneous skinfolds, the prevalence of overweight/obesity, and LDL cholesterol (LDL-CH) were significantly lower in patients than in controls, whereas HDL cholesterol (HDL-CH) was higher. Pubertal boys with T1D did not differ significantly from controls in either anthropometry or lipid profile. Pubertal girls with T1D had a higher BMI and higher triceps skinfolds than controls but not significantly different prevalence of overweight/obesity or lipid profile. Compared to controls, participants with T1D had a lower intake of lipids and simple carbohydrates, a higher ratio of unsaturated/saturated fats and fibre, and a dietary intake closer to the National Reference Dietary Intakes (RDIs). The odds of having an HbA1c higher than 7.5, adjusted for BMI, lipid, and fibre intake, increases by 53% for every 1% increase of energy intake from saturated fat in the diet and by 30% for every year of duration of diabetes.

Bamoshmosh et al. (2013) studied 3114 Yemeni children (1564 boys, 1550 girls) aged 6-19 years participating in the Hypertension and Diabetes. Average WC increased with age for both genders. Boys had a higher WC than girls until early adolescence and thereafter girls had higher values than boys. WHR decreased both in boys and girls until early adolescence. Thereafter while in boys it plateaued in girls it continued to decrease. Mean WHtR decreased until early adolescence with no gender related differences and thereafter increased more in girls than in boys towards adult age.

Meguid et al. (2014) studied 100 children with ASD from the Outpatient Clinic for "Autistic Children" at the Medical Research Hospital of Excellence, National Research Centre in Cairo, Egypt. Of these children at age of 3-10 years, 71 were males and 29 females. Weight and body mass index increased because of a significant increase in subcutaneous fat thickness. This tendency with a probable decrease in muscle mass was more evident in male or in older children, likely resulting from sedentary life style and food selectivity.

Flora et al. (2015) studied A representative sample of 1610 high school adolescents (42.2% boys, 57.8% girls; mean age ± sd 14.4 ± 1.72 years) participated in this cross-sectional study in Attica, Greece, in 2013. Boys had significantly higher mean in all measures than girls, except for BMI where there was no statistical difference in terms of gender. BMI, WC and HC showed an increasing trend with age. WC leveled off in both genders at the age of 17 years. WHR and WHtR showed a continuous decrease with advancing age.

2.2 NATIONAL CONTEXT

In India numerous growth studies have been carried out in different geographic regions of the country which provide important nutritional and anthropometric profiles of children (ICMR 1989, 1996). There is a wide range of data on growth studies and anthropometric measurements among different ethnic groups in India (Singh and Meenakshi 1969, Singh 1970, Murty et al. 1983, Bhasin et al. 1990, Khan et al. 1990, Talwar and Singh 1995, Bishnoi et al. 2004). However, scarce information is available on the anthropometric dimension of Bengalee children and adolescents (Bhadra et al. 2004, Bose et al. 2005). The only previous anthropometric studies on Bengalee boys were undertaken by Hauspie et al. (1980), Pakrasi et al. (1988) and de Onis et al. (2001). However, these investigations did not study body fat distribution and body composition in details.

Nutritional status is a sensitive indicator of community health and nutrition. The growth pattern of a child is a useful criterion for judging his nutritional status. Anthropometry can be used in health programmes to monitor health and nutritional status of individual children (Bishnoi et al. 2004). During school age period, children have special nutritional needs because of their extensive growth and development. A number of studies have been undertaken on the nutritional status of school children and adolescents in India (Bhandari 1975, Rao et al. 1976, Singh et al. 1996, Aneja 1997, Anand et al. 1999, Bhalla 2000, Bhadra et al. 2004).

One of the major health problems in many developing countries including India is widespread prevalence of undernutrition among primary school children. The scourge of undernutrition is even more acute among rural children. National Nutrition Monitoring Bureau collected information in the rural areas of the nine States in India (Venkaiah et al. 2002). Anthropometric and socio-economic information reveals that the extent of undernutrition was high among adolescents and was higher among boys than girls. The prevalence of undernutrition was higher (53.1%) in boys than in girls (39.5%).

A cross-sectional study was carried out by Deshmukh et al. (2006) in rural areas of Wardha district to study the nutritional status of adolescents. Results revealed that overall, 53.8% of the adolescents were thin, 44% were normal and 2.2% were overweight. The mean BMI for boys and girls was 16.88 kg/m^2 and 15.54 kg/m^2 respectively. Kapoor et al. (1998) evaluated fat distribution pattern on growing Jat Sikh boys using WHR and skinfold thickness rankings. The subcutaneous fat distribution pattern as depicted from skinfold thicknesses was found to change with age.

Patterns of growth in anthropometric measurements among the Manipuri children aged 5 to 14 years was reported by Gaur and Singh (1995). All body measurements, except skinfolds, gradually increased from 5 to 14 years. The boys were found to be taller and heavier than the girls up to 10 years and then from 13 years onwards. In between, from 10 to 12 years the girls measured more than the boys for HT and WT.

In another investigation (Talwar and Singh 1995) growth pattern was determined using anthropometric technique in adolescent Meitei boys and girls of Manipur in the age group 11 to 18 years. The findings revealed that Meitei girls show distinctly more subcutaneous fat at all ages than boys. For all other morphological traits boys exhibited larger dimensions except for 13 to 15 years.

In general, data are scarce on the anthropometric and nutritional status of various tribal populations of India (Bose and Chakraborty 2005). The tribal population in India constitutes 7.7% of the total population is characterised by widespread poverty, malnutrition and unhygienic living conditions, which are contributing factors for dismal health conditions. Although, health is one of the crucial parameters of development of a community, researchers have not paid much attention to studying the growth and nutritional status of the tribal communities of India (Reddy and Papa Rao 2000). It has been recently suggested (Bose and Chakraborty 2005) that there is urgent need to evaluate the nutritional status of various tribes of India.

Rao et al. (2005) undertook a cross-sectional investigation based on anthropometric measurements of pre-school children of Gond tribal community in Madhya Pradesh to study the nutritional status. The findings of the study revealed that more than 60 per cent children were underweight.

A cross sectional study of the physical growth status was made on 655 Kamar tribe of Chhattisgarh (341 boys and 314 girls aged 5 to 18 years), by Mitra et al. (2002).

Kamar boys showed higher anthropometric values than girls in almost all measurements except in biilliocrystal diameter and in measured skinfolds.

A mixed longitudinal study of Nagesia, Kanwar and Oraon tribes of Surguja District of Madhya Pradesh was undertaken by Mukherjee et al. (1982). At about 7 years of age an increase in fat thickness occurs in both the sexes. In boys, TS reaches a peak between 11 and 12 years and then falls. But in girls after a similar rise as in boys, there is slight fall between 9 and 10 years.

There are few studies on adiposity, central body fat distribution and body composition among children and adolescents in India. Agarwal et al. (2001) studied BMI, PI and skinfold thicknesses of Indian school going adolescents. It has been suggested by Ramachandran et al. (2002) that overweight increased with age and life style factors influenced BMI in adolescent age. The study highlighted the high prevalence of overweight in adolescent school children in urban India.

Raju et al. (2003) carried out a study to evaluate lung functions and develop prediction equations in Indian schoolboys from Hyderabad city who were in the age group of 5 to 15 years. The anthropometric parameters such as HT, SHT, WT, and CC were measured and BSA and PBF were derived. Age, HT, SHT, WT, CC and FFM showed significant association with lung functions.

Misra et al. (2004) Studied the relationships of insulin resistance with generalised and abdominal obesity, and body fat patterning in 250 urban post -pubertal Asian Indian children. Results revealed that a high prevalence of insulin resistance was associated with excess body fat, abdominal adiposity, and excess truncal subcutaneous fat.

In another study, Vikram et al. (2006) studied the clinical, anthropometric and biochemical characteristics of patients with early onset Type 2 diabetes mellitus (< 30 years of age) and compare them with healthy, non-diabetic individuals. The mean values and the prevalence of abnormal values of measures of generalised obesity (BMI and PBF) and abdominal obesity (WC and WHR) were significantly higher in cases as compared with controls. Early identification of the simple clinical, anthropometric and biochemical parameters which are strongly associated with early onset Type 2 diabetes mellitus in young Asian Indians may be useful for primary prevention.

Pandit et al. (2009) studied Body Fat Percentages by Dual-energy X-ray Absorptiometry Corresponding to Body Mass Index Cutoffs for Overweight and Obesity in Indian Children. High BF% was seen in 38.5% boys and 54.0% girls ($p < 0.05$). Percentage of obese children as defined by the BMI cutoffs of International Obesity Task Force (IOTF) (2.1% for boys and 6.9% for girls) was lower than that using Indian (13.7% for boys and 20.9% for girls) and CDC (14.1% for boys and 20.9% for girls) cutoffs. The point closest to one on the ROC curves of CDC BMI Z-scores indicated high adiposity at BMI cutoff of 22 at the age of 17 yr in both the genders.

A recent research (Swaminathan and Vaz 2012) on childhood physical activity, sports, exercise and non communicable disease reported that the relationship between childhood physical inactivity and noncommunicable disease (NCD) is difficult, since chronic disease and mortality are not direct health outcomes of physical inactivity in children. Published literature explores the relationship of physical inactivity with appearance of early childhood disease risk markers, the adverse impact of which may take some time to appear. Promoting childhood physical activity has multiple benefits including delay in evolution of risk factors contributing to adult degenerative disease. It is clear from available literature that physical inactivity or its surrogates constitute an important independent risk factor for NCD. This is likely to be underestimated not only because of measurement issues, but also because physical inactivity may act through other risk factors for NCD. To recognize and intervene on the issue of physical inactivity in children is important not only for the benefit of the child but in the context of NCD in later life. Studies on physical inactivity and its functional correlates are limited in India and this would be an important area for future research.

Anuradha et al. (2015) studied the prevalence of overweight and obesity and its association with social and environmental determinants among the adolescent school children of Tirupati town of Andhra Pradesh, India. Result reveals that 11.2 percent and 4.8 percent of boys and 10.3 percent and 4.8 percent of girls were overweight and obese.

2.3 REGIONAL CONTEXT

Exploring the previous published reports it is evident that there is very little information on the anthropometric dimensions and nutritional status of adolescent Bengalee boys of West Bengal (de Onis et al. 2001, Woodruff and Duffield 2002, Bhadra et al. 2004). Moreover, none of these studies have dealt, in detail, with adiposity, central body fat distribution and body composition. Majority of studies on adiposity, body fat distribution and body composition on Bengalees have been conducted on adults or elderly (Ghosh et al. 2000, Bhadra et al. 2002, Bose and Das Chaudhuri 2003). Detailed information on body fat distribution and body composition among adolescent Bengalees is lacking (Bhadra et al. 2001, 2005a).

A longitudinal study of 303 Bengalee boys and 260 Bengalee girls was undertaken by Hauspie et al. (1980) in a semi-urban area of south Calcutta to study the growth in HT of the boys and girls aged six months to 20 years. In both sexes, mean HT are below the 10th centile line of the British standards from an early age onwards, mainly due to a smaller prepubertal growth. The adolescent growth spurt in the Indians similar to that seen in British children, as is the age at which it occurs (peak height velocity at 14.0 years in boys, 12.5 years in girls). In another study, Hauspie et al. (1982) investigated the degree of resemblance of the pattern of growth among sibs in Bengalee families.

Chatterjee and Mandal (1994) carried out an anthropometric survey on boys aged 9-18 years of Hooghly district of rural West Bengal to study the growth pattern of boys. Maximum gain in HT and WT of boys was attained at 13-15 yr of age, other anthropometric measurements followed almost similar pattern.

de Onis et al. (2001) undertook a cross-sectional anthropometric investigation and described the growth of adolescent school boys of Calcutta. It was observed that the prevalence of being at risk of overweight was low (4.2%). Mean age at peak height velocity was 13.0 years and peak height velocity was 7.0 cm per year.

Rebato et al. (2005) examined sibling resemblance for HT, WT and BMI in a mixed longitudinal sample from West Bengal, ages 2-19 years, in order to analyse the variations with age of the sibling resemblance for these phenotypes during growth. The results show clear variations with age in the sibling resemblance for the traits HT and WT, though to a lesser extent for BMI.

Bhadra et al. (2004) carried out a cross-sectional study to investigate sex differences in anthropometric characteristics, including central body fat distribution, among 11–14-year-old urban Bengalees of West Bengal. Results revealed that significant sex differences existed in mean anthropometric characteristics. On average, girls were significantly taller and heavier and had greater mean WC than boys until 13 years of age, after which boys had significantly greater mean HT, WT and WC. Girls had significantly greater mean HC and mean skinfolds at all ages, compared with boys. Furthermore, significant positive age trends were observed, in both sexes, for all anthropometric variables except WHR. Thus, central body fat distribution remains unchanged during this period, in both sexes.

A comparative study (Mukhopadhyay et al. 2005a) of 215 sedentary and 313 physically active Bengalee boys aged 10-17 years was undertaken to investigate the differences in overall adiposity, subcutaneous adiposity and body composition. The results revealed that boys who did not undertake regular physical exercise had a significantly greater mean BMI compared with those who undertook regular physical exercise. The means for all the skinfolds as well as PBF, FM and FMI were significantly higher among the sedentary group. The percentile distributions of all these variables and indices were consistently higher among the sedentary group. In conclusion, this study provided evidence that Bengalee boys, who undertook regular physical exercise, had significantly less adiposity compared with those who did not undertake regular physical exercise.

Mukhopadhyay et al. (2005b) conducted a cross-sectional study of 502 Bengalee boys aged 10-16 years of North 24 Parganas, West Bengal, was undertaken to study regional adiposity, body composition and central body fat distribution. In general, there was a significant linear increasing trend from 10 to 16 years for all the anthropometric variables. Significant linear increasing trend was observed for all the body composition measures. However, an overall decreasing trend was observed, in mean WHR from 10 to 16 years. Boys aged 10 years had the highest mean WHR while those aged 15 years had the lowest mean WHR. There was an increase in mean WHR among 16 year old boys.

Bose and Mukhopadhyay (2004) studied the level of undernutrition among 10-16 year old Bengalee boys of North 24 Parganas, West Bengal. The overall rate of undernutrition was 37.65%. The rates of undernutrition varied between 19.3% among 16 years olds to 53.4% at age 14 years. There was a consistent increase in the rate of undernutrition from 10 (36.5%) to 14 years (53.4%). Thereafter, there was a steady decline at ages 15 (36.8%) and 16 (19.3%) years.

Mukhopadhyay et al. (2005) conducted a comparative study of 215 sedentary (no regular physical exercise undertaken) and 313 physically active (regular physical exercise undertaken) Bengalee boys aged 10-17 years was undertaken to investigate the differences in overall adiposity (body mass index), subcutaneous adiposity (skinfolds) and body composition (percent body fat, fat mass and fat mass index). Both groups had a similar age. The results revealed that boys who did not undertake regular physical exercise (NPE) had a significantly greater mean body mass index (BMI) compared with those who undertook regular physical exercise (PE); $p < 0.001$. The means for all the skinfolds as well as percent body fat (PBF), fat mass (FM) and fat mass index (FMI) were significantly higher among the NPE group. In conclusion, the study provided evidence that Bengalee boys, who undertook regular physical exercise, had significantly less adiposity compared with those who did not undertake regular physical exercise.

Chowdhury et al. (2007) studied the fat patterning among 1012 Santal children, aged 5-12 years, in Puruliya district of West Bengal, India. Maximum gaining of %BF and FFM was found at ages 11-12 years in both sexes. Difference of FFM between 5 and 12 years of age was found to be highest in girls (18.7 kg) than in boys (14.92 kg). Body fat percentage of girls was significantly ($p < 0.05$) higher (except in 8 and 9 years old) than that of boys. FMI and FFMI of girls showed different pattern than that of boys. FFM and %BF showed significant ($p < 0.01$) relationship with all anthropometric variables.

Ghosh (2010) investigated association of anthropometric, body composition and physiological measures with physical activity level among the children and adolescents of Asian Indian origin: the Calcutta obesity study. The study reported that habitual moderate physical activity may be beneficial to prevent excess accumulation of fat during childhood and adolescence and warranted further investigation about the importance of physical activity to prevent increasing trend of childhood obesity.

Dasgupta et al. (2010) studied Assessment of Malnutrition Among Adolescents:Can BMI be Replaced by MUAC among the adolescents of an urban slum of Kolkata. Results showed 47.93% of study population as per BMI and 60.30% as per MUAC were malnourished.

Mandal et al. (2011) studied the Impact of social class on body fatness among rural pre-school Bengalee Hindu children in 1012 boys and girls (aged 2- 6 years) of Arambagh, West Bengal, India.There was an increasing age trend in both these variables in both sexes in the two groups. All three factors had a significant effect on MUAC, whereas only age and social class had a significant impact on SS. In the case of MUAC, only one second order interaction (sex-age) was significant. In conclusion, they found that after controlling for age and sex, children belonging to the SC group had lower body fatness. These results implied that they were under more nutritional stress. There was also some evidence that at the early ages, girls belonging to the SC group probably received inadequate nutrition and as a result had lower body fat.

Sen et al. (2013) studied the Fat mass and fat-free mass as indicators of body composition among Bengalee Muslim children. The age-specific mean values of FM and FFM ranged from 1.93-3.07 kg (boys) and 1.91-3.62 kg (girls) and from 14.69-23.44 kg (boys) and 14.18-22.87 kg (girls), respectively. Statistically significant sex differences were observed in FM and FFM ($p<0.05$).

Singh et al. (2014) studied among 1545 (770 boys; 775 girls) Sonowal Kacharis of Dibrugarh District, Assam, Northeast-India. Age and sex-specific muscularity were found significantly greater among boys than girls ($p<0.01$), while adiposity was significantly greater among girls ($p<0.01$), particularly when they approached to puberty. The overall prevalence of low and below-average UAMAH was found to be 16.38% and 22.65% respectively. The overall prevalence of thinness was 23.69% (26.36% boys, 21.03% girls) ($p>0.05$).