ASSESSMENT OF NUTRITIONAL STATUS AMONG THE RAJBANSHI POPULATION OF NORTH BENGAL

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Dedicated to My Parents

Mr. Fani Bhusan Mondal

And

Mrs. Shephali Mondal

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LIST OF ABBREVIATIONS

Σ4SKF	Sum of Four Skinfolds
24-HR	24-hour recall
AFI	Arm Fat Index:
ANOVA	One-Way Analysis of Variance
BFMA	Bone Free Muscle Area
BMI	Body Mass Index
BSF	Biceps Skin Fold
CBR	Crude Birth Rate
CED	Chronic Energy Deficiency
CFR	Centripetal Fat Ratio
CI	Conicity Index
CIAF	Composite Index of Anthropometric Failure
FAO	Food and Agriculture Organization
FFQ	Food Frequency Questionnaire
GLV	Green Leafy Vegetables
HC	Hip circumference
HLA	Human Leukocyte Antigen
ICDS	Integrated Child Development Scheme
ICMR	Indian Council of Medical Research
IDECG	International Dietary Energy Consultative Group
INP	India Nutrition Profile
LBW	Low Birth Weight
mt-DNA	Mitochondrial-Deoxyribo Nucleic Acid
MUAC	Mid Upper Arm Circumference

NCBI	National Center for Biotechnology Information
NCD	Non-Communicable Disease
NCHS	National Centre of Health Statistics
NFHS	National Family Health Survey
NIN	National Institute of Nutrition
NLM	National Library of Medicine
NNAP	National Nutritional Anaemia Prophylaxis Programme
NNMB	National Nutrition Monitoring Bureau
PBF	Percent of Body Fat
PCM	Protein-Caloric Malnutrition
PEM	Protein-Energy Malnutrition
RDA	Recommended Dietary Allowance
RI	Rohrer Index
SES	Socio-Economic Status
SISF	Suprailiac Skin Fold
SSF	Sub-Scapular Skin fold
TEM	Technical Errors of Measurement
TSF	Triceps Skin Fold
TUA	Upper Arm Area
UFA	Upper Arm Fat Area
UMA	Upper Arm Muscle Area
WC	Waist Circumference
WHO	World Health Organization
WHR	Waist-Hip Ratio
WHtR	Waist-Height Ratio

CONTENTS

CHAPTER-I:

INTRODUCTION

INTRODUCTION

1.1. INTRODUCTORY NOTES

Food contains various substances that are required for normal growth and development. These substances ("*nutrients*") comprise of proteins, carbohydrates, fats, vitamins and minerals. The amount of each nutrient required by an individual depends upon his/her age and physiological status. Adult individuals need nutrients for maintaining constant body weight and ensuring proper body functions. Infants and growing children require more nutrients not only for the maintenance of body function but also for their growth and development. A balanced diet and proper nutrition are two very important issues in the promotion and maintenance of good health throughout life. Their role as deterrents of malnutrition and Non-Communicable Diseases (NCDs) is well established and this occupies a prominent position in nutritional assessment. Nutritional status is now recognized to be a prime indicator of the overall health of a population or an individual. The World Health Organization (WHO) goes on to state that the ultimate objective of nutritional assessment is the overall improvement of the quality of human health (Beghin *et al.*, 1988). The prevalence of under-nutrition is now a major public health concern in many of the developing countries. The assessment of nutritional status thus has a potential role to play in formulating developmental nutritional intervention strategies of the concerned populations. Nutritional status is reflected in a variety of metabolic processes that provide the basis for the number of methods for its assessment.

Hunger and malnutrition remain two of the most important issues facing the majority of worlds' poor and under-privileged populations. Nearly 30.00% of the populations are currently suffering from malnutrition. Over 2000 million people world-wide are currently suffering from iron deficiency. Nearly 250 million children under 5 years of age suffer from iron deficiency, which remains the single-most cause of childhood under-nutrition.

Approximately 60% of the 10.9 million deaths each year among children aged less than 5 years of age in the developing world are associated with malnutrition. Malnourished children suffer from longer and more severe illnesses (Black *et al.*, 1984; Sepulveda *et al.*, 1988) and have a higher risk of mortality and morbidity (Pelletier, 1994, 1998; Schroeder and Brown, 1994) as compared to well nourished ones. Malnutrition can also lead to delayed motor development (Pollitt *et al.*, 1994) and lower cognitive function and school performance (Pollitt, 1990) among children. Adult individuals who were malnourished as children exhibit impaired physical work capacity (Haas *et al.*, 1995) and lower reproductive performance (WHO, 1995; Martorel *et al.*, 1996). Malnutrition can also have negative effects on the children of the affected individuals (Ramakrishnan *et al.*, 1999).

Nutrition is the single most important component of preventive health care in a country and individual nutritional levels are closely related to health and disease. The nature of the diet is associated with diseases such as cancer, heart disease, diabetes, hypertension, arteriosclerosis, and liver cirrhosis. An optimum and sufficient nutrition level is the level of intake that promotes the highest level of health. However, an excess caloric intake leads to obesity, whereas a deficit results in depletion of essential nutrients. These alterations can lead to biochemical changes and eventually to clinical signs and symptoms. Nutrition requirements are influenced by many factors such as gender, age, physical activity, physiological status, drugs and alcohol intake. The ability of the human individual to respond to stresses like high altitude, heat, trauma, surgery, and infection are also strongly associated with nutritional status. However, as individuals grapple with ever-increasing sedentary life styles and less physically demanding jobs, the caloric requirements are reduced. This has made nutritionally sound food choices more difficult.

It is a well known fact that contemporary India is composed of a sizeable number of ethnic and indigenous elements having enormous amounts of ethnic and genetic diversity

(Beiteille, 1998; Majumder, 1998; Indian Genome Variation Consortium 2008). The country has one of the highest burdens of under-nutrition in the world and is beginning to experience the emerging problem of overweight and obesity (Visscher and Seidell, 2001; Mendez *et al.*, 2005; Vas *et al.*, 2005). Although, a rapid overall development has occurred in India during the last two decades in the field of public health (Griffiths and Bentley, 2001), the country shows disappointing results in the context of nutritional assessment as more than half of the world's undernourished population lives here (Krishnaswami, 2000). During the last twenty five years, a large database has been accumulated on the diet and nutritional status of rural populations belonging to different states of India. The National Nutrition Monitoring Bureau (NNMB) and the National Institute of Nutrition (NIN) have carried out extensive diet and nutrition surveys in twelve states where the diets were found to be inadequate and/or deficient in most of the nutrients (Vijayaraghavan and Rao, 1998). The reasons behind this inadequacy and/or deficiency were attributed to extreme poverty, low socio-economic status (low SES), poor living conditions and inadequate dietary intake (Ramachandran, 2007; Antony and Laxmaiah, 2008; Mahal and Karan, 2008). Lack of diversity in diets is another particularly severe problem encountered among the poor populations, where diets are based predominantly cereal based and often included little or no animal products and only seasonal fruits and vegetables (Gopalan *et al.*, 2003). It has also been observed by Rao (2001) that the nutritional scenario in India is passing through a transitional phase where the vast majority of the adult populations are suffering from Chronic Energy Deficiency (CED) and NCDs such as diabetes, hypertension and coronary heart disease. Lower maternal nutritional status, high prevalence of low birth weight (LBW), high morbidity and mortality in children are some of the other major nutritional manifestations associated with lower SES among Indian populations (Ramachandran, 2007).

1.2. DEFINITIONS OF THE TERMS "NUTRITION", "UNDER-NUTRITION" AND "MALNUTRITION"

The terms '*nutrition*', '*under-nutrition*' and '*malnutrition*' have been conceptualized and defined in many ways. The Webster's dictionary defines '*nutrition*' as "the series of processes by which an organism takes in and assimilates food for promoting growth and replacing worn and injuries tissue" (Webster's New Universal Unabridged Dictionary, 1983). The term '*undernourished*' has been defined as "to provide with less than the least amount of food needed for health and growth". This dictionary also includes the term '*under-nutrition*' which has been defined as "deficient bodily nutrition due to inadequate food intake or faulty assimilation". The 6th World Food Survey Report published by the Food and Agriculture Organization (FAO) defines '*under-nutrition*' as a state of dietary energy deficiency whereby an individual is unable to maintain good health (in the sense of being free from avoidable morbidity, risk for premature mortality and so on) or the desire level of physical activity" (FAO, 1996). Although this definition considers energy as the primary nutrients of interest, it is suggested that the optimal state of "good health" be considered as a point of reference. The Webster's dictionary has also defined 'malnutrition' as "faulty or inadequate nutrition, undernourishment resulting from insufficient food, improper diet etc" (Webster's New Universal Unabridged Dictionary, 1983).

In the literature, the terms '*under-nutrition*' and '*malnutrition*' have often been used interchangeably, traditionally in reference to the situation when an individual has an inadequate intake (or utilization) of protein and energy (or total calories). Presently, these terms are still widely used in a generic sense to refer Protein-Energy Malnutrition (PEM) or Protein-Caloric Malnutrition (PCM). However, with the gradual recognition of the critical role of micronutrients in maintaining good health and survival, the concepts of under-nutrition and malnutrition needed to be expanded.

The term '*micronutrient malnutrition*' is now commonly used to describe under-nutrition. It refers to the situation where individuals have an inadequate intake, absorption or utilization of one or more of the micronutrients. In recent years, research projects and intervention programmes especially in developing countries have focused on micronutrients such as vitamin-A, iron, iodine and zinc. Each micronutrient has multiple functions in the human body and an inadequate intake, absorption, or utilization of any one of them may result in a variety of adverse health consequences. Deficiencies in vitamin-A, iron deficiency, iodine and zinc, along with PEM represent different forms of under-nutrition that again contribute to the global burden of mortality and morbidity.

1.3. THE NUTRITIONAL TRANSITION IN INDIA

In the global context, a number of countries are witnessing demographic and nutritional transitions. The term '*nutritional transition*' is used to depict the shift in disease patterns towards nutrition related NCDs. This shift is associated with changes in behaviour, lifestyle, diet, physical activity, smoking and alcohol consumption (Amuna and Zotor, 2008). The rapidity of such nutritional transitions is clearly visible in the emerging developing nations of Asia (Kosulwat, 2002; Lipoeto *et al.*, 2004). There is also an evidence of such a rapid nutritional transition amplifying the burden of chronic diseases and obesity in India (Shetty, 2002). Time trends in childhood obesity has already predicted an escalating burden of obesity related issues in the near future in this country. A number of other countries have also reported significant levels of malnutrition and child mortality together with rising prevalence of obesity and NCDs. This double burden is a result of an interaction between various factors where social inequality merits more attention than others. Social inequality has also emerged as a major factor in differential mortality in both the developed and developing countries.

The background to Indian's nutritional transition can be traced back to the rapid economic and demographic transformations that had taken place. During the last 30 years, there has been a sustained rise in average living standards. The gross domestic product per capita rose by 23%. Poverty continued to decline at an annual rate of 0.88% during the period from 1983 to 1994 and at a slightly lower rate of 0.77% from 1993 to 1905. Life expectancy has also steadily risen from 54 years to 69 years while the Crude Birth Rate (CBR) has fallen from 34 to 22 from 1980 to 2008. Rapid economic growth has been also been accompanied by rising urbanization. During the last two decades of the 20th Century, the share of the urban population rose from 23.00% to 28.00%. By the year 2030, it is estimated to rise to 41.00%. This momentum in growth has been strongly influenced and accelerated by a wide ranging domestic and external liberalization of the Indian economy set in the 1990s. A key feature of this economic transformation has been the change reflected in the nature of the diet. There has been a perceptual shift from inferior to nutritionally sound superior foods and a substitution of the traditional staples by primary food products that are more prevalent in the western diets. These shifts were subsequently reflected in higher consumptions of proteins, sugars, fats and vegetables.

However, India still remains one of the poorest countries in the world with a population of over one billion and a fertility rate well above the replacement level (World Bank, 2000). With more than half of the world's undernourished individuals living in this country (Krishnaswami, 2000), the improvements in nutritional status of these individuals have not been quite impressive (Griffiths and Bentley, 2001). Measham and Chatterjee (1999) suggested that one of the key causes of malnutrition among the individuals in this country was the lack of access to sufficient food and resources. Nutrition research in India has mainly focused on the problem of under-nutrition, particularly among women and children. A study conducted by the National Family Health Survey 1998-1999 (NFHS-2) showed that a significant proportion of Indian women were affected with under-nutrition and anaemia. Moreover, the health status of women in this country reflected gender discrimination from birth (Sharma, 1995; Murthy, 1996; Measham and Chatterjee, 1999), along with inadequate distribution of health resources (Ganatra and Hirve, 1994; Sharma, 1995; Choi and Lee, 2006; Singh, 2012) and early and frequent reproductive cycling and infections (Coyaji, 1991; Sarin, 1992; Ghosh, 1995; Koblinsky, 1995; Rajaram *et al.*, 1995; Brabin *et al.*, 1998).

It is now an established fact that India is in the midst of rapid socio-economic, demographic, nutritional and health transitions. While the country is yet to overcome poverty, under-nutrition and the incidence of communicable diseases, it is increasingly facing problems related to affluence as a result of industrialization, urbanization and economic betterment. Over the last two decades, over-nutrition and obesity have emerged as major public health issues. There has also been a progressive increase in the prevalence of diabetes and cardiovascular diseases especially in the urban areas. Their magnitude varied between states, between urban and rural areas and between different socio-economic groups. The NNMB and the India Nutrition Profile (INP) surveys (NNMB, 1979-2002; INP, 1995-96) observed that the prevalence of under-nutrition was lower among urban adults than rural adults. Prevalence of over-nutrition was higher in the urban areas, while over the last three decades there has been a progressive decline in under-nutrition and some increase in over-nutrition in both the urban and rural areas. Data from the NFHS (1998-99) showed the prevalence of under-nutrition in urban areas to be 50% of that in rural areas of India. The data also suggested that the prevalence of under-nutrition continued to be higher among poorer women while over-nutrition and obesity were emerging as major problems among wealthier women. As a result, it has been opined that the country should gear up for the detection and management of this dual burden (Subramanian and Smith, 2006; Subramanian *et al.*, 2007).

The NNMB surveys were the only surveys that provided data on time trends in intra-family distribution of food and dietary intake and nutritional status of all age groups over the last three decades among different populations. The amount of food consumed was compared with the Recommended Dietary Allowance (RDA) as drawn up by the Indian Council of Medical Research (ICMR) in 1989 (Gopalan *et al.*, 1993). It was observed that over the last three decades, there has been some decline in cereal consumption in both the urban and rural areas. Over the same period there has been a steady decline in the consumption of pulses, which remains a major source of protein in Indian diets. The consumption of vegetables and fruits continued to be very low. In the rural areas there were no significant increases in per-capita consumption of fats, oils, sugar and jaggery. It has been further suggested that the dietary intake has not undergone any major shift towards increases in the consumption of processed food and energy intake.

The country is now facing a dual burden of high communicable and rising NCDs (World Bank, 1993). A progressive decline in poverty ratio and a steep increase in per capita income have been suggested to be the main reasons. Economic improvement inevitably results in improved purchasing power and that can lead to increases in energy intake from fats, sugar, refined carbohydrates, and reduction in energy intake from complex carbohydrates and reduction in dietary fiber. Simultaneously there has been a reduction in physical activity and perhaps an increase in work-related stress because of changes in occupation. The increase in the proportion of body fat as measured by the body mass index (BMI) and the prevalence of abdominal obesity is higher among Indians (Ramachandran, 2004; Ramachandran *et al.*, 2004). The prevalence of over-nutrition and abdominal obesity are closely associated with increased risks of hypertension and diabetes among Indians adults

(Yagnik, 1998; Gupta *et al.*, 2003; Gupta 2004; Bhargava *et al.*, 2004; Deshmukh *et al.* 2006a; Gupta *et al.* 2007; Gupta *et al.*, 2008). A review of the studies suggested a steady increase in the number of NCDs in the country and that this increase is most marked in the urban areas.

Nearly one-third of all Indian infants weigh less than 2.5 kg at birth. Incidence of LBW appears to be the highest among low-income groups (Prema, 1989). With an increase in survivability of LBW neonates, there are growing concerns about the relationship between LBW and poor growth during childhood and adolescence as well as the increased risk of chronic degenerative diseases in later life. A sizable number of studies are available from India on the prevalence of LBW and its associated factors (Rajanikumari *et al.*, 1986; Bhargava *et al.*, 1991; Kinare *et al.*, 2000; Rao *et al.*, 2001; Dwarkanath *et al.*, 2007).

The prevalence of anaemia and iron deficiency is widespread among Indian populations, especially among women and children. Anaemia remains to be major cause of maternal mortality accounting for over 20.00% of all maternal deaths. The nationally representative data from the NFHS (1998-1999) on anaemia among women described the magnitude of this problem. More than a third of all Indian women had a BMI <18.50 kg/m^2, thereby reflecting CED and micronutrient deficiency. The prevalence of anaemia among them was 52%, whereas 15% of them were classified as moderately anaemic and 2% as severely anaemic. A recent study has also suggested that nearly 50% of all young Indian women were anaemic (Thankachan *et al.*, 2007). The preponderance of malnutrition in terms of micronutrient deficiency appears to be the primary factor responsible for the high prevalence of anaemia and iron deficiency. It has been reported by Singh (2004) that over two-thirds of all Indian children exhibited clinical evidences of iron deficiency and also that deficiencies of trace minerals such as iodine and zinc were quite common. As a result, India became the first developing country to take up a National Nutritional Anaemia Prophylaxis Programme (NNAP) to prevent anaemia among pregnant women and children.

1.4. METHODS OF NUTRITION STATUS ASSESSMENT IN HUMANS

The nutritional status of an individual is the result of many interrelated factors such as his/her physical health (WHO, 1978). The objectives of nutritional assessments are twofold:

a) To obtained precise information on the prevalence and the geographic distribution of under- and over-nutrition status of a given population.

b) To identify the at-risk group within the population who are in need of nutritional assistance.

The objectives have been aptly reviewed by Hetzel (1985) who also observed that the main thrust of nutritional assessment studies was to develop health care facilities that met the needs defined by the assessment, including evaluation and effectiveness of subsequent programmes. The assessment of nutritional status of an individual or a population involves various techniques. Proper evaluation demands a multi-dimensional approach, covering all the different strategies. Jelliffe (1966) in his excellent monograph "*The Assessment of the Nutritional Status of the Community*" has proposed six methods for the assessment of nutritional status. In general, the WHO has classified the available methods of assessing nutritional status into two categories:

a) Direct methods (e.g., anthropometry and biochemical techniques)

b) Indirect methods (e.g., vital statistics)

1.4.1. ANTHROPOMETRY

Anthropometry is a non-invasive and an inexpensive technique that has been widely used to assess the size and proportion of the human body. It is a useful technique to assess nutritional status and body composition of an individual or a population (Jelliffe, 1966; WHO, 1966; Hamieda and Billot, 2002).

The measurements of height, weight, skinfold thicknesses and arm circumference are valuable indicators of nutritional status. The additional measurements include head circumference and chest circumference. The measurements of Mid-Upper Arm Circumference (MUAC) (James *et al*., 1994; de Onis *et al*., 1997) and Waist Circumference (WC) (WHO, 2000) are also useful in the assessment of under- and over-nutrition respectively. Skinfold measurement such as Biceps Skin Fold (BSF), Triceps Skin Fold (TSF), Sub-scapular Skin Fold (SSF) and Supra-iliac Skin Fold (SISF) are also frequently used to estimate subcutaneous adiposity and thus nutritional status (Weiner and Lourie, 1981; Gibson, 1990; Lee and Neiman, 2005). Percent of Body Fat (PBF), upper arm composition in terms of Upper Arm Muscle Area (UMA), Upper Arm Fat Area (UFA) and TSF-for-age can are also used for the assessment of nutritional status.

A number of indices are calculated from the anthropometric measurements. The commonly used ones are stunting (low height-for-age), underweight (low weight-for- age), wasting (low weight-for-height), thinness (low BMI-for-age), MUAC-for-age and MUAC-for-height. These indices are expressed in terms of Z-scores or percentiles. The WHO recommends a comparison of these indices with an international reference population to determine under-nutrition (Dibley *et al*., 1987). The justification for use of a reference population is the empirical finding that well-nourished children of all populations follow very similar growth patterns (Habicht *et al*., 1974).

The BMI is a surrogate anthropometric indicator of overall adiposity (both overweight and obesity) and is an established indicator for adult nutritional assessment (Weiner and Lourie, 1981; Gibson, 1990; Lee and Nieman, 2005; WHO, 1995). Such assessments using BMI is very suitable in the field situations (James *et al*., 1988; Ferro-Luzzi *et al*., 1992; Ferro-Luzzi and James, 1996). The use of BMI, together with WC, Waist-Hip

Ratio (WHR), Waist-Height Ratio (WHtR), and Conicity Index (CI) have been found to be quite useful for the differentiation of overweight and obesity among adult individuals.

1.4.2. Biochemical Assessment

The underlying principle of this method is that any changes in the quantity and composition of the diet and nutrients are reflected by variations in the concentrations of nutrients or their associated compounds in different body tissues and fluids along with the appearance or disappearance of metabolites. Such estimations of the concentration levels reflect the nutritional status of the individuals. The most important laboratory tests include haemoglobin estimation and stool and urine tests. With the increasing knowledge of the metabolic functions of vitamins and minerals, assessment of nutritional status by clinical signs has given way to more precise biochemical tests which may be applied to measure individual nutrient concentration in fluids and biomarkers (*e.g.*, whole blood, serum and head hair). The tests can also include the determination of metabolites in urine (*e.g.*, urinary iodine) or estimation of enzymes to document malnutrition in the pre-clinical stages. The biochemical tests also include estimation of vitamins and essential trace element concentrations.

1.4.3. Clinical Examination

The 1963 WHO Expert Committee on Medical Assessment of Nutritional Status provided a classification of the physical signs that can be utilized for nutritional assessments. This classification was subsequently updated in the WHO Monograph Series No. 53 entitled "*The Assessment of the Nutritional Status of the Community*" (Jelliffe, 1966). The WHO classification is very helpful when a rapid nutritional screening of a population is required within a stipulated time frame and also for specific research studies that needs to evaluate certain signs and symptoms.

1.4.4. DIETARY INTAKE

Methods of dietary intake at the individual or the population level utilize various procedures to estimate food, energy and nutrient intakes. Direct assessment of food consumption involves a dietary survey which may be conducted either at the household or the individual level. Such a survey provides information about the dietary intake patterns of specific foods consumed and estimated nutrient intakes. The dietary assessment methods are useful to evaluate the nutrient intake for research or large scale surveillances and in clinical assessment. This method has also assumed prime importance as nutritionists now recognize the major role that nutrition plays in the prevalence of obesity, heart diseases and diabetes (together termed as "*etiology of common chronic diseases*"). Accurate and reliable methods for assessing dietary intake of a free living population are desirable to answer important questions regarding associations between the processes involved in the etiologic of disease (Beaton *et al.*, 1983). Dietary investigations are carried out using a number of methods. These methods are the 24-hour recall (24-HR) method, weighted intake method, food frequency questionnaire (FFQ), food diary, dietary history and oral questionnaire method (Gibson, 1990; Lee and Nieman, 2005).

The most widely used method for field of dietary intake is the 24-HR method (Beaton *et al.*, 1983; Baranowski *et al.*, 1991; Egger *et al.*, 1991; Nicklas *et al.*, 1995; Olinto *et al.*, 1995). In the developed countries, the FFQ have been also utilized for identifying dietary risk factors associated with chronic diseases like coronary artery disease and various forms of cancers (Graham *et al.*, 1967; Bjelke, 1975; Date *et al.*, 1996; Shu *et al.*, 2004).

Bingham *et al.* (1994) compared the FFQ and the 24-HR methods and observed that these methods were closely associated with diet and there was no significant different between the in average food and nutrient intake. A validation study conducted by Beer-Borst and Amada (1995) on self-administered 24-HR questionnaires among 3,653 individuals concluded that the self-administered 24-HR questionnaire was a valid method for estimating the median and mean dietary intakes of such large groups of individuals. The feasibility and relative validity of the 24-HR method was also tested on 60 pregnant women in rural southern Malawi by Ferguson *et al.* (1995). Relative validity was assessed by comparing the intakes from two 24-HRs with those assessed by using two weighed records (reference method) conducted on the same two days. The average intakes obtained by the two methods were in good agreement with each other, thus confirming that the 24-HR method could be used to determine average intakes. Schatzkin *et al.* (2003) in their comparison of the FFQ and 24-HR methods also observed the utility of these methods for detecting protein and energy intake statuses.

SES plays a major role in the dietary intake the dietary intake of individuals and population groups. A number of studies was undertaken to understand the effects of SES on the dietary intake of populations (Egger *et al.*, 1991; Ivanovic, 1992; Bialostosky *et al.*, 2002; Barquera *et al.*, 2003; Capdevila *et al.*, 2003; Borges-Yañez *et al.*, 2004; Vitolo *et al.*, 2006; Manios *et al.*, 200 9; Montenegro-Bethancourt *et al.*, 2009). Using the 24-HR method, Egger *et al.* (1991) showed that children belonging to a lower SES had a lower fat intake, a lower contribution of fat to the energy intake and a higher contribution of carbohydrates to the energy intake as compared to children belonging to a higher SES. Barquera *et al.* (2003) reported that socioeconomic status reflected an increasing availability of inexpensive calorie-dense foods in marginal groups, and total energy, cholesterol, saturated and total fat were consumed in greater quantities by women from higher SES of the urban areas. Similar results were also reported on the consumption pattern and SES among Spanish adult individuals (Capdevila *et al.*, 2003). Studies have also reported that certain demographical and socio-economic factors influenced the dietary habits of individuals (Manios *et al.*, 2009; Velasco *et al.*, 2009).

1.4.5 Vital Statistics

An analysis of the mortality and morbidity data, along with infant mortality rate, second year child mortality rate, rate of low birth weight and the life expectancy can also identify the at-risk groups with regards to nutritional status. The data on morbidity in the clinical settings or community health and morbidity surveys particularly those in relation to the protein energy malnutrition (PEM) and vitamin deficiencies are valuable in providing additional information with regards to the nutritional status of populations.

1.4.6. Ecological Studies

Malnutrition is the end result of many interacting ecological factors. In many nutritional surveys it becomes necessary to collect the ecological information of the given community in order to make a complete nutritional assessment. A study of the ecological factors comprised food balance sheets, a number of socio-economic factors, health and educational services and finally conditioning influences.

1.5. REVIEW OF THE PUBLISHED LITERATURE

As the scope of the present study is limited to nutritional assessment using the methods of anthropometry and dietary intake, a review of the studies done in these two aspects are being detailed below.

1.5.1. Non-Indian Studies done on Nutritional Assessment using Anthropometry

Anthropometry is a useful technique to assess nutritional status and body composition of an individual or population (Jelliffe, 1966; Rao *et al.*, 1976; Gorstein *et al.*, 1994). This technique has been successfully utilized by various researchers to document nutritional status of different human populations. The studies of Rolland Cachera, (1989), Rolland Cachera *et al.* (1991), Pelletier *et al.* (1991, 1994, 1998), Dittwyler (1992), Ferro-Luzzi *et al.* (1992) Strickland and Ulijaszek (1993), Giay and Khoi (1994), Aiken (1995), Alemu and Lindbjorn (1995), Rotimi *et al.* (1995), Ferro-Luzzi and James (1996), Martorel *et al.* (1996), Higgins and Alderman (1997), Zerihun *et al.* (1997), Smolej-Narancić (1999), Teller and Yimar (2000), Kuczmarski *et al.* (2000), Bloom *et al.* (2001), Chilima and Ismail (2001), Bakr *et al.* (2002), Schutz *et al.* (2002), Nubé and van den Boom (2003), Kyle *et al.* (2003), Zohoori *et al.* (2003), Zverev and Chisi (2004), Pichard *et al.* (2004), Nikolic *et al.* (2005), Tur *et al.* (2005), Barker *et al.* (2006), Sánchez-García *et al.* (2007), Shafique *et al.* (2007), Huxley *et al.* (2008) and Nubé (2009) may be cited here.

The BMI is a useful indicator in assessing the health condition of a community. It is also now an established anthropometric indicator used for the assessment of adult nutritional status (Weiner and Lourie, 1981; James *et al.*, 1988, 1994; Gibson, 1990; Ferro-Luzzi *et al.*, 1990, 1992; Naidu and Rao, 1994; Shetty and James, 1994; Bailey and Ferro-Luzzi, 1995; WHO, 1995; Ferro-Luzzi and James, 1996; Lee and Nieman, 2005). The FAO and the International Dietary Energy Consultative Group (IDECG) have suggested that BMI should also be used to define adult CED (Weisell, 2002). Studies have recognized that BMI was a good indicator for the understanding of under-nutrition in terms of CED among different populations (Ferro-Luzzi *et al.*, 1990, 1992; Gibson, 1990; WHO 1995; Ferro-Luzzi and James, 1996; Lee and Nieman, 2005). Several studies have also investigated the relationship between SES, BMI and CED among different ethnic populations (Deurenberg *et al.*, 1991; Pryer, 1993; Shetty and James, 1994; Delpeuch *et al.*, 1994; Ahmed *et al.*, 1998; Nubé *et al.*, 1998; Khongsdier, 2001, 2002, 2005; Pryer *et al.*, 2003; Clausen *et al.*, 2006; Monteiro *et al.*, 2007; Shannon *et al.*, 2008). Studies have also focused on the association of percent body fat with BMI (Deurenberg-Yap *et al.*, 2000; Shah *et al.*, 2005; Kolt *et al.*, 2007). Studies have also evaluated the relationship between BMI and mortality (Costa, 1993; Allison *et al.*, 1997; Calle *et al.*, 1999; Khongsdier, 2002, 2005). A study conducted in the developing countries has observed that women with a BMI less than 18.50 kg/m^2 showed a progressive increase in mortality rate and an increased risk of illness (Rotimi *et al.*, 1999) and associated health problems during pregnancy and lactation (Allen *et al.*, 1994; Prentice *et al.*, 1994).

An understanding of distribution and redistribution of fat is necessary in order to assess obesity and under-nutrition within a population. The BMI, together with different adiposity indicators such as WHR, CI and WHtR has been observed to be very useful for the differentiation of over-nutrition (overweight and obesity) among adults. The WHR provides an indication of the predominance of fat storage in the abdominal region (regional adiposity). Furthermore, WC can also be useful to assess nutritional status (*e.g.*, overweight and obesity) of adults and children (WHO, 2000). The skinfold measurements have been the most frequently used for the estimation of subcutaneous adiposity. The measurement of BSF, TSF, SSF and SISF gives the adiposity measures and reflects the nutritional status (Siri, 1956; Durnin and Womersely, 1974; Frisancho, 1974, 1981, 1989; Gibson, 1990; VanItallie *et al.*, 1990; Eckhardt *et al.*, 2003).

The MUAC is another simple anthropometric measurement that has been extensively used to determine the nutritional status of adult individuals, particularly from different ethnic population in the developing countries (Bern and Nathanail, 1995; Collins, 1996; Ferro-Luzzi and James, 1996; Gartner *et al.*, 2001; Khadivzadeh, 2002; Zverev and Chisi, 2004; Bose *et al.*, 2007a; Bisai and Bose, 2009; Lemma and Shetty, 2009; Chakraborty *et al.*, 2009; Chakraborty *et al.*, 2011). James *et al.* (1994) after an extensive study in eight countries (Mali, India, Senegal, Zimbabwe, Somalia, Ethiopia, Papua New Guinea and China) suggested that MUAC could be used for a simple screening of adult nutritional status. It has also been opined that BMI in combination with MUAC can provide a much better assessment of CED (Ferro-Luzzi *et al.*, 1992; James *et al.*, 1994; Bern and Nathanail, 1995; Ferro-Luzzi and James, 1996; Ahmed *et al.*, 1998; Dorlencourt *et al.* 2000; Gartner *et al.*, 2001; Suzana *et al.*, 2002; Nair *et al.*, 2006). It has been noted that since MUAC is a simpler measure than BMI and require a minimum of equipment, it can predict morbidity and mortality as accurately as deficits in weight (Breind *et al.*, 1989). It could be used both in emergency situation where semi-skilled monitors are available. It can thus, be used as a substitute for BMI when rapid screening of an adult population is required as a prelude to targeting intervention for the undernourished (James *et al.*, 1994).

1.5.2. INDIAN STUDIES DONE IN THE ASSESSMENT OF NUTRITIONAL STATUS USING ANTHROPOMETRY

The basic causes of under-nutrition in the developing countries such as India are related to poverty, poor hygienic conditions and little access to preventive health care (WHO, 1990). In these developing countries, anthropometry remains the most practical technique for the assessment of nutritional status of individuals or populations (Khongsdier, 2001, 2002, 2005). Several studies have been undertaken to assess the nutritional status of individuals belonging to different ethnic Indian populations using anthropometry. Most of the studies have assessed nutritional status using the conventional anthropometric indices of stunting (height-for-age), underweight (weight-for-age) and wasting (weight-for-height) and comparing them with the reference data of National Centre of Health Statistics (WHO/NCHS, 1983; WHO, 1995).

1.5.2.1. STUDIES DONE ON PRE-SCHOOL CHILDREN USING ANTHROPOMETRY

India shows the highest occurrence of childhood under-nutrition in the world (Bamji, 2003). It has been estimated that more than half of the country's children are undernourished (Measham and Chatterjee, 1999). The prevalence of under-nutrition among Indian children is far higher than the countries with similar levels of economic development (Gragnolati *et al.*, 2005). A number of studies have been undertaken to assess and document the prevalence of under-nutrition among Indian pre-school children utilizing the conventional anthropometric indices. The studies of Upadhyay *et al.* (1992), Rajasree and Soman (1994), Pal (1999), Yadav *et al.* (1999), George *et al.* (2000), Rao *et al.* (2000, 2004), Awasthi *et al.* (2003), Rajaram *et al.* (2003), Shaikh *et al.* (2003), Bishno *et al.* (2004), Kumari (2005), Kaur *et al.* (2005), Pooni *et al.* (2006), Rao *et al.* (2006b), Sharma *et al.* (2006), Singh *et al.* (2006), Som *et al.* (2006, 2007), Bose *et al.* (2007a, 2008a), Bharati *et al.* (2008, 2009), Das and Bose (2009a), Dutta *et al.* (2009) and Bisai and Mallick (2011) may be cited here. Due to the high prevalence of under-nutrition among pre-school children, the Government of India started the Integrated Child Development Scheme (ICDS) aimed for early detection and prompt and effective treatment of under-nutrition among them. However, studies have reported a high level of under-nutrition among these children. Here the studies of Bose *et al.* (2007a), Mandal *et al.* (2008) and Biswas *et al.* (2009) are mentionable.

Very recently, studies have reported the prevalence of under-nutrition among pre-school children in India utilizing the Composite Index of Anthropometric Failure (CIAF). In this connection, the studies of Nandy *et al.* (2005), Seetharaman *et al.* (2007), Biswas *et al.* (2009), Das and Bose (2009b), Deshmukh *et al.* (2009), Mandal and Bose (2009), Mukhopadhyay *et al.* (2009) and Mukhopadhyay and Biswas (2011) are mentionable.

1.5.2.2. Studies done on children aged more than 5 years using anthropometry

In India, extensive studies have been undertaken to assess the prevalence of under-nutrition status among Indian children in the ages of 5-12 years. Using the conventional indices, a large number of studies have reported high prevalence of under-nutrition among them. Here the studies of Chhabra *et al.* (1996); Kumar *et al.* (1996), Vazir *et al.* (1998), Yadav and Singh (1999), Brahmbhatt *et al.* (2001), Choudhary (2001), Mitra *et al.* (2002; 2007), Elizabeth and Muraleedharan (2003), Vashisht *et al.* (2005), Bhanderi and Choudhary (2006), Mittal and Srivastava (2006), Medhi *et al.* (2006), Bisai *et al.* (2008), Bose *et al.* (2008a), Chowdhury *et al.* (2008), Chakrabarty and Bharati (2010a), Mondal and Sen, (2010a), Banik and Chatterjee (2010) and Gupta *et al.* (2011) may be cited. Very recently, studies have used the CIAF to report the prevalence of under-nutrition among children aged more than 5 years (Sen *et al.*, 2011a; Sen and Mondal, 2012).

Kishor (1993) and Gopaldas and Gujral (1995) have reported that in almost all Indian populations, boys have a better access to food and basic amenities than girls and that there was a pronounced preference for the male child. Numerous studies have further reported discriminations in diet and basic amenities against the girl child and that the girls were engaged in many different strenuous household chores thereby affecting their nutritional status (Ghosh, 1990; Devendra, 1995; Borooah, 2004). Several studies have also documented the fact that girls were more affected by under-nutrition than boys (Singh *et al.*, 1996; Yadav and Singh, 1999; Vashisht *et al.*, 2005; Bose *et al.*, 2007a; Mondal and Sen, 2010a, b; Sen *et al.*, 2011a, b; Sen and Mondal, 2012).

The body build of a child can be very accurately assessed using BMI (Bhalla, 2002). Mitra *et al.* (2002) carried out a cross sectional growth study on the Kamar, a primitive tribe of Chhattisgarh using this index. They compared the data with that of other Indian tribes and the ICMR all India data, and concluded that poor SES of this primitive tribe may be one of the reasons for the poor growth pattern of the children.

Very recently, the use of low-BMI-for-age or thinness has been introduced by Cole *et al.* (2007) to assess child nutritional status. Studies have subsequently been conducted to document the prevalence of under-nutrition using thinness among Indian children. Here the studies of Bose and Bisai (2008a), Mandal *et al.* (2008), Chakraborty and Bose (2009), Ghosh and Bandyopadhyay (2009), Mondal and Sen (2010c) and Sil *et al.* (2011) may be cited.

1.5.2.3. STUDIES DONE ON ADOLESCENTS USING ANTHROPOMETRY

The adolescent period is a very important phase in the life span of an individual. It is defined as the period of transition between childhood and adulthood and is characterized by an exceptionally rapid rate of growth (Tanner, 1978). In India, the adolescents comprise a nutritionally vulnerable segment of the Indian population. Most of the adolescents belonging to the lower socio-economic groups are reported to be affected by under-nutrition. Several studies have been undertaken to document the prevalence of under-nutrition using stunting (low-height-for-age) and thinness (low-BMI-for-age). A significant number of studies have reported the prevalence of under-nutrition among Indian adolescents. They include those of Anand *et al.* (1999), Bose and Mukhopadhyay (2004), Das and Biswas (2005), Khongsdier *et al.* (2005), Bose and Bisai (2008b), Banerjee *et al.* (2009), Prashant and Shaw (2009), Banik and Chatterjee (2010), Bisai *et al.* (2011) and Shivaramakrishna *et al.* (2011).

The studies of Deshmukh *et al.* (2006b), Das *et al.* (2007) and Medhi *et al.* (2007) have reported that a significant proportion of the adolescent population exhibited a high prevalence of under-nutrition. Utilizing data from the NNMB, Venkaiah *et al.* (2002) reported that 39% of the rural adolescents were stunted. Malhotra and Passi (2007) reported the prevalence of stunting to be 29.7% among rural adolescent girls from North India. Anand *et al.* (1999) reported the prevalence of stunting to be 37.2% among adolescent girls and 41% among adolescent boys, with an overall prevalence of 38.5%. Recently, Mondal and Sen (2010c) has reported that a high prevalence of stunting (46.6%) among rural adolescent boys and girls from North Bengal. Very recently, Maiti *et al.* (2011) have reported the prevalence of stunting to be 34.2% among adolescents from Paschim Medinipur district of West Bengal.

A number of studies have reported a high prevalence of thinness utilizing BMI-for-age (Anand *et al.*, 1999; de Onis *et al.*, 2001; Venkaiah *et al.*, 2002; Deshmukh *et al.*, 2006b; Malhotra and Passi, 2007; Medhi *et al.*, 2007; Mondal and Sen, 2010c). It is now a generally accepted fact that there existed a high prevalence of thinness among Indian communities and that more than 50.00% of the adolescents were affected (de Onis *et al.*, 2001; Deshmukh *et al.*, 2006b). Venkaiah *et al.* (2002) reported that the prevalence of thinness to be higher among boys (53.10%) than girls (39.50%). Rao *et al.* (2006a) utilizing the NNMB data from 9 Indian states, reported the prevalence of thinness among tribal adolescent to be 63% among boys and 42% among girls. They also obtained a significant association between under-nutrition and different socio-economic parameters (family type, size of land holding and occupation). Low prevalence thinness among adolescent girls (30.6%) has also been reported from North India (Malhotra and Passi, 2007). In a very recent study, Maiti *et al.* (2011) reported the overall extent of thinness to be as high as 37.7% among adolescents of Paschim Medinipur district of West Bengal.

1.5.2.4. STUDIES DONE ON ADULT INDIVIDUALS USING ANTHROPOMETRY

There have been a sizeable number of contributions in the issue of adult nutritional among different populations of India. Here the studies of Visweswara Rao *et al.* (1990, 1992, 1995), Durandhar and Kulkarni, (1992), Ferro-Luzzi *et al.* (1992), Gopinath *et al.* (1994), Reddy (1998), Yadav *et al.* (1999), Mehta and Shringarpure (2000), Zargar *et al.* (2000), Dudeja *et al.* (2001), Khongsdier (2001, 2002, 2005), Gogoi and Sengupta (2002), Shukla *et al.* 2002, Sahani (2003), Snehalatha *et al.* (2003), Bose and Chakraborty (2005), Arlappa *et al.* (2005), Khongsdier *et al.* (2005), Venkatramana *et al.* (2005), Adak *et al.* (2006), Ghosh and Bharati (2006), Bhardwaj *et al.* (2006), Bose *et al.* (2006a, b, c), Gautam *et al.* (2006), Subramanian and Smith (2006), Bose *et al.* (2007 a, b, 2008 a, b, 2009), Banik (2007), Banik *et al.* (2007, 2009), Bharati *et al.* (2007, 2009), Subramanian and Smith (2006), Subramanian *et al.* (2007), Chakrabarty *et al.* (2008, 2009), Bisai and Bose (2009), Sarkar *et al.* (2009) Chakrabarty and Bharati (2010b) and Masoodi *et al.* (2010) are mentionable.

It has been suggested that most of the adult individuals from India were affected by different grades of undernourishment or CED (James *et al.*, 1999). It was reported that a high proportion of them (49%) suffer from different grades of CED (Naidu and Rao, 1994). In a significant study among the War Khasi of rural Meghalaya, Khongsdier (2002) reported that

35% of them were suffering from CED. In another important study involving 81,712 rural women from 26 states and 6 zones, Bharati *et al.*, (2007) reported that 31.2% of them were suffering from CED.

A number of studies have been done using BMI as an indicator of nutritional status and socio-economic conditions (Shetty and James, 1994; Khongsdier, 2002; Subramanian and Smith, 2006; Subramanian *et al.*, 2007). Recently, a review of the studies done in the field of nutritional assessment using BMI in India has been published (Mondal and Sen, 2009). A review of the studies done using MUAC in India has also been recently published (Sen *et al.*, 2010a). The BMI along with WC, HC and WHR have also been used to assess body composition and regional adiposity in many studies (Misra *et al.*, 2001; Bose *et al.*, 2005; Das and Bose, 2006; Misra *et al.*, 2003). Association between body fat densities, disease risk factors with BMI among different populations of India have also been reported (Zaadstra *et al.*, 1993; Singh *et al.*, 2000; Misra *et al.*, 2001, 2003, 2004; Bose *et al.*, 2003; Ghosh and Das Chaudhuri, 2005; Ghosh *et al.*, 2004, 2006; Ghosh, 2006; Ghosh and Bandyopadhyay, 2007).

There have been a number of studies in the assessment of nutritional status among individuals belonging to different Indian tribal populations. Using BMI, the recent studies of Bose *et al.* (2006a) among the Santal, Mittal and Srivastava (2006) among the Oraon, Bose *et al.* (2006b) among the Savar and Chakrabarty and Bharati (2010b) also among the Savar have documented a high prevalence of under-nutrition. Arlappa *et al.*, (2005) conducted a study among the tribal elderly population from 9 provincial states of India and reported that females were more affected than males (65.4% versus 61.8%). Bose *et al.* (2006a) reported a high prevalence of under-nutrition among adult Santal individuals (males: 26.2%; females: 33.7%).

A large scale study was conducted adult males belonging to 38 different populations and comprising of 5 major social groups that included scheduled tribe, scheduled caste, other backward caste, general caste and Muslim populations from central India by Adak *et al.* (2006). It was observed that the prevalence of under-nutrition was the lowest among the general castes (43.1%) as compared to the scheduled castes (60.3%), the scheduled tribes (51.5%), other backward castes (51.7%) and the Muslims (47.5%).The higher level of nutritional status among the general caste was corroborated by their higher social and economic status.

Gautam *et al.* (2006) utilized anthropometric data collected by the Anthropological Survey of India to assess the nutritional status using BMI of 31 populations residing in 38 districts of central India They reported a higher level of nutritional status among the populations of the non-backward districts. However, they opined the need for further intensive investigations in these populations, as because BMI being a measure of CED, the severity of CED and morbidity, mortality and health status need to be studied.

A recent study was conducted by Chakrabarty *et al.* (2008) on body composition and nutritional status among adult individuals belonging to the major social groups of the states of Odisha and Bihar. The results indicate that in Odisha, individuals belonging to the scheduled tribes have lower mean values of BMI and cormic index as compared to those of the other groups, whereas in Bihar, schedule caste individuals had lowest mean values of BMI. The scheduled castes and tribes of Bihar showed the highest prevalence of CED (64.71% and 57.45% respectively). The results further suggested that Muslims were more affected with CED (52.62%), but the overall prevalence of CED was lower in Odisha (49.11%) than in Bihar (54.62%).

1.6.1. Non-Indian studies done on nutritional status utilizing dietary methods

Extensive studies have been undertaken using dietary methods to depict under-nutrition in different populations (Fogarty and Nolan, 1992; Heitmann and Lissner, 1996; Gharbi *et al.*, 1998; Mennen *et al.*, 2000; Banjong *et al.*, 2003; Corrêa Leite *et al.*, 2003; Wu *et al.*, 2005; Esmaillzadeh *et al.*, 2008). Studies have also highlighted the dietary intake and food-related behaviour among different populations (Hatloy *et al.*, 1998; Onyango *et al.*, 1998; Trudeau *et al.*, 1998; Tarini *et al.*, 1999; Gray-Donald *et al.*, 2000; Mennen *et al.*, 2000; Mennen *et al.*, 2001; Starkey *et al.*, 2001; Capps *et al.*, 2002; Neuhouser *et al.*, 2004; Roos *et al.*, 2004; Alves and Boog, 2007).

A number of studies have been conducted in this aspect among pre-school children aged less than 5 years (Baranowski *et al.*, 1991; Davies, 1997; Omar, 2000; Weker *et al.*, 2000; Chen *et al.*, 2002; Navia *et al.*, 2003; Cooke *et al.*, 2004; Faber, 2005; Manu and Khetarpaul, 2006; Manios *et al.*, 2009; Frackiewicz *et al.*, 2011; Jennings *et al.*, 2011). Studies have also been done among children more than 5 years of age and adolescent (Egger *et al.*, 1991; Royo-Bordonada *et al.*, 2003; Adams *et al.*, 2005; Heath and Panaretto, 2005; Blum *et al.*, 2005; Al Sabbah et *al.*, 2007; Martin *et al.*, 2008; Abudayya et *al.*, 2009; Kollataj *et al.*, 2011; Shiu *et al.*, 2012). Studies have also been conducted among adult by Taylor *et al.* (1992), Adachi and Hino (2005), Wang *et al.* (2008) and elderly individuals by Fogarty and Nolan (1992), Posner *et al.* (1994), Maruapula and Chapman-Novakofski (2006), Johnson *et al.* (2008) and Risonar *et al.* (2009).

Studies have also pointed out the specific dietary and nutrient intake patterns with respect to urban and rural individuals by Fogarty and Nolan (1992), Taylor *et al.* (1992), Posner *et al.* (1994), Barquera *et al.* (2003), Tooze *et al.* (2007), Wang *et al.* (2008) and Manios *et al.* (2009). Most of these studies have shown the mean consumption of different food and nutrients to be higher among urban individuals as compared to rural individuals.

Deficiencies in vitamin-D, vitamin-A, vitamin-E and thiamine are a serious problem in the developing countries (Christian *et al.*, 1998, 2000; Krishna *et al.*, 1999; Andiran *et al.*, 2002; Pehlivan *et al.*, 2003; Maghbooli *et al.*, 2007; Khatib and Elmadfa, 2009; Lips, 2010; Dror and Allen, 2011). Studies have also indicated that a majority of the elderly individuals were suffering from vitamin deficiencies (Charlton *et al.*, 1997; Huang *et al.*, 2001; Martins *et al.*, 2002; Watanabe *et al.*, 2004; Chen *et al.*, 2005; Hinds *et al.*, 2011). It has been reported by Asobayire *et al.* (2001) that the prevalence of iron deficiency was 41%-63% among women and children and 13% among males from Africa. Zinc deficiency has also been observed to be widespread in the developing countries particularly among children and pregnant females (Ferguson *et al.*, 1993; Huddle *et al.*, 1998).

1.6.2. Indian Studies done on Nutritional Status utilizing Dietary Methods

The inadequacy in diet is one of the key causes of under-nutrition among Indian populations. The vulnerable groups are children, adolescents, pregnant mothers and the elderly (Singh, 2002; Arlappa *et al.*, 2005, 2011; Rao *et al.*, 2006a, 2010; Malhotra and Passi, 2007; Mitra *et al.*, 2007; Harinarayan *et al.*, 2008; Laxmaiah *et al.*, 2012). These inadequacies are believed to be due to poor living conditions and inadequate intake of dietary micronutrients (Thankachan *et al.*, 2007). A number of studies have been conducted in the field of nutritional status assessment and dietary intake among individuals belonging to different Indian populations. Here the studies of Venkatachalam *et al.* (1962), Jyothi *et al.* (1963), Gill *et al.* (1968), Rao and Gopalan (1969), Bamji (1970), Swaminathan *et al.* (1973), Narayanan *et al.* (1974), Purohit and Sharma (1975), Vijayalakshmi and Devaki (1976), Rajalakshmi and Ramakrishnan (1978), Vijayadurgamba and Geervani (1979), Pushpamma *et al.* (1982), Vijayaraghavan and Rao (1998), Mittal and Srivastava (2006), Yajnik *et al.* (2006), Harinarayan *et al.* (2007) and Puri *et al.* (2008) may be mentioned.

1.6.2.1. INDIAN STUDIES DONE ON NUTRITIONAL STATUS UTILIZING DIETARY METHODS AMONG CHILDREN AND ADOLESCENTS

A number of studies have been conducted to assess the food, nutrition and dietary habits of the children (Sidhu *et al.*, 1993; Begum, 1994; Rao *et al.*, 1994; Khader, 1996; Jood *et al.*, 2000; Singh *et al.*, 2006; Kulsum *et al.*, 2009) and adolescents (Choudhary *et al.*, 2003; Rao *et al.*, 2006a; Malhotra and Passi, 2007; Gupta *et al.*, 2010; Sanwalka *et al.*, 2010) belonging to different Indian populations. Joshi *et al.* (1989) have reported the nutritional status among pre-school children from Hyderabad using dietary methods. The association of SES with dietary intake showed that dietary inadequacy was significantly higher among children belonging to a lower SES than a higher SES (Qamra *et al.*, 1990). Khader (1996) has reported dietary intake and nutrient adequacy status of rural pre-school children from Andhra Pradesh. The food intake and nutrient distribution patterns among Rajput children of Rajasthan were studied by Saxena and Ulijaszek (1998). A study was also been conducted on children belonging to different tribal populations of Maharashtra by Singh (2002).

Utilizing the NNMB (1998-1999) data recorded from tribal adolescent girls of 9 states in India, Rao *et al.* (2006a) reported that food and nutrient intake was grossly inadequate. The mean intake of the foodstuffs, especially the income elastic foods such as pulses, milk and milk products, oils and fats and sugar and jaggery were lower than the RDA of the ICMR (2000). Choudhary *et al.* (2003) reported the energy expenditure and energy balance among rural adolescents girls in Varanasi utilizing the 24-HR oral questionnaire method. They observed that the average energy intake of 1609.42 ± 528.87 kcal/day was less than their mean energy expenditure of 1896.19 kcal/day. The energy expenditure was also significantly influenced by age, caste and family type.

A recent study by Malhotra and Passi (2007) assessed the diet quality and nutritional status of beneficiaries of the Adolescent Girl Scheme, a national programme targeted towards the nutritional/health needs of adolescents. They reported that the girls followed a two-meal pattern and their diets were monotonous and cereal-based. Nearly half of them (49.3%) were observed to have an energy intake less than 75% of the RDA. A substantial proportion of them had inadequate nutrient intake with respect to most of the food groups and nutrients, especially iron (84.7%), folic acid (79.4), vitamin-A (73.2%), milk and milk products (47%), pulses (36%), green leafy vegetables (GLVs) (26%), other vegetables (34%) and fruits (3%) as compared to the suggested levels of the RDA.

1.6.2.2. Indian studies done on nutritional status utilizing dietary methods among adults

A large amount of scientific literature is present on the assessment of dietary intake using the 24-HR method from adult individuals belonging to different populations of India (Chaturvedi *et al.*, 1994; Mehta and Shringarpure; 2000; Choudhary *et al.*, 2003; Goyal and Grewal, 2004; Harinarayan *et al.*, 2004; Arlappa *et al.* 2005; Mittal and Srivastava, 2006; Gupta *et al.*, 2010; Bowen *et al.*, 2011; Radhika *et al.*, 2011; Venkaiah *et al.*, 2011).

Murty and Reddy (1994) observed that 30% of women from a slum exhibited dietary inadequacies. A study on pregnant women reported a high incidence of dietary zinc deficiency (Pathak *et al.*, 2003). Low dietary intake in terms of energy, protein, iron, and vitamin-C was also reported from Khasi women (Agrahar-Murugkar and Pal, 2004). Insufficient amount of dietary intake and prevalence of under-nutrition has also been reported from elderly tribal individuals (Arlappa *et al.* 2005). The inadequate nutrient intakes with respect to most of the micronutrients, especially iron (84.7%), folic acid (79.4%) and vitamin-A (73.2%) have been reported from north India (Malhotra and Passi, 2007). Gautam *et al.* (2008) in their study among rural pregnant women have reported the dietary allowance to be less than the RDA.

The consumption patterns of food and nutrients are diverse in nature in India. These vary from region to region and population to population. Several researchers have studied these diverse food habits. Mital and Gopaldas (1985) reported the food habits of adult females from Gujarat. Kaur (1987) reported the dietary patterns of adult female individuals belonging to low and medium socio-economic groups from Punjab. Hira (1993) has observed nutrient adequacy among rural adult males also from Punjab. The dietary habits and food consumption related to nutritional status have been reported from adults in Madhya Pradesh (Dubey and Koley, 1995). Studies have also been undertaken to document the food habits and dietary patterns among expectant mothers of different states (Gupta, 1998; Sahoo and Panda, 2005). Recently, a study has been conducted to understand the food consumption patterns and nutritional status among rural females from Odisha (Rout, 2009).

A number of studies have been conducted to assess the food habits, dietary and nutrients intakes of adult individuals belonging to different ethnic populations of India (Banerjee and Sinha, 2001; Sharma and Dwivedi, 2005; Mohanty *et al.*, 2007; Koshal *et al.*, 2008; Chakma *et al.*, 2009). Rajyalakshmi and Geervani (1992) reported the food habits along with nutritional status and related morbidity of 4 tribal populations of south India. A dietary evaluation study has been done among the Dimasa of North Cachar hills by Khongsdier and Basu (1998). Reddy and Reddy (2000) has reported the bio-ecological aspects of food and nutrition and its change among 5 tribal ethnic populations of Tamil Nadu. Bera (2004) has reported a higher consumption of food, nutrients and nutritional status among the Tibetan women in India. Periodical data from the NNMB and NFHS have indicated that there are clear differences in diet between urban and rural areas within a specified region. The existence of a diverse dietary profile in India is closely linked to the religion, ethnicity and geographical regions. These make assessments about national dietary profile difficult. The problem is further compounded by the methodological issues related to dietary assessments. An extensively review on the methodological issues has been published by Vas *et al.* (2005).

1.7. STUDIES DONE IN BIOLOGICAL ANTHROPOLOGY AMONG THE DIFFERENT POPULATIONS OF NORTH BENGAL

Popularly called North Bengal, the northern part of West Bengal and comprises the 6 districts of Malda, Uttar Dinajpur, Dakshin Dinajpur, Darjeeling, Cooch Behar and Jalpaiguri. A number of indigenous populations such as the Rajbanshi, the Lepcha, the Rabha and the Toto are found in this area. A thorough search of the existing scientific literature on various aspects of biological anthropology among different populations of North Bengal was done using 'Pubmed". This is an on-line database developed by the National Center for Biotechnology Information (NCBI) at the National Library of Medicine (NLM), United States of America. It consists of indexed citations and abstracts pertaining to medical, nursing, dental, veterinary, health care, nutrition and pre-clinical science journals. As of 15th January 2012, PubMed has over 21.47 million records going back to 1966, selectively to the year 1865, and very selectively to 1809. About 500,000 new records are added each year to this database.

One of the earliest studies in the field of biological anthropology among the populations of North Bengal was that of Sarkar (1969) who observed variations in certain dermatoglyphic variables among some caste and tribal populations of Jalpaiguri district. Later on, dermatoglyphic studies were done among the Oraon and the Munda who had migrated to North Bengal (Sarkar, 1971) and the Meche (Sarkar and Biswas, 1972) of Jalpaiguri district. Notable studies have also been conducted on the dermatoglyphics patterns among the Rajbanshi by Sen and Mondal (2008) and Sen *et al.* (2011c).

Studies have also been undertaken in the areas of blood genetic markers (Saha *et al.*, 1988), mitochondrial-DNA (Chakrabarti *et al.*, 2002) and HLA (Debnath and Chaudhuri, 2006). In their study on blood genetic markers, Bajpai and Bajpai (1990) concluded that although the overall intergroup heterogeneity was not significant for the Rabha and the Meche, the Toto showed a difference from the local population and differed slightly from the Meche and the Rabha. There exists just a single study on the age at menarche among the Rajbanshi (Chakravarty, 1994). There is, however, a very significant contribution on the Rajbanshi in the form of a book. It is authored by Sanyal (1965) and entitled '*Rajbanshi of North Bengal*'. Sen and Ghosh (2008) and Sen *et al.* (2011d) reported the estimation of stature and sex utilizing the foot dimensions of the Rajbanshi individuals of North Bengal respectively. Limited number of studies has reported the health status and practices among different indigenous population of North Bengal. Here the study of Bagchi (2003) among the Meche can be cited.

1.7.1. STUDIES DONE IN THE AREA OF NUTRITIONAL ASSESSMENT AMONG THE DIFFERENT POPULATIONS OF NORTH BENGAL

Studies on the assessment of nutritional status among the different populations of North Bengal are relatively scarce in the existing literature. Mittal and Srivastava (2006) in their study among the Oraon, observed the incidence of under-nutrition to be 54.00% and 40.00% respectively. Banik *et al.* (2007) reported a high incidence of under-nutrition (36.40%) among the Dhimal. Recently, Banik *et al.* (2009) conducted a cross-sectional study among the Dhimal, the Meche and the Rajbanshi and reported high incidences of under-nutrition and CED (Dhimal: 37.45%; Meche: 13.20%; Rajbanshi: 23.56%). Mondal and Sen (2010a) reported very high prevalence of under-nutrition from children belonging to the the Rajbanshi, tribal and the Bengalee Muslim populations. They observed the overall incidences of stunting, underweight and wasting to be higher among children belonging to the tribal (41.67%, 50.85% and 23.46%) followed by those of the Bengalee Muslim (33.7%, 43.8% and 26.61%) followed by those of the Rajbanshi (35.85%, 37.4% and 13.6%) populations.

The prevalence of thinness (low BMI-for-age) was also observed to be higher among children of this region (Mondal and Sen, 2010b). A high prevalence of under-nutrition has been also reported utilizing the conventional anthropometric indices and CIAF among Muslim children of North Bengal (Sen *et al.*, 2011c). In another study, Mondal and Sen, (2010c) observed that the adolescents exhibited a high prevalence of stunting (low height-for-age: 46.6%) and thinness (low BMI-for-age: 42.4%). The incidence of LBW was also found to be high among the populations of North Bengal and this has been observed to be closely associated with maternal nutritional status (Sen *et al.*, 2010b).

Using the recently developed CIAF along with the conventional indices, Mukhopadhyay *et al.* (2009) and Sen *et al.* (2011c) reported a very high prevalence of under-nutrition among children of North Bengal. In a very significant study, Sen and Mondal (2012) have documented the socio-economic and demographic factors affecting the CIAF, using children from North Bengal as the subjects of study.

There have been some very recent studies dealing with the development of new methodologies involved in assessing nutritional status of individuals and populations. Dutta Banik (2011) has tried to assess the nutritional status among Dhimal individuals using arm span as a proxy measure of under-nutrition. Sen *et al.* (2011b) have tried to assess under-nutrition among children using upper arm composition.

1.8. STATEMENT OF THE PROBLEM

The knowledge of the nutritional status of a population is necessary to have a comprehensive idea about the development process. This is primarily because under-nutrition is one of the major health problems in the developing countries. Hence, the assessment of the nutritional status of a population becomes a prime objective.

From the foregoing paragraphs, it is apparent that the nutritional status of Indian populations is observed to be very poor. There is an existence of high prevalence of under-nutrition in all segments of the populations. Given the above facts, a comprehensive approach on the assessment of nutritional status using anthropometry and dietary assessment is proposed to be taken up in the present study. There has been hardly any such comprehensive study done earlier to document the nutritional status of an ethnic population of North Bengal using these two parameters. So the present study also bears importance from the methodological point of view. The present study also focuses on the socio-economic and demographic variables that can affect nutritional status.

1.9. OBJECTIVES OF THE PRESENT STUDY

The main objectives of a nutritional assessment study is to obtain precise information on the prevalence of under-nutrition in a given community and identification of the individuals who comprise the "at risk group", i.e., those who need of the nutritional assistances. Therefore, the present study was done keeping the following objectives in mind:

1. To assess the nutritional status of adult individuals aged 20 years to 49 years and belonging to an ethnic population of North Bengal using anthropometric measurements, standard anthropometric indices and internationally accepted cut-off points.
2. To compare the overall prevalence of under-nutrition among these individuals with the available international and national data.
3. To find out the association between different indicators of nutritional status with the different socio-economic, demographic and lifestyle variables.
4. To evaluate dietary intake of different foodstuffs, essential nutrients, vitamins and minerals using quantitative 24-HR method.
5. To compare the dietary consumptions of the different foodstuffs and nutrients of the individuals under study with the RDA as suggested for the Indian population.

6. To compare the dietary intakes of the individuals with the available dietary data of different populations of Indian.
7. To document the factors affecting energy, protein inadequacy and PEM status with different socio-economic, demographic and lifestyle variables.

CHAPTER-II:

MATERIAL AND METHOD

MATERIAL AND METHOD

2.1 THE POPULATION UNDER STUDY

The northern part of the state of West Bengal, India is separated from the southern part by the Farakka Barrage. The area covers the gigantic Himalayan and sub-Himalayan regions as well as the plains. It extends over an area of 21332 km^2 which is about 24.00% of the state and has a population of 14.72 million (14,72,14940) individuals, which is a little less than $1/5^{th}$ of the state's population (Census, 2001; IAMR, 2002). North Bengal is the home to a large number of heterogeneous tribal populations, caste groups and religious communities. The region has a number of Mongoloid tribal populations such as the Lepcha, the Bhutia, the Meche, the Rabha, and the Hajong. It also has a number of Proto-Australoid tribal populations (*e.g.*, the Oraon, the Munda and the Santal). Initially it was the British who were instrumental in bringing these individuals belonging to the Proto-Australoid tribal communities from the Chotanagpur plateau of Bihar to North Bengal in the mid-19^{th} century to be employed as workers in the tea gardens. They are now collectively referred to as 'Tea-labourer' in North Bengal (Bhadra and Chakraborty, 1997). Besides these tribal populations, there are several scheduled caste populations living various part of North Bengal. The most important scheduled caste populations are the Rajbanshi, the Bhuimali, the Namasudra, the Bhuiya, the Kaibarta and the Turia.

Among the scheduled caste populations, the largest and most widely distributed is the Rajbanshi. The Rajbanshi also constitutes the second largest percentage of the scheduled caste population in West Bengal (3,386,617 individuals; 18.40%) and is mainly concentrated in the districts of Cooch Behar, Jalpaiguri and Darjeeling. The Rajbanshi population has been selected for the present study because of its numerically larger strength, and wider distribution in North Bengal. They also appear to satisfy the condition of moderate numerical size as compared to the surrounding populations.

2.1.1 The Rajbanshi

The northeastern part of India is inhabited by many tribal and caste populations that have their own distinct social, linguistic and biological affinities (Kumar *et al.*, 2004). Ethnically speaking, most of the tribal groups belong to the Mongoloid group, whereas the caste groups are either Caucasoids or show a mosaic of features of both these ethnic groups. The ethnic groups belonging to the Mongoloids/Indo-Mongoloids have entered India from different directions at different times and perhaps earlier than the Caucasoids (Das *et al.*, 1987). While the Mongoloids have migrated from the eastern, southeastern, and central Asian regions, the Caucasoids may have entered the country from the western and northern boundaries (Rapson, 1955; Dani, 1960).The majority of the Mongoloid tribes are affiliated to the Tibeto-Chinese linguistic family, excepting the Khasi. Most of the Caucasoids are caste groups who speak the Indo-European languages. Both the Mongoloid and the Caucasoid groups show a certain degree of differentiation within themselves in cultural and biological traits such as anthropometry, genetic markers, and dermatoglyphics (Das, 1971, 1973, 1979; Das and Das, 1981; Roychoudhury, 1992; Bhasin and Walter, 2001). Moreover, the Caucasoid and Mongoloid populations have cohabited for a long period of time and presumably there was gene flow between them, as is evident from the conclusions drawn from different studies (Das, 1977; Das *et al.*, 1980a, 1980b). The Indo-European group comprises of the Brahmin, the Kalita, the Kaibarta, the Muslim and the Rajbanshi of north-eastern India, the Brahmin and the Chetri of Sikkim and the Brahmin of Manipur. The migrations of Indo-European-speaking people to this region started from the protohistoric period (Majumdar, 1980). The Kalitas, who claim to be Rajputs or Kshatriyas, were probably one of the earliest to arrive in the northeastern part of India.

Ethnically, the Rajbanshi has been identified by Risley (1915) as Kshatriya (an upper-caste Hindu population). According to Dalton (1872), they belong to a Dravidian stock that came in contact with the Mongoloids of Assam. Das (1981) considers them to be a conglomerate of various tribes that were converted into Hindus and in the process became admixed with certain caste groups. Later on, Das *et al.* (1987) hypothesized the Rajbanshi to be a mixture of different tribal groups (such as the Rabha, the Tiwa, the Kachari, the Garo and the Karbi) who were converted to Hinduism and in the process became admixed with certain Caucasoid caste populations. Some researchers consider the Rajbanshi as one of the groups of the great Bodo/Boro/Bara family that entered India in the 10th century B.C. from the east and settled in the banks of the Brahmaputra before spreading over Assam, north eastern Bengal and eastern Nepal (Sanyal, 1965; Gautam, 1994). It is been also conjectured that the Rajbanshi was a Dravidian caste of North Bengal and originally called the Koch, but presently claim to be an outlying branch of the Kshatriya. The Koch possessed a powerful kingdom at the foot hills especially at Koch Behar. They gradually became Hinduized by contact with their neighbours in the plains and discarded the name Koch.

Based on their physiognomy and racial traits, the Rajbanshi has been classified as Mongoloid a population (Sanyal, 1965; Gautam, 1994). In fact, Waddel (1975) considered them to be a heterogeneous Mongoloid population. A recent study on the ethic affinities of 22 populations of north-eastern India based on 11 genetic markers was carried out by Kumar *et al.* (2004). It was observed that the Rajbanshi, along with the Chutia and the Ahom, constituted a separate compact cluster positioned in the centre of the multidimensional scaling used for depicting relationship among populations based on frequency of distance data analysis. The result also highlighted a strong indication of a biological effect on the process of tribe-caste continuum that has been in the assimilation of some of the tribes in the caste hierarchy. This has been reflected in the broad constellation of populations in the multidimensional plot. At one end it was the constellation of populations subscribing to the caste system, while the other end of the plot had the constellation of tribal groups. In between lay the Rajbanshi, the Chutiya and the Ahom, which were supposed to have undergone the process of tribe-caste continuum.

Bose (1941) studied the Hindu method of tribal absorption which opined that tribes over a period of time assumed the characteristics and status of castes and this process of transformation of a tribe into a caste resulted in a Tribe- Caste continuum This social concept of a Tribe -Caste continuum postulates that one end of the continuum is formed by caste populations, while the tribal populations constituted the other end. In between are the populations who were once tribes but gradually adopted the attributes of the caste population and ultimately became absorbed as an integral part of a caste system, although at the lowest step of caste hierarchy. However, they do maintain a separate group identity and over a period of time become distinct castes. Risley (1981) discerned four processes by which a tribe is converted into a caste and gradually becomes a distinct caste group. He describes in detail the case of Rajbanshi, who claims to be Kshatriya, although a majority of them are Koch. Similar processes have also reported from the Koch of Cooch Behar (Kumar *et al.*, 2004). It may be pertinent to note that Das (1981) suggests that Rajbanshi is a fit example of a Tribe-Caste continuum both in their socio-cultural aspects and biological makeup.

2.2 THE STUDY AREA

The area of the present study covers the Rajbanshi dominated villages under Block: Phansidewa (Latitude 26° 34' 59" N, Longitude 88° 22' 00" E), Sub-division: Siliguri, Police Station: Phansidewa, District: Darjeeling, West Bengal, India. The geographical location of the district of Darjeeling is shown in ***Figure 2.1.*** The study area is essentially a rural area, situated adjacent to the Indo-Bangladesh international border and at an approximate distance of 30 km to 40 km from the sub-divisional town of Siliguri. The data was collected from over

665 Rajbanshi families residing in 8 Rajbanshi dominated villages of the block. The block covers an area of 308.65 km^2, having a total population of 1,71,508 individuals (males: 87,945; females: 83,563). The total literacy rate is 41.59% (males: 51.85%; females: 30.80%). The villages covered in course of the present study are located under 2 Gram Panchayets (village level local governing authorities) named Phansidewa Basgaon Kismat Gram Panchayet and Chathat Kismat Gram Panchayet. These Gram Panchayets covered an area of 33.34 km^2 and 49.91 km^2 respectively. The names of the villages are Mahipal Jote, Kantivita, Heragachh, Balaigach, Bangagach, Chakchaki, Sudamgachh and Chathat. The first 5 villages are located under the Phansidewa Bas Gaon Kismat Gram Panchayet, while the last 3 villages are located under the Chathat Gram Panchayet. Each village had a Rajbanshi population of over 90.00%. The geographical position of study areas under Phansidewa block is shown in ***Figure 2.2***.

2.3. METHOD OF SAMPLING AND SAMPLE SIZE

The data for the present study was systematically drawn based upon three stages of sampling procedures to meet the study objectives. The data was recorded during the period from January 2009 to April 2011.

In the first stage, 12 Rajbanshi dominated villages were identified and listed from the official records of the respective Block and Gram Panchayets. These villages were physically visited to ascertain the actual existence of Rajbanshi individuals. The villages were surveyed to explore the number of Rajbanshi families' vis-à-vis total number of families in each village.

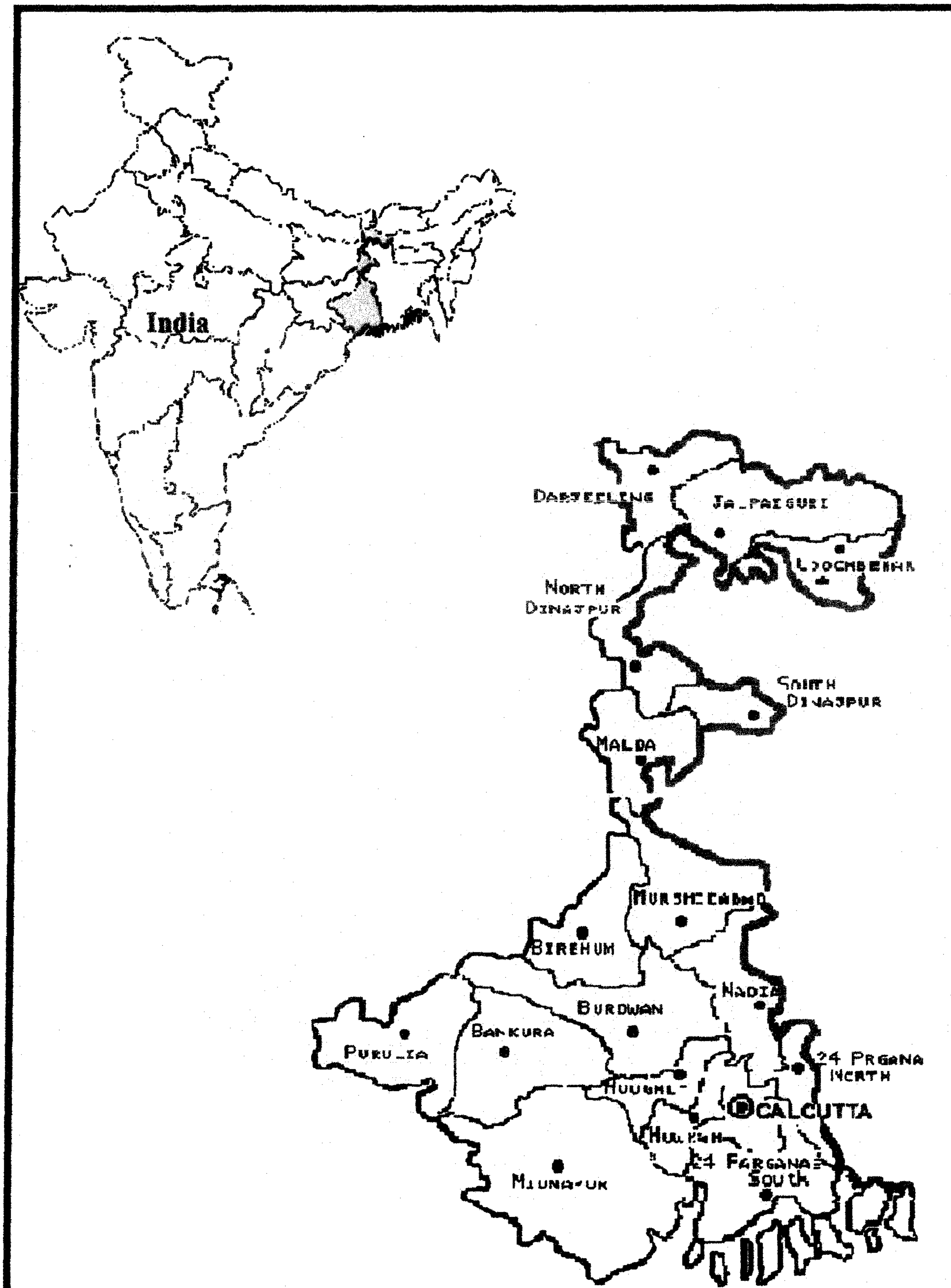


Figure 2.1: Figure showing the geographical location of Darjeeling district, West Bengal, India

Figure 2.2: Figure showing the geographic location of Phansidewa Block under Siliguri sub-division of Darjeeling district, West Bengal

Special attention was given to those villages which were convenient for data collection, subjects' availability and easy communicability and accessibility, so that the actual sample size of the present study could be met. Finally the 8 villages mentioned above were selected for the study. The villages were situated at a distance of about 15 km to 20 km from the Phansidewa Block office, Phansidewa.

In the second stage, the selected villages were surveyed to collect the data on anthropometric, demographic, socio-economic and lifestyle related factors. The selections of the Rajbanshi individuals were done based on the surnames, physical characters and cultural practices. The ethnicity was subsequently verified from the official records of the block and Gram Panchayets. Opinion of the village headmen were also taken into consideration. The non-Rajbanshi individuals were simply excluded from the study.

The anthropometric data was collected from adult male and female Rajbanshi individuals aged between 20 years to 49 years using simple random sampling methods. The data on demographic, socio-economic and lifestyle related factors was also collected from the same individuals and families.

After verification of the initial information related to ethnicity and age, 1116 Rajbanshi individuals (males: 674; females: 442) were approached for taking part in the study. None of the females were pregnant or lactating. The objectives of the present study were then explained them prior to data collection. Of these 1116 individuals, 80 of them (7.17%) refused to take any further part in the study. Hence, the final sample comprised of 1036 adult Rajbanshi individuals (males: 620; females: 416) females) aged 20 years to 49 years. Age of the individuals was collected from available official records, birth certificates and voter identity cards. Informed consent was taken from each Rajbanshi individual prior to collection of the data.

In the third stage, data related to the dietary aspects (food habit, dietary intake and nutrient consumption) were collected from some selective Rajbanshi households. For the collection of dietary intake data, the family was taken as a primary unit of the survey. The consumptions were calculated in terms of an individual's level for the assessment of dietary intake and nutrient consumption in order to evaluate nutritional status. The families were selected using a purposive random sampling method. The selected families were approached for the data collection related to their food habits, dietary intake and nutrient consumption. The purpose and objectives of the dietary survey and approximate time needed to complete the procedures and role of their participation were explained to the family members primarily selected for the dietary survey. A total of 120 Rajbanshi families were selected for the collection of food habits and assessment of dietary intakes. However, 18 of them (15%) disagreed to participate in the dietary survey. So the final sample for the dietary and nutrient intake evaluation was 102 families. The dietary survey was done using the 24-HR method.

2.4. PROCEDURES OF DATA COLLECTION

In order to achieve the objective of the present study, standard procedures of data collection were taken into consideration to obtain data from the field situation. The data collection procedures are briefly described below.

2.4.1. DEMOGRAPHIC, SOCIO-ECONOMIC AND LIFE STYLE FACTORS

To obtain the demographic, socio-economic and lifestyle factors of the Rajbanshi individuals, a pre-structured and pre-tested questionnaire are used. Validation of the questionnaire was done earlier to assess its reliability (Mondal and Sen, 2010a, 2010b). The data on demographic, socio-economic and life-style related factors were collected using pre-structured and pre-tested schedules at the time of the dietary survey.

2.4.1.1 Demographic variables

The explanatory variables that summarize the demographic behavior of a population are considered as demographic variables. In the present study both qualitative and quantitative variables were considered to assess their effects on nutritional status. The demographics variables examined were age, marital status, family size, dependent children and family type. The households were also classified according to per-capita monthly expenditure. Poverty was evaluated on the basis of family expenditure observed to be less than 80% of the total family income. Based on the classification provided by Chakraborty and Bharati (2010), those in the < 80% of the family income was considered as 'low expenditure' group and ≥ 80% of the family income as 'high expenditure' group.

2.4.1.2. Socio-economic variables

The variables which reflect the social and economic status of any population or group are known as socio-economic variables. These variables are important to the assessment of the nutritional status and dietary intake. The socio-economic variables utilized in the present study were education, occupation, family income, per-capita income and land holding pattern. The SES of the population under study was subsequently utilized using the modified scale of Kuppuswami proposed by Mishra and Singh (2003) and Kumar *et al.*, (2007). The socio-economic scale has been described in ***Table 2.1***.

2.4.1.3. Lifestyle related variables

The lifestyle variables have added influences on the nutritional status of an individual or population. The variables recorded in the present study were sources of drinking water, toilet facility and house type.

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

(A) Education	***Score***
1. Professional or Honours	7
2. Graduate or post graduate	6
3. Intermediate or post high school diploma	5
4. High school certificate	4
5. Middle school certificate	3
6. Primary school certificate	2
7. Illiterate	1
(B) Occupation	
1. Professional	10
2. Semi-professional	6
3. Clerical, shop owner and farmer	5
4. Skilled worker	4
5. Semi-skilled worker	3
6. Unskilled worker	2
7. Unemployment	1
(C) Income per month (in Rs.) (as modified by Kumar et al. 2007)	
1. 19, 575 >	12
2. 9,788-19,574	10
3. 7,323-9.787	6
4. 4.894-7.322	4

Contd.: (C) Income per month (in Rs.) (as modified by Kumar et al. 2007)	*Score*
5. 2,936-4,893	3
6. 980-2,935	2
7. <979	1
Socio-economic status	*Total score*
Upper (I)	*26-29*
Upper-middle (II)	*16-25*
Lower-middle (III) (Middle)	*11-15*
Upper lower (Lower)	*10-5*
Lower	*< 5*

2.5. ASSESSMENT OF NUTRITIONAL STATUS USING ANTHROPOMETRIC MEASUREMENTS

Before obtaining the anthropometric measurements full explanation, procedure and objective of the present study were described to the each and every individual. Subsequently a verbal consent was taken from them prior to taking the measurements. All the individuals were healthy and not suffering from any diseases at the time of recording the measurements. They were free from any physical deformity and abnormality.

2.5.1 ANTHROPOMETRIC MEASUREMENTS RECORDED

The anthropometric measurements were recorded following the standard techniques of Weiner and Lourie (1981). Singh and Bhasin (1989) and Lee and Neiman (2005). Each measurement was taken twice and the mean recorded. The procedures of recording the measurements are briefly enumerated below:

2.5.1.1. Height

Height of the individuals was measured with the help of anthropmeter rod (GPM type, Galaxy Informatics, New Delhi) to the nearest 0.1 cm. They were made to stand on a horizontal platform (plastic board) with the both heels together. The head was kept stretched upward to the fullest extent in the Frankfurt horizontal plane. The horizontal arm of the anthropometer was brought down lightly to touch the vertex.

2.5.1.2. Weight

Body weight of the individuals was recorded using a portable weighing machine (Libra®, Edryl-India, Tiswadi, Goa). The individuals were barefooted and wearing minimum clothing at the time of measurement. Body weight was recorded to the nearest 0.5 kg. The weighing machine was checked regularly against a standard weight after weighing 15 individuals.

2.5.1.3. Mid-Upper Arm Circumference (MUAC)

MUAC was measured on the left arm of each individual with the arm hanging relaxed. It was measured midway between tip of the acromion and the olecranon process. The measurement points were marked by a marker and the measurements taken with the help of a Gulick measuring tape (Galaxy Informatics, New Delhi, India) to the nearest 1 mm. The measurement was recorded in such a way that the tape was touching the skin but not compressing the tissue.

2.5.1.4. Waist Circumference (WC)

WC was measured between the lowermost costal margin of the ribs and the iliac crest with the individual standing erect. The measurement was taken with the help of a Gulick measuring tape to the nearest 1 mm.

2.5.1.5. Hip Circumference (HC)

HC was measured as the maximum circumference or elevation of the buttocks with the individual standing erect with his feet placed together with the help of a Gulick measuring tape. The measurement was recorded to the nearest 1 mm.

2.5.1.6. Skinfold measurement

The skinfold measurements of biceps skinfold (BSF), triceps skinfold (TSF), sub-scapular skinfold (SSF) and supra-iliac (SISF) were measured using a skinfold caliper (GPM type Cat # SFGPMT, Galaxy Informatics, New Delhi, India) on the left side of each individual to the nearest to 0.2 mm. A pressure of 10 mm^2 was exerted during recording these measurements.

The procedures of taking the skinfold measurement are described below:

2.5.1.6.1. Biceps Skinfold (BSF)

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

2.5.1.6.2. Triceps Skinfold (TSF)

TSF was taken on the triceps at a point marked 1 cm above the midpoint between the tip of the acromion and the olecranon process. The elbow was placed at right angles to the middle of the upper arm and marked. The skinfold was pinched vertically and lifted off the muscle about 1 cm above the marked line. The measurement was then recorded.

2.5.1.6.3. Sub-Scapular Skinfold (SSF)

SSF was measured under the angle of the left scapula. The skinfold was kept vertical or pointing slightly downwards and outwards. The skinfold was pinched vertically and the measurements was taken about 1 cm above the marked point.

2.5.1.6.4. Suprailiac Skinfold (SISF)

SISF was recorded on the superiority portion of the iliac crest directly on the mid-auxiliary line slanting and directly on top of the iliac crest. The skinfold was pinched vertically and the measurement taken about 1 cm above the marked point.

2.5.2. TECHNICAL ERRORS OF MEASUREMENT

The Technical Errors of Measurement {TEM= $\sqrt{(\sum D^2/2N)}$, D=difference between the measurements, N number of individuals measured} is usually determined to check the validity and reliability of the anthropometric measurements (Ulijaszek and Kerr, 1999; Goto and Mascie-Taylor, 2007). For the calculation of intra-observer TEM, height, weight, MUAC, WC, HC, BSF, TSF, SSF and SISF were recorded from 50 adult Rajbanshi individuals (males:25; females: 25). The measurements were taken thrice on each individual by the investigator. The co-efficient of reliability (R), which ranges from 0 (not reliable) to 1 (complete reliability), was subsequently determined. The results of intra-observer TEM and the R value are shown in ***Table 2.2.*** Very high R values ($R>0.980$) were obtained for the intra-observer TEM analysis. All the values of R were appreciably higher than the accepted cut-off value of 0.95 as suggested by Ulijaszek and Kerr (1999). Hence, the recorded anthropometric measurements were reliable and reproducible and the TEM were not incorporated for the further analysis.

2.5.3. ASSESSMENT OF NUTRITIONAL STATUS FROM THE ANTHROPOMETRIC MEASUREMENTS

The nutritional status of the 1036 adult Rajbanshi individuals (males: 620; femles: 416), in the age of 20 years to 49 years was assessed using standard anthropometric indicators and body composition indicators. These are described as follows:

2.5.3.1. Body Mass Index (BMI)

BMI is considered to be a suitable indicator to estimate the intensity of under-nutrition or CED and over-nutrition (overweight and obesity) of an individual or a population. BMI has been calculated using the following standard equation of WHO (1995):

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

Nutritional status has been assessed using the internationally accepted BMI cut-off points as suggested by WHO (WHO, 1995) (***Table 2.3***). For the screening of under-nutrition, different CED grades of BMI were used. Studies have indicated the BMI value of < 18.50 kg/m^2 as the cut-off point to determine under-nutrition among different Indian and non-Indian populations (James *et al.*, 1988; Gibson, 1990; Ferro-Luzzi *et al.*, 1992; James *et al.*, 1994; WHO, 1995; Ferro-Luzzi and James, 1996; James *et al.*, 1999; Khongsdier, 2001, 2005; Lee and Nieman, 2005; Bose *et al.*, 2006 a, b, c; Chakraborty and Bharati, 2010). The WHO Expert Committee (WHO, 1995) has further suggested the following classification of CED based on BMI among adult populations (***Table 2.4***).

2.5.3.2. Rohrer Index (RI)

The Rohrer index (RI) was calculated to assess body composition and nutritional status using the following equation:

$$Rohrer\ index\ (RI)\ (kg/m^3) = Weight\ (kg) / Height^3\ (m^3)$$

2.5.3.3. Waist-Hip Ratio (WHR)

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

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

A high WHR was defined as >0.9 in males and >0.8 in females by Web *et al.* (2002) and Huxley *et al.* (2008). These cutoffs are used to assess the amount of higher regional adiposity among the individuals studied.

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

Name of the Measurement	*Intra-observer*	
	TEM	*Coefficient of Reliability*
Weight	0.100	0.998
Height	0.066	0.994
MUAC	0.066	0.997
WC	0.159	0.998
HC	0.201	0.998
BSF	0.138	0.999
TSF	0.137	0.985
SSF	0.012	0.999
SISF	0.242	0.987

Table 2.3: Cut-off points for assessing nutritional status of adult individuals as specified by WHO (1995)

Category	*BMI value (kg/m²)*
CED Grade III	*< 16.00*
CED Grade II	*16.00 – 16.99*
CED Grade I	*< 17.00 – 18.49*
Normal	*18.50 – 24.99*
Overweight	*≥ 25.00 – 29.99*
Obese	*≥ 30.00*

Table 2.4: Classification of CED based on BMI for adult individuals as specified by WHO (1995)

Prevalence of CED	*BMI value (kg/m^2)*
Low prevalence	*Warning sign: 5-9% of population with BMI < 18.50*
Medium prevalence	*Poor situation: 10-19% of population with BMI < 18.50*
High prevalence	*Serious situation: 20-39% of population with BMI < 18.50*
Very high prevalence	*Critical situation: ≥ 40% of population with BMI < 18.50*

2.5.3.4. Waist-Height Ratio (WHtR)

The WHtR was calculated from the measurements of WC and height using the following equation:

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

A cut-off value of 0.5 was proposed by Hsieh and Muto (2004) to assess higher level of adiposity for both sexes. This cut-off has also been validated on the Kayastha population of North Bengal, India (Sarkar *et al.*, 2009). The present study has used this cut-off to assess adiposity among the Rajbanshi individuals.

2.5.3.5 Conicity index (CI)

CI was also computed in the present study to assess body composition following the equation of Valdez *et al.* (1993):

$$CI = \text{Waist circumference (m)} / 0.109 \times \sqrt{\{\text{Weight (kg)} / \text{Height (m)}\}}.$$

2.5.3.6. Mid Upper arm circumference (MUAC)

Nutritional status was also been evaluated in the present study using the internationally accepted cut-off points of MUAC. The individual values of MUAC found below 23 cm and below 22 cm were characterized as under-nutrition among the males and females respectively (James *et al.*, 1994).

2.5.4. ASSESSMENT OF BODY COMPOSITION

2.5.4.1. Upper Arm Composition

The upper arm composition of the individuals was evaluated in terms of total Upper Arm Area (TUA), Upper Arm Muscle Area (UMA), Upper Arm Fat Area (UFA) and Arm Fat Index (AFI). These indices were calculated using MUAC and TSF by the following equations of Frisancho (1974, 1981, 1989):

$$TUA\ cm^2 = (MUAC)^2/(4\times\pi)$$

$$UMA\ cm^2 = \{MUAC - (TSF\times\pi)\}^2/(4\times\pi),$$

$$UFA\ cm^2 = TUA - UMA$$

$$AFI = (UFA/TUA)\times 100$$

The standard equations of Frisancho (1989) were also utilized to assess the corrected Bone Free Muscle Area (BFMA) among the Rajbanshi male and female individuals. The equations are as follows:

$$BFMA_{MALE}\ cm^2 = (UMA - 10.0)$$

$$BFMA_{FEMALE}\ cm^2 = (UMA - 6.5)$$

2.5.4.2. Body Density Assessment

The body density of the Rajbanshi individuals was computed in order to assess PBF. The sum of four skinfold thickness (e.g., BSF, TSF, SSF, SISF) were also utilized for calculation of body density. Sex specific standard equations of Durnin and Womersely (1974) were utilized for the purpose. These equations assumed a logarithmic relationship between obesity or higher level of adiposity and sum of BSF, TSF, SSF and SISF skinfolds among the individuals. These equations have been validated in different Indian populations by Kuriyan *et al.* (1998), Dudeja *et al.* (2001), Das and Bose (2006) and Chakraborty and Bharati (2010). The following equations of Durnin and Womersely (1974) were utilized to assess the body density:

$$\textit{Male body density} = 1.1765 - 0.0744 \times \log_{10}(BSF+TSF+SSF+SISF)$$

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

2.5.4.3. Assessment of PBF

The following standard equation of Siri (1956) was used to assess PBF for both male and female Rajbanshi individuals in the present study.

$$PBF = (4.95 / \textit{Body Density} - 4.50) \times 100$$

The body density values of the Rajbanshi individuals were used in the PBF equations after calculating them from the Durnin and Womersely equations (1974) given earlier. Several researchers have utilized Siri's equation in order to estimate the body fat content in different Indian ethnic populations and here the studies of Dudeja *et al.* (2001), Das and Bose (2006) and Chakrabarty and Bharati (2010b) may be cited.

Higher levels of adiposity were evaluated in terms of sex specific PBF cut off values that were >25% in the males and >30% in the females as recommended by several researchers (Pollock and Wilmore, 1990; Hortobagyi *et al.*, 1994). These cut-off points have also been found to be appropriate for Indian populations (Dudeja *et al.*, 2001; Das and Bose, 2006).

2.5.4.4. Assessment of Fat mass (FM) and Fat free mass (FFM)

The body mass consists of both fat mass (FM) and fat free mass (FFM). The standard equations of Van Itallie *et al.* (1990) and Eckhardt *et al.* (2003) have been utilized to assess the amount of FM and FFM among the Rajbanshi individuals. Several researchers have utilized these equations to assess the FM and FFM among different Indian populations (Das and Bose, 2006; Bhadra *et al.*, 2005a; Choudhury *et al.*, 2006). The equations are as follows:

$$\textit{Fat Mass (FM) (kg)} = (PBF/100) \times \textit{Weight (kg)}$$

$$\textit{Fat Free Mass (FFM) (kg)} = \textit{Weight (Kg)} / \textit{FM (kg)}$$

2.5.4.5. Assessment of Fat mass index (FMI) and Fat free mass index (FFMI)

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

$$\textit{Fat Mass Index } (kg/m^2) = FM/\,Height^2\ (m^2)$$

$$\textit{Fat Free Mass Index (FFMI) } (kg/m^2) = FFM/\,Height^2\ (m^2)$$

2.5.4.6. Assessment of body fat-body mass ratio (PBF/BMI ratio)

The percent of body fat-body mass ratio (PBF/BMI ratio) index was calculated to evaluate the relationship between the indices of BMI and PBF in order to assess the body composition of the adult Rajbanshi individuals. For this purpose, the following standard equation of Dudeja *et al.* (2001) was used:

$$\textit{PBF/BMI ratio} = PBF\,/\,BMI.$$

This equation has also been used in an Indian population by Das and Bose (2006).

2.5.4.7. Assessment of status of body fatness

The studied Rajbanshi individuals were classified according to the PBF proportion in order to assess body fitness status. For this purpose, age and sex classifications of Nieman (1995) and Lee and Nieman (2005) were used to determine the fitness level (***Table 2.5)***.

2.5.4.8. Assessment of related risk factor with PBF

The risk factor associated with the PBF content among the individuals was evaluated using the standard sex specific cut-off values as proposed by Sodhi (1984). The cut-off values used for the assessment of related risk factor with PBF is depicted in ***Table 2.6.***

2.5.4.9. Calculation of different skinfold ratios, indices and measurements for assessing body composition

Skinfold measurements can be utilized for the assessment of fat proportion and fat distribution in an individual or population so as to assess body composition. In the present study, several skinfold ratios, indices and measurements have been calculated to assess fat proportions and patterns, thereby assessing the body composition of the Rajbanshi individuals. The standard equations of Bose and Mascie-Taylor (2001) and Bose (2002) have been used to calculate the fat proportions. These equations are calculated the 4 subcutaneous skinfold measurements of BSF, TSF, SSF and SSIF. The following 14 skinfold ratios and indices have been calculated using the following equations:

1. *Sum of four skinfolds (∑4SKF) = BSF+TSF+SSF+SSIF*
2. *∑4SKF-BMI ratio = (BSF+TSF+SSF+SSIF)/ BMI*
3. *Centripetal Fat Ratio (CFR) = SSF/ (SSF+TSF)*
4. *SSF-TSF ratio = SSF/ TSF*
5. *SSF-BSF ratio = SSF/ BSF*
6. *SSIF-BSF ratio = SSIF/ BSF*
7. *SSIF-TSF ratio = SSIF/ TSF*
8. *BSF-∑4SKF = BSF/ ∑4SKF*
9. *TSF-∑4SKF = TSF-∑4SKF*
10. *SSF-∑4SKF = SSF-∑4SKF*
11. *SISF-∑4SKF = SSIF-∑4SKF*
12. *Log_{10} ∑4SKF = Log_{10} (BSF+TSF+SSF+SSIF)*

Table 2.5: Age and sex specific cut off value for the assessment of body fatness status after Nieman (1995)

Age	*Male*			*Female*		
(in years)	*Risky*	*Excellent*	*Good*	*Risky*	*Excellent*	*Good*
19-24	<6.0	10.8	14.9	<9	18.0	22.1
25-29	12.8	16.5	20.3	18.9	22.0	25.4
30-34	14.5	18.0	21.5	19.7	22.7	26.4
35-39	16.1	19.4	22.6	21.0	24.0	27.7
40-44	17.5	20.5	23.6	22.6	25.6	29.3
45-49	18.6	21.5	24.5	24.3	27.3	30.9

Table 2.6: Sex specific cut-off values for assessment of related risk factor with PBF after Sodhi (1984)

Classification	*Male %*	*Female %*
Lean	< 8	< 13
Optimal	+ 8 to15	+ 13 to 23
Slightly overweight	+ 15 to 20	+ 24 to 27
Fat	+ 21 to 24	+ 27 to 32
Obese (Over fat)	> 25	> 33

2.6. METHODS OF DIETARY INTAKE ASSESSMENT

Several methods have been used for the estimation of dietary intake of individual or families. These include the direct weighing of foods consumed, food diary, general dietary history and 24-HR methods (Mojonnier and Hall 1968; Balogh *et al.* 1971; Gibson, 1990; Lee and Neiman, 2005). Food weighing is adequate only for small samples, food diaries may not show changes in dietary habits while general dietary histories may be affected by recall bias. So the best method that may be adopted is the 24-HR method.

Therefore, in order to assess the dietary intake of the Rajbanshi individuals in the present study, the 24-HR method has been used. Attempts have also been made to estimate the amounts of each food ingested so as to calculate the intake of nutrients (calories, protein, fats, vitamins and minerals) using standard food composition values of Indian foods as given by Gopalan *et al.* (2003). Although the food and nutrient intakes calculated using the 24-HR method does not represent the usual or average intakes of an individual, it is more reliable for estimating intakes at a group level, where the participants' under-and over- consumption produces a fairly stable estimate of their mean consumption (Carter *et al.*, 1981; Karvetti *et al.*, 1985). Studies investigating the validity of 24-HR recall method have pointed to its acceptable levels of validity in most populations (Karvetti *et al.*, 1985; Boeing *et al.*, 1997; Buzzard, 1998). Moreover, this method has acceptable levels of concurrent validity with weighed food records, dietary history method and FFQs (Boeing *et al.*, 1997).

2.6.1. 24-HR METHOD

The '24-HR' method using oral interview was utilized to assess the dietary patterns of the Rajbanshi individuals. The 24-HR method using oral interview has been considered reliable and feasible for recording food and nutrient intakes of adult individuals by a number of researchers (Taskar *et al.*, 1967; Swaminathan, 1971; Carter *et al.*, 1981; Sorenson, 1985; Karvetti and Kriets, 1985; Thimmayamma and Rao, 2003).

The food consumed by the individuals in the present study was assessed using standardized bowls, glasses, cups and plates as suggested by the NIN, Hyderabad so as to estimate the appropriate amounts. As pointed out by Gibson (1990) and Ferguson *et al.* (1995), standard sets of bowls, glasses, cups and plates are provided to the individuals to help them visualize the amount of food consumed and weighing portions of salted replicas of vegetables and tubers. Hence, the actual amount of foods consumed by them could be ascertained. In some cases, the daily raw food stuffs were weighed to obtain the actual consumption quantity of various food items cooked by the individuals.

The 24-HR dietary recall interview was conducted in 4 stages by using the standard protocols of Gibson (1990) and Thimmayamma and Rao (2003). In the first stage a complete list of all the food stuffs and beverages consumed on the preceding day were obtained by using structured schedules. In the second stage, detailed descriptions of all the foods and beverages consumed, including the cooking procedures were recorded together with the time and place of consumption. Information on the types of cooking vessels used in the family (such as iron or steel pots) was also recorded. Estimates of the amounts of food items and beverages consumed were obtained using standard bowls, cups, glass and spoons. Information on the ingredients of mixed dishes consumed by the individuals was collected during the third stage. In the fourth and final stage of the dietary recall survey, the information obtained was reviewed to ensure that all details been correctly recorded.

2.6.1.1. Precautions Taken While Using 24-HR Method

As suggested by Thimmayamma and Rao (2003), the following precautions were taken into consideration during the dietary evaluation:

a) A thorough knowledge of the local measurements, quantities used to prepare the food and methods of preparation were meticulously noted during data collection.

b) The ingredients used in the preparation of the food stuffs and local diets preparations were precisely noted.

c) In case of beverages, the amount of dilution was taken into consideration.

d) Uses of the dense calorific foods such as cooking oils, hydrogenated fats, *'ghee'* were noted carefully.

e) In case of handmade preparation such as unleavened breads made from dough, standard size of the ingredients such as dough was shown to estimate the approximate amount used during preparation. In some cases, dough samples were collected in order to assess the exact amount utilized.

f) The individual consumptions of different food items like bread, biscuits and cakes, that include the number of fractions (slices) were taken into consideration.

g) The states of certain fruits (*e.g.*, fresh or dried) were taken into consideration.

h) For meat and fish, data was collected in terms of number of pieces and appropriate sizes at the time of consumption. The quantification of the flesh and fishes were done by comparing the sizes with standardized sizes.

2.6.2. Quantitative Estimation of the Food stuffs Consumed

The quantification of the raw food items and vegetables were estimated by showing the salted replicas of the vegetables and tubers to assess the actual consumption or utilization for meal preparations. The metric values of cooked quantities of such preparations were calculated by using a set of standardized cups, plates, bowls and spoons of varying sizes as recommended by NIN, Hyderabad.

The quantity of raw food was calculated by using the following formula of Thimmayamma and Rao (2003):

$$\text{Individual intake in terms of quantity of raw food consumed for each item} = \frac{\text{Total quantity of raw food used for each items}}{\text{Total volume of cooked food items}} \times \text{Volume of the cooked food consumed by the individuals}$$

2.6.3. ASSESSMENT OF DIETARY INTAKE

The quantification of the different nutrient components from the raw foods consumed by the individuals were calculated using the food consumption tables for Indian food items published by the ICMR (Gopalan *et al.*, 1993). The average daily nutritive intake of each individual was evaluated based on calories, proteins, fats, minerals and vitamins. The food and nutrient intakes in terms of adequacy and inadequacy status have been assessed by comparing the intake levels with the RDA for Indians populations as proposed by the ICMR (1992; 2000). The recommended food and nutrient values for the both male and female adult Indian individuals are summarized in *Tables 2.7* and *2.8* respectively.

2.6.4. ASSESSMENT OF PROTEIN AND ENERGY ADEQUACY STATUS

The protein and energy adequacy status of the individuals were evaluated based on the indices proposed for the Indian adults by the ICMR (1992) and Reddy and Rao (2000).

The protein and energy requirement curves are assumed to follow the Gaussian distribution with a coefficient of variation of 15%. The Gaussian distribution has the property that the mean ± 2 SD would cover approximately 95% of the individual values within the distribution. If any individual value was observed to be below mean – 2 SD, the values cannot be treated as having occurred by chance. Hence, an individual is considered to be consuming adequate energy (*e.g.*, calories) or protein if the intakes are equal to or greater than mean – 2 SD of the RDA for the corresponding age, gender and activity level.

Table 2.7: RDA of different food groups (gm/day) for the Indian adult population as recommended by Indian Council of Medical Research (ICMR, 2000)

Food groups	*Male*	*Female*
Cereals	520	440
Pulses and legumes	50	50
GLVs	40	100
Other vegetables	70	40
Root and Tubers	60	50
Milk and Milk product	200	50
Meat and Flesh	30	30
Nut and seeds	-	-
Fat and oils	45	25
Condiments	-	-
Sugar	35	20

Table 2.8: RDA of the different nutrients for the Indian adult population as recommended by Indian Council of Medical Research (ICMR, 2000).

Nutrients	*Male*	*Female*
Energy (kcal)	2875	2225
Protein (gm)	60	50
Fat (gm)	20	20
Calcium (mg)	400	400
Iron (mg)	28	30
Vitamin-A (µg)	600	600
Thiamin (mg)	1.4	1.1
Riboflavin (mg)	1.6	1.3
Niacin (mg)	18	14
Vitamin-C (mg)	40	40

2.6.4. Assessment of Protein and Energy Adequacy Status

The protein and energy adequacy status of the individuals were evaluated based on the indices proposed for the Indian adults by the ICMR (1992) and Reddy and Rao (2000).

The protein and energy requirement curves are assumed to follow the Gaussian distribution with a coefficient of variation of 15%. The Gaussian distribution has the property that the mean ± 2 SD would cover approximately 95% of the individual values within the distribution. If any individual value was observed to be below mean − 2 SD, the values cannot be treated as having occurred by chance. Hence, an individual is considered to be consuming adequate energy (*e.g.*, calories) or protein if the intakes are equal to or greater than mean − 2 SD of the RDA for the corresponding age, gender and activity level. An individual is considered to be consuming inadequate calories or proteins when the intake is less than mean – 2 SD of the RDA. Thus, the cut-offs values of 2425 Kcal of energy and 46 gm of the protein were taken to daily requirement of an individual (Reddy and Rao, 2000; Kumar *et al.*, 2005). Hence, if in a Rajbanshi family, the per individual intake of energy and protein was found to be equal or more than the lower to the -2 SD of the requirement, the individuals were considered to consume an inadequate amount of these nutrients (e,g,. protein and energy). The classification given by Reddy and Rao (2000) has been used to evaluate the protein and caloric status of the Rajbanshi individuals (***Table 2.9***).

Table 2.9: Classification based on the protein and caloric of Reddy and Rao (2000)

Category/Classification	*Index*
protein adequacy-calorie adequacy	*P + C+*
protein adequacy-calorie inadequacy	*P + C–*
protein inadequacy-calorie adequacy	*P – C+*
protein inadequacy-calorie inadequacy	*P – C–*

2.7. STATISTICAL COMPUTATION

The data obtained in the present study was statistically analyzed using statistical constants and relevant statistical tests. The statistical analyses were performed utilizing the Statistical Package for Social Sciences (SPSS; version 15.0). A p-value of <0.05 and <0.01 was considered to be statistically significant.

Chi-square (χ^2) analysis was utilized to assess the sex differences in socio-economic, demographic and life style related factors (population size, education, occupation, family income, per capita income, family size, dependent children, family type, marital status, drinking water facility, toilet facility, landholding pattern, house pattern type, socio-economic status, likelihood ratio and expenditures group).

The anthropometric variables recorded have been described using descriptive statistics (mean ± standard deviation). Sex differences and age specific differences within sexes in the anthropometric variables were analysed using one-way analysis of variance (ANOVA). The Pearson correlation coefficient analysis was done to understand the association between the anthropometric variables. Linear regression analysis was done to assess the dependency of the sex, age and BMI on the anthropometric variables.

χ^2 analysis was also done to assess the sex differences in the anthropometric indices which are important in the assessment of under-nutrition and over-nutrition. χ^2 analysis was also performed to assess the sex difference in the non-parametric anthropometric features between the male and female Rajbanshi individuals. The Yates correction factor was taken into consideration if a cell/category possessed less than 5 individuals. This correction term adds to the accuracy of the χ^2 analysis when the numbers of classes are small. χ^2 analysis was also utilized to assess the sex differences in the nutritional indices related to fatness, body composition, over-nutrition and regional adiposity measurements between the male and the female individuals. The differences in BMI, WHR, WHtR with respect to the different socio-economic, demographic and lifestyle related variables were also assessed using χ^2 analysis.

A multinomial logistic regression model was fitted to estimate the odds of being affected by under-nutrition and over-nutrition in the categories of BMI, WHR and WHtR among the Rajbanshi individuals. The model with the calculation of corresponding adjusted odds (ORs) and 95% confidence interval (CIs) was used to examine possible difference between the individuals are fall in the category of under-nutrition or over-nutrition. The predictor variables were socio-economic, demographic and life style related factors such as population size, education, occupation, family income, per capita income, family size, dependent children, family type, marital status, drinking water facility, toilet facility, landholding pattern, house pattern type, socio-economic status, likelihood ratio and expenditure groups. The multinomial regression model allows controlling effects of these variables to create dependency in selective variables. Therefore, individuals affected by under-nutrition and over-nutrition were categorized dichotomously by using different sex specific cut-offs points for BMI (WHO, 1995), WHR (WHO, 2000) and WHtR (Hsieh and Muto, 2004). The individuals with any nutritional deficiency using a particular parameter such as BMI and with over-nutrition also using a particular parameter such as WHR and WHtR were coded as 1. The individuals observed to be normal and also above the relevant nutritional cut-off points were coded as 0. These values were entered in the regression model as response variables and termed as dummy variables instead of the actual values. Similarly, the predictor variables were coded separately and entered in the regression model as sets of dummy variables. The reference categories used for the multinomial regression model includes 20 years to 29 years in age, secondary and above in education, labour and housewife in occupation, Rs. >6000 family income, Rs. >1400 in per capita income, $\leq$ 4 in family size, 0-1 in dependent children, nuclear family in family type, unmarried in marital status, own well or tube well in water facility, 'yes' in toilet facility, 2.5 acre in land holding pattern, bricked house type in house type, medium in socio-economic group and < 80% in income expenditure groups. The multi-logistic regression model was tested separately for the male and the female individuals.

The descriptive statistics (mean ± standard deviation) were used to describe the data on the food and dietary intake of the male and the female Rajbanshi individuals. Sex differences in dietary intake and nutrient intake were done using ANOVA. χ^2 analysis was done to assess the sex differences in protein and caloric deficiency and different combinations of protein-energy malnutrition. A multinomial logistic regression analysis was fitted to obtained odds values for inadequate consumption of caloric, protein and protein-energy deficiency among them. A multinomial regression analysis was also done to assess the influence of socio-economic and demographic variables on the deficiency intake of caloric and protein-energy deficiency. The deficiency status was documented utilizing the cut-off values considered to be consuming inadequate calories or proteins when the intakes were less than mean – 2 SD of the RDA, based on the Gaussian distribution. The cut-offs values of 2425 Kcal of energy and 46 gm of the protein were taken as the daily requirement of an individual (Reddy and Rao, 2000; Kumar *et al.*, 2005). The individuals deficient for energy, protein and protein and caloric deficiency were coded as '0' and normal as '1'. These values were entered in the regression model as response variables and termed as dummy variables instead of the actual values. Similarly, the predictor variables include socio-economic and demographic include sex, age, family type, dependent children, education of head, income, number of earning head, monthly expenditure, nature of occupation, per-capita expenditure, and per-capita income variables were coded separately and entered in the regression model as sets of dummy variables. The reference categories were used from the used variables for the multinomial regression model includes male in sex, 4 years to 49 year in age, nuclear family in family type, 4 > members in family size, 0-1 in dependent children, 5 ≥ in standard education of head of family, Rs. 6000> in family income, 3 ≥ in family earning head and Rs. 4500> in monthly expenditure group.

CHAPTER-III:

RESULTS

RESULTS

3.1. DEMOGRAPHIC, SOCIO-ECONOMIC AND LIFE STYLE RELATED VARIABLES AMONG THE RAJBANSHI INDIVIDUALS

3.1.1. POPULATION SIZE

The age and sex distributions of the Rajbanshi individuals in the present study are depicted in ***Table 3.1.*** The results showed that 59.85% and 40.15% of the individuals were males and females respectively (***Figure 3.1***). The overall age specific distribution showed that most of the individuals belonged to the age group of 20-29 years (45.46%) followed by those in the 30-39 years age group (28.96%) and finally those in the 40-49 years age group (25.58%). ***Figure 3.2*** shows the sex specific distributions of the individuals. It is seen that 43.87% and 47.84% of the males and the females belonged to the 20-29 years age group. The distribution was lower in the age group of 40-49 years (males: 25.65%; females: 25.48%).

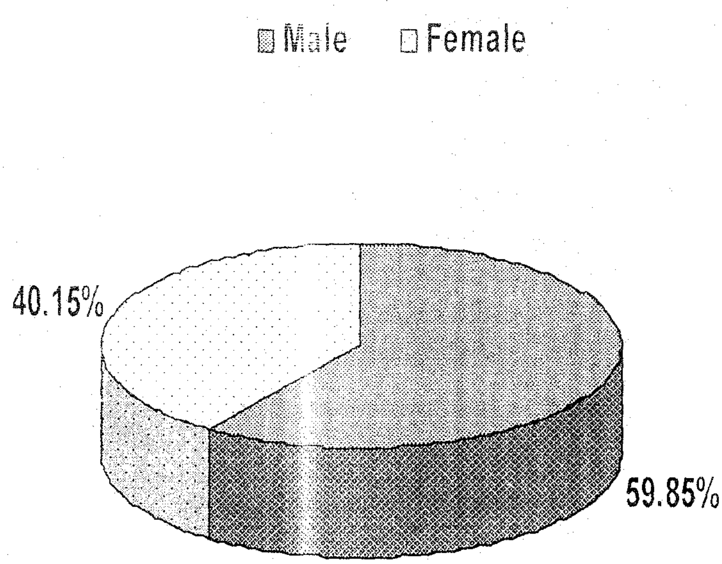


Figure 3.1: Pie chart showing the sex distribution among the Rajbanshi individuals

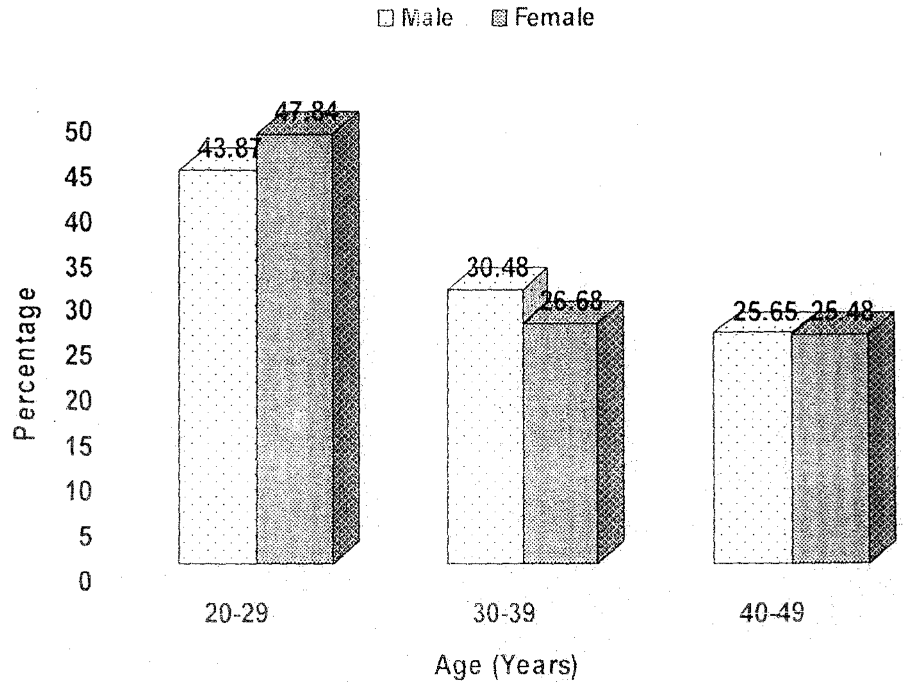


Figure 3.2: Bar diagram showing the age and sex distribution among the Rajbanshi individuals

3.1.2. EDUCATIONAL STATUS

The educational status among the Rajbanshi individuals is shown in ***Table 3.1.*** The results indicated that more than a fifth of the individuals were illiterate (21.33%) and only 3.38% of them were graduates. Most of the individuals studied up to the secondary level (56.95%). The rest (18.34%) studied up to the primary level. The distribution of educational status according to sex shows that a higher proportion of the male individuals completed their secondary education as compared to the females (60.16% versus 52.16%). The results also showed that a low proportion of the male and female individuals completed graduation (4.84% versus 1.20%). The distribution of educational status is graphically displayed in ***Figure 3.3.*** The sex-wise breakup of educational status is depicted in ***Figure 3.4.*** Using χ^2 analysis, the sex differences were observed to be statistically significant (χ^2-value= 27.59: d.f. 4; p<0.01).

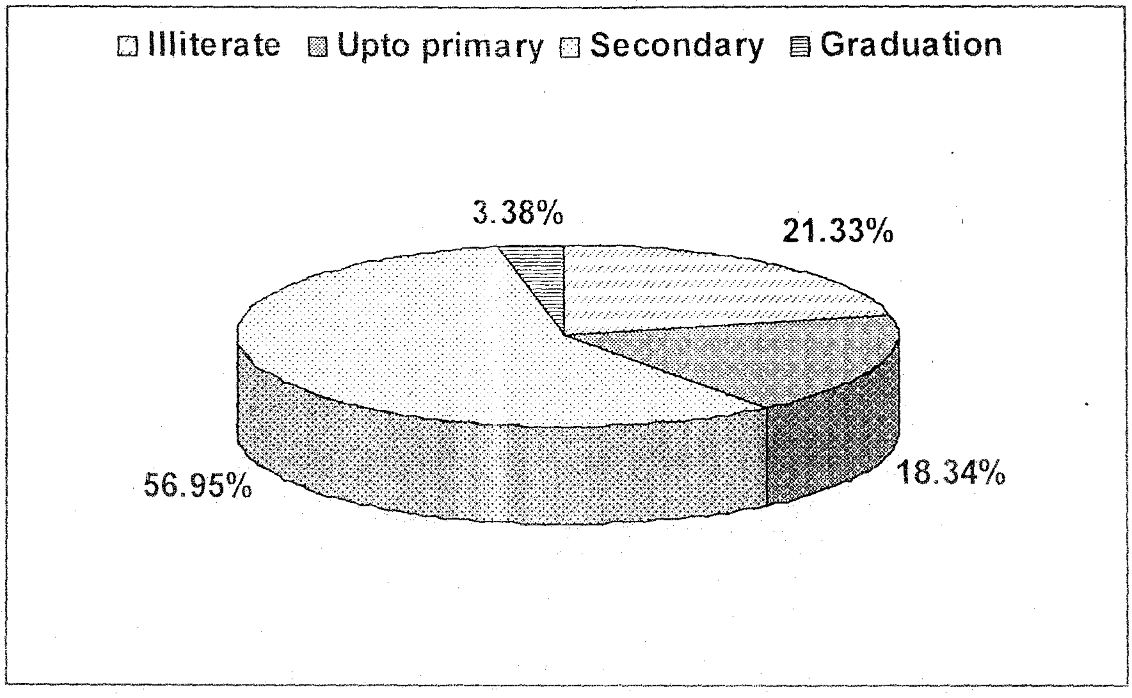


Figure 3.3: Pie chart showing the overall educational status among the Rajbanshi individuals

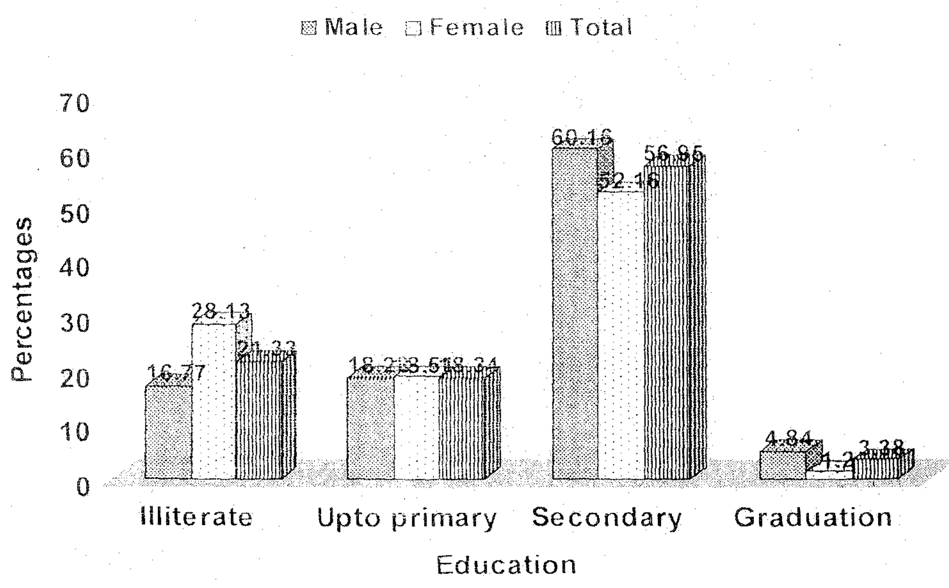


Figure 3.4: Bar diagram showing the sex-wise education status among the Rajbanshi individuals

3.1.3. Occupational status

The occupational status among the Rajbanshi individuals is presented in ***Table 3.1.*** Cultivation and agricultural-related activities were the main occupations of the individuals. A majority of them were engaged in cultivation (39.96%) followed by the 'others' (35.33%) and finally the daily labour categories (24.71%). The 'others' category included those male individuals who were engaged in small businesses and service, and females who were engaged as housewives. Daily labour was practiced in the agricultural, tea gardens, wage and skilled labour sectors. It was observed that majority of the males were engaged in cultivation (52.58%). Similarly, majority of the females were engaged in household work (64.42%). A small proportion of the males were engaged in business or service (15.81%) while only 14.42% of the females were engaged as tea garden workers (***Figure 3.5***). The results further indicated that the male Rajbanshi individuals were engaged in heavy field activities while their female counterparts were involved in lighter activities. Using χ^2 analysis, it was observed that statistically significant sex differences existed in occupational status (χ^2-value= 257.86; d.f. 3; $p<0.01$).

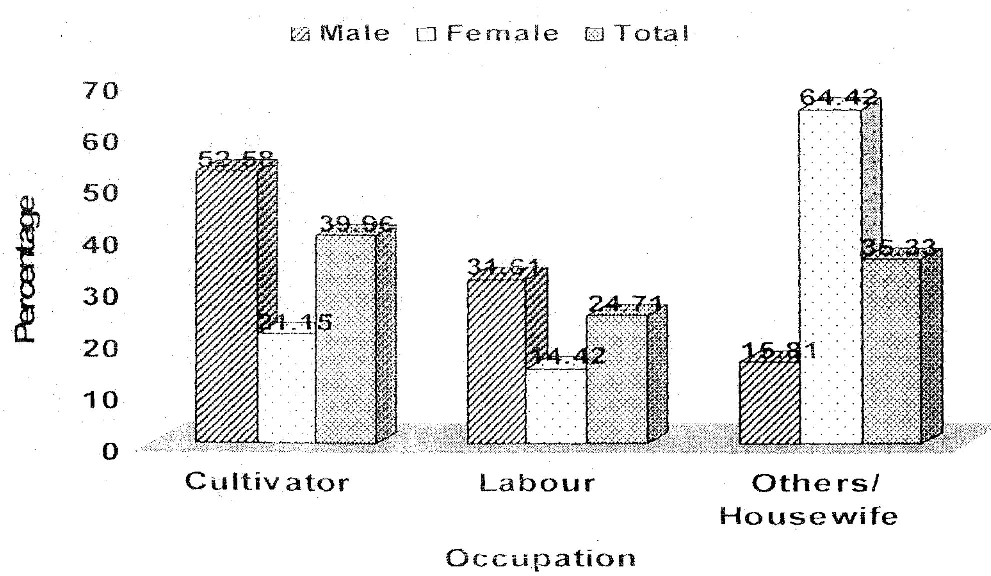


Figure 3.5: Bar diagram showing the occupational status among the Rajbanshi individuals

3.1.4. Monthly family income

The distribution of monthly family income among the Rajbanshi individuals is presented in ***Table 3.1.*** The mean income was Rs. 5596.13. Most of the individuals belonged to the Rs. 4001- Rs. 6000 income category (45.17%), followed by up to Rs. 4000 income category (33.4%) and finally the >Rs. 6000 income category (21.43%). The sex specific breakup of monthly family income showed the highest incidence of males and females belonged to the Rs.4001 - Rs. 6000 income group (46.45% versus 43.27%). The lowest incidence was in the >Rs.6000 income category (males: 21.61%; females: 21.15%). The data is graphically represented in ***Figure 3.6.*** There was no statistically significant sex difference in monthly family income (χ^2-value = 1.57; d.f. 3; $p>0.05$).

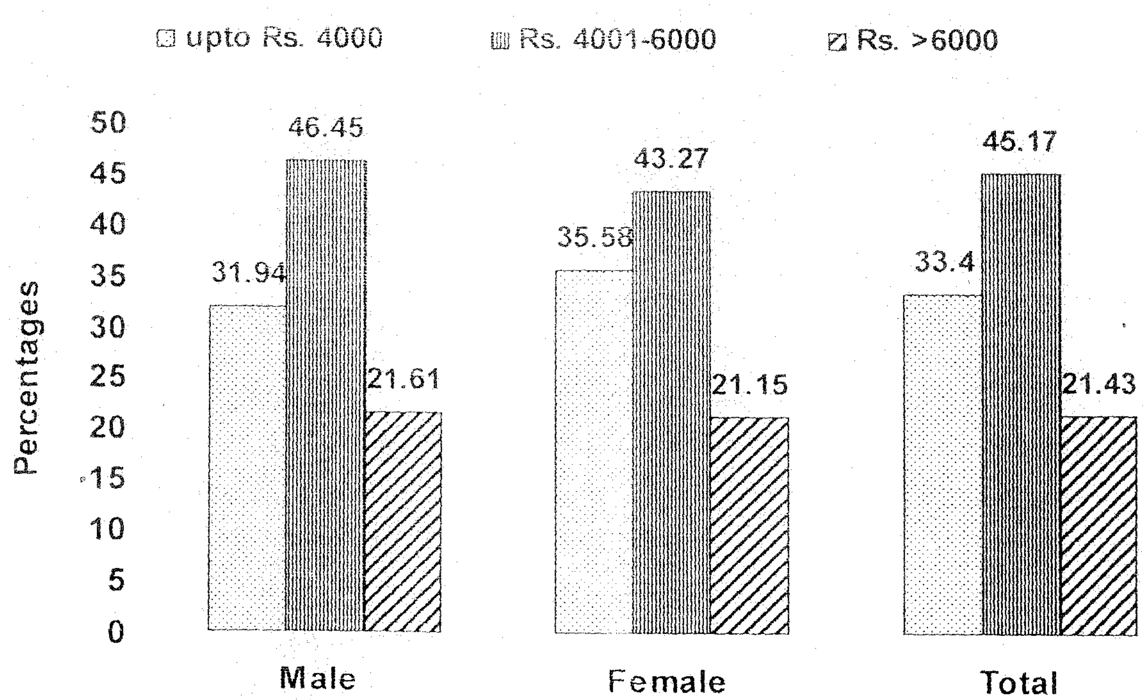


Figure 3.6: Bar diagram showing the monthly family income among the Rajbanshi individuals

3.1.5. Per capita income

The distribution of per capita income among the Rajbanshi individuals is depicted in ***Table 3.1.*** The overall mean and standard deviation of per capita income is Rs.1136.39 ± 595.15. The highest number of individuals comprise the Rs. 701-Rs. 1400 category (61.29%) followed by the > Rs. 1400 category (20.85%) and finally up to the Rs. 700 income category (17.86%). The majority of the males and the females belonged to the Rs. 701-Rs. 1400 income group (66.13% versus 54.09%). The lowest incidences were observed in the category of up to Rs. 700 (males: 15.16%; females: 21.88%). The data is represented graphically in ***Figure 3.7.*** Using χ^2 analysis, the sex difference in per capita income was statistically significant (χ^2-value = 15.57; d.f. 3; $p<0.05$).

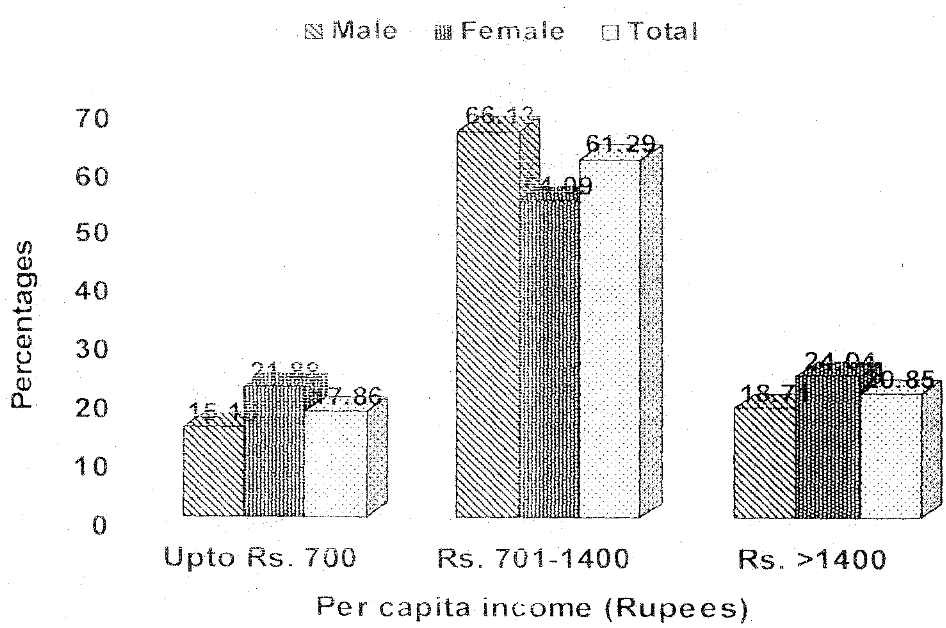


Figure 3.7: Bar diagram showing the per capita income among the Rajbanshi individuals

3.1.6. Family size

The mean and standard deviation of family size in the present study is 5.26 ± 1.69. The age and sex distribution of family size are shown in ***Table 3.1***. The results indicated that most of the families belonged to the family size of 5-6 members (49.23%) (***Figure 3.8***). The least number of individuals comprised the family size of >9 members (4.73%). Most of the males and the females belonged to the family size of 5-6 members (50.65% versus 47.12%) (***Figure 3.9***). Using χ^2 analysis, the sex difference in the distribution of family size between the male and the female individuals was statistically insignificant (χ^2-value= 4.07; d.f. 4; p>0.05).

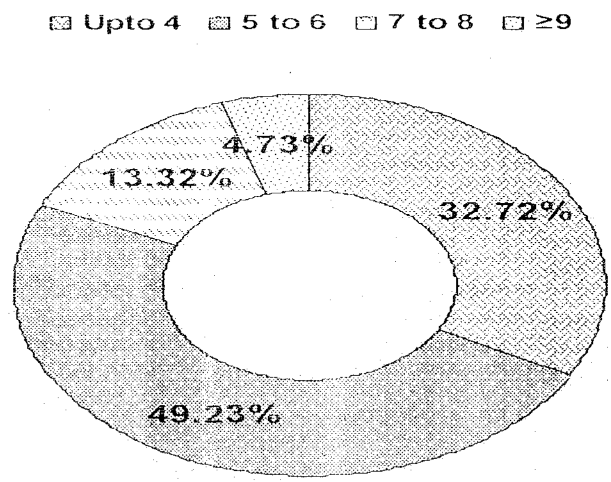


Figure 3.8: Figure showing the family size among the Rajbanshi individuals

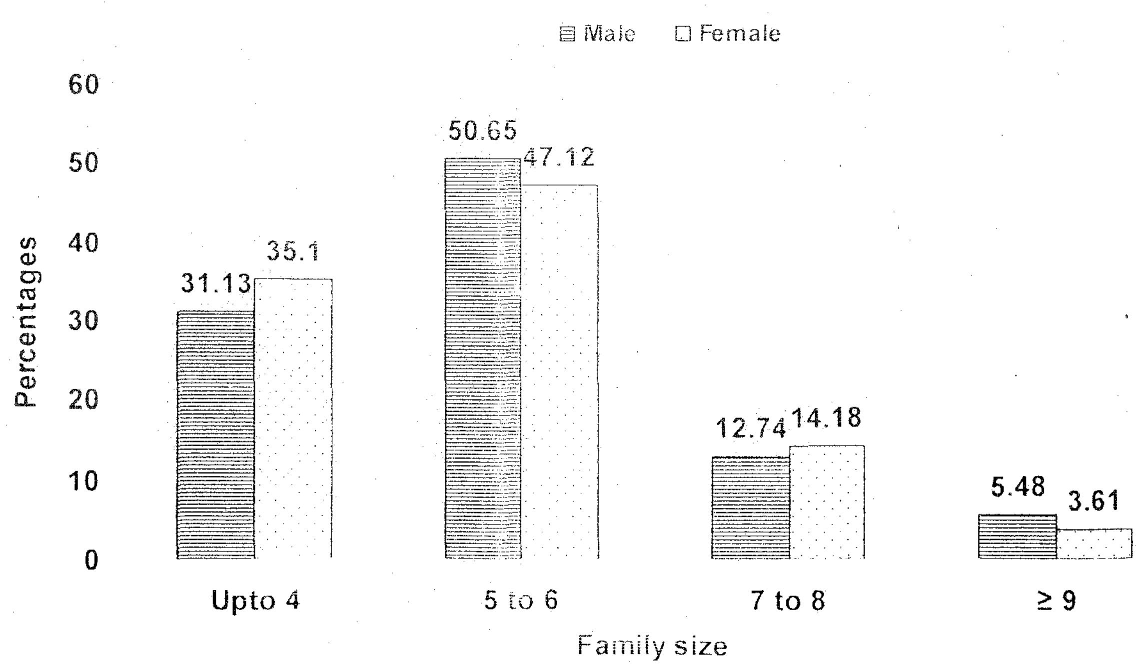


Figure 3.9: Bar diagram showing the sex-wise break up of family size among the Rajbanshi individuals

3.1.7. Dependent children

Table 3.1 shows the age and sex distribution of the number of dependent children among the Rajbanshi individuals in the present study. The mean and standard deviation of the total number of dependent children were 2.03 ± 1.28. The results indicated that most of the dependent children were found in the '0-1' category (35.62%). The least number of dependent children was observed in the '≥4' category (11.49%). The categories of '2' and '3' dependent children showed overall incidences of 32.14% and 20.75% respectively. The comparative evaluation of the sex specific distribution in the number of dependent children is depicted in ***Figure 3.10.*** The sex specific distribution showed that the males had the highest prevalence in the '2' category (34.35%) while the females had the highest incidence in the '0-1' category (37.98%). Using χ^2 analysis, the sex difference in the distribution of dependent children was statistically not significant (χ^2-value = 5.48; d.f. 4; $p>0.05$).

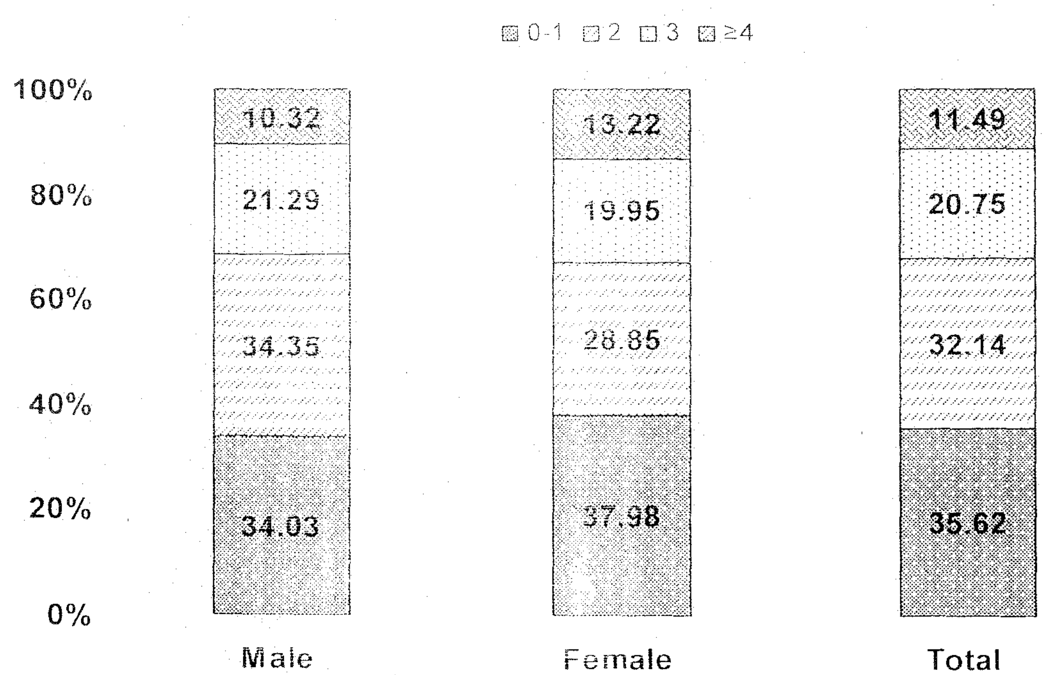


Figure 3.10: Column chart diagram showing the sex-wise distribution of dependent children among the Rajbanshi individuals

3.1.8. Family type

The age and sex distribution of family types among the Rajbanshi individuals are shown in ***Table 3.1.*** It is evident that most of the individuals belonged to the nuclear family (72.20%) followed by the joint/extended one (27.80%) (***Figure 3.11***). The sex-wise breakup showed that 72.10% and 72.36% of the male and female individuals belonged to the nuclear family respectively. The rest 29.90% among the males and 27.64% among the females belonged to the joint/extended type. Utilizing χ^2 analysis, the sex difference in the distribution of family size was statistically not significant (χ^2-value= 0.01; d.f. 2; p>0.05).

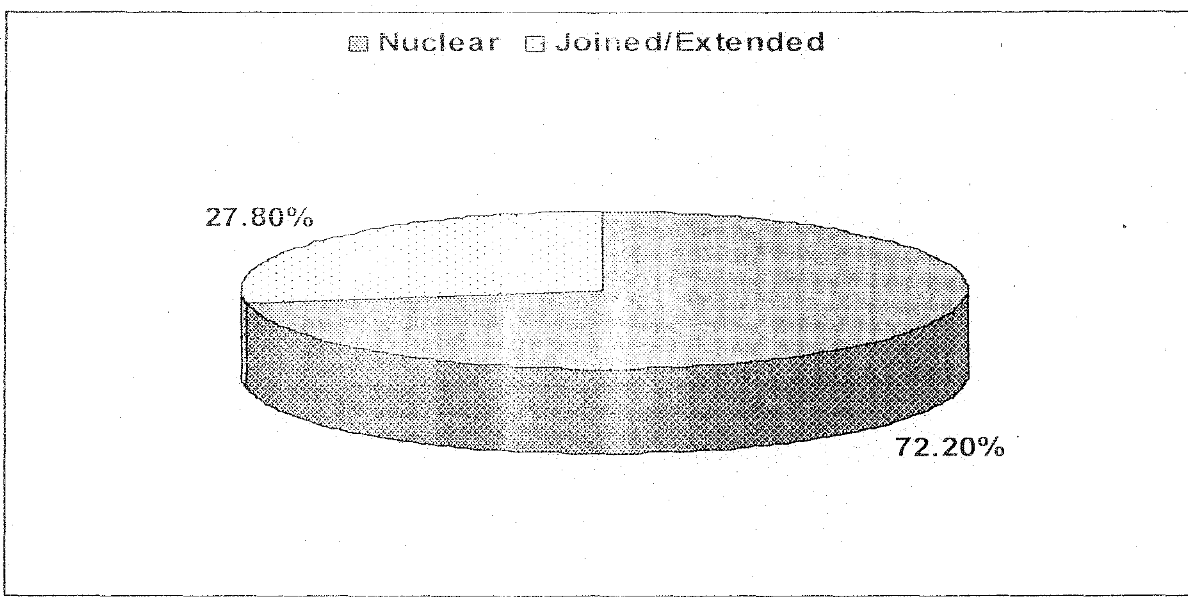


Figure 3.11: Pie chart showing the distribution of family types among the Rajbanshi individuals

1.3.9. Marital status

The information on marital status among the Rajbanshi individuals is presented in ***Table 3.1.*** The majority of the individuals were married (70.08%), followed by unmarried (26.93%) and finally the widow and widower (2.99%). Most of the males and the females were married (70.65% versus 69.23%) (***Figure 3.12***). The sex specific distribution further depicted that 28.71% and 24.28% of the males and the females were unmarried. Very few of them comprised the categories of widower (0.65%) and widow (6.49%). The sex difference in the distribution of marital status was statistically significant (χ^2-value= 30.31; d.f. 3; p<0.01).

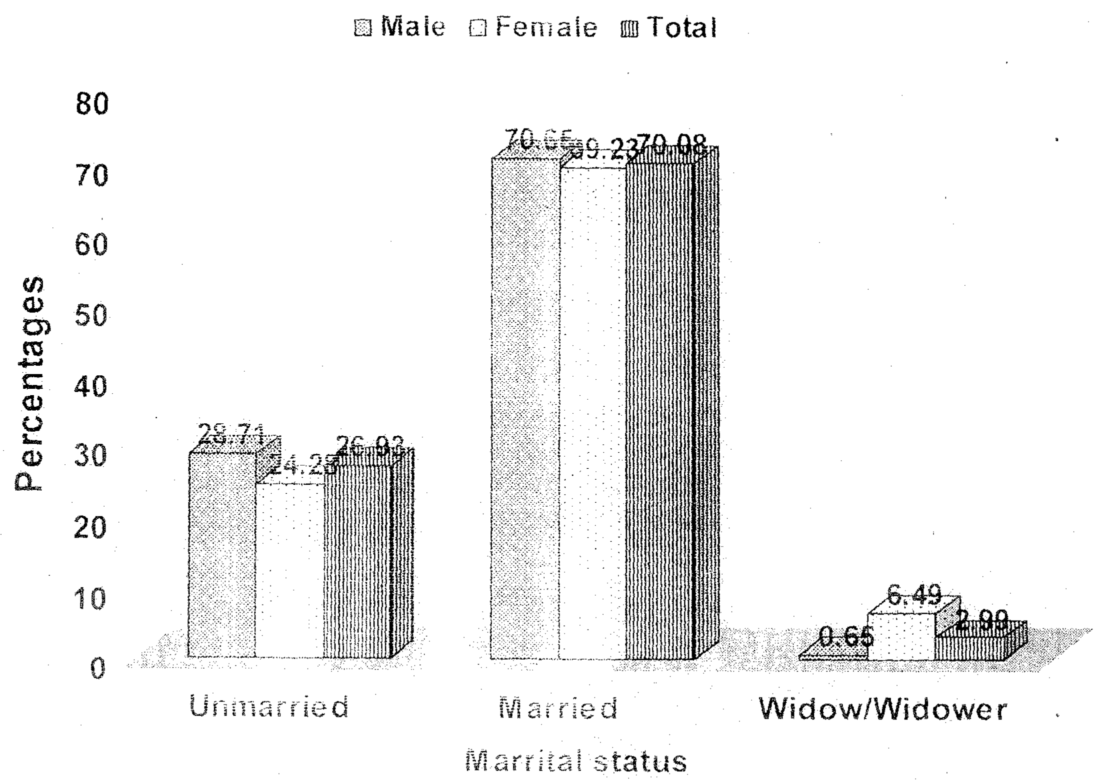
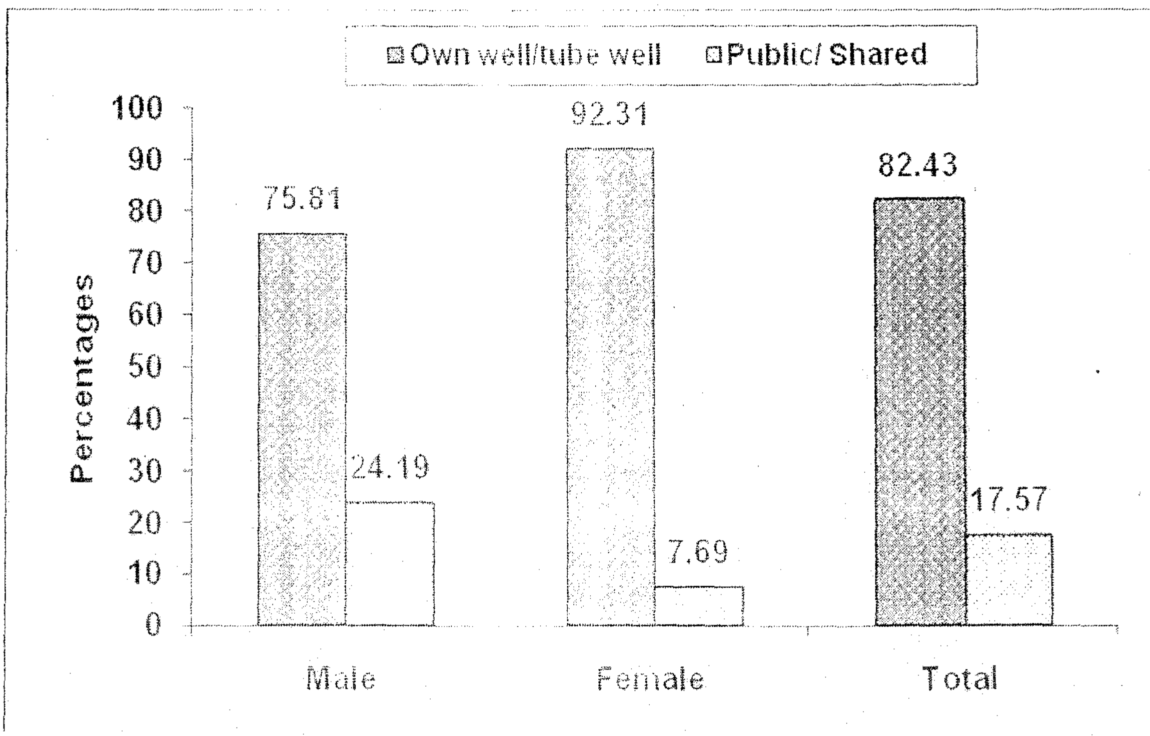


Figure 3.12: Bar diagram showing the marital status among the Rajbanshi individuals

3.1.10. Drinking water facility

The data obtained on the presence of drinking water facilities among the Rajbanshi individuals is depicted in *Table 3.1.* The majority of the individuals had their own wells or tube wells as water facilities (82.43%). Only (17.57%) of them were using the public or shared drinking water facilities. Among the males, 75.81% had their own wells or tube wells, whereas 92.31% of the female individuals had their own wells or tube well. The usage of public or shared drinking water facilities was comparatively low (males: 24.19%, females: 7.96%) (*Figure 3.13*). Using χ^2 analysis, the sex difference in the distributions of drinking water facilities was found to be statistically significant (χ^2-value= 46.81; d.f. 2; p<0.01).



3.13: Bar diagram showing the drinking water facilities among the Rajbanshi individuals

3.1.11. Toilet facilities

Table 3.1 shows the distribution of toilet facilities among the Rajbanshi individuals. The results indicated that 51.64% of the individuals (males: 58.39%; females: 41.59%) had access to toilet facilities. The rest 48.36% of the individuals (males: 41.61%; females: 58.41%) had no access to toilet facilities (***Figure 3.14***). The sex difference in distribution of toilet facilities was observed to be statistically significant (χ^2-value = 28.14; d.f. 2; $p<0.01$).

3.1.12. Landholding pattern

The nature of landholding pattern among the Rajbanshi individuals is shown in ***Table 3.1.*** Most of the individuals owned <2.5 acres of land (89.29%). The rest 10.71% owned >2.5 acres of the land. The pattern is graphically represented in ***Figure 3.15.*** The comparative distribution of the land holding pattern showed that 90.65% and 87.26% of the males and females had <2.5 acres of land respectively. Only 9.35% and 12.74% of the male and the female individuals had >2.5 acres of land (***Figure 3.16***). The sex difference in land holding pattern was statistically insignificant (χ^2-value = 2.98; d.f. 2; $p>0.05$).

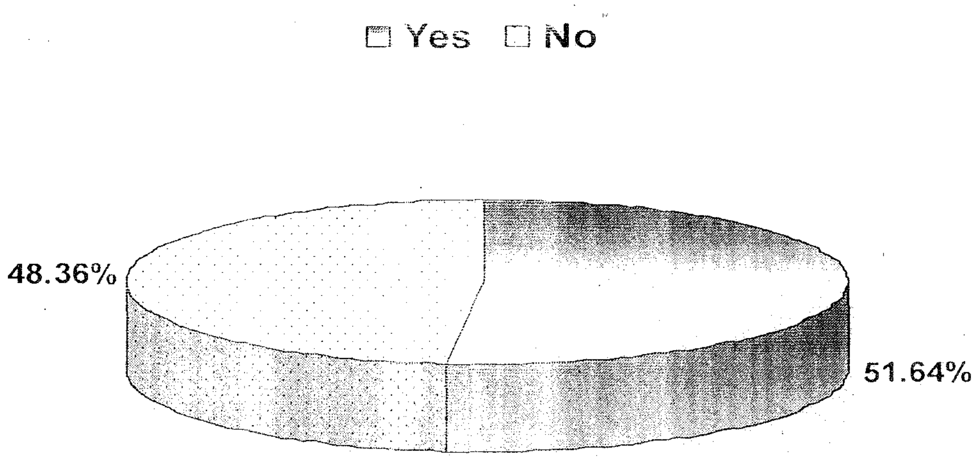


Figure 3.14: Pie chart showing the access to toilet facilities among the Rajbanshi individuals

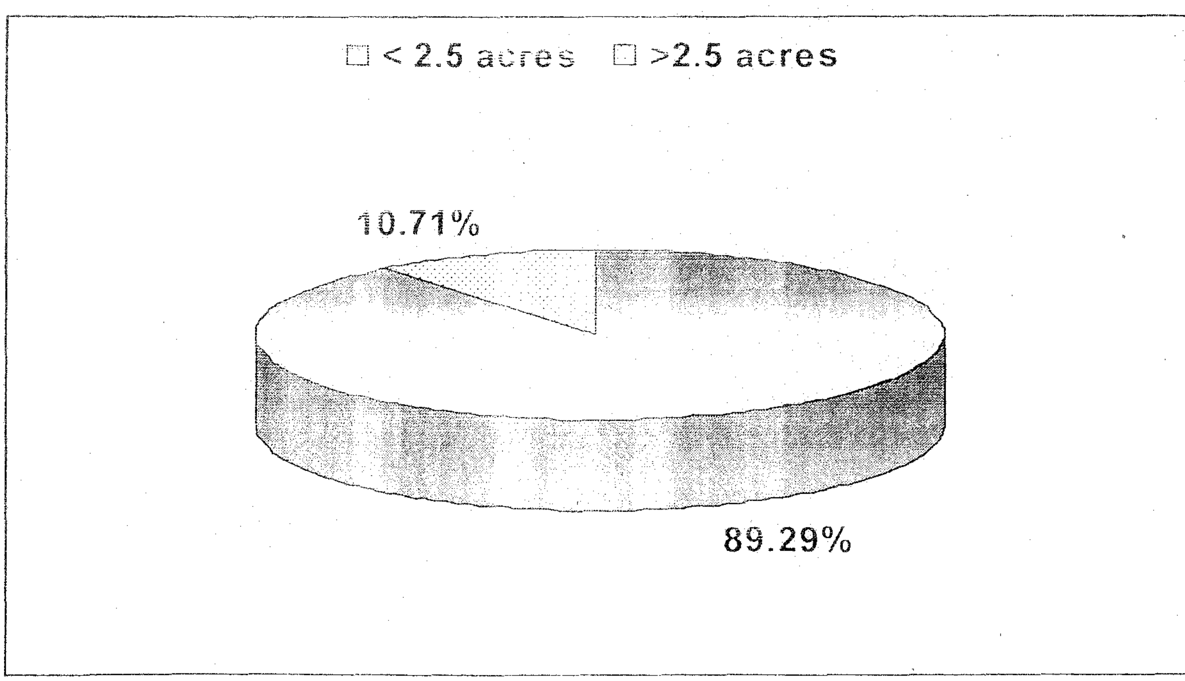


Figure 3.15: Pie chart showing the land holding patterns among the Rajbanshi individuals

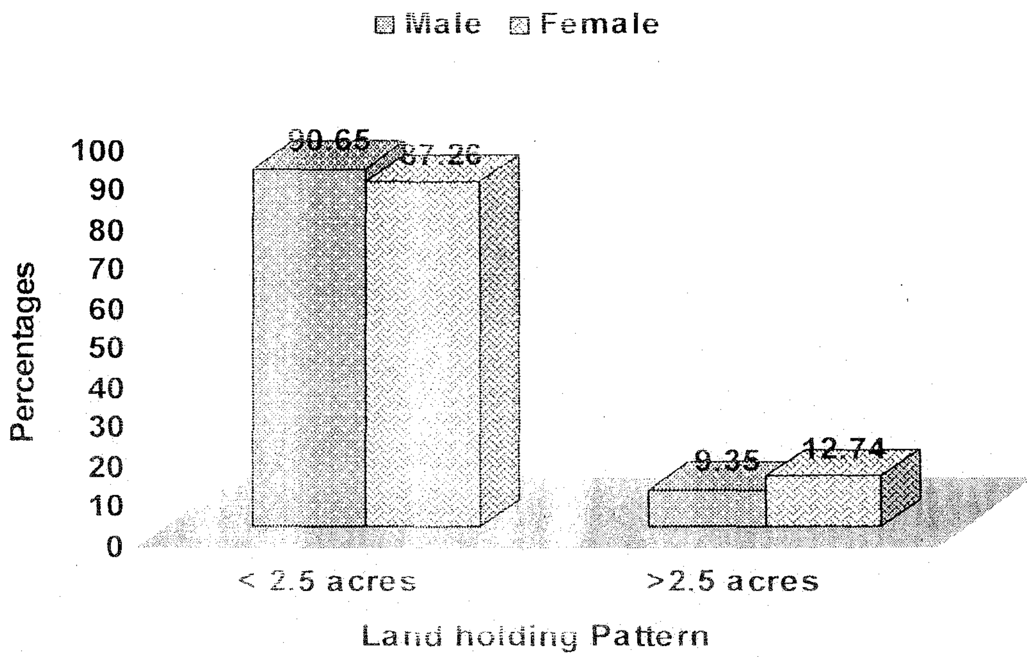


Figure 3.16: Bar diagram showing the landholding pattern among the Rajbanshi individuals

3.1.13. House type

The house type obtained in the present study is depicted in ***Table 3.1.*** The majority of the individuals had non-bricked type of houses (75.39%) and the rest 24.61% of the individuals had bricked houses (***Figure 3.17***). It needs to be mentioned here that the entire bricked houses was a combination of bricked and semi-bricked types. Among the males, 26.29% had a bricked house type, while the percentage was 22.12% among the females. Utilizing χ^2 analysis, the sex difference in house pattern types was statistically not significant (χ^2-value 2.34; d.f.2; $p>0.05$).

3.1.14. Socio-economic status (SES)

The SES of the Rajbanshi individuals was evaluated using the modified scale of Kuppuswami proposed by Singh and Mishra (2003) and modified by Kumar et al. (20070. The socio-economic status of the individuals is presented in ***Table 3.1.*** Most of the individuals belonged to the lower socio-economic group (62.74%) and the rest to the medium socio-economic group (37.26%) (*Figure 3.18*). None of them comprised the upper socio-economic group. A total of 53.39% of the males and 86.78% of the females belonged to the medium and lower socio-economic group respectively (***Figure 3.19***). Using χ^2 analysis, the sex difference in socio-economic status was statistically significant (χ^2-value = 171.81; d.f. 2; p<0.01).

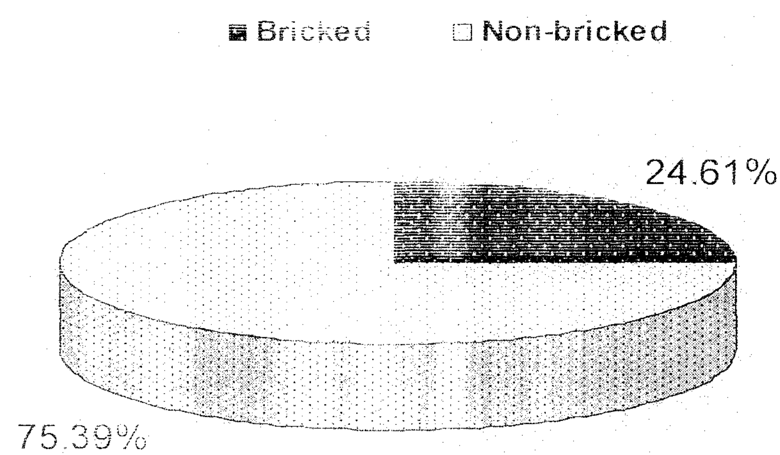


Figure 3.17: Pie chart showing the house types among the Rajbanshi individuals

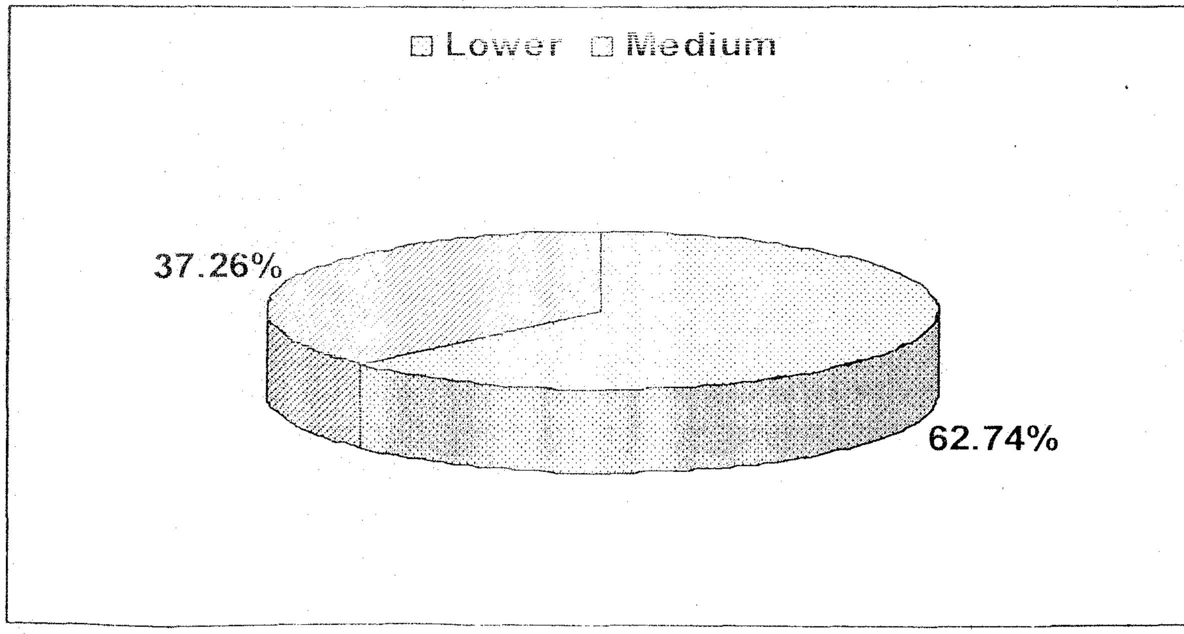


Figure 3.18: Pie chart showing the socio-economic status among the Rajbanshi individuals

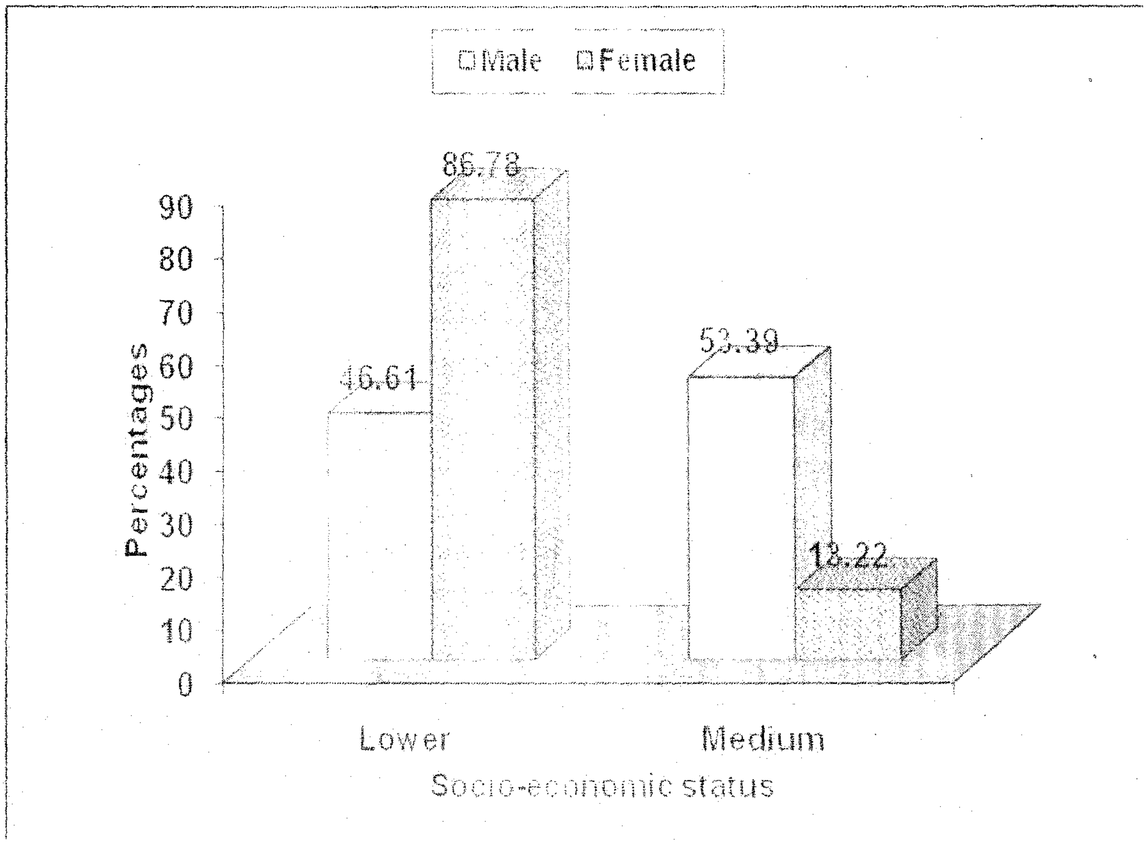


Figure 3.19: Bar diagram showing the sex-wise distribution in SES among the Rajbanshi individuals

3.1.15. Likelihood ratios

The results of the likelihood ratio among the Rajbanshis are presented in ***Table 3.1***. The likelihood ratio was evaluated using the scale of Som *et al.* (2008). The results indicated that 63.42% and 36.58% of the individuals exhibited low to medium and high likelihood ratios respectively. Both the male and female individuals show higher ratios in the low to medium groups (63.71% versus 62.98%). The 'high likelihood' ratio was observed among 36.29% of the males and 37.02% of the females (***Figure 3.20***). χ^2 analysis was used to assess the sex difference in the distribution of likelihood ratios. The differences was observed to be statistically not significant (χ^2-value 0.057; d.f. 2; $p>0.05$).

3.1.16. Expenditure groups

Table 3.1 depicts the distribution of expenditure groups among the Rajbanshi individuals. The scale of Chakraborty and Bharati (2010a, 2010b) has been utilized to classify the expenditure groups. The results indicate that 54.54% and 45.46% of the individuals belonged to the high and low income groups respectively (***Figure 3.21***). It was also seen that 55.32% and 53.37% of the male and female individuals belonged to the high expenditure group. The low expenditure group comprised of 44.68% of the males and 46.63% of the females (***Figure 3.22***). The sex difference in the distribution of expenditure groups was observed to be statistically not significant (χ^2-value 0.385; d.f. 2; $p<0.05$).

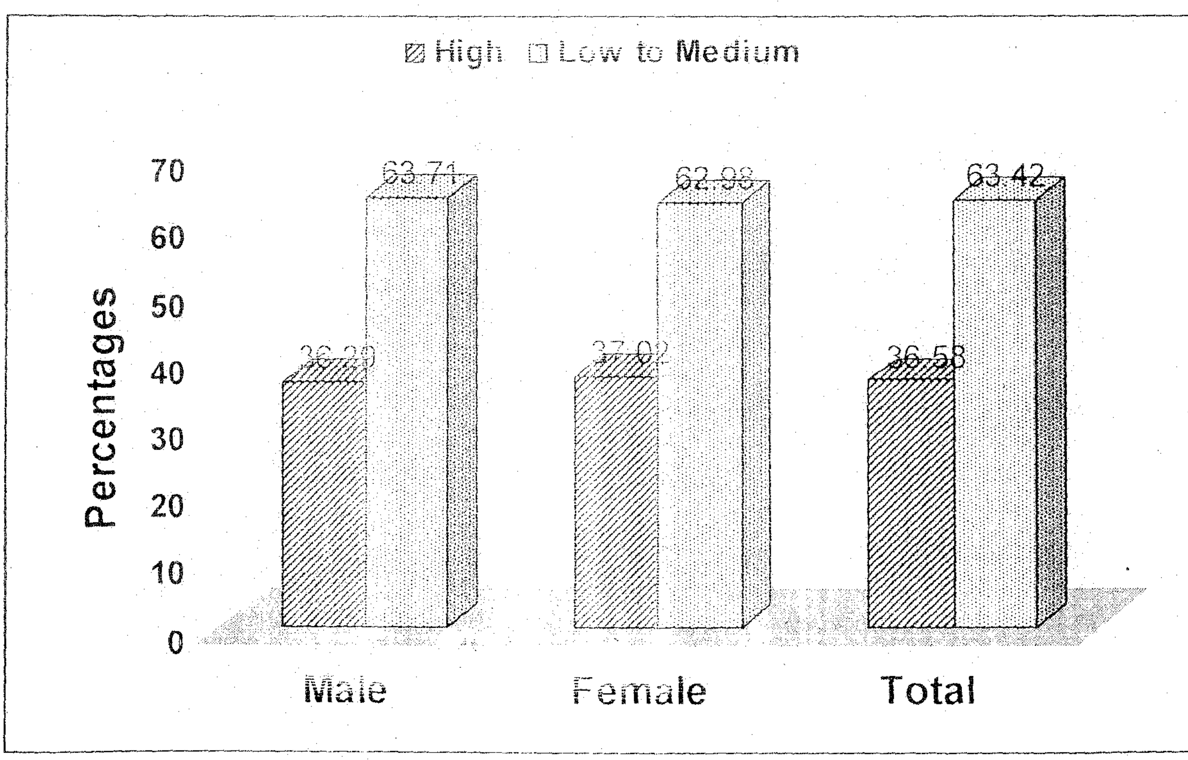


Figure 3.20: Bar diagram showing the distribution of likelihood ratios among the Rajbanshi individuals

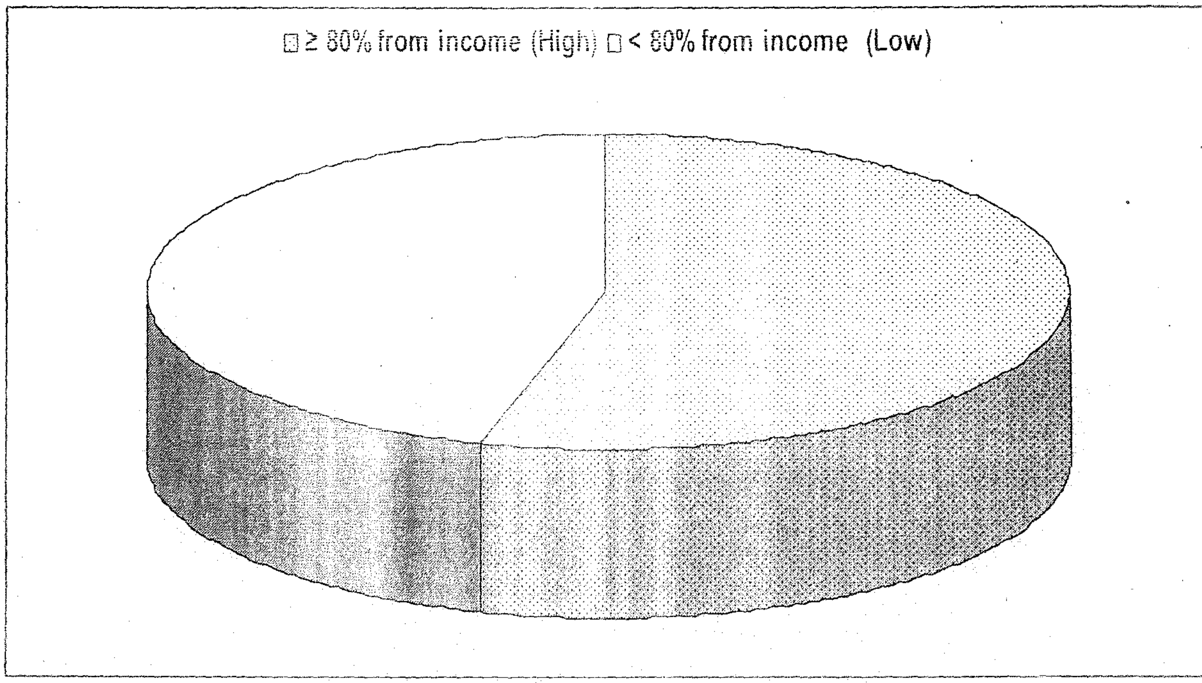


Figure 3.21: Pie chart showing the expenditure groups among the Rajbanshi individuals

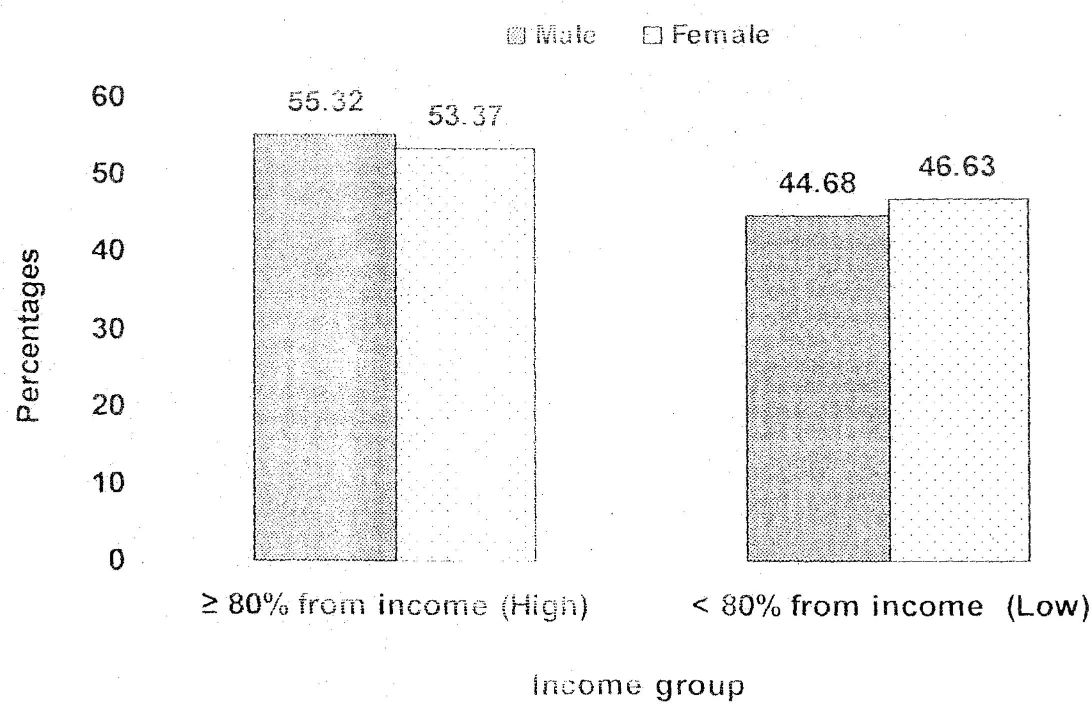


Figure 3.22: Bar diagram showing the sex-wise break up of expenditure groups among Rajbanshi individuals

Table 3.1. Demographic, socio-economic profile and lifestyle related factors among the Rajbanshi individuals

Variable		*Males (N=620)*	*Females (N=416)*	*Total (N=1036)*
Age (in years)	*20-29*	272 (43.87)	199 (47.84)	471 (45.46)
	30-39	189 (30.48)	111 (26.68)	300 (28.96)
	40-49	159 (25.65)	106 (25.48)	265 (25.58)
Education	*Illiterate*	104 (16.77)	117 (28.13)	221 (21.33)
	Upto primary	113 (18.23)	77 (18.51)	190 (18.34)
	Secondary and above	373 (60.16)	217 (52.16)	590 (56.95)
	Graduation	30 (4.84)	5 (1.20)	35 (3.38)
Occupation	*Cultivator*	326 (52.58)	88 (21.15)	414 (39.96)
	Daily labour (Agricultural/ Tea garden)	196 (31.61)	60 (14.42)	256 (24.71)
	Others/ Housewife	98 (15.81)	268 (64.42)	366 (35.33)

Monthly family income (in Rupees)	*Up to Rs. 4000*	198 (31.94)	148 (35.58)	346 (33.40)
	Rs. 4001 - Rs. 6000	288 (46.45)	180 (43.27)	468 (45.17)
	> Rs. 6000	134 (21.61)	88 (21.15)	222 (21.43)
Per-capita income (in Rupees)	*Up to Rs. 700*	94 (15.16)	91 (21.88)	185 (17.86)
	Rs. 701-Rs. 1400	410 (66.13)	225 (54.09)	635 (61.29)
	> Rs. 1400	116 (18.71)	100 (24.04)	216 (20.85)
Family size	*≤ 4*	193 (31.13)	146 (35.10)	339 (32.72)
	5-6	314 (50.65)	196 (47.12)	510 (49.23)
	7-8	79 (12.74)	59 (14.18)	138 (13.32)
	≥9	34 (5.48)	15 (3.61)	49 (4.73)
Dependent children	*0-1*	211 (34.03)	158 (37.98)	369 (35.62)
	2	213 (34.35)	120 (28.85)	333 (32.14)
	3	132	83	215

		(21.29)	(19.95)	(20.75)
	≥4	64 (10.32)	55 (13.22)	119 (11.49)
Family tpe	*Nuclear*	447 (72.10)	301 (72.36)	748 (72.20)
	Joint/Extended	173 (27.90)	115 (27.64)	288 (27.80)
Marital status	*Unmarried*	178 (28.71)	101 (24.28)	279 (26.93)
	Married	438 (70.65)	288 (69.23)	726 (70.08)
	Widower/Widow	04 (0.65)	27 (6.49)	31 (2.99)
Drinking water facility	*Own well/tube well*	470 (75.81)	384 (92.31)	854 (82.43)
	Public/shared	150 (24.19)	32 (7.69)	182 (17.57)
Toilet facility	*Yes*	362 (58.39)	173 (41.59)	535 (51.64)
	No	258 (41.61)	243 (58.41)	501 (48.36)
Landholding pattern	*< 2.5 acres*	562 (90.65)	363 (87.26)	925 (89.29)
	>2.5 acres	58 (9.35)	53 (12.74)	111 (10.71)

House type	*Bricked*	163 (26.29)	92 (22.12)	255 (24.61)
	Non-bricked	457 (73.71)	324 (77.88)	781 (75.39)
Socio-economic status	*Lower group*	289 (46.61)	361 (86.78)	650 (62.74)
	Medium group	331 (53.39)	55 (13.22)	386 (37.26)
Likelihood Ratio	*High ratio*	225 (36.29)	154 (37.02)	379 (36.58)
	Low to Medium ratio	395 (63.71)	262 (62.98)	657 (63.42)
Expenditure Group	*≥80% from income (High)*	343 (55.32)	222 (53.37)	565 (54.54)
	< 80% from income (Low)	277 (44.68)	194 (46.63)	471 (45.46)

Values in parenthesis indicates percentages

3.2. ASSESSMENT OF NUTRITIONAL STATUS USING ANTHROPOMETRY AND BODY COMPOSITION CHARACTERISTICS

3.2.1. General descriptive statistics of age and the anthropometric variables

The descriptive statistics (mean ±SD) of the age and the anthropometric variables recorded in the present study are presented in ***Table 3.2.*** The measurements recorded were weight, height, MUAC, WC, HC, BSF, TSF, SSF and SISF.

The results showed the mean age to be higher among the males than females (32.36 ± 9.56 years versus 31.24 ± 10.21 years). The results further indicated the mean weight, height, MUAC and WC were found to be considerably higher among the male individuals when compared with the female individuals. The mean values of weight and height were observed to be 53.43 ± 6.98 kg and 162.13 ± 5.65 cm for males and 46.20 ± 7.58 kg and 150.03 ± 5.42 cm for females. In case of the circumference measurements, the mean values of MUAC and WC were higher among the males (23.59 ± 1.28 cm and 73.67 ± 6.57 cm) as compared to the females (22.49 ± 2.07 cm and 72.18 ± 6.89 cm). The mean HC was observed to be slightly higher among the females (84.93 ± 6.29 cm) when compared with the males (83.52 ± 5.64 cm). The skinfold adiposity measurements of BSF, TSF, SSF and SISF were higher among the female individuals.

The sex differences in anthropometric variables were assessed utilizing ANOVA and results are shown in ***Table 3.2.*** There were statistically sex differences in weight (F ratio: 248.38; d.f. 1,1035; $p<0.01$), height (F ratio: 1181.67; d.f. 1,1035; $p<0.01$), MUAC (F ratio: 109.65; d.f. 1,1035; $p<0.01$), WC (F ratio: 12.38; d.f. 1,1035; $p<0.01$), HC (F ratio: 14.20; d.f. 1,1035; $p<0.01$), BSF (F ratio: 128.03; d.f. 1,1035; $p<0.01$), TSF (F ratio: 206.23; d.f. 1,1035; $p<0.01$), SSF (F ratio: 117.11; d.f. 1,1035; $p<0.01$) and SISF (F ratio: 73.40; d.f. 1,1035; $p<0.01$). The only exception was observed in age where the difference was statistically not significant (F ratio: 3.26; d.f. 1,1035; $p>0.05$).

Table 3.2. Descriptive statistics (mean ±SD) of age and anthropometric variables among the Rajbanshi individuals

Variable	*Male (N=620)*	*Female (N=416)*	*F ratio*	*d.f.*	*p*
Age (year)	32.36 ± 9.56	31.24 ±10.21	3.26	1, 1035	0.071
Weight (kg)	53.43 ± 6.98	46.20 ± 7.58	248.38	1, 1035	0.000
Height (cm)	162.13 ± 5.65	150.03 ± 5.42	1181.67	1, 1035	0.000
MUAC (cm)	23.59 ±1.28	22.49 ± 2.07	109.65	1, 1035	0.000
WC (cm)	73.67 ±6.57	72.18 ± 6.89	12.38	1, 1035	0.000
HC (cm)	83.52 ± 5.64	84.93 ± 6.29	14.20	1, 1035	0.000
BSF (mm)	3.37 ± 0.86	4.17 ± 1.42	128.03	1, 1035	0.000
TSF (mm)	5.39 ± 1.36	7.03 ± 2.30	206.23	1, 1035	0.000
SSF (mm)	8.67 ± 2.60	10.83 ± 3.83	117.11	1, 1035	0.000
SISF (mm)	7.84 ± 2.86	9.41 ± 2.96	73.40	1, 1035	0.000

3.2.2. *Age specific descriptive statistics of age and the anthropometric variables*

The age and sex specific descriptive statistics (mean ±SD) of age and the anthropometric variables among the male and the female Rajbanshi individuals are depicted in ***Table 3.3.*** Age variations in the anthropometric variables among them were found to be strongly associated with the age groups (20-29 years; 30-39 years; 40-49 years). Among the males, the age specific mean values of weight, height, TSF, SSF and SSIF were observed to be highest in the age group of 20-29 years. The mean value of MUAC was the highest in the age group of 30-39 years, whereas, WC, HC and BSF were the greatest in the age group of 40-49 years. Females exhibited higher mean values in the age group of 20-29 years only in respect to weight and WC. The mean height, MUAC, HC, BSF, TSF and SSIF were observed to be higher in age group of 40-49 years.

Table 3.3. Descriptive statistics (mean ±SD) of age and the anthropometric variables among the Rajbanshi individuals

Variable	Males (N=620)						Females (N=416)					
	20-29 years (N= 272)	30-39 years (N=189)	40-49 years (N=159)	F ratio	d.f.	P value	20-29 years (N=199)	30-39 years (N=111)	40-49 years (N=106)	F ratio	d.f.	P value
Weight(kg)	53.89 ±7.01	53.84 ±5.79	52.13 ±8.04	3.72	2,619	0.025	48.08 ±8.77	43.73 ±5.21	45.28 ±6.32	13.53	2,415	0.000
Height cm)	162.60 ±5.72	162.16 ±5.17	161.29 ±6.00	2.72	2,619	0.066	150.15 ±5.67	149.38 ±5.32	150.47 ±5.00	1.19	2,415	0.305
MUAC m)	23.59 ±1.28	23.68 ±1.25	23.45 ±1.32	1.48	2,619	0.228	22.97 ±2.22	22.13 ±1.83	21.98 ±1.82	10.79	2,415	0.000
WC (cm)	72.74 ±6.09	74.05 ±6.17	74.83 ±7.58	5.58	2,619	0.004	72.95 ±6.72	70.96 ±6.43	72.02 ±7.51	3.06	2,415	0.048
HC (cm)	83.28 ±5.54	83.61 ±5.59	83.83 ±5.86	0.51	2,619	0.599	84.35 ±6.35	84.42 ±6.18	86.57 ±6.04	4.94	2,415	0.008
BSF (mm)	3.33 ±0.78	3.36 ±0.81	3.45 ±1.03	0.99	2,619	0.371	3.93 ±1.24	4.36 ±1.35	4.43 ±1.69	5.79	2,415	0.003
TSF (mm)	5.37 ±1.09	5.28 ±1.25	5.55 ±1.79	1.77	2,619	0.171	6.38 ±1.70	7.53 ±2.38	7.72 ±2.81	16.52	2,415	0.000
SSF (mm)	8.79 ±2.22	8.47 ±2.78	8.69 ±2.95	0.90	2,619	0.407	10.44 ±3.38	10.75 ±3.80	11.64 ±4.50	3.46	2,415	0.032
SISF (mm)	7.86 ±2.60	7.67 ±2.86	7.98 ±3.27	0.54	2,619	0.581	9.42 ±2.76	8.92 ±2.71	9.92 ±3.46	3.15	2,415	0.044

The differences in the variables between the age groups were evaluated using ANOVA (***Table 3.3***). In case of the males, the differences in weight (F ratio: 3.72; d.f. 2, 619; $p<0.05$) and WC (F ratio: 5.58; d.f. 2, 619; $p<0.01$) were observed to be statistically significant. However, the differences in height (F ratio: 2.72; d.f. 2, 619; $p>0.05$), MUAC (F ratio: 1.48; d.f. 2, 619; $p>0.05$), HC (F ratio: 0.51; d.f. 2, 619; $p>0.05$), BSF (F ratio: 0.99; d.f. 2, 619; $p>0.05$), TSF (F ratio: 1.77; d.f. 2, 619; $p>0.05$), SSF (F ratio: 0.90; d.f. 2, 619; $p>0.05$) and SISF (F ratio; 0.54; d.f. 2, 619; $p>0.05$) were statistically not significant. The differences were statistically significant in almost all the anthropometric variables among the females. The ratios were 13.53 (d.f. 2, 415; $p<0.01$) for weight, 10.79 (d.f. 2, 415; $p<0.01$) for MUAC, 3.06 (d.f. 2, 415; $p<0.05$) for WC, 3.06; (d.f. 2, 415; $p<0.05$) for HC, 5.79 (d.f. 2, 415; $p<0.01$) for BSF, 16.52 (d.f. 2, 415; $p<0.01$) for TSF, 3.46 (d.f. 2, 415; $p<0.05$) for SSF and 3.46 (d.f. 2, 415; $p<0.05$) for SISF. The F ratio was statistically insignificant in case of height (F ratio: 1.19; d.f. 2, 415; $p>0.05$).

3.2.3. Descriptive statistics of derived nutritional indices and body composition variables

The descriptive statistics (mean ±SD) of the derived nutritional status and body composition variables among the Rajbanshi individuals are depicted in ***Table 3.4*** The mean BMI values were slightly higher among the females (20.50 ± 3.06 kg/m^2) as compared to the males (20.31 ± 2.33 kg/m^2). The mean values of RI were also found to be higher among the females ($13.69 + 2.13$ kg/m^3) than the males (12.54 ± 1.53 kg/m^3). However, the male individuals had higher mean values of WHR, TUA, UMA, BFMA, FFM and FFMI than the females. In case of the nutritional and body composition variables of WHtR, CI, UFA, AFI%, PBF%, FM, FMI and PBF-BMI ratio, mean values were higher among the females than the males. The mean values were observed to be higher among the females than the males in the variables of body fat (UFA, AFI%, PBF%, FM and FMI). The variables connected with muscle proportions (TUA, UMA, BFMA, FFM and FFMI) were observed to be higher among the males when compared with the females.

The sex differences in the derived nutritional indices and body composition variables were evaluated using ANOVA and the results shown in ***Table 3.4.*** There were statistically significant sex differences in most of the indices and variables. These included the RI (F ratio: 101.19; d.f. 1,1035; $p<0.01$), WHR (F ratio: 82.04; d.f. 1,1035; $p<0.01$), WHtR (F ratio; 94.78; d.f. 1,1035; $p<0.01$), CI (F ratio: 360.47; d.f. 1,1035; $p<0.01$), TUA (F ratio: 95.52; d.f. 1,1035; $p<0.01$); UMA (F ratio: 256.16; d.f. 1,1035; $p<0.01$), UFA (F ratio: 102.39; d.f. 1,1035; $p<0.01$); AFI% (F ratio: 350.28; d.f. 1,1035; $p<0.01$), BFMA (F ratio: 26.95; d.f. 1,1035; $p<0.01$), PBF% (F ratio: 1905.56; d.f. 1,1035; $p<0.01$); FM (F ratio: 158.16; d.f. 1,1035; $p<0.01$), FFM (F ratio: 1089.65; d.f. 1,1035; $p<0.01$), FMI (F ratio: 995.72; d.f. 1,1035; $p<0.01$), FFMI (F ratio: 625.75; d.f. 1,1035; $p<0.01$) and PBF-BMI ratio (F ratio: 2205.21; d.f. 1,1035; $p<0.01$). The only exception was in BMI where the sex difference was found to statistically not significant (F ratio: 1.35; d.f. 1,1035; $p>0.05$).

3.2.4. Descriptive statistics of the skinfold indices and skinfold ratios

The descriptive statistics (mean ± SD) of different skinfold indices and skinfold ratios as measures of nutritional status and body fat proportion among the individuals are presented in ***Table 3.5.*** The mean ∑4SKF was found to be distinctly higher among the female (31.44 ± 9.24 mm) than the male (25.27 ± 6.60 mm) individuals, thereby indicating that the amount of body fat proportion was sex specific. The mean value of CFR was observed to be slightly higher among the males (0.61 ± 0.05) than the females (0.60 ± 0.07). The results also tended to show that the mean values of SSF/TSF, SISF/TSF, BSF/∑4SKF and SISF/∑4SKF were higher among the males than the females. The sex specific mean values of ∑4SKF/BMI, SSF/BSF, TSF/∑4SKF, SSF/∑4SKF and $\log_{10}$ ∑4SKF values were observed to be higher among the females than the males.

Table 3.4. Descriptive statistics (mean ± SD) of the derived anthropometric indices relating to nutritional status and body composition among the Rajbanshi individuals

Indices	*Males (N=620)*	*Females (N=416)*	*F ratio*	*d.f.*	*p value*
BMI (kg/m²)	20.31 ± 2.33	20.50 ± 3.06	1.35	1, 1035	0.246
R I (kg/m³)	12.54 ± 1.53	13.69 ± 2.13	101.19	1, 1035	0.000
WHR	0.88 ± 0.05	0.85 ± 0.06	82.04	1, 1035	0.000
WHtR	0.45 ± 0.04	0.48 ± 0.05	94.78	1, 1035	0.000
CI	0.87 ± 0.06	0.95 ± 0.08	360.47	1, 1035	0.000
TUA (cm²)	44.39 ± 4.90	40.60 ± 7.58	95.52	1, 1035	0.000
UMA cm²)	38.23 ± 3.92	33.05 ± 6.48	256.16	1, 1035	0.000
UFA (cm²)	6.16 ± 1.74	7.55 ± 2.67	102.39	1, 1035	0.000
AFI %	13.77 ± 2.85	18.54 ± 5.31	350.25	1, 1035	0.000
BFMA (cm²)	28.21 ± 3.92	26.55 ±6.48	26.95	1, 1035	0.000
PBF %	11.32 ± 3.20	21.19 ± 4.02	1905.56	1, 1035	0.000
FM (kg)	6.16 ± 2.39	9.89 ± 2.86	518.16	1, 1035	0.000
FFM (kg)	9.53 ± 2.73	4.91 ± 1.03	1089.65	1, 1035	0.000
FMI (kg/m²)	2.33 ± 0.86	4.39 ± 1.24	995.72	1, 1035	0.000
FFMI (kg/m2)	3.65 ± 1.12	2.19 ± 0.50	625.75	1, 1035	0.000
PBF-BMI ratio	0.56 ± 0.14	1.04 ± 0.09	2205.21	1, 1035	0.000

Table 3.5. Sex specific descriptive statistics (mean ± SD) of different skinfold indices relating to nutritional status among the Rajbanshi individuals

Index	*Males (N=620)*	*Females (N=416)*	*F ratio*	*d.f.*	*p value*
∑4SKF mm	25.27 ± 6.60	31.44 ± 9.24	156.967	1, 1035	.000
∑4SKF/ BMI	1.24 ± 0.28	1.54 ± 0.42	188.318	1, 1035	.000
CFR	0.61 ± 0.05	0.60 ± 0.07	7.965	1, 1035	.005
SSF/TSF	1.63 ± 0.38	1.59 ± 0.51	1.747	1, 1035	.187
SSF/BSF	2.61 ± 0.63	2.70 ± 0.88	3.078	1, 1035	.080
SSIF/BSF	2.34 ± 0.64	2.36 ± 0.73	.310	1, 1035	.578
SISF/TSF	1.46 ± 0.46	1.40 ± 0.45	6.100	1, 1035	.014
BSF/ ∑4SKF	0.14 ± 0.02	0.13 ± 0.03	.225	1, 1035	.636
TSF/ ∑4SKF	0.22 ± 0.04	0.23 ± 0.04	12.664	1, 1035	.000
SSF/ ∑ 4SKF	0.34 ± 0.04	0.35 ± 0.04	.617	1, 1035	.432
SISF/ ∑4SKF	0.31 ± 0.05	0.30 ± 0.04	4.294	1, 1035	.038
Log_{10} ∑4SKF	1.39 ± 0.10	1.48 ± 0.13	162.265	1, 1035	.000

The sex differences in the different skinfold indices and ratios using ANOVA are depicted in ***Table 3.5.*** The sex differences were observed to be statistically significant in ∑4SKF (F ratio: 156.97; d.f. 1,1035; $p<0.01$), ∑4SKF/BMI (F ratio: 188.32; d.f. 1,1035; $p<0.01$), CFR (F ratio: 7.965; d.f. 1,1035; $p<0.01$), SISF/TSF (F ratio: 6.10; d.f. 1,1035; $p<0.05$), TSF/∑4SKF (F ratio: 12.66; d.f. 1,1035; $p<0.01$), SISF/∑4SKF (F ratio: d.f. 4.29; 1,1035; $p<0.05$) and Log_{10}∑4SKF (F ratio: 162.27; d.f. 1,1035; $p<0.01$). The sex differences were statistically insignificant in SSF/TSF (F ratio: 1.75; d.f. 1,1035; $p>0.05$), SSF/BSF (F ratio: 3.08; d.f. 1,1035; p>0.05), SSIF/BSF (F ratio: 0.31; d.f. 1,1035; p>0.05), BSF/∑4SKF (F ratio: 0.23; d.f. 1,1035; p>0.05) and SSF/∑4SKF (F ratio: 0.62; d.f. 1,1035; p>0.05).

3.2.5. Effect of Age on nutritional status and body composition variables

The mean and standard deviations of the anthropometric variables showed significant age variations among the male and the female Rajbanshi individuals. The age specific mean values of most of anthropometric variables were observed to be higher in the age group of 30-39 years in case of males and in the age group of 40-49 years in case of females (***Tables 3.6***). Age group wise mean and standard deviations of the derived anthropometric nutritional indices and body composition variables among the male and female individuals are depicted in ***Table*** 3.6. The age specific mean values of BMI, RI, BFMA, FFM, and FFMI were observed to be higher in the age group of 30-39 years followed by the age group of 40-49 years and finally the age group of 20-29 years.

In case of the male individuals, the age specific mean values of PBF, FM, FMI and PBF-BMI ratio were observed to be higher in the age group of 20-29 years, followed by the age group of 40-49 years and finally the age group of 30-40 years. With the only exception in TUA, the mean values of adiposity indices (CI, TUA, UFA and AFI) were seen to be higher among the older age group of 40-49 years, followed by the age group of 20-30 years and finally the age group of 20-29 years. The mean values of WHR and WHtR were identical in the age groups of 30-39 years and 40-49 years.

The female individuals exhibited higher values of BMI, RI, WHR, WHtR, TUA, UMA, BFMA, FFM and FFMI in the age group of 20-29 years. The age specific mean values of WHR, TUA, UMA, BFMA, FFM, and FFMI showed a general trend, with the individuals of the age group 20-29 years showing higher means, followed by those in the age group 30-39 years and finally those in the age group of 40-49 years. The mean values were higher in UFA, AFI, PBF%, FM, FMI and PBF-BMI ratio in the age group of 40-49 years. The mean values of UFA, AFI and PBF-BMI ratio generally decreased from the age group of 40-49 years, followed by the age group of 30-39 years and finally the age group of 20-29 years. The mean values of PBF%, FM and FMI were following the same trend from the age group of 40-49 years, followed by the age group of 20-29 years and finally the age group of 30-39 years. The mean CI was observed to be higher in the age group of 30-39 years. The mean WHtR values were identical in the age groups of 30-39 years and 40-49 years.

The difference in age groups in the anthropometric nutritional indices and body composition variables using ANOVA is shown in ***Table 3.6.*** Among the males, the differences were observed to be statistically significant in WHR (F ratio: 6.47; d.f. 2,619; $p<0.01$), WHtR (F ratio: 8.60; d.f. 2,619; $p<0.01$), CI (F ratio: 24.66; d.f. 2,619; $p<0.01$), UMA (F ratio: 3.57; d.f. 2,619; $p<0.05$), BFMA (F ratio: 3.57; d.f. 2,619; $p<0.05$), FFMI (F ratio:3.42; d.f. 2,619; $p<0.05$) and PBF-BMI (F ratio: 3.12; d.f. 2,619; $p<0.05$) ratios. The F ratios were statistically significant among the females in BMI (F ratio: 13.06; d.f. 2,415; $p<0.01$), RI (F ratio: 10.89; 2,415; $p<0.01$), WHR (F ratio: 14.49; 2,415; $p<0.01$), TUA (F ratio: 11.15; 2,415; $p<0.01$), UFA (F ratio; 26.84; 2,415; $p<0.01$), AFI% (F ratio: 28.20; 2,415; $p<0.01$), BFMA (F ratio; 26.84; 2,415; $p<0.01$), PBF% (F ratio: 3.34; 2,415; $p<0.05$) and PBF-BMI ratio (F ratio: 16.87; 2,415; $p<0.01$). The differences in ages in BMI, RI, TUA, UFA, AFI%, PBF%, FM, FFM and FM among the males and WHtR, CI, FM, FFM, FMI and FFMI among the females were statistically insignificant ($p>0.05$) (***Table 3.6***).

3.2.6. Age and sex specific distribution of descriptive statistics of skinfold indices

The age and sex specific descriptive statistics (mean and standard deviation) of the different derived skinfold index among the male and female Rajbanshi individuals are presented in ***Table 3.7.***

Among the male individuals, higher age specific mean values were observed in CFR, SSF/BSF, SSF/TSF, SISF/BSF, SISF/TSF, SSF/ $\sum$SKF and log10 $\sum$SKF in the age group of

20-29 years. ∑4SKF and ∑4SKF/BMI were found to higher in the age group 40-49 years. The age specific mean values were found to identical in TSF/ ∑4SKF (0.22 ± 0.04) and SISF/∑SKF (0.31 ± 0.05) in three age groups, while the mean values were identical in the age groups of 30-39 years and 40-49 years with respect to CFR (0.61 ± 0.05), BSF/ ∑4SKF (0.14 ± 0.02) and SSF/∑4SKF (0.34 ± 0.04).

Among the female individuals, the age specific mean values were higher in CFR, SSF/TSF, SSF/BSF, SISF/BSF, SISF/TSF and SISF/∑4SKF in the age group of 20-29 years. The mean values of BSF/∑4SKF and TSF/ ∑4SKF were higher in the age group of 30-39 years. The mean values of ∑4SKF, ∑4SKF/BMI and log10∑4SKF were elevated in the age group of 40-49 years. The mean values of BSF/∑4SKF were identical in the age groups of 20-29 years and 40-49 years (0.13 ± 0.02). The mean values of SSF/ ∑4SKF were identical in all the 3 age groups (0.34 ± 0.04).

The differences between the age groups among the male and the female individuals with respect to the different skinfolds indices using ANOVA is shown in ***Table 3.7***. The differences in the age groups with respect to ∑4SKF/BMI, SSF/BSF and BSF/∑4SKF were statistically significant ($p<0.05$) among the male individuals. The differences in ∑4SKF, CFR, SSF/TSF, SISF/BSF, SISF/TSF, TSF/∑4SKF, SSF/∑4SKF, SISF/∑4SKF and $\log_{10}$∑4SKF were not statistically significant between the age groups among them ($p>0.05$). The differences in the skinfold indices among the female individuals were observed to be statistically significant in almost all the derived indices ($p<0.05$), with the only exception being in SSF/∑4SKF ($p>0.05$).

Table 3.6. Age and sex specific descriptive statistics (mean ± SD) of anthropometric indices relating to nutritional status and body composition among the Rajbanshi individuals

Index	Males (N=620)						Females (N=416)					
	20-29 years	30-39 years	40-49 years	F-value	d.f.	p value	20-29 years	30-39 years	40-49 years	F-value	d.f.	p value
BMI (kg/m^2)	20.36 ±2.66	20.48 ±2.00	20.02 ±2.77	1.80	2.619	0.177	21.27 ±3.42	19.61 ±2.28	20.00 ±2.71	13.03	2,415	0.000
RI (kg/m^3)	12.54 ±1.48	12.65 ±1.36	12.43 ±1.80	0.85	2.619	0.428	14.18 ±2.33	13.16 ±1.71	13.32 ±1.93	10.89	2,415	0.000
WHR	0.87 ±0.06	0.89 ±0.05	0.89 ±0.05	6.47	2.619	0.002	0.87 ±0.06	0.84 ±0.05	0.83 ±0.06	14.49	2,415	0.000
WHtR	0.45 ±0.04	0.46 ±0.04	0.46 ±0.05	8.60	2,619	0.000	0.49 ±0.04	0.48 ±0.05	0.48 ±0.05	1.92	2,415	0.149
CI	0.85 ±0.06	0.87 ±0.06	0.89 ±0.06	24.66	2,619	0.000	0.94 ±0.09	0.96 ±0.07	0.95 ±0.08	1.44	2,415	0.237
TUA (cm^2)	44.43 ±4.88	44.76 ±4.79	43.89 ±5.07	1.38	2,619	0.253	42.38 ±8.27	39.21 ±6.58	38.72 ±6.42	11.15	2,415	0.000
UMA cm^2)	38.29 ±4.08	38.69 ±3.76	37.57 ±3.78	3.57	2,619	0.029	35.33 ±7.14	31.27 ±5.15	30.63 ±4.82	26.84	2,415	0.000

UFA (cm^2)	6.14 ±1.42	6.08 ±1.64	6.32 ±2.29	0.89	2,619	0.411	7.05 ±2.16	7.95 ± 2.77	8.08 ±3.24	6.97	2,415	0.001
AFI %	13.75 ±2.39	13.45 ±2.59	14.19 ±3.71	2.97	2,619	0.052	16.63 ±3.88	20.05 ±5.46	20.55 ±6.20	28.20	2,415	0.000
BFMA (cm^2)	28.29 ±4.08	28.69 ±3.76	27.57 ±3.78	3.57	2,619	0.029	28.83 ±7.14	24.77 ±5.15	24.13 ±4.82	26.84	2,415	0.000
PBF %	11.47 ±2.77	11.03 ±3.26	11.40 ±3.77	1.11	2,619	0.330	20.74 ±3.54	21.22 ±4.10	21.98 ±4.65	3.34	2,415	0.036
FM (kg)	6.25 ±2.01	6.04 ±2.27	6.14 ±3.03	0.41	2,619	0.667	10.06 ±2.84	9.39 ±2.59	10.08 ±3.11	2.27	2,415	0.105
FFM (kg)	9.25 ±2.43	9.83 ±2.87	9.67 ±3.00	2.77	2,619	0.064	4.98 ±0.99	4.91 ±1.06	4.77 ±1.09	1.51	2,415	0.222
FMI (kg/m^2)	2.35 ±0.71	2.29 ±0.83	2.24 ±1.01	0.31	2,619	0.737	4.45 ±1.20	4.21 ±1.14	4.46 ±1.40	1.61	2,415	0.202
FFMI (kg/m2)	3.52 ±0.99	3.76 ±1.16	3.75 ±1.26	3.42	2,619	0.033	2.22 ±0.48	2.21 ±0.52	2.11 ±0.51	1.81	2,415	0.165
PBF-BMI ratio	0.57 ±0.13	0.54 ±0.14	0.57 ±0.15	3.12	2,619	0.046	0.99 ±0.18	1.08 ±0.19	1.10 ±0.20	16.87	2,415	0.000

Table 3.7. Age and sex specific descriptive statistics descriptive statistics (mean± SD) of the skinfold indices among the Rajbanshi individuals

Index	Males (N=620)						Females (N=416)					
	20-29 years	30-39 years	40-49 years	F-value	d.f.	p value	20-29 years	30-39 years	40-49 years	F-value	d.f.	p value
Σ 4SKF	25.37 ±5.50	24.78 ±3.69	25.70 ±8.07	0.88	2,619	0.417	30.17 ±7.43	31.56 ±9.30	33.71 ±11.59	5.22	2,415	0.006
Σ 4SKF/ BMI	1.25 ±0.25	1.26 ±0.27	1.28 ±0.31	3.04	2,619	0.048	1.43 ±0.34	1.60 ±0.42	1.68 ±0.48	14.68	2,415	0.000
CFR	0.62 ±0.05	0.61 ±0.05	0.61 ±0.06	2.04	2,619	0.131	0.61 ±0.08	0.58 ±0.06	0.60 ±0.06	6.70	2,415	0.001
SSF/TSF	1.66 ±0.37	1.62 ±0.39	1.60 ±0.39	1.48	2,619	0.229	1.70 ±0.59	1.46 ±0.38	1.54 ±0.41	9.12	2,415	0.000
SSF/BSF	2.70 ±0.65	2.54 ±0.61	2.56 ±0.62	4.44	2,619	0.012	2.80 ±0.99	2.52 ±0.79	2.69 ±0.73	3.71	2,415	0.025
SISF/BSF	2.38	2.28	2.32	1.38	2,619	0.254	2.53	2.10	2.32	3.71	2,415	0.025

	±0.64	±0.62	±0.69				±0.83	±0.54	±0.61			
SISF/TSF	1.48 ±0.44	1.47 ±0.47	1.46 ±0.49	0.11	2,619	0.900	1.54 ±0.52	1.22 ±0.28	1.34 ±0.35	22.22	2,415	0.000
BSF/∑ 4SKF	0.13 ±0.21	0.14 ±0.02	0.15 ±0.02	4.08	2,619	0.017	0.13 ±0.30	0.14 ±0.03	0.15 ±0.02	4.35	2,415	0.013
TSF/∑ 4SKF	0.22 ±0.03	0.22 ±0.04	0.22 ±0.04	0.84	2,619	0.434	0.22 ±0.04	0.24 ±0.04	0.23 ±0.04	11.75	2,415	0.000
SSF/∑ 4SKF	0.35 ±0.04	0.34 ±0.04	0.34 ±0.04	2.64	2,619	0.072	0.34 ±0.05	0.34 ±0.04	0.34 ±0.04	0.66	2,415	0.519
SISF/∑ 4SKF	0.31 ±0.05	0.31 ±0.05	0.31 ±0.05	0.02	2,619	0.982	0.31 ±0.05	0.28 ±0.03	0.30 ±0.03	19.74	2,415	0.000
Log_{10}∑ 4SKF	1.37 ±0.09	1.38 ±0.10	1.39 ±0.02	1.17	2,619	0.313	1.47 ±0.11	1.48 ±0.13	1.50 ±0.14	3.24	2,415	0.040

3.2.7. Correlations between the anthropometric variables among the male Rajbanshi individuals

The results of the Pearson's correlation analysis between the anthropometric variables among the male individuals are presented in ***Table 3.8.*** The results showed that most of anthropometric variables were significantly correlated with each other ($p<0.05$). Age was significantly higher correlated with WHR, WHtR, FFM, WC and CI. Height and weight were significantly correlated with all the anthropometric variables, except in height with BMI ($r= -0.07$; $p>0.05$). Both weight ($r= -0.40$) and height ($r= -0.18$) were significantly negatively correlated with FFM ($p<0.05$). BMI was significantly correlated ($p<0.05$) with most of the variables, except with STR ($r= 0.05$), CI ($r= 0.06$) and CFR ($r= 0.05$). The 'r' values were statistically significant between anthropometric variables with WHR and WHtR. The correlations between WHR and STR ($r= 0.05$), FFM ($r= -0.02$), BSF ($r= 0.03$) and CFR ($r= -0.05$) and between WHtR in STR ($r= 0.03$) and CFR ($r= 0.03$) were not significant ($p>0.05$). The correlations of UMA and UFA with all the anthropometric variables were statistically significant ($p<0.05$). Both FM and FFM were significantly correlated with all the anthropometric variables but the correlation of FFM with CI ($r= -0.03$) was not statistically significant ($p>0.05$). The correlation of PBF was observed to be significantly correlated with all the anthropometric variables, except with RI ($r= 0.34$; $p>0.05$). Both TSF and BSF were significantly correlated with most of the anthropometric variables. However, the 'r' value was not statistically significant between BSF and WHR ($r= 0.03$; $p>0.05$). In case of STR and CFR, the 'r' values were statistically significant with almost all the variables ($p<0.05$).

3.2.8. Correlations between the anthropometric variables among the female Rajbanshi individuals

Table 3.9 depicts the correlation coefficients between the anthropometric variables among the female Rajbanshi individuals. Most of anthropometric variables were significantly correlated with each other ($p<0.05$). Age also showed significantly strong correlations with BMI, WHR, UMA, UFA, PBF, weight, BSF, TSF and RI ($p<0.01$). All the variables were significantly correlated with weight, WHtR and BMI, except height and BMI ($r= -0.07$). The UMA and UFA were also significantly correlated with most of the variables. However, the 'r' values between UMA and height ($r= 0.07$), UMA and CI ($r= 0.03$), UFA and height ($r= 0.06$) and UFA and WHR ($r= 0.04$) were not statistically significant ($p>0.05$). In case of PBF, the correlation coefficients between PBF and WHR ($r= 0.07$), PBF and height ($r= -0.01$) and between PBF and TSF ($r= 0.78$) were not significant. The correlation coefficients for FM and FFM were significantly correlated with all the anthropometric variables ($p<0.05$), except between FFM and WHR ($r= -0.02$), FFM and height ($r= 0.07$) and between FFM and CI ($r= 0.07$). The 'r' values for TSF and BSF were also significantly correlated with most of the variables. But the correlation coefficients between TSF and WHR ($r= -0.04$), TSF and height ($r= 0.04$), BSF and WHR ($r= 0.02$), and between BSF and height ($r= 0.01$) were not statistically significant ($p>0.05$). The correlation coefficients between CI and STR ($r= 0.08$) and CI and CFR ($r= 0.07$) were not statistically significant ($p>0.05$).

3.2.9. Linear regression analysis of sex on the different anthropometric and body composition variables among the Rajbanshi individuals

Linear regression analysis was undertaken taking sex as the dependent variable and the different anthropometric and body composition variables as the independent variables (***Table 3.10***). Age was significantly associated with BMI ($p<0.01$), WHR ($p<0.01$), WHtR ($p<0.01$), UMA ($p<0.01$), UFA ($p<0.01$), PBF ($p<0.01$), weight ($p<0.01$), TSF ($p<0.01$), BSF

($p<0.01$), RI ($p<0.01$), STR ($p<0.05$) and FFM ($p<0.05$). All the anthropometric variables were significantly associated with sex ($p<0.05$), except in the case of BMI ($p>0.05$). A significant positive effect also existed for WHtR (t= 9.724), UFA (t= 10.119), PBF (t= 43.777), FM (t =22.763), TSF (t =14.361), RI (t =10.059) and CI (t =18.360). A negative effect was observed with WHR (t = -9.070), UMA (t = -16.005), STR (t =1.320), FFM (t = -33.010), weight (t = -15.76), height (t = -34.375), WC (t = -3.514) and CFR (t = -54.360).

3.2.10. Linear regression of age on the different anthropometric and body composition variables among the Rajbanshi individuals

Linear regression analysis was done to assess the dependency of age on the anthropometric and body composition variables among the Rajbanshi individuals. The results of linear regression analysis among the male and female individuals are separately presented in ***Tables 3.11 and 3.12 respectively***.

The results of the regression analysis among the male individuals showed that age had a negative effect on BMI (t = -1.226), UMA (t = -1.683), STR (t = -1.707), PBF (t = -1.191), FM (t = -1.197), weight (t = -2.246), height (t = -2.223), BSF (t = -0.183), RI (t = -0.529), and CFR (t = -1.707). However, age had a positive effect on WHR (t = 3.874), WHtR (t = 3.996), UFA (t = 0.265), FFM (t = 2.548), TSF (t = 0.479), WC (t = 3.207) and CI (t = 6.680) among the males. The age dependency was statistically significant with WHR, WHtR, FFM, weight, height, WC and CI ($p<0.05$), while it was statistically not significant with BMI, UMA, UFA, STR, PBF, FM, STR, PBF, FM, TSF, BSF, RI and CFR ($p>0.05$) (***Table 3.11.***). The linear regression plots showing the dependencies of age on the different anthropometric measurements among the Rajbanshi males are shown in ***Figures 3.23 a, 3.23b*** and ***3.23c***.

It is evident from the ***Table 3.12*** that age had a negative impact on most of the anthropometric and body composition variables among the female Rajbanshis. The variables of BMI (t= -3.909), WHR (t= -5.569), WHtR (t= -1.774), UMA (t= -6.936), STR (t= 2.473), FFM (t= -2.565), weight (t= -3.596), WC (t= -1.764), RI (t= -3.790), and CFR (t= -1.892) showed a negative impact with age. Age was positively dependent on UFA (t= 4.023), PBF (t=3.509), TSF (t=5.992), height (t= 0.317), BSF (t= 4.082) and CI (t= 0.818). The linear regression coefficients were statistically significant between age and BMI, WHR, UMA, UFA, STR, PBF, FFM, weight, TSF, BSF and RI ($p<0.05$). The variables of WHtR, FM, height, WC, CI and CFR showed no statistically significant linear regression coefficients with age (***Table 3.12.***). The linear regression plots showing the dependencies of age on the different anthropometric variables among the female Rajbanshi individuals are shown in ***Figures 3.24a, 3.24b and 3.24c***.

Table 3.8. Pearson correlation coefficients between the anthropometric variables among the Rajbanshi male individuals

Variable	*Age*	*BMI*	*WHR*	*WHtR*	*UMA*	*UFA*	*STR*	*PBF*	*FM*	*FFM*	*Weight*	*Height*	*TSF*	*WC*	*BSF*	*RI*	*CI*	*CFR*
Age	1	-0.05	0.15**	0.16**	-0.07	0.01	-0.07	-0.09	-0.05	0.10*	-0.09*	-0.09*	0.02	0.19**	-0.01	-0.02	0.26**	-0.07
BMI	-0.05	1	0.40**	0.66**	0.48**	0.47**	0.08	0.42**	0.64**	-0.34**	0.84**	-0.07	0.40**	0.64**	0.33**	0.96**	0.06	0.05
WHR	0.15**	0.40**	1	0.68**	0.22**	0.19**	-0.05	0.08**	0.19**	-0.02	0.29**	-0.13**	0.16**	0.64**	0.03	0.41**	0.56**	-0.05
WHtR	0.16**	0.66**	0.68**	1	0.41**	0.46**	0.03	0.39**	0.49**	-0.29**	0.47**	-0.22**	0.41**	0.92**	0.29**	0.68	0.76	0.03
UMA	-0.07	0.48**	0.22**	0.41**	1	0.41**	0.14**	0.32**	0.41**	-0.31**	0.47**	0.09*	0.25**	0.45**	0.23**	0.43**	0.11**	0.14**
UFA	0.01	0.47**	0.19**	0.46**	0.41**	1	-0.18**	0.73**	0.77**	-0.59**	0.49**	0.15**	0.98**	0.53**	0.66**	0.39**	0.16**	-0.20**
STR	-0.07	0.05	-0.05	0.03	0.14**	-0.20**	1	0.39**	0.32**	-0.38**	0.09*	0.08*	-0.24**	0.06	0.11**	0.02	-0.02	1.00
PBF	-0.09	0.42**	0.09*	0.39**	0.32**	0.73**	0.39**	1	0.94**	-0.91**	0.48**	0.20**	0.72**	0.47**	0.76**	0.34	0.09	0.39**
FM	-0.05	0.64**	0.19**	0.49**	0.41**	0.77**	0.32**	0.94**	1	-	0.73**	0.31**	0.73**	0.62**	0.75**	0.51**	0.03**	0.32

										0.81**								
FFM	0.10*	-0.34**	-0.02	-0.29**	-0.31**	-0.59**	-0.38**	-0.91**	-0.81**	1	-0.40**	-0.18**	-0.58**	-0.36**	-0.63**	-0.27**	-0.03	-0.38**
Weight	-0.09*	0.84**	0.29**	0.47**	0.47**	0.494**	0.09*	0.48**	0.73**	-0.40**	1	0.48**	0.43**	0.66**	0.40**	0.66**	-0.19**	0.09*
Height	-0.09*	-0.07	-0.13**	-0.23**	0.09*	0.152**	0.08*	0.20**	0.31**	-0.18**	0.48**	1	0.14**	0.17**	0.19**	-0.35**	-0.46**	0.08*
TSF	0.02	0.40**	0.16**	0.41**	0.25**	0.984**	-0.24*	0.72**	0.73**	-0.58**	0.43**	0.14**	1	0.47**	0.65**	0.33**	0.15**	-0.24
WC	0.19**	0.64**	0.64**	0.92**	0.45**	0.527**	0.06	0.47**	0.62**	-0.36**	0.66**	0.17**	0.47**	1	0.37**	0.55**	0.59**	0.06
BSF	-0.01	0.33**	0.03	0.29**	0.232**	0.66**	0.11**	0.76**	0.75**	-0.63**	0.40**	0.19**	0.65**	0.37**	1	0.26**	0.05	0.11**
RI	-0.02	0.96**	0.41**	0.68**	0.43**	0.39**	0.02	0.34	0.51	-0.27**	0.66**	-0.35**	0.33**	0.55**	0.26**	1	0.18**	0.02
CI	0.26**	0.06	0.56**	0.76**	0.11**	0.16**	-0.02	0.09*	0.03	-0.03	-0.19**	-0.46**	0.15**	0.59**	0.05	0.18**	1	-0.02
CFR	-0.07	0.05	-0.05	0.03	0.14**	-0.20**	1.00**	0.39**	0.32**	-0.38**	0.09*	0.08*	-0.24**	0.06	0.11**	0.02	-0.021	1

$** p < 0.01$, $* p < 0.05$

Table 3.9. Pearson correlation coefficients of anthropometric variables among the Rajbanshi female individuals

Variable	Age	BMI	WHR	WHtR	UMA	UFA	STR	PBF	FM	FFM	Weight	Height	TSF	WC	BSF	RI	CI	CFR
Age	1	-0.19**	-0.26**	-0.09	-0.32**	0.19**	-0.12*	0.17**	0.02	-0.13*	-0.17**	0.02	0.28**	-0.09	0.19**	-0.18**	0.04	-0.09
BMI	-0.19**	1	0.37**	0.55**	0.50**	0.36**	0.18**	0.38**	0.76**	-0.37**	0.89**	-0.07	0.23**	0.54**	0.32**	0.97**	-0.15**	0.19**
WHR	-0.26**	0.37**	1	0.63**	0.29**	0.04	0.18**	0.07	0.22**	-0.07	0.31**	-0.08	-0.04	0.62**	0.02	0.37**	0.45**	0.16**
WHtR	-0.09	0.55**	0.63**	1	0.41**	0.38**	0.18**	0.38**	0.48**	-0.34**	0.39**	-0.26**	0.28**	0.93**	0.35**	0.58**	0.72**	0.18**
UMA	-0.32**	0.50**	0.29**	0.41**	1	0.24**	0.21**	0.15**	0.38**	-0.17**	0.49**	0.07	-0.01	0.45**	0.12*	0.46**	0.03	0.18**
UFA	0.19	0.36**	0.04	0.38**	0.24**	1	-0.26**	0.79**	0.72**	-0.71**	0.35**	0.06	0.97**	0.42**	0.78**	0.33**	0.11*	-0.25**
STR	-0.12	0.18**	0.18**	0.18**	0.21**	-0.26**	1	0.28**	0.24**	-0.30**	0.11*	-0.11*	-0.32**	0.14**	-0.12*	0.20**	0.08	0.97**
PBF	0.17	0.38**	0.07	0.38**	0.15**	0.79**	0.28**	1	0.84**	-0.96**	0.34**	-0.003	0.78**	0.39**	0.74**	0.36**	0.11*	0.31**
FM	0.02	0.76**	0.22**	0.48**	0.38**	0.72**	0.24**	0.84**	1	-0.80**	0.79**	0.21**	0.64**	0.57**	0.66**	0.68**	-0.11*	0.26**
FFM	-0.13	-0.37**	-0.02	-	-0.17**	-0.71**	-	-0.96**	-	1	-0.34**	-0.02	-0.70**	-	-0.65**	-0.35**	-0.07	-

				0.34**			0.30**		0.80**					0.36**				0.32**
Weight	-0.17**	0.89**	0.31**	0.39**	0.49**	0.35**	0.11*	0.34**	0.79**	-0.34**	1	0.38**	0.22**	0.54**	0.29**	0.76**	-0.34**	0.13**
Height	0.02	-0.07	-0.08	-0.26**	0.07	0.06	-0.11*	-0.01	0.21**	-0.02	0.38**	1	0.04	0.12*	0.01	-0.30**	-0.44**	-0.08
TSF	-0.28**	0.23**	-0.04	0.28**	-0.01**	0.97**	-0.32**	0.78	0.64**	-0.70**	0.22**	0.04	1	0.30**	0.77**	0.21**	0.10*	-0.30**
WC	-0.09	0.54**	0.62**	0.93**	0.45**	0.42**	0.14**	0.39**	0.57**	-0.36**	0.54**	0.12**	0.30**	1	0.36**	0.49**	0.57**	0.15**
BSF	-0.19**	0.32**	0.02	0.35**	0.12*	0.78**	-0.12*	0.74**	0.66**	-0.65**	0.28**	0.01	0.77**	0.36**	1	0.31**	0.12*	-0.10*
RI	-0.18**	0.97**	0.37**	0.58**	0.46**	0.33**	0.20**	0.36**	0.67**	-0.35**	.076**	-0.30**	0.21**	0.49**	0.31**	1	-0.04	0.20**
CI	0.04	-0.15**	0.45**	0.72**	0.03	0.11*	0.08	0.11**	-0.11*	-0.07	-0.34**	-0.44**	0.10*	0.57**	0.12*	-0.04	1	0.07
CFR	-0.09	0.19**	0.16**	0.18**	0.18**	-0.25**	0.97**	0.31**	0.26**	-0.32**	0.13**	-0.08	-0.03**	0.15**	-0.10*	0.20**	0.07	1

*** $p < 0.01$, * $p < 0.05$*

Table 3.10. Linear regression analyses of sex on the different anthropometric and body composition variables among the Rajbanshi individuals

Variable	*B*	*S.E.*	*Beta*	*Adjusted R^2*	*t*	*p value*
BMI	0.006	.006	.036	0.000	1.162	0.246
WHR	-2.311	0.255	-0.271	0.073	-9.070	0.000
WHtR	3.121	0.321	0.289	0.083	9.724	0.000
UMA	-0.038	0.002	-0.446	0.198	-16.005	0.000
UFA	0.065	0.006	0.300	0.089	10.119	0.000
STR	-0.045	0.035	-0.041	0.001	-1.320	0.187
PBF	0.066	0.002	0.806	0.649	43.777	0.000
FM	0.089	0.004	0.578	0.333	22.763	0.000
FFM	-0.111	0.003	-0.716	0.513	-33.010	0.000
Weight	-0.027	0.002	-0.440	0.193	-15.760	0.000
Height	-0.044	0.001	-0.730	0.533	-34.375	0.000
TSF	0.102	0.007	0.408	0.165	14.361	0.000
WC	-0.008	0.002	-0.109	0.011	-3.514	0.000
BSF	0.138	0.012	0.332	0.109	11.315	0.000
RI	0.078	0.008	0.299	0.088	10.059	0.000
CI	3.044	0.160	0.508	0.258	18.986	0.000
CFR	-0.720	0.013	-0.861	0.741	-54.360	0.000

Table 3.11. Linear regression analyses of age on the different anthropometric and body composition variables among the male Rajbanshi individuals

Variable	*B*	*S.E.*	*Beta*	*Adjusted R^2*	*t*	*p*
BMI	-0.202	0.164	-0.049	0.001	-1.226	0.221
WHR	27.623	7.131	0.154	0.022	3.874	0.000
WHtR	37.177	9.305	0.159	0.024	3.996	0.000
UMA	-0.165	0.098	-0.068	0.003	-1.683	0.093
UFA	0.058	0.220	0.011	-0.002	0.265	0.791
STR	-1.714	1.004	-0.068	0.003	-1.707	0.088
PBF	-0.143	0.120	-0.048	0.001	-1.191	0.234
FM	-0.193	0.161	-0.048	0.001	-1.197	0.232
FFM	0.357	0.140	0.102	0.090	2.548	0.011
WEIGHT	-0.123	0.055	-0.090	0.006	-2.246	0.025
HEIGHT	-0.151	0.068	-0.089	0.005	-2.223	0.027
TSF	0.136	0.284	0.019	-0.001	0.479	0.632
WC	0.186	0.058	0.128	0.015	3.207	0.001
BSF	-0.082	0.448	-0.007	-0.002	-0.183	0.855
RI	-0.133	0.250	-0.021	-0.001	-0.529	0.597
CI	39.395	5.897	0.260	0.066	6.680	0.000
CFR	-1.714	1.004	-0.069	0.003	-1.707	0.088

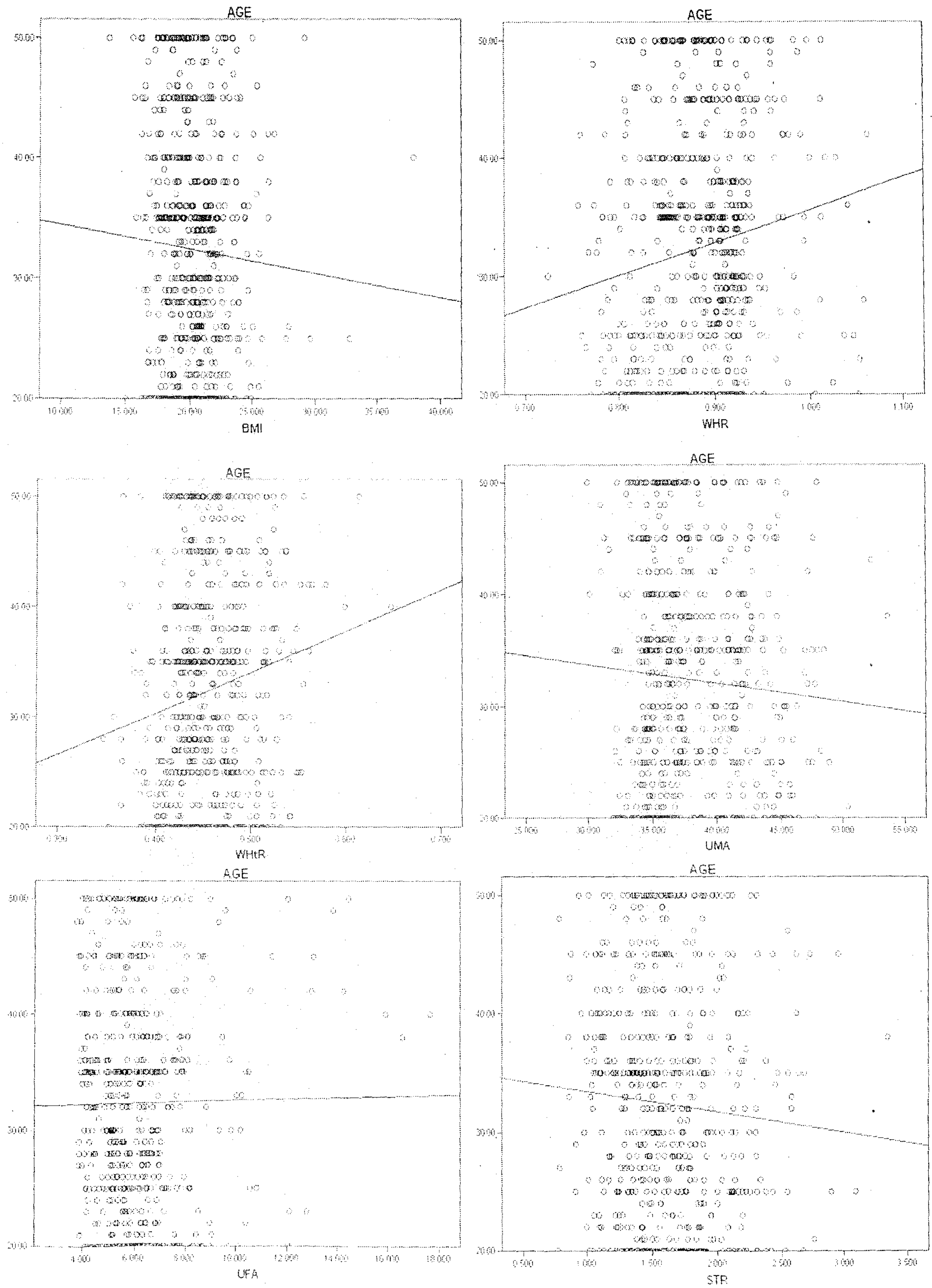


Figure 3.23a: Linear regression plots of age vs. BMI, WHR, WHtR, UMA, UFA, and STR among the male Rajbanshi individuals

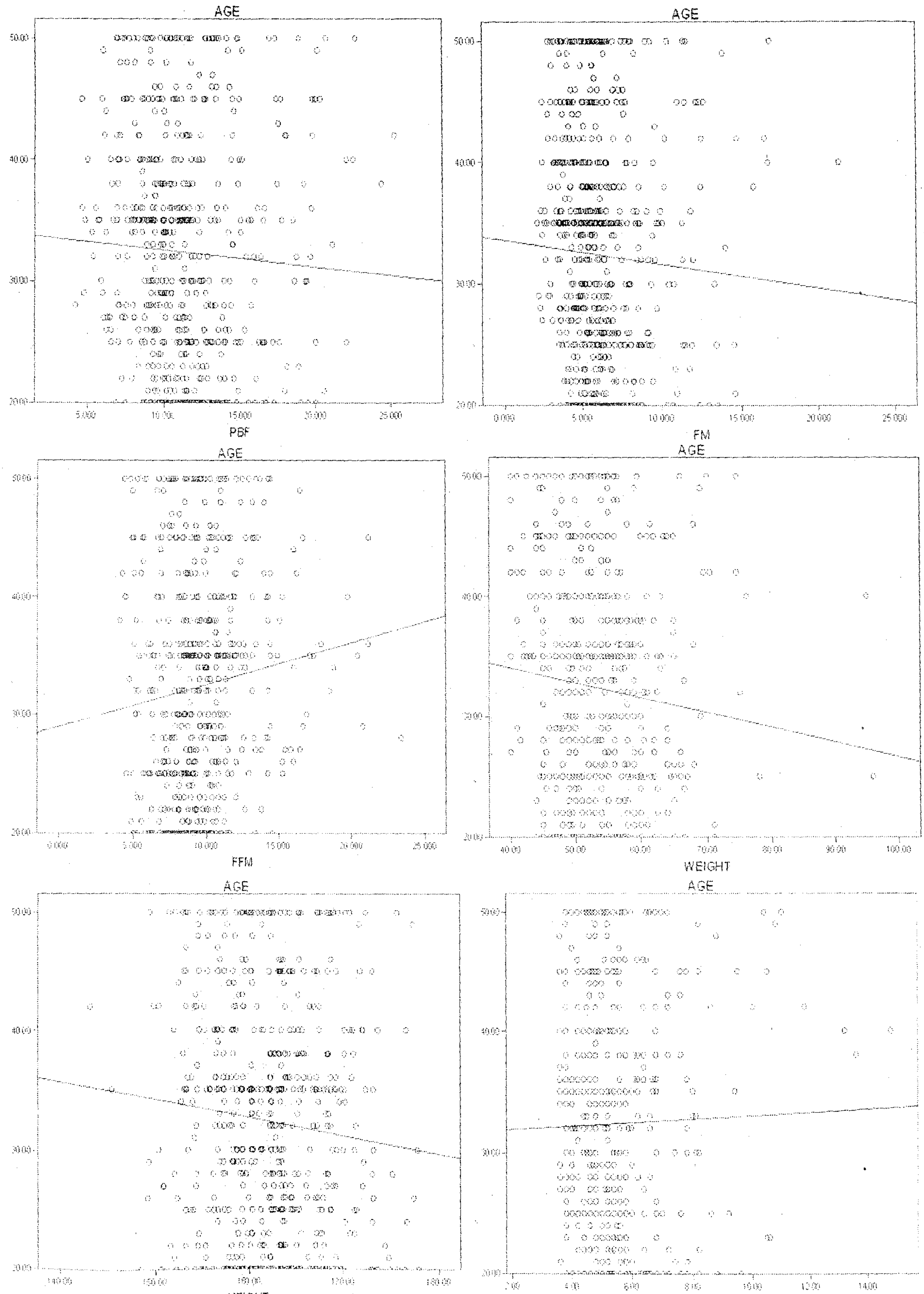


Figure 3.23b: Linear regression plots of age vs. PFB, FM, FFM, Weight, Height and TSF among the male Rajbanshi individuals

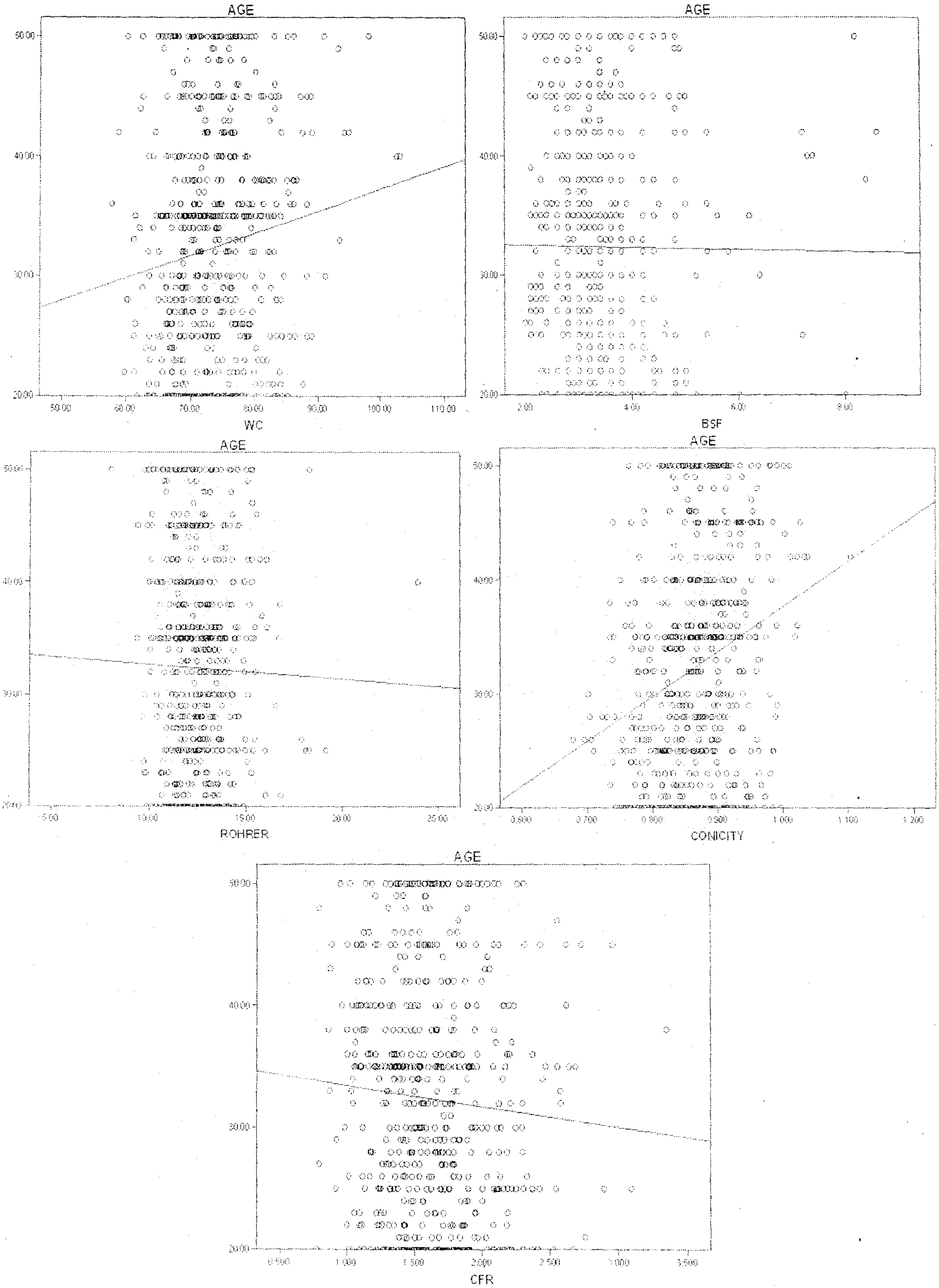


Figure 3.23c: Linear regression plots of age vs. WC, BSF, RI, CI and CFR among the male Rajbanshi individuals

Table 3.12. Linear regression analyses of age on the different anthropometric and body composition variables among the female Rajbanshi individuals

Variable	*B*	*S.E.*	*Beta*	*Adjusted R^2*	*t*	*p value* °
BMI	-0.630	0.161	-0.189	0.033	-3.909	0.000
WHR	-45.961	8.254	-0.264	0.067	-5.569	0.000
WHtR	-18.711	10.548	-0.087	0.005	-1.774	0.077
UMA	-0.508	0.073	-0.323	0.102	-6.936	0.000
UFA	0.741	0.184	0.194	0.035	4.023	0.000
STR	-2.417	0.978	-0.121	0.012	-2.473	0.014
PBF	0.432	0.123	0.170	0.027	3.509	0.000
FM	0.069	0.175	0.020	-0.002	0.398	0.691
FFM	-1.234	0.481	-0.125	0.013	-2.565	0.011
WEIGHT	-0.234	0.065	-0.174	0.028	-3.598	0.000
HEIGHT	0.029	0.093	0.016	-0.002	0.317	0.752
TSF	1.255	0.209	0.283	0.078	5.992	0.000
WC	-.0128	0.073	-0.086	0.005	-1.764	0.078
BSF	1.419	0.347	0.197	0.036	4.082	0.000
RI	-0.879	0.232	-0.183	0.031	-3.790	0.000
CI	5.088	6.221	0.040	-0.001	0.818	0.414
CFR	-13.509	7.140	-0.093	0.006	-1.892	0.059

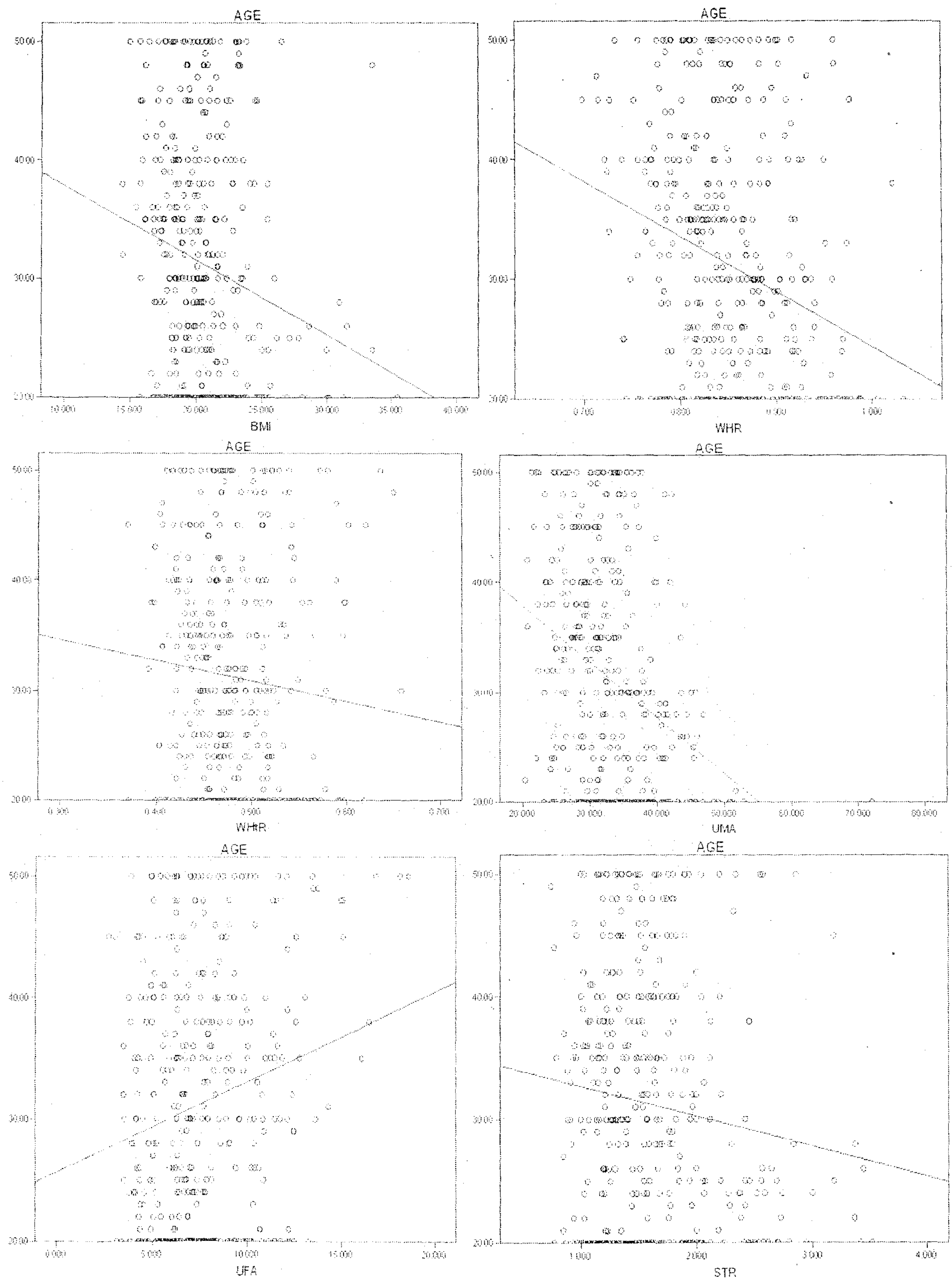


Figure 3.24a: Linear regression plots of age vs. BMI, WHR, WHtR, UMA, UFA, and STR among the female Rajbanshi individuals

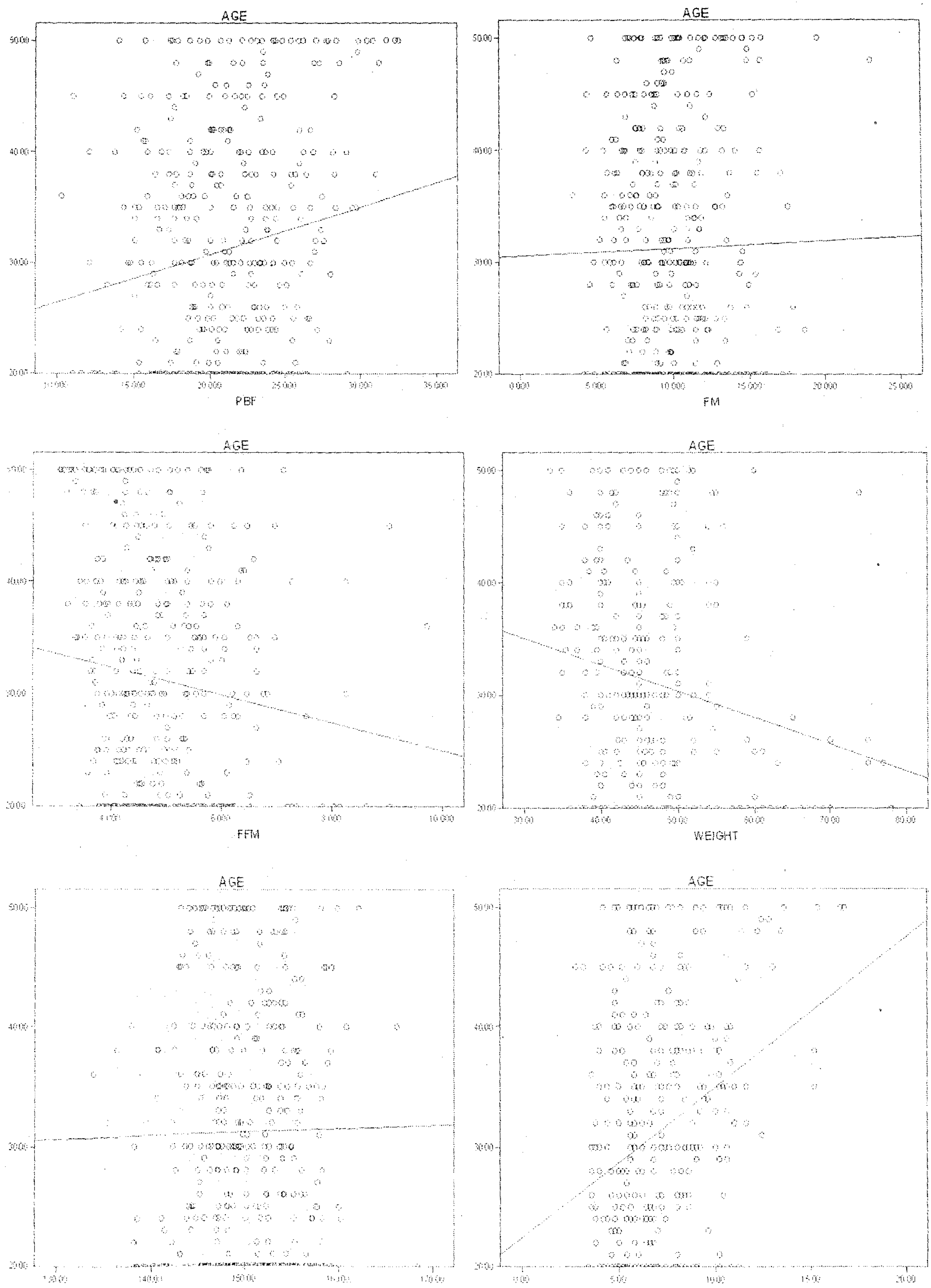


Figure 3.24b: Linear regression plots of age vs. PFB, FM, FFM, Weight, Height and TSF among the female Rajbanshi individuals

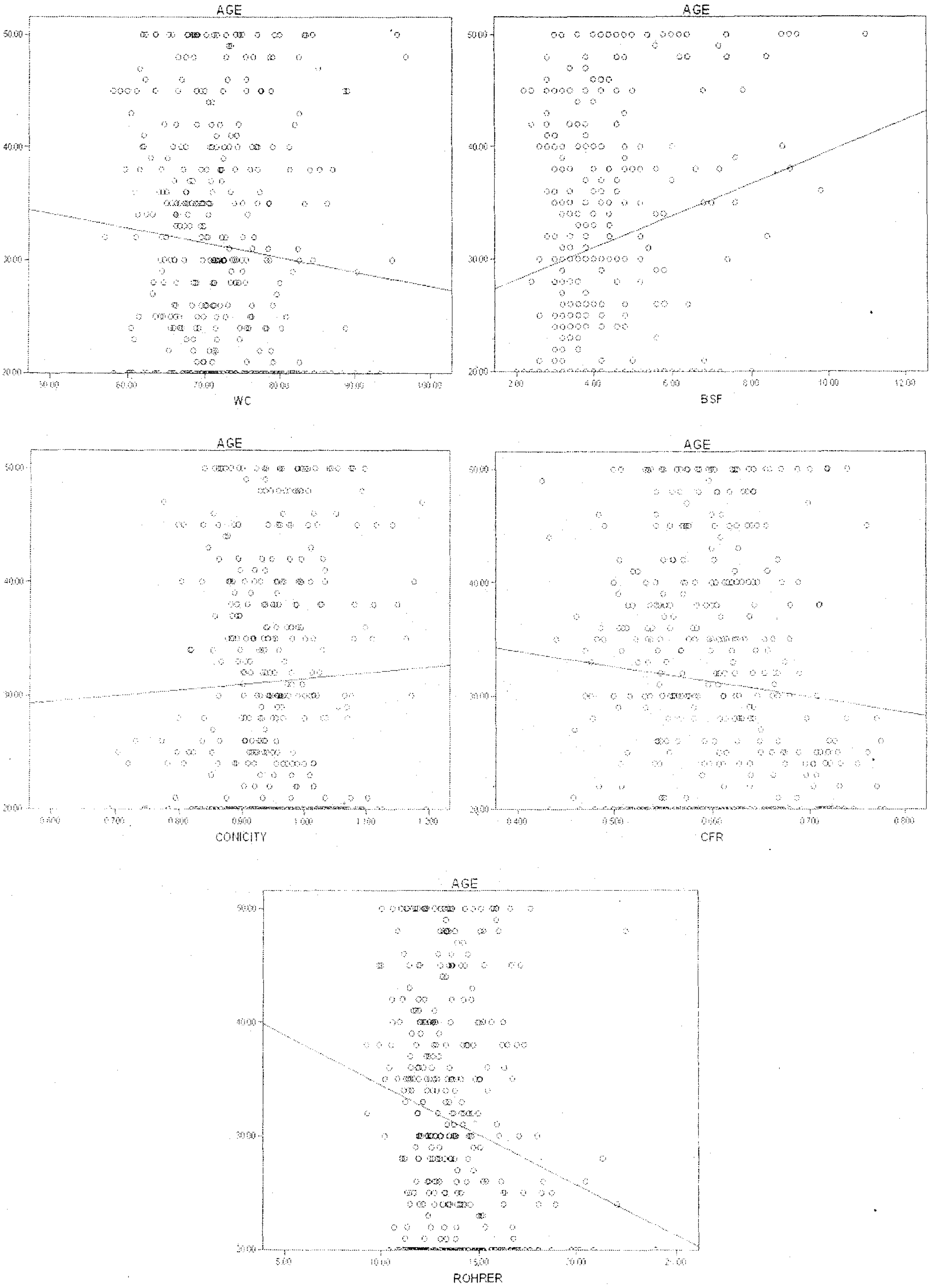


Figure 3.24c: Linear regression plots of age vs. WC, BSF, RI, CI and CFR among the female Rajbanshi individuals

3.2.11. Linear regression of BMI on the different anthropometric and body composition variables among the Rajbanshi individuals

The results of linear regression of BMI on the anthropometric variables among the male and female Rajbanshi individuals are separately presented in ***Tables 3.13*** and ***3.14*** respectively.

It was observed that among males, BMI was strongly dependent on the majority of the anthropometric and body composition variables. These variables were WHR (t= 10.912), WHtR (t= 22.026), UMA (t= 13.646), UFA (t= 13.071), STR (t= 1.192), PBF (t= 11.561), FM (t= 20.427), weight (t= 39.193), TSF (t= 10.834), WC (t= 20.89), BSF (t= 8.812), RI (t= 83.348), CI (t= 1.447) and CFR (t= 1.192). BMI was negatively dependent on FFM (t= -9.033) and height (t= -1.630). The linear regression coefficients were statistically significant in majority of the anthropometric variables ($p<0.05$), except in case of STR, height, CI and CFR with BMI ($p>0.05$) (***Table 3.13***). The linear regression plots showing the dependencies of BMI on the different anthropometric variables among the Rajbanshi males are shown in ***Figures 3.25a, 3.25b*** and ***3.25c***.

The linear regression analysis of BMI on the anthropometric variables among the Rajbanshi females also showed that BMI was positively dependent on most of the variables. These variables were WHR (t= 8.129), WHtR (t= 13.228), UMA (t= 11.781), UFA (t= 7.771), STR (t= 3.726), PBF (t= 8.304), FM (t= 23.731), weight (t= 40.51), TSF (t= 4.776), WC (t= 12.953), BSF (t= 6.842), RI (t= 83.079) and CFR (t= 3.865). However in case of FFM (t= -8.067), height (t= -1.411) and CI (t = -3.089), BMI was negatively dependent. The results also indicated that most of the regression coefficients were statistically significant ($p<0.05$), except in case of height ($p>0.05$) (***Table 3.14***). The linear regression plots showing the dependencies of BMI on the different anthropometric variables among the female Rajbanshi individuals are shown in ***Figures 3.26a, 3.26b*** and ***3.26c***.

Table 3.13. Linear regression analysis of BMI on the different anthropometric and body composition variables among the male Rajbanshi individuals

Variable	*B*	*S.E.*	*Beta*	*Adjusted R^2*	*t*	*p value*
WHR	17.617	1.614	0.402	0.160	10.912	0.000
WHtR	37.957	1.723	0.663	0.440	22.026	0.000
UMA	0.286	0.021	0.481	0.232	13.646	0.000
UFA	0.623	0.048	0.465	0.217	13.071	0.000
STR	0.293	0.246	0.048	0.002	1.192	0.234
PBF	0.307	0.027	0.422	0.178	11.561	0.000
FM	0.621	0.030	0.635	0.403	20.427	0.000
FFM	-0.292	0.032	-0.342	0.117	-9.033	0.000
WEIGHT	0.282	0.007	0.844	0.713	39.193	0.000
HEIGHT	-0.027	0.017	-0.065	0.004	-1.630	0.104
TSF	0.688	0.064	0.400	0.160	10.834	0.000
WC	0.228	0.011	0.643	0.414	20.890	0.000
BSF	0.908	0.103	0.334	0.112	8.812	0.000
RI	1.458	0.017	0.958	0.918	83.348	0.000
CI	2.156	1.489	0.058	0.003	1.447	0.148
CFR	0.293	0.246	0.048	0.002	1.192	0.234

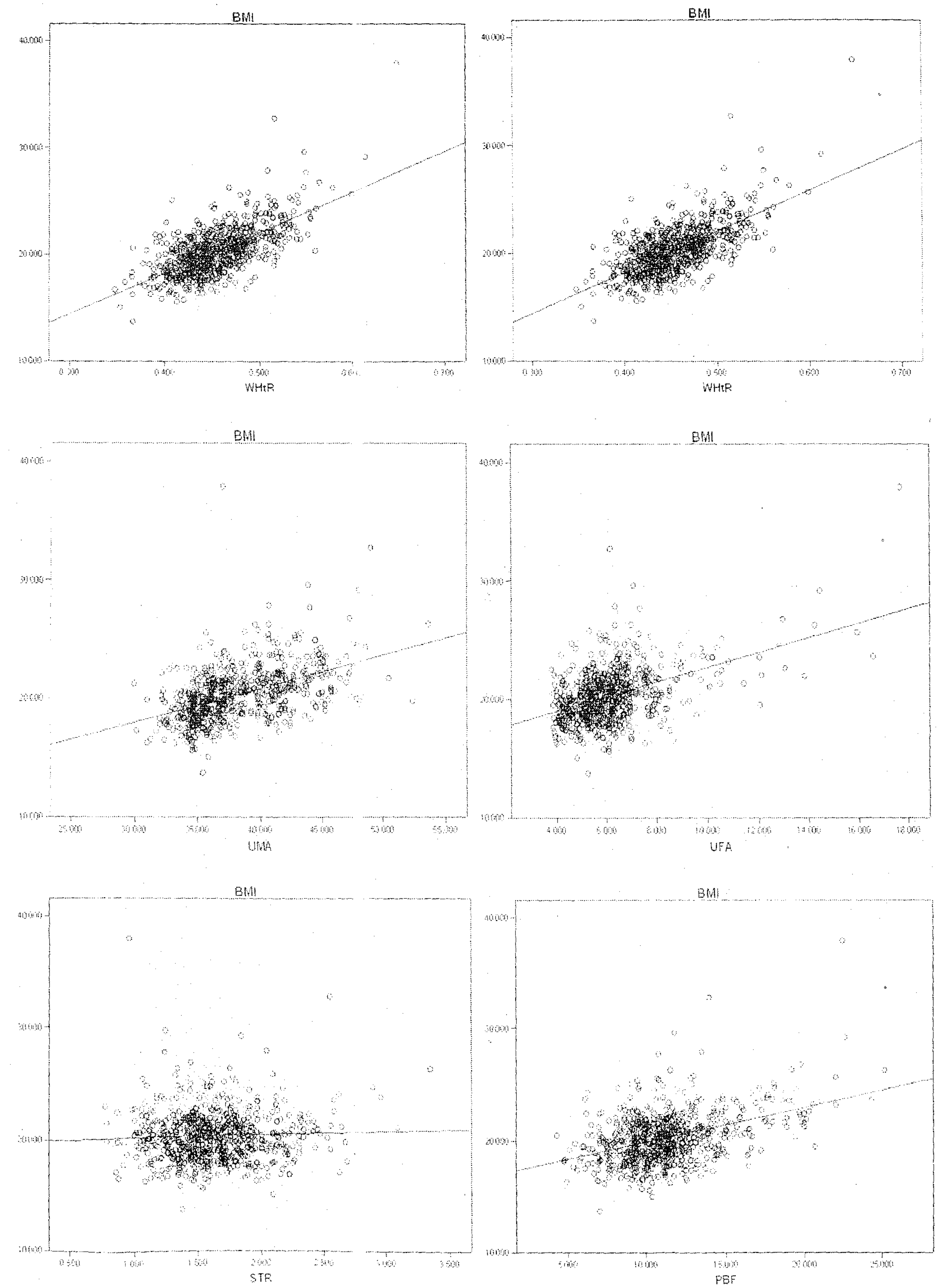


Figure 3.25a: Linear regression plots of BMI vs. WHR, WHtR, UMA, UFA, STR and PBF among the male Rajbanshi individuals

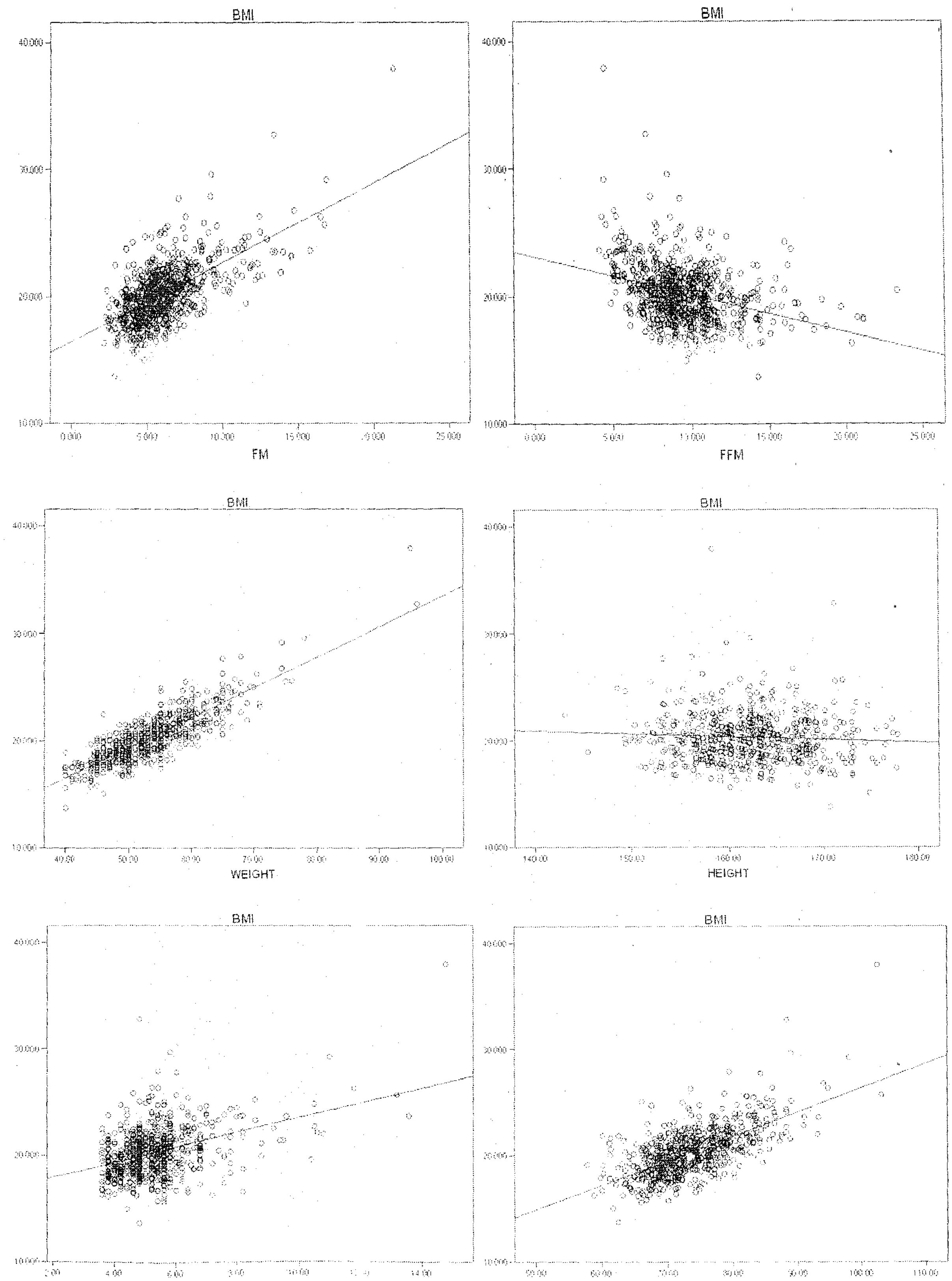


Figure 3.25b: Linear regression plots of BMI vs. FM, FFM, Weight, Height, TSF and WC among the male Rajbanshi individuals

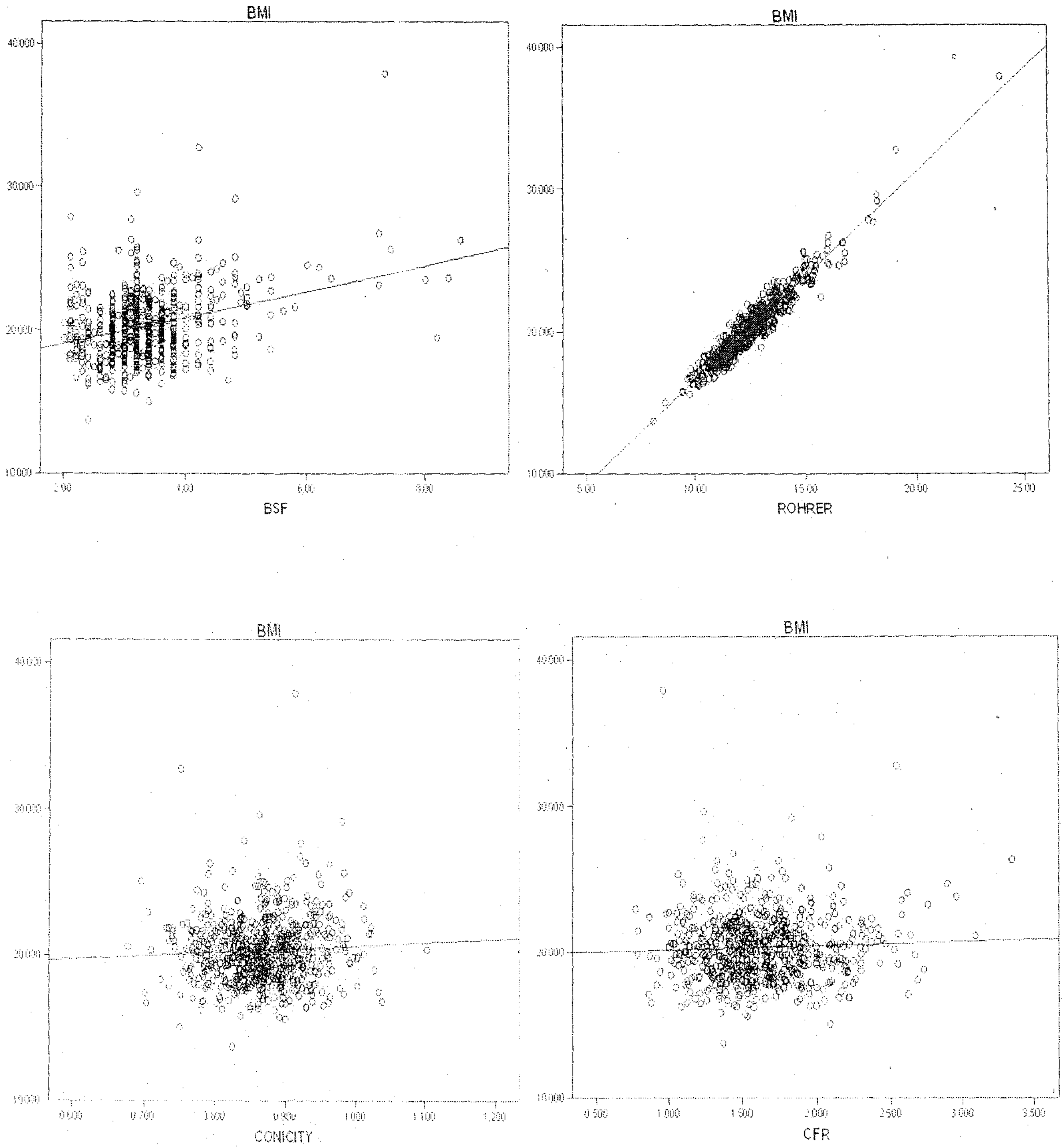


Figure 3.25c: Linear regression plots of BMI vs. BSF, RI, CI and CFR among the male Rajbanshi individuals

Table 3.14. Linear regression analyses of BMI with different anthropometric and body composition variables among female Rajbanshi individuals

Variable	*B*	*S.E.*	*Beta*	*Adjusted R^2*	*t*	*p value*
WHR	19.351	2.381	0.371	0.138	8.129	0.000
WHtR	35.179	2.659	0.545	0.297	13.228	0.000
UMA	0.236	0.020	0.501	0.251	11.781	0.000
UFA	0.408	0.053	0.357	0.127	7.771	0.000
STR	1.081	0.290	0.180	0.032	3.726	0.000
PBF	0.287	0.035	0.378	0.143	8.304	0.000
FM	0.812	0.034	0.759	0.576	23.731	0.000
FFM	-1.090	0.135	-0.369	0.136	-8.067	0.000
WEIGHT	0.361	0.009	0.894	0.799	40.510	0.000
HEIGHT	-0.039	0.028	-0.069	0.005	-1.411	0.159
TSF	0.304	0.064	0.229	0.052	4.776	0.000
WC	0.238	0.018	0.537	0.288	12.953	0.000
BSF	0.689	0.101	0.319	0.102	6.842	0.000
RI	1.396	0.017	0.971	0.943	83.079	0.000
CI	-5.697	1.844	-0.150	0.023	-3.089	0.002
CFR	8.157	2.110	0.187	0.035	3.865	0.000

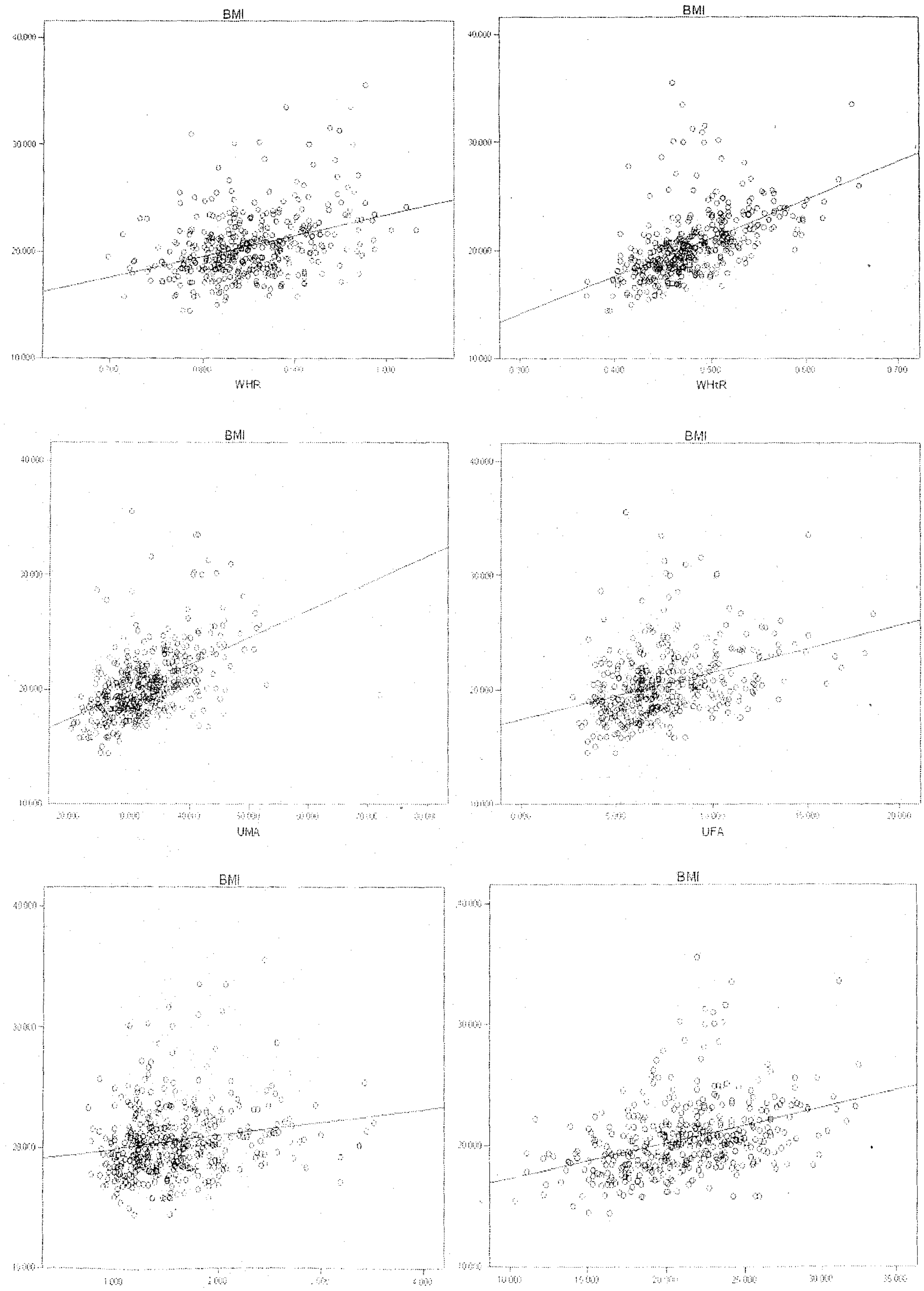


Figure 3.26a: Linear regression plots of BMI vs. WHR, WHtR, UMA, UFA, STR and PBF among the female Rajbanshi individuals

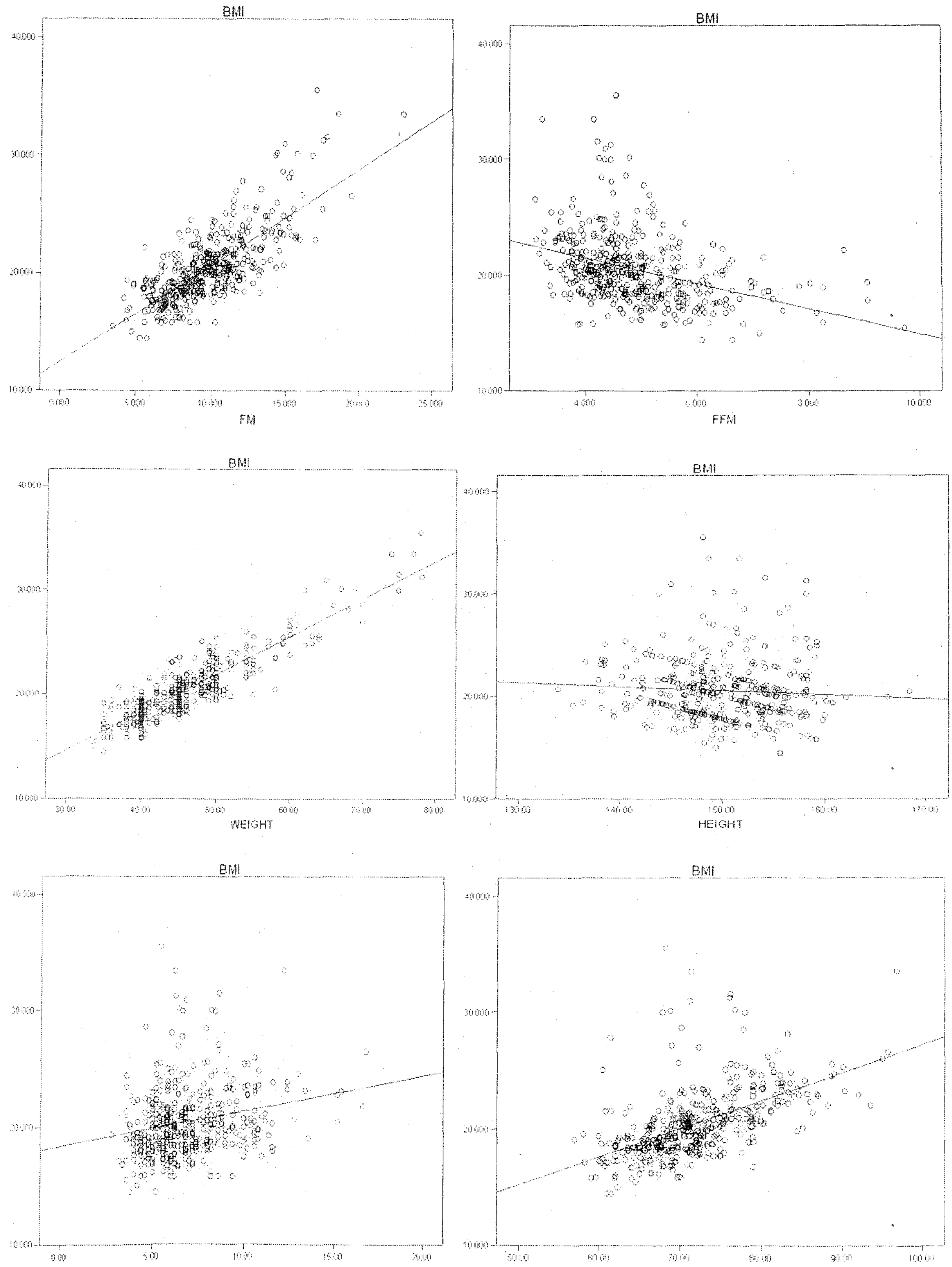


Figure 3.26b: Linear regression plots of BMI vs. FM, FFM, Weight, Height, TSF and WC among the female Rajbanshi individuals

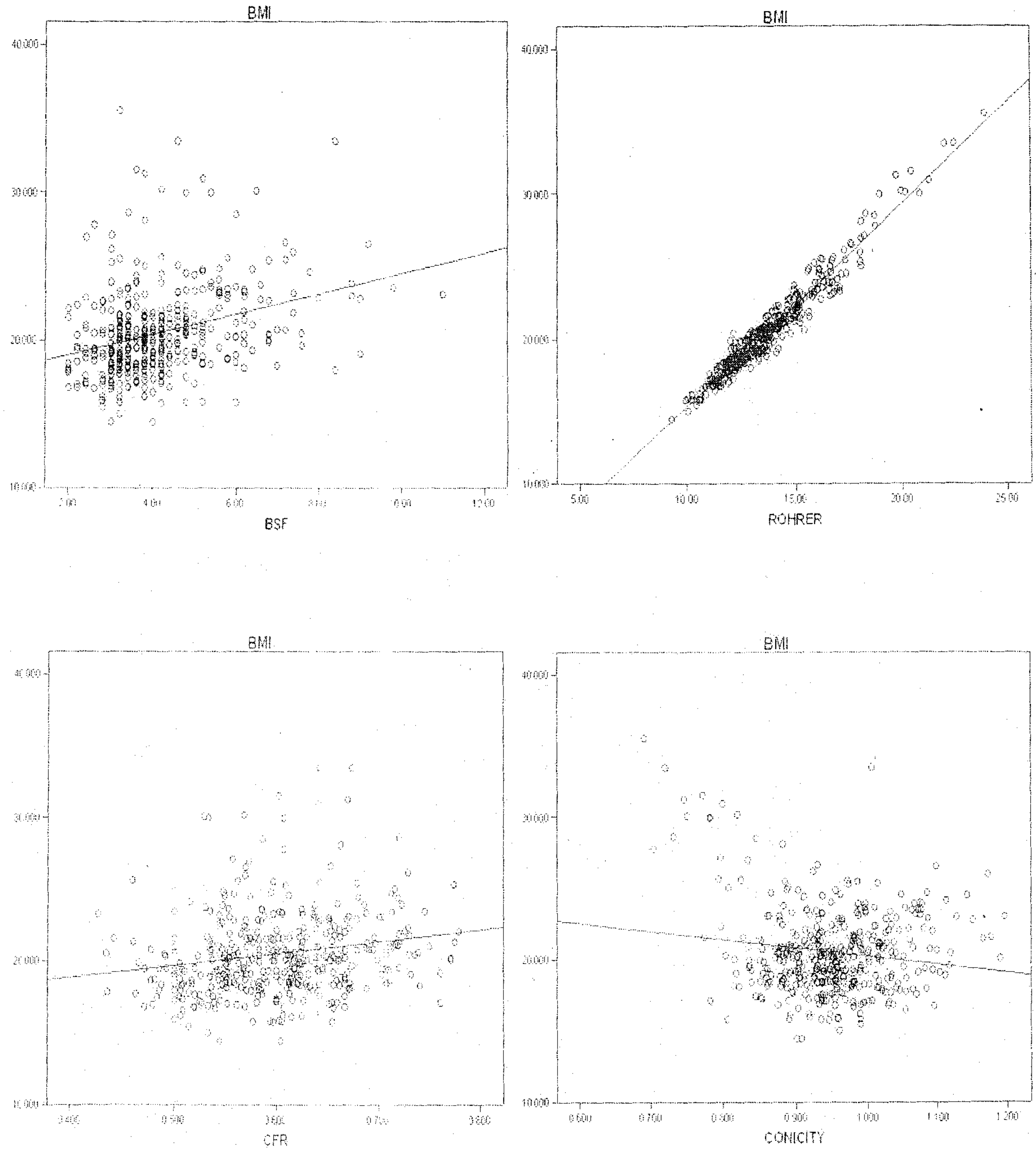


Figure 3.26c: Linear regression plots of BMI vs. BSF, RI, CI and CFR among the female Rajbanshi individuals

3.2.12. Assessment of nutritional status among the Rajbanshi individuals using BMI

The nutritional status of the Rajbanshi individuals based on standard BMI cut-off points of WHO (1995) is shown in ***Table 3.15.*** The overall prevalence of nutritional status among the Rajbanshi individuals is graphically depicted in ***Figure 3.27.*** The results suggested that the overall prevalence of overweight (BMI: $\geq$25.00 kg/m^2) and obesity (BMI: $\geq$30.00 kg/m^2) were 38 (3.67%) and 10 (0.97%) respectively (***Table 3.15***). The results further indicated that a quarter of the individuals comprised the 'at risk' group of low weight normal (24.61%). Nearly half of the individuals (47.59%) were normal. The results also showed that 23.17% of the individuals (BMI< 18.50 kg/m^2) were undernourished (***Figure 3.28***).

Among the males, 20.81% were undernourished while the corresponding percentage among the females was 26.68%. The sex difference between them was not statistically significant (χ^2-value = 2.986; d.f. 1; p>0.05). The sex specific comparative evaluation of under-nutrition among the individuals is depicted in ***Figure 3.28.*** It was observed that 49.35% of the males and 44.95% of the females were normal. The Rajbanshi males were more nutritionally at-risk when compared to the females (26.77%) versus 21.39%). However, this sex difference was not statistically significant (χ^2-value = 2.37; d.f.1; p>0.05). The sex specific prevalence of overweight and obesity was found to be higher among the females (5.05% and 1.92%) when compared with the males (2.74% and 0.32%). The sex difference in the prevalence of obesity was statistically significant (χ^2-value = 4.98; d.f.1; p<0.05), while the sex difference in overweight was statistically insignificant (χ^2-value= 3.47; d.f.1, p>0.05).

Table 3.15. Nutritional status of the Rajbanshi individuals based on internationally accepted cut-offs of BMI (after WHO, 1995)

Grades	*BMI kg/m²*	*Males*	*Females*	*Total*
Under-nutrition	*<18.50*	129 (20.81)	111 (26.68)	240 (23.17)
Low weight normal	*18.50 – 20.00*	166 (26.77)	89 (21.39)	255 (24.61)
Normal	*20.01-24.99*	306 (49.35)	187 (44.95)	493 (47.59)
Overweight	*≥ 25.00 – 29.99*	17 (2.74)	21 (5.05)	38 (3.67)
Obese	*≥ 30.00*	02 (0.32)	08 (1.92)	10 (0.97)
	Total	620 (100.00)	416 (100.00)	1036 (100.00)

Figures in parenthesis indicates percentages

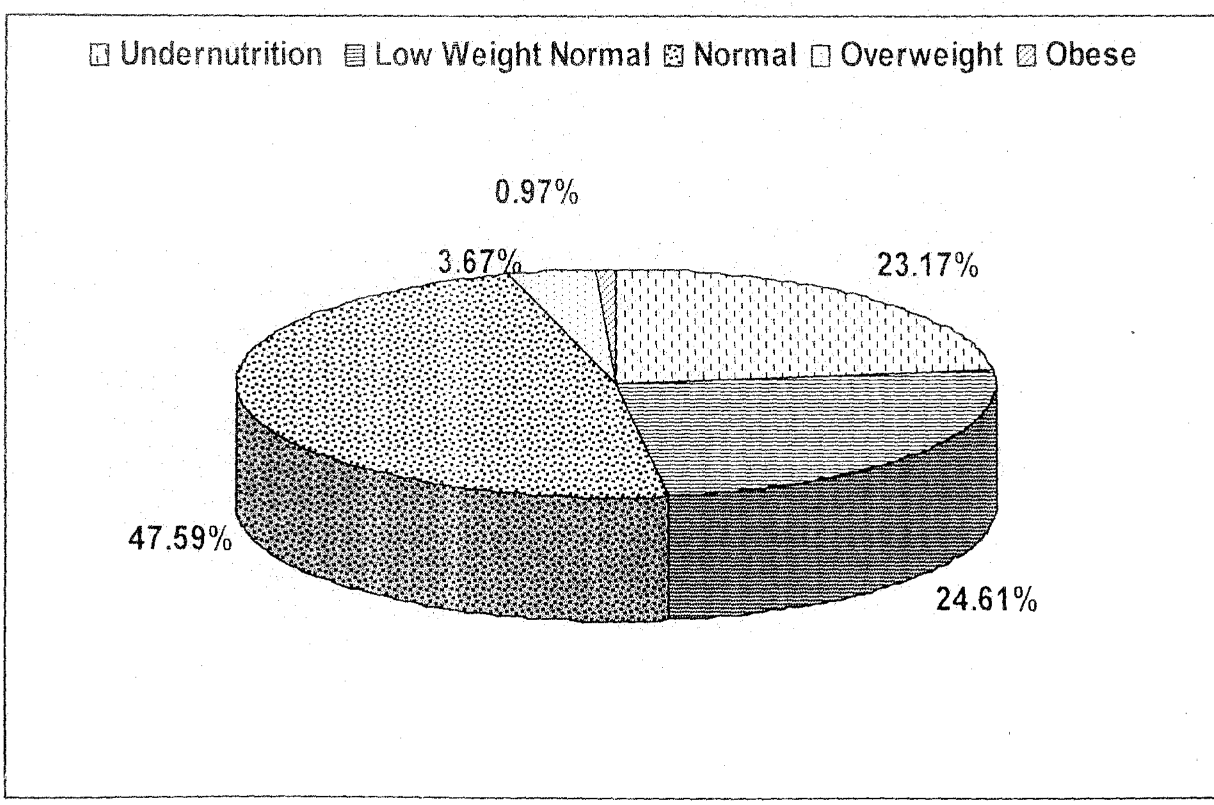


Figure 3.27: Pie chart showing the overall prevalence of nutritional status using BMI among the Rajbanshi individuals

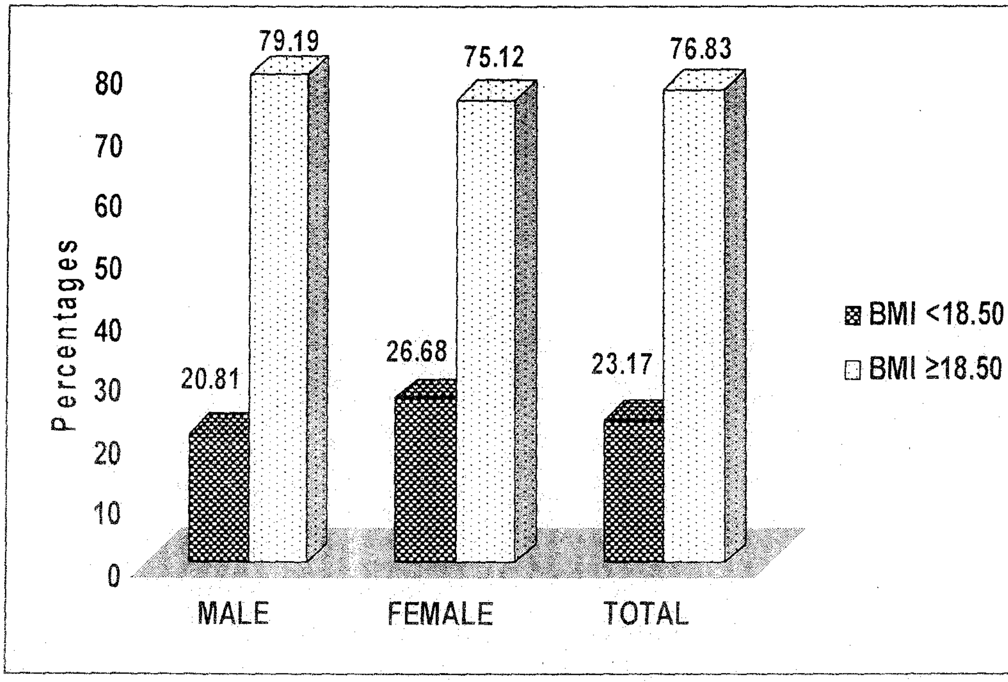


Figure 3.28: Bar diagram showing the prevalence of the overall under-nutrition based on BMI (<18.50) among the Rajbanshi individuals

3.2.12.1 Different grades of under-nutrition (CED) among the Rajbanshi individuals using BMI

The sex specific prevalence of different grades of under-nutrition or CED among the Rajbanshi individuals was assessed using BMI (***Table 3.16***). The results showed that most of the undernourished individuals comprised mild under-nutrition (CED Grade I: 17.37%) followed by moderate under-nutrition (CED Grade II: 4.05% and finally severe under-nutrition (CED Grade III: 1.74%). It has been also noticed that the females were more nutritionally vulnerable than the males in CED Grades I, II and III (***Figure 3.29***). The sex difference in CED Grade I (χ^2-value = 1.17; d.f. 1) and CED Grade II (χ^2-value= 0.12; d.f. 1) were observed to be statistically not significant ($p>0.05$), while in case of CED Grade III this difference was statistically significant (χ^2-value= 7.54; d.f. 1; $p<0.05$). The overall sex difference in all the 3 CED grades was statistically insignificant (χ^2-value= 3.44; d.f. 3; $p>0.05$).

Table 3.16. Different grades of under-nutrition (CED) based on BMI among the Rajbanshi individuals

Grade	*BMI kg/m²*	*Males*	*Females*	*Total*
CED Grade III	*BMI < 16.00*	05 (0.81)	13 (3.13)	18 (1.74)
CED Grade II	*BMI 16.00 – 16.99*	24 (3.87)	18 (4.33)	42 (4.05)
CED Grade I	*BMI 17.00 – 18.49*	100 (16.13)	80 (19.23)	180 (17.37)
Total (Under-nutrition)	*BMI ≤ 18.50*	129 (20.81)	111 (26.68)	240 (23.17)

Figure in parenthesis indicates percentages

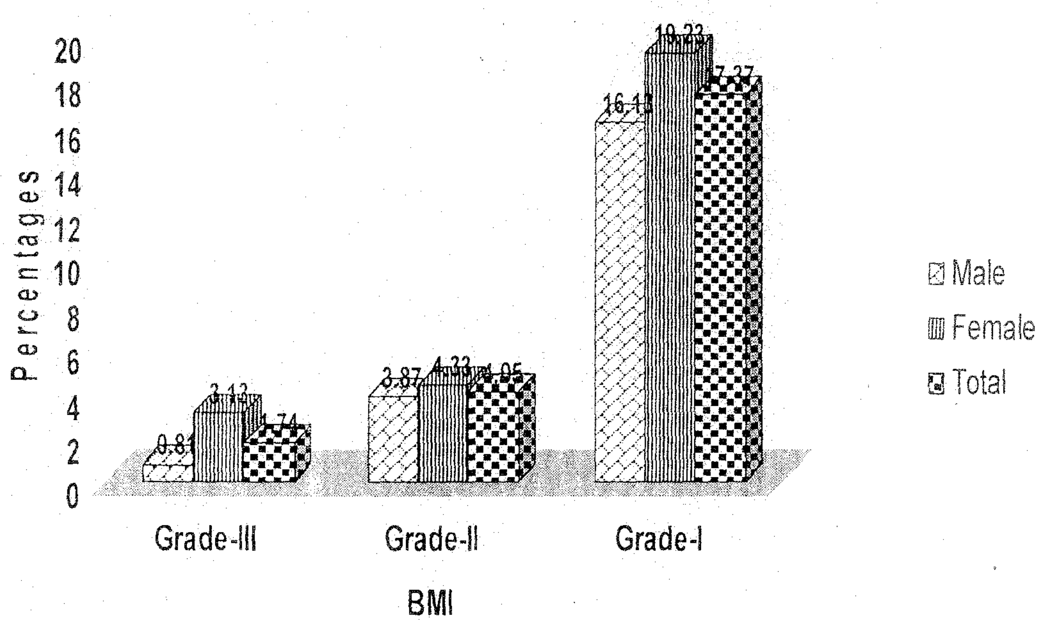


Figure 3.29: Bar diagram showing the sex specific prevalence of different grades of CED among the Rajbanshi individuals

3.2.12.2. Age and sex specific prevalence in different grades of CED using BMI

The age and sex specific prevalence of different grades of CED based on BMI among the Rajbanshi individuals are shown in ***Table 3.17*** and ***Figure 3.30***. The prevalence of mild under-nutrition (CED Grade I) was found to be higher among the male individuals in the age group of 40-49 years (24.81%) and the female individuals in the age group of 30-39 years (23.42%). Moderate under-nutrition (CED Grade II) and severe under-nutrition (CED Grade III) under-nutrition was observed to be higher among the males (5.66% and 1.89%) and the females (5.66% and 5.66%) in the age group of 40-49 years. The magnitude of age specific under-nutrition was higher among the older age group (40-49 years) that the younger ones (e.g., 20-30 years). A lower prevalence of mild and moderate under-nutrition was exhibited among the males (12.70% and 2.12%) and the females (15.58% and 3.52%) in the age groups of 30-39 years and 20-29 years respectively. A lower prevalence of severe grade of under-nutrition was observed in the age group of 20-29 years among both male (0.03%) and female (0.50%) individuals. The age specific prevalence of under-nutrition based on the different CED grades is depicted in ***Figures 3.31 and 3.32*** respectively.

*Table 3.17. Age and sex specific prevalence of different grades of CED based on **BMI** among the Rajbanshi individuals*

CED Grade	***20-29 years***		***30-39 years***		***40-49 years***		***Total***	
	Males	***Females***	***Males***	***Females***	***Males***	***Females***	***Males***	***Females***
CED Grade III	01 (0.03)	01 (0.50)	01 (0.53)	06 (5.41)	03 (1.89)	06 (5.66)	05 (0.81)	13 (3.13)
CED Grade II	11 (4.04)	07 (3.52)	04 (2.12)	05 (4.50)	09 (5.66)	06 (5.66)	24 (3.87)	18 (4.33)
CED Grade I	44 (16.18)	31 (15.58)	24 (12.70)	26 (23.42)	32 (24.81)	23 (21.70)	100 (16.13)	80 (19.23)
Normal	216 (79.41)	160 (80.40)	160 (84.66)	74 (66.67)	115 (72.32)	71 (66.98)	491 (67.58)	305 (73.32)
Total	272 (100.00)	199 (100.00)	189 (100.00)	111 (100.00)	159 (100.00)	106 (100.00)	620 (100.00)	416 (100.00)

Figures in parenthesis indicates percentages

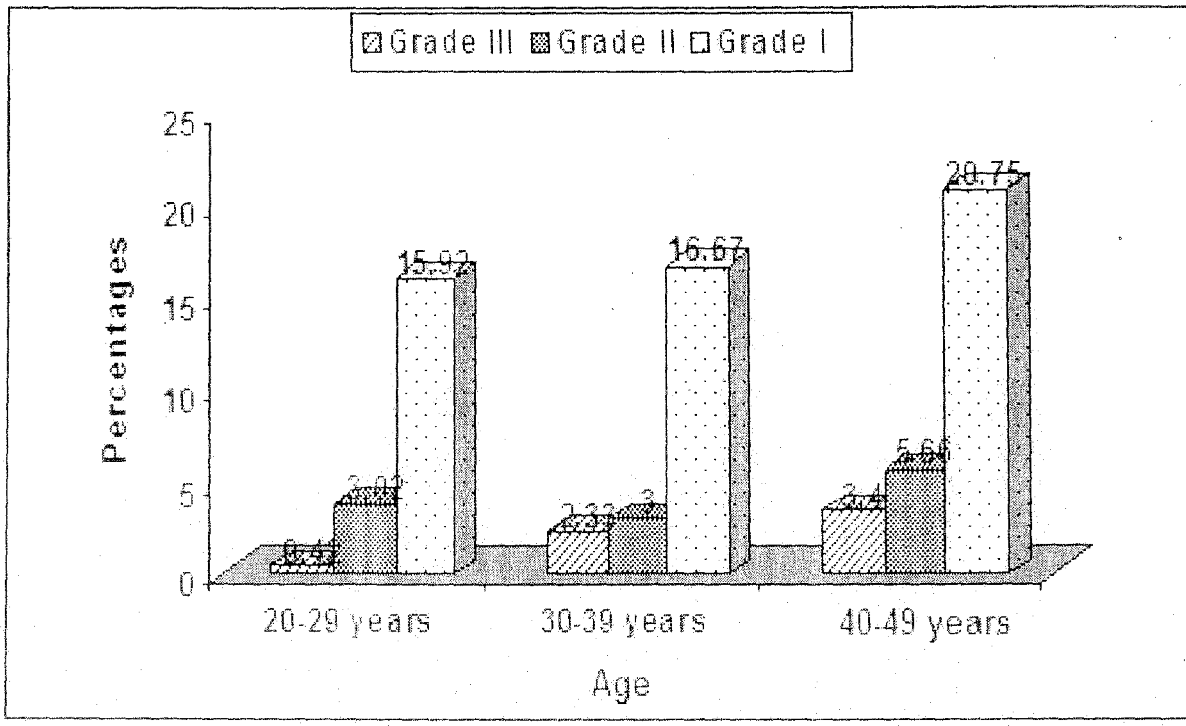


Figure 3.30: Bar diagram showing the age specific overall prevalence of different grades of CED among the Rajbanshi individuals

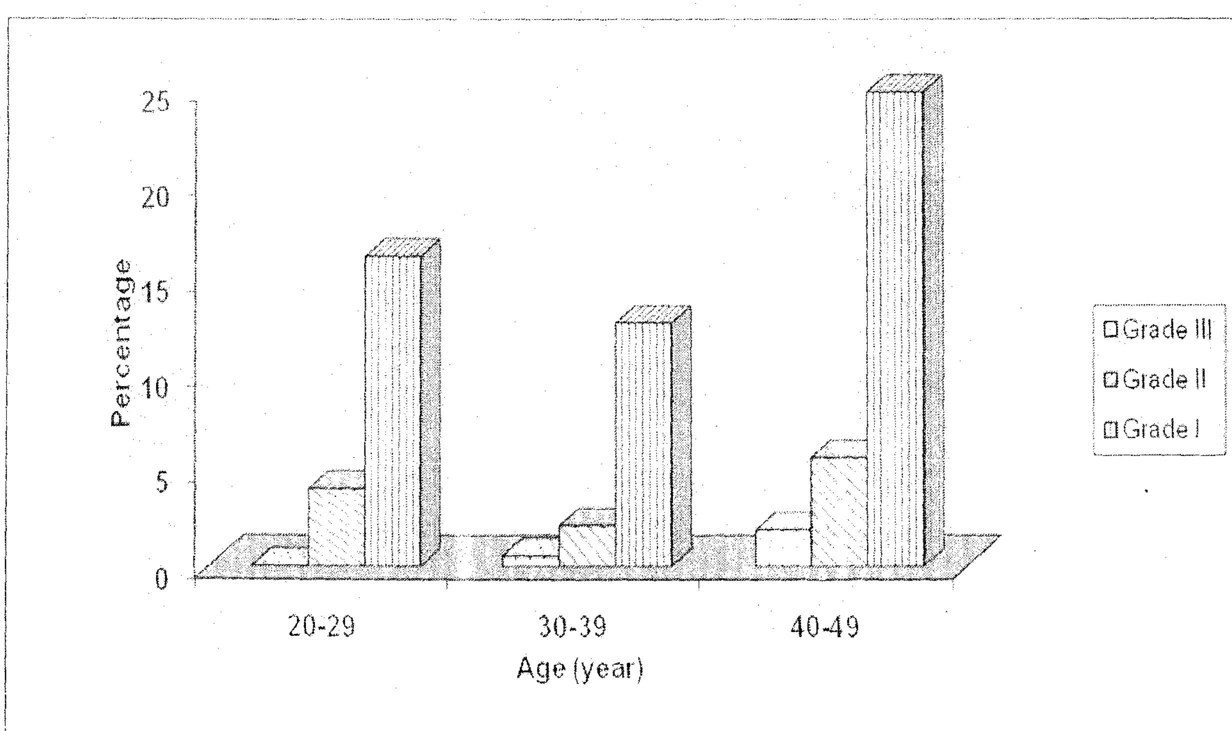


Figure 3.31: Bar diagram showing the age group wise prevalence of different grades of CED among the Rajbanshi male individuals

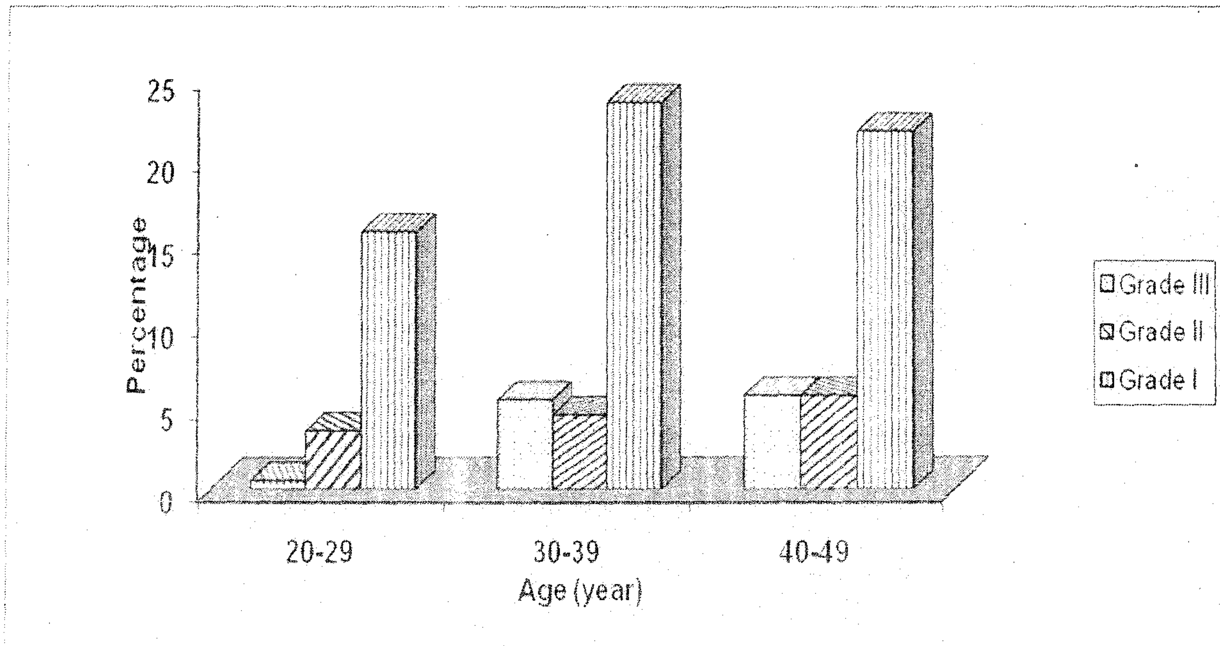


Figure 3.32: Bar diagram showing the age group wise prevalence of different grades of CED among the Rajbanshi female individuals

The sex difference within the age groups among the males and females was observed to be statistically not significant in the different grades (χ^2 value: 7.71; d.f. 6; p>0.05 versus χ^2 value: 10.44; d.f. 6; p>0.05). The sex difference in the prevalence of under-nutrition within the age groups of 30-39 years was statistically significant (χ^2 value: 11.06; d.f.3; p<0.05). The differences were not significant in the age group of 20-29 years (χ^2 value: 0.15; d.f.3; p>0.05) and 40-49 years (χ^2 value: 2.58; d.f.3; p>0.05).

3.2.13. Assessment of nutritional status among the Rajbanshi individuals using MUAC

Nutritional status was also assessed using the sex specific cut-off points of <23 cm for males and <22 cm for females, as specified by James *et al.* (1994). The results are shown in ***Table 3.18.*** The overall prevalence of under-nutrition was 40.64%, while 59.36% were normal (***Figure 3.33***). The sex specific prevalence of under-nutrition was observed to be slightly higher among the males than the females (40.97% versus 40.17%). Using χ^2 analysis, the sex difference in the prevalence of under-nutrition status was not statistically significant (χ^2-value= 0.03; d.f.1; p>0.05).

Table 3.18. Nutritional status of the Rajbanshi individuals based on internationally accepted cut offs of MUAC (after James et al. 1994)

Nutritional status	*Males*	*Females*	*Total*
Under-nutrition	254 (40.97)	167 (40.14)	421 (40.64)
Normal	366 (59.03)	249 (59.86)	615 (59.36)
Total	620 (100.00)	416 (100.00)	1036 (100.00)

Figures in parenthesis indicates percentages

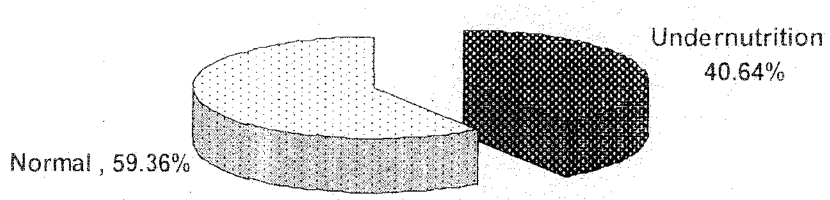


Figure 3.33: Pie chart showing the prevalence under-nutrition based on MUAC cut-offs of James et al. (1994) among the Rajbanshi individuals

3.2.14. Assessment of nutritional status among the Rajbanshi individuals using the combination of MUAC with BMI

The nutritional status of the Rajbanshi individuals were also classified using the combination of MUAC with BMI (***Table 3.19***). The results are also graphically represented in ***Figure 3.34.*** It was observed that 17.26% and 20.67% of the male and the female individuals were below the combined under-nutrition cut-offs of MUAC with BMI. The sex difference was however, found to be statistically not significant (χ^2-value= 1.31; d.f.1; p>0.05). The results also indicated that 3.55% and 6.01% of the male and the female individuals who were undernourished using BMI (<18.50 kg/m^2) exhibited normal MUAC values (χ^2-value= 3.17; d.f.1; p>0.05). The prevalence was higher among the males (23.71%) than the females (19.47%) in combination of undernourished MUAC and normal BMI (>18.50 kg/m^2) although the sex difference was statistically not significant (χ^2-value= 1.68; d.f.1; p>0.05). It was also seen that 55.48% and 53.85% of the male and the female individuals exhibited normal BMI and MUAC values (χ^2-value= 0.08; d.f.1; p>0.05).

Table 3.19. Nutritional status of the Rajbanshi individuals based on classified according to MUAC with BMI

	MUAC Cut-offs	*BMI <18.5 kg/m^2*	*BMI ≥ 18.5 kg/m^2*	*Total*
	<23.0 cm	107 (17.26)	147 (23.71)	254 (40.97)
Males	*≥ 23.0 cm*	22 (3.35)	344 (55.48)	366 (59.03)
(N=620)	*Total*	129 (20.81)	491 (79.19)	620 (100.00)
	<22.0 cm	86 (20.87)	81 (19.47)	167 (40.14)
Females	*≥ 22.0 cm*	25 (6.01)	224 (53.85)	249 (59.86)
(N=416)	*Total*	111 (26.68)	305 (73.32)	416 (100.00)

Figures in parenthesis indicates percentages

3.2.15. Prevalence of overweight, obesity and regional obesity among the Rajbanshi individuals

The prevalence of overweight, obesity and regional obesity among the Rajbanshi individuals were evaluated using the derived indices of BMI (>25 kg/m^2), WC (males: ≥90 cm: females: ≥80.00), WHR (males: >0.9; females: >0.8), WHtR (≥0.5 for both sexes), PBF (males: >25%; females: >30%) and ∑SKF (>50 mm). The sex specific prevalence is presented in ***Table 3.20.*** It has been observed that when BMI was used to assess overweight and obesity, only 4.63% of the individuals had BMI values >25 kg/m^2. The females were more overweight and obese than the males (6.97% versus 3.06%) ($p<0.01$).

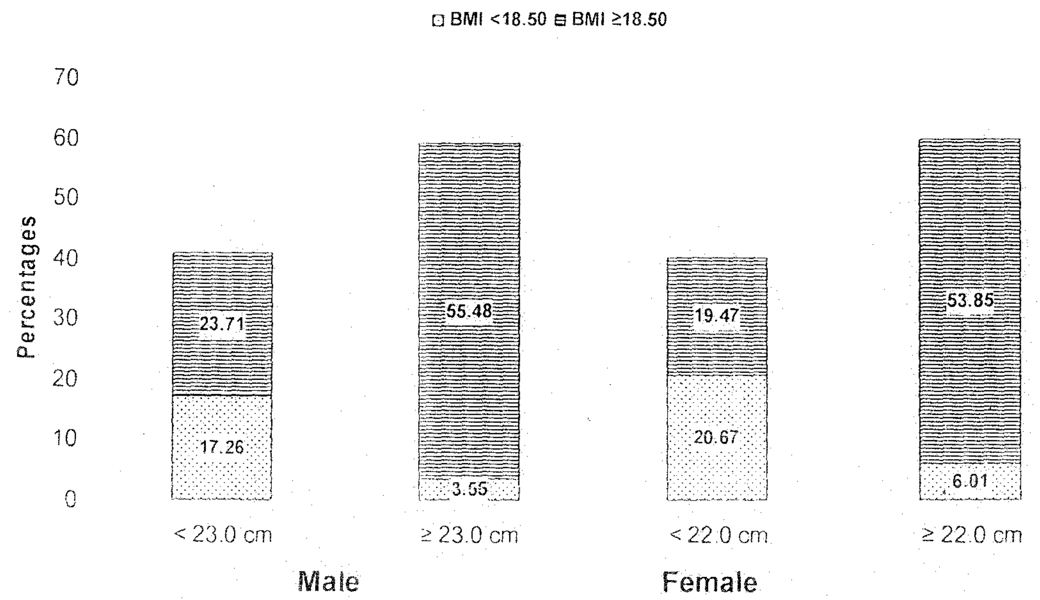


Figure 3.34: Column diagram showing the prevalence of under-nutrition using MUAC with BMI among the Rajbanshi individuals

When regional adiposity was assessed using WC, it was noticed that the prevalence of overall obesity was 6.56% (N 68). The sex specific prevalence was higher among the females (13.70%) than the males (1.77%). This prevalence was substantially altered when WHR and WHtR were taken as indicators of obesity (WHR: 56.76%; WHtR: 21.14%. The sex specific prevalence of obesity using these two indicators was also higher among the females (81.73% and 32.45%) than the males (40% and 13.55%). The prevalence high PBF and ∑SKF were 0.87% and 2.12% among the individuals. The sex differences were observed to be statistically ($p<0.01$). A total of 6 males and 16 females exhibited high skinfold thickness (0·97% versus 3.85 %) (***Table 3.20***). The levels of adiposity were significantly higher among the females as compared to the males for all the anthropometric measures and derived indices (***Figure 3.35***). There were statistically significant sex differences in BMI (χ^2-value 7.78; d.f.1, $p<0.01$), WC (χ^2-value 49.69; d.f.1, $p<0.01$), WHR (χ^2-value 47.06;

d.f.1, $p<0.01$), WHtR (χ^2-value = 33.89; d.f.1, $p<0.01$), PBF (χ^2-value = 5.24; d.f.1, $p<0.05$) and $\sum$SKF (χ^2-value = 9.46; d.f.1, $p<0.01$) (***Table 3.20***).

The combination of the single and combined anthropometric measurements and indices were also utilized to assess overweight, obesity and elevated adiposity among the Rajbanshi individuals (***Tables 3.21*** and ***3.22)***. The prevalence is graphically represented in ***Figure 3.36.*** It was observed that 3.06%, 40.00% and 13.55% of the male individuals had higher level adiposity, overweight and obesity using the single indices of BMI (>25 kg/m^2), WHR (>0.9) and WHtR ($\geq$ 0.5) respectively. The prevalence was 3.06%, 2.42% and 11.94% using the combination of BMI and WHR, BMI and WHtR, and between WHR and WHtR. The combination of BMI, WHR and WHtR had 15 individuals belonging to the risk group (2.42%). When the risk of ill-health was assessed using the single and combined anthropometric indices, the female individuals seemed to have higher prevalence in all the measures than the males. The single adiposity indices showed that 6.97%, 81.73% and 32.45% of the females exhibited higher levels of adiposity using BMI (>25 kg/m^2), WHR (>0.9) and WHtR ($\geq$0.5) respectively. The usage of the combination of two indices, BMI and WHR, BMI and WHtR, and WHR and WHtR showed that 6.25%, 3.13% and 31.49% of the females exhibited increased risks of adiposity. Only 13 (3.13%) of them was in the combination of 3 adiposity indices of BMI, WHR and WHtR. The sex differences in the prevalence of the individuals falling in the risk of ill-health were evaluated utilizing the χ^2 analysis (***Table 3.23***). The differences were statistically significant in BMI, WHR, WHtR, BMI and WHR, and between WHR and WHtR ($p<0.05$) while the differences were not statistically significant between BMI and WHtR, and between BMI, WHR and WHtR ($p>0.05$).

Table 3.20. Prevalence of overweight, obesity and regional adiposity among the Rajbanshi individuals

Index		Males (N= 620)	Females (N=416)	Total (N=1036)	χ^2 value	d.f.	p value
Over weight (BMI >25kg/m^2)	Normal	601 (96.94)	387 (93.03)	988 (95.37)	7.78	1	0.005
	Overweight	19 (3.06)	29 (6.97)	48 (4.63)			
Abdominal obesity WC*	Normal	609 (98.23)	359 (86.30)	968 (93.44)	49.69	1	0.000
	Obesity	11 (1.77)	57 (13.70)	68 (6.56)			
WHR**	Normal	372 (60.00)	76 (18.27)	448 (43.24)	47.06	1	0.000
	Obesity	248 (40.00)	340 (81.73)	588 (56.76)			
WHtR***	Normal	536 (86.45)	281 (67.55)	817 (78.86)	33.90	1	0.000
	Obesity	84 (13.55)	135 (32.45)	219 (21.14)			
PBF****	Normal	618 (99.68)	409 (98.32)	1027 (99.13)	5.24	1	0.022
	Obesity	02 (0.32)	07 (1.68)	09 (0.87)			
High Skinfold fat (∑SKF)	Normal	614 (99.03)	400 (96.15)	1014 (97.88)	9.46	1	0.002
	High	06 (0.97)	16 (3.85)	22 (2.12)			

Figures in parenthesis indicates percentages

*[*WC: males: ≥90 cm; females: ≥80 cm (WHO, 2000; Lau et al., 2007); **WHR: males: >0.9; females: >0.8 (Webb et al., 2002; Huxley et al., 2007); ***WHtR >0.5 for both sexes (Hsieh and Muto, 2004); **** PBF: males: >25%; females >30% (Pollock and Wilmore, 1990; Dudeja et al., 2001); ∑SKF >50 mm for both sexes (Dudeja et al., 2001)]*

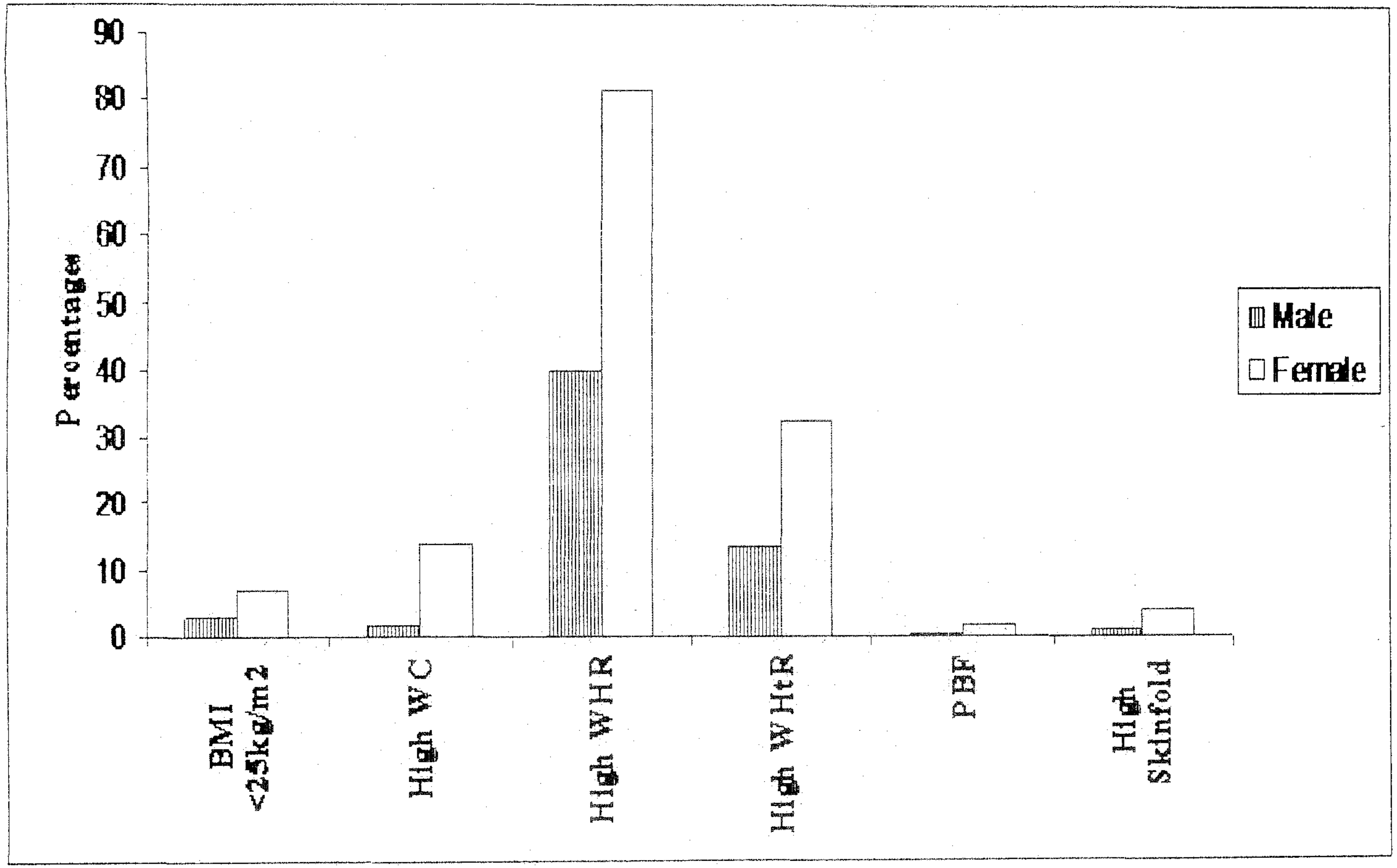


*Figure 3.35: Bar diagram showing the prevalence of overweight and adiposity among the Rajbanshi individuals [*WC: males: ≥90 cm; females: ≥80 cm (WHO, 2000; Lau et al., 2007); **WHR: males: >0.9; females: >0.8 (Webb et al., 2002; Huxley et al., 2007); ***WHtR >0.5 for both sexes (Hsieh and Muto, 2004); **** PBF: males: >25%; females: >30% (Pollock and Wilmore, 1990; Dudeja et al., 2001); ∑SKF >50 mm for both sexes (Dudeja et al., 2001)]*

Table 3.21. Number of Rajbanshi males (N=620) who 'might be at risk of ill health' as assessed by a single and a combinations of different anthropometric adiposity indices

Indices	*Number of individuals*	*Percentage*
BMI ≥25 kg/m²	19	3.06
WHR >0.9	248	40.00
WHtR ≥0.5	84	13.55
BMI ≥25 kg/m² and WHR >0.9	19	3.06
BMI ≥25 kg/m² and WHtR ≥0.5	15	2.42
WHR ≥0.9 and WHtR ≥0.5	74	11.94
BMI ≥ 25 kg/m², WHR >0.9 and WHtR 0.5	15	2.42

Table 3.22. Number of Rajbanshi females (N=416) who 'might be at risk of ill health' as assessed by a single and a combinations of different anthropometric adiposity indices

Indices	*Number of individuals*	*Percentage*
BMI ≥25 kg/m²	29	6.97
WHR >0.8	340	81.73
WHtR ≥0.5	135	32.45
BMI ≥25 kg/m² and WHR >0.8	26	6.25
BMI ≥25 kg/m² and WHtR ≥0.5	13	3.13
WHR >0.8 and WHtR ≥0.5	131	31.49
BMI ≥25 kg/m², WHR >0.8 and WHtR ≥0.5	13	3.13

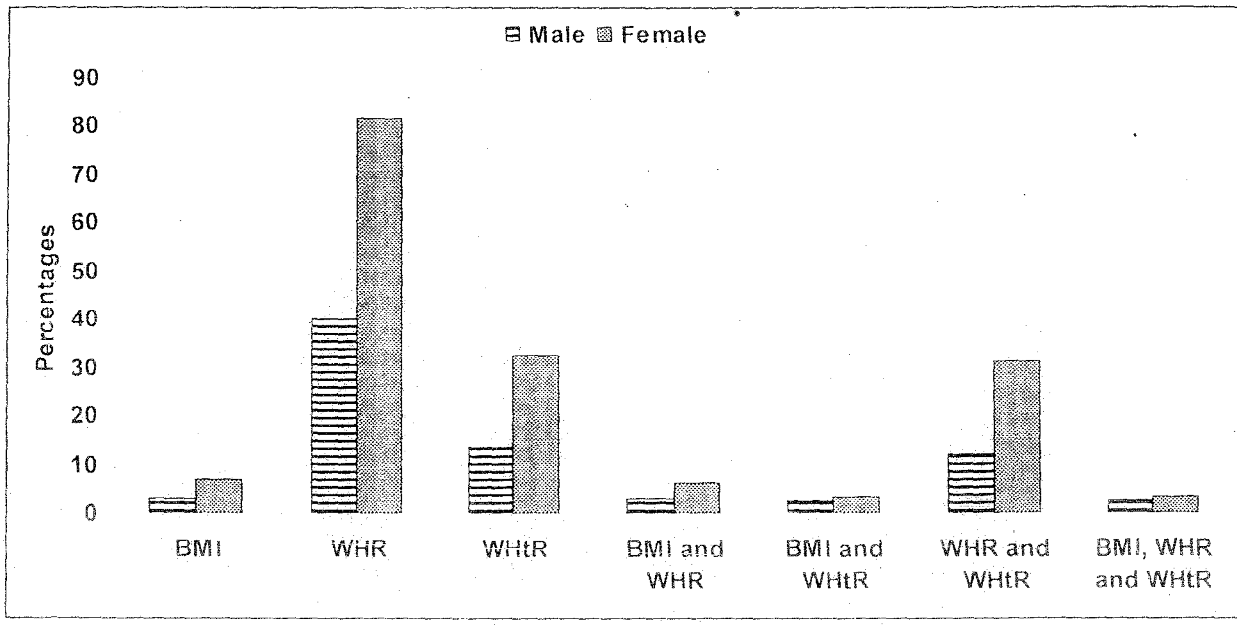


Figure 3.36: Bar diagram showing the male and female individuals who might be at risk of ill health as assessed by a single and combination of the adiposity indices.

Table 3.23. Sex differences in the parameter of 'might be at risk of ill health' as assessed by a single and a combination of anthropometric adiposity indices

Indices	χ^2-*value*	*d.f.*	*p value*
BMI	7.78	1	0.005
WHR	47.06	1	0.000
WHtR	33.9	1	0.000
BMI and WHR	5.54	1	0.018
BMI and WHtR	0.45	1	0.502
WHR and WHtR	39.16	1	0.000
BMI, WHR and WHtR	0.45	1	0.502

3.2.16. Classification of the individuals based on BMI with WHR and WHtR

The Rajbanshi individuals have been also categorized based on BMI that included normal and overweight, with WHR and WHtR to find out the association of the higher levels of adiposity among them. The results are depicted ***Tables 3.24*** and ***3.25*** respectively. It is evident from ***Table 3.24*** that only 19 (3.06%) and 15 (2.42%) of the male individuals exhibited higher levels of regional adiposity in WHR (>0.9 and BMI ($\geq$25 kg/m^2), and WHtR ($\geq$0.5) and BMI ($\geq$25 kg/m^2) respectively. Higher prevalence of regional adiposity in terms of WHR (>0.9) and WHtR ($\geq$0.5) were also observed among those males who comprised the under normal category of BMI (<25 kg/m^2) (N=229, 36.94% and N=69, 11.13%. A low level of regional adiposity (WHtR<0.5) but higher BMI (>25 kg/m^2) was found among only among 4 (0.65%) of the male individuals. When the combination of the 3 indices (BMI with WHR and WHtR) among the female Rajbanshi individuals was evaluated, it was observed that 26 (6.25%) and 14 (3.37%) of the females were overweight (BMI $\geq$25.00 kg/m^2). The results also showed that 75.48% (N=314) and 29.09% (N=121) of them exhibited higher levels of regional adiposity but comprised the normal category of BMI (<25 kg/m^2) (***Table 3.25***). A lower level of regional adiposity in terms of WHR and WHtR but higher level of BMI ($\geq$25 kg/m^2) were among 3 (0.72%) and 15 (3.61%) of the females respectively. The higher levels of regional adiposity in terms of BMI with WHR and WHtR among both the male and female individuals are graphically represented in ***Figures 3.37 and 3.38***.

The within sex differences between WHR and WHtR in the two categories of BMI (normal and overweight) were evaluated using χ^2 analysis. The differences are found to statistically significant among the male individuals with normal BMI (<25 kg/m^2) and overweight BMI ($\geq$25 kg/m^2) in respect to WHR (>0.9) (χ^2-value 8.941; d.f. 1, $p<0.05$) and

WHtR ($\geq$0.5) (χ^2-value= 35.219; d.f. 1. p<0.05). The differences were not statistically significant in both WHR (>0.8) (χ^2-value= 0.127; d.f. 1, p>0.05) and WHtR ($\geq$0.5) (χ^2-value= 1.637; d.f. 1, p<0.05) among the females.

Table 3.24. Number of Rajbanshi male individuals (N=620) classified based on BMI with WHR and WHtR.

Indices	*Cut-off*	*BMI <25 kg/m²*	*BMI ≥ 25 kg/m²*	*Total*
	> 0.9	229 (36.94)	19 (3.06)	248 (40.00)
WHR	*< 0.9*	372 (60)	0 (0.00)	372 (60)
	Total	601 (96.94)	19 (3.06)	620 (100)
	≥ 0.5	69 (11.13)	15 (2.42)	84 (13.55)
WHtR	*<0.5*	532 (85.81)	4 (0.65)	536 (86.45)
	Total	601 (96.94)	19 (3.06)	620 (100)

Figures in parenthesis indicates percentages

Table 3.25. Number of Rajbanshi female individuals (N=416) based on BMI with WHR and WHtR

Indices	*Cut-off*	*BMI <25 kg/m²*	*BMI ≥ 25 kg/m²*	*Total*
	> 0.8	314 (75.48)	26 (6.25)	340 (81.73)
WHR	*< 0.8*	73 (17.55)	3 (0.72)	76 (18.27)
	Total	387 (93.03)	29 (6.97)	416 (100.00)
	≥ 0.5	121 (29.09)	14 (3.37)	135 (32.45)
WHtR	*<0.5*	266 (63.94)	15 (3.61)	281 (67.55)
	Total	387 (93.03)	29 (6.97)	416 (100)

Figures in parenthesis indicates percentages

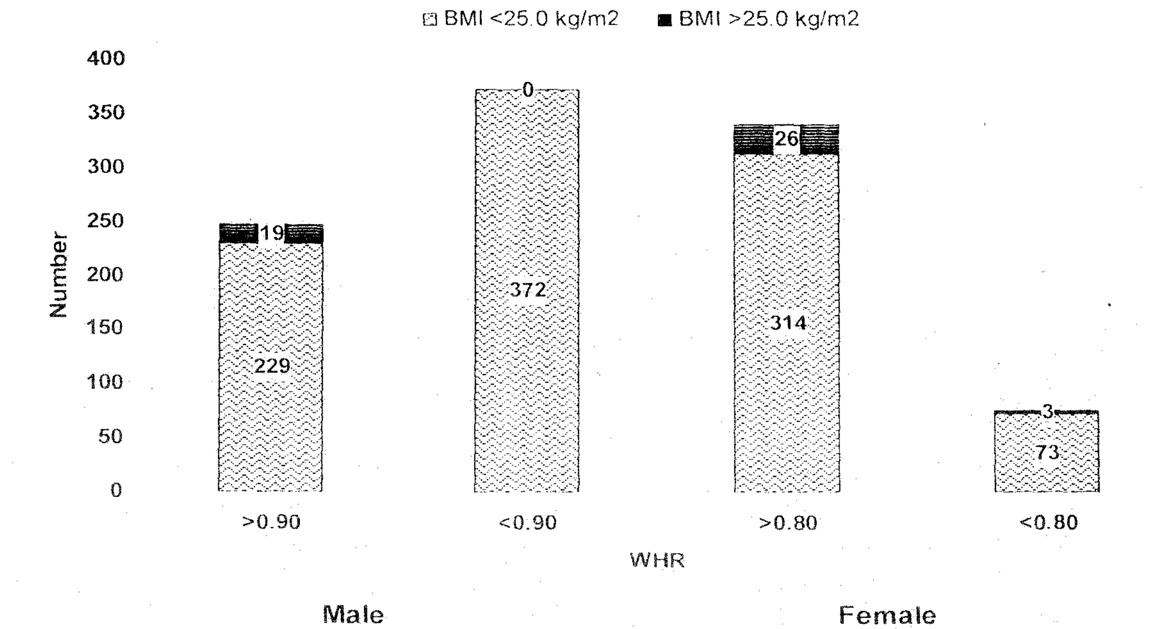


Figure 3.37: Column chart showing the Rajbanshi individuals classified according to BMI with WHR

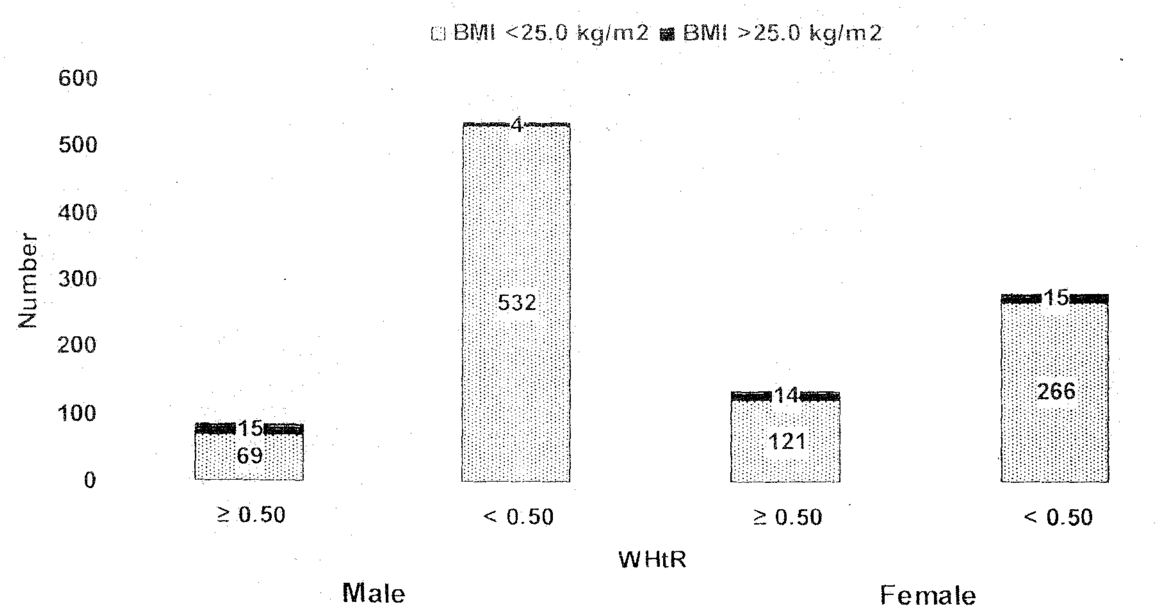


Figure 3.38: Column chart showing the Rajbanshi individuals classified based on BMI with WHtR

3.2.17. Body fitness among the Rajbanshi individuals

The Rajbanshi individuals were categorized in terms of fitness status based on PBF using the fitness scale proposed by Neiman (1995) and Lee and Neiman (2005). The PBF content was evaluated using the age and sex specific equation of Durnin and Womersley (1974). The body fitness status among them is depicted in ***Table 3.26***. More than half of the individuals exhibited risky fitness status (51.93%), followed by good (20.37%), then excellent (19.59%) and finally fair fitness status (8.11%) (***Figure 3.39***). Risky fitness status were exhibited by 64.68% and 32.93% of the males and the females (χ^2-value = 33.53, d.f.1; $p<0.01$). The results also indicated that good and fair fitness were higher among the females (27.16% and 16.35%) than the males (15.81% and 2.58%). The sex differences in good fitness (χ^2-value = 12.89, d.f.1; $p<0.01$) and fair fitness (χ^2-value = 52.70, d.f.1; $p<0.01$) status were observed to be statistically significant. The overall sex difference in fitness status was also found to be statistically significant (χ^2-value = 127.83, d.f.4; $p<0.01$). The sex specific evaluation of fitness status is shown in ***Figure 3.40***.

3.2.18. Age specific body fitness status based on PBF among the Rajbanshi individuals

Age and sex specific fitness based on PBF among the Rajbanshi individuals is depicted in ***Table*** 3.27. The results indicated that risky fitness status increased with age among both sexes, with the highest number being observed in the 45-49 years age group (males: 94.12%; females: 75.36%). The prevalence of risky fitness is absent in 20-24 years age group in both sexes. The fitness grades of 'excellent', 'good' and fair were found to be higher in the early age groups among them. The sex differences in fitness status were evaluated using χ^2 analysis (***Table 3.27***). The values were observed to be statistically significant in almost all the age groups ($p<0.01$), with except in the 40-44 years age groups (χ^2-value = 3.79, d.f. 3; $p>0.05$).

Table 3.26. Fitness status among the Rajbanshi male and female individuals

Fitness group	*Males*	*Females*	*Total*	*χ^2-value*	*d.f.*	*p value*
Risky	401 (64.68)	137 (32.93)	538 (51.93)	33.53	1	0.00
Excellent	105 (16.94)	98 (23.56)	203 (19.59)	4.61	1	0.03
Good	98 (15.81)	113 (27.16)	211 (20.37)	12.89	1	0.00
Fair	16 (2.58)	68 (16.35)	84 (8.11)	52.70	1	0.00
Total	620 (100)	416 (100)	1036 (100)	127.83	4	0.00

Figure in parenthesis indicates percentages

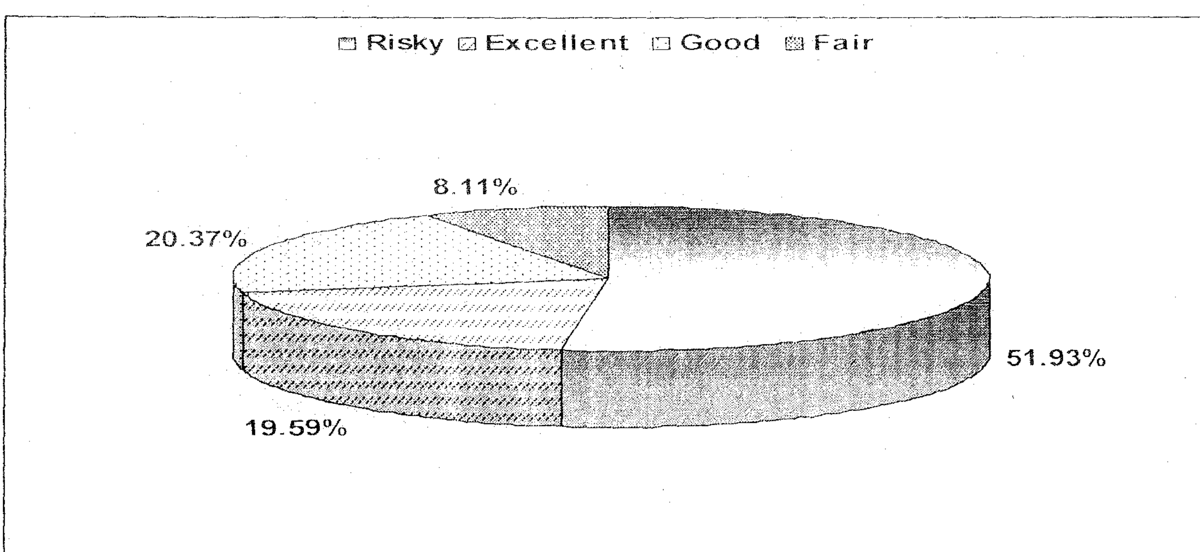


Figure 3.39: Pie chart showing the fitness status among the Rajbanshi individuals

Table 3.27. Age and sex specific fitness status based on PBF among the Rajbanshi individuals

Age (in years)	Males					Females					Sex difference		
	N	Risky	Excellent	Good	Fair	N	Risky	Excellent	Good	Fair	χ^2-value	d.f.	p value
20-24	155	0 (0)	58 (37.42)	83 (53.55)	14 (9.03)	151	0 (0)	45 (29.80)	55 (36.42)	51 (33.77)	28.34	3	0.000
25-29	117	87 (74.36)	24 (20.51)	5 (4.27)	1 (0.85)	48	10 (20.83)	16 (33.33)	16 (33.33)	6 (12.5)	50.96	4	0.000
30-34	75	63 (84.00)	6 (8.00)	6 (8.00)	0 (0.00)	57	20 (35.09)	15 (26.32)	16 (28.07)	6 (10.53)	34.87	4	0.000
35-39	114	105 (92.11)	7 (6.14)	1 (0.88)	1 (0.88)	54	28 (51.85)	9 (16.67)	12 (22.22)	5 (9.26)	40.55	4	0.000
40-44	57	50 (87.72)	4 (7.02)	3 (5.26)	0 (0)	37	27 (72.97)	4 (10.81)	6 (16.22)	0 (0)	3.79	3	0.286
45-49	102	96 (94.12)	6 (5.88)	0 (0)	0 (0)	69	52 (75.36)	9 (13.04)	8 (11.59)	0 (0.00)	13.91	3	0.001
Total	620	401 (64.68)	105 (16.94)	98 (15.81)	16 (2.58)	416	137 (32.93)	98 (23.56)	113 (27.16)	68 (16.35)	127.83	4	0.000

Figure in parenthesis indicates percentages

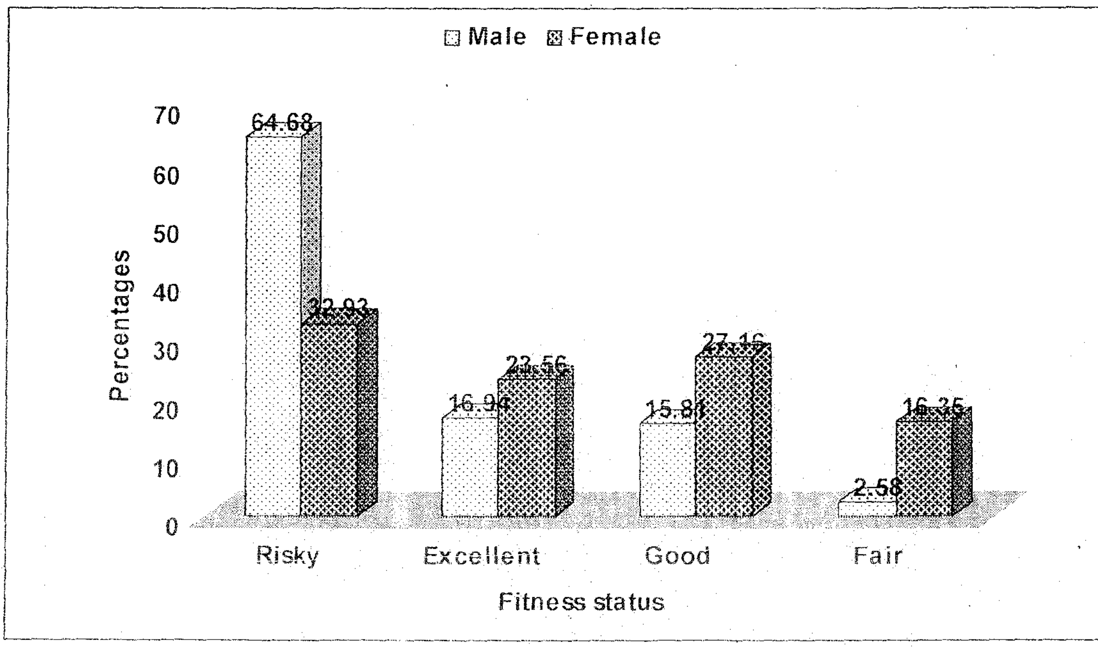


Figure 3.40: Bar diagram showing the sex specific distribution of fitness status among the Rajbanshi individuals

3.2.19. Assessment of risk factor associated with percent of body fat among Rajbanshi

The amount of risk factor associated with PBF among the Rajbanshi individuals was evaluated using the sex specific cut-off points of Sodhi (1984) and the results are depicted in ***Table 3.28***. It was noticed that the majority of the individuals had an optimal risk (76.16%). The individuals comprising the slightly overweight and lean categories were observed to be 12.26% and 7.72% respectively (***Figure 3.41***). The sex specific prevalence was seen to be higher in both the males (77.42%) and the females (74.28%) in the lean category. The amount of fat content was found to be significantly higher among females (6.97%) as compared to the males (1.45%). The sex specific comparison in risk factors is shown in ***Figure 3.42***. The sex differences were statistically significant in lean (χ^2-value = 26.31; d.f. 1; $p<0.01$), slightly overweight (χ^2-value = 9.35; d.f. 1; $p<0.01$) and fat (χ^2-value = 19.75; d.f. 1; $p<0.01$) categories. However the sex difference was observed to be statistically not significant in optimal (χ^2-value = 0.18; d.f. 1;

p>0.05) and obese (χ^2-value= 0.19; d.f. 1; p>0.05) categories. Furthermore, the sex difference in overall risk factor groups was observed to be statistically significant (χ^2-value= 60.78; d.f. 5; p<0.01).

Table 3.28. Risk factors associated with PBF among the Rajbanshi individuals after Sodhi (1984)

*Classification**	*Males*	*Females*	*Total*	$\chi 2$	*d.f.*	*p*
Lean	71 (11.45)	9 (2.16)	80 (7.72)	26.31	1	0.00
Optimal	480 (77.42)	309 (74.28)	789 (76.16)	0.18	1	0.67
Slightly overweight	58 (9.35)	69 (16.59)	127 (12.26)	9.35	1	0.00
Fat	9 (1.45)	29 (6.97)	38 (3.67)	19.75	1	0.00
Obese (Over fat)	2 (0.32)	0 (0)	2 (0.19)	0.19	1	0.66
Total	620 (100.00)	416 (100.00)	1036 (100.00)	60.78	5	0.00

Figures in parenthesis indicates percentages

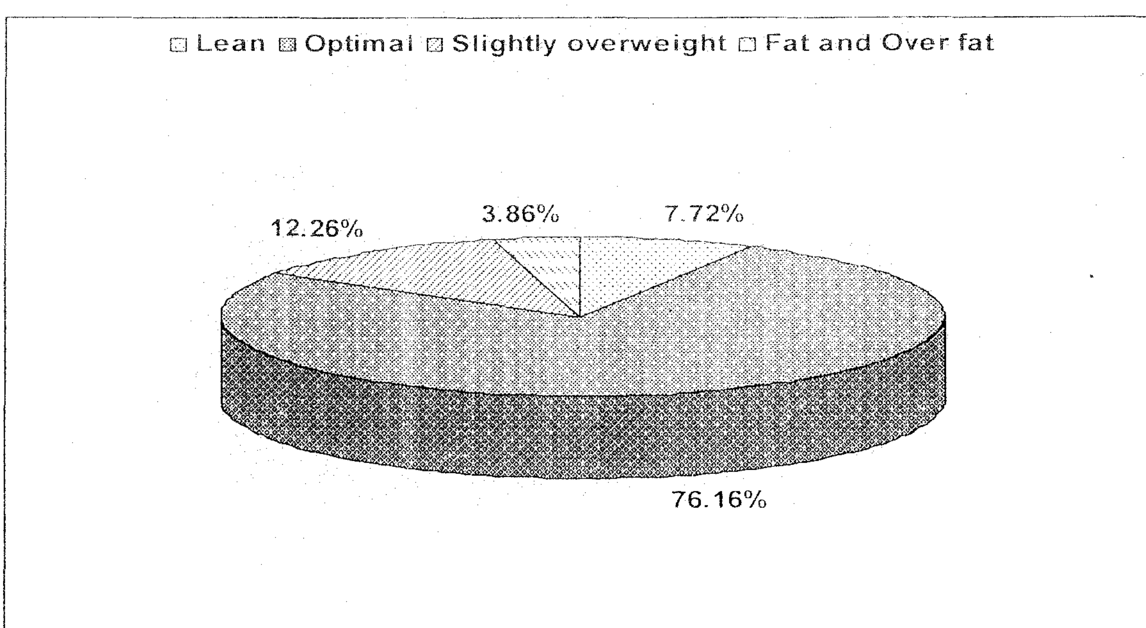


Figure 3.41: Pie chart showing the overall risk factor based on PBF among the Rajbanshi individuals

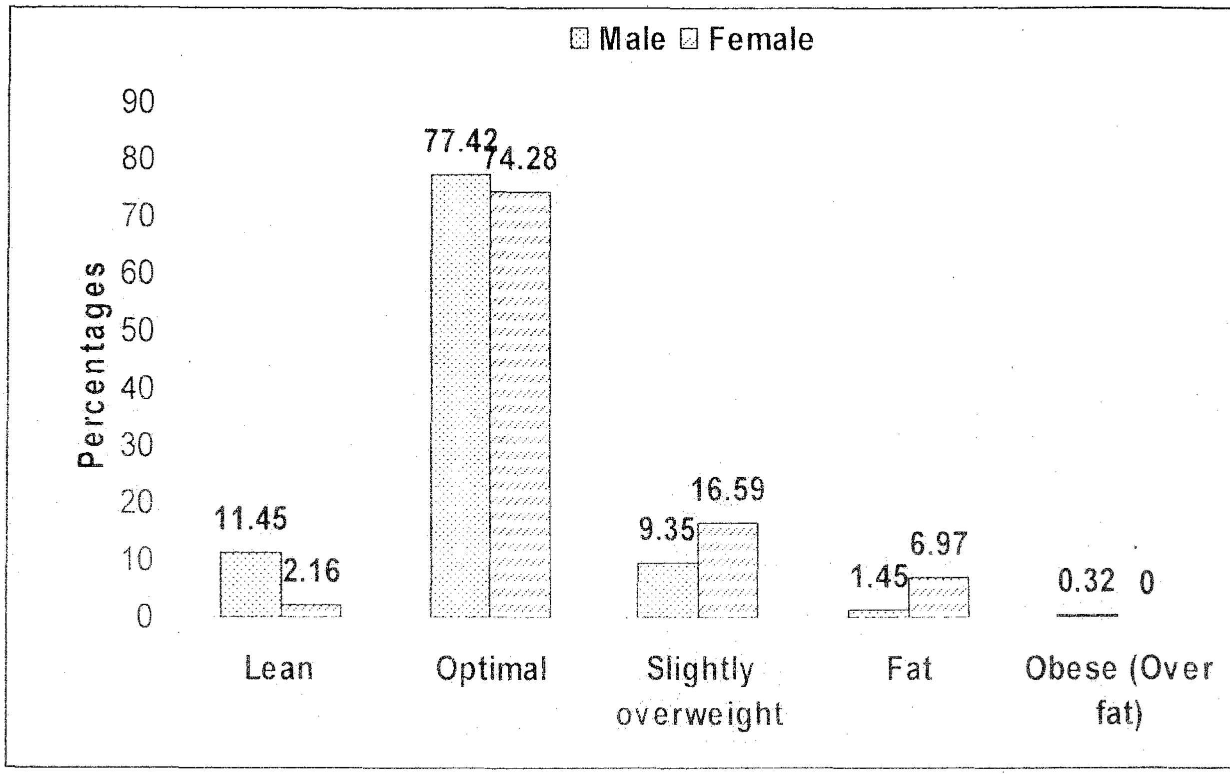


Figure 3.42: Bar diagram showing the sex specific distribution of risk factors using PBF among the Rajbanshi individuals

3.2.20. Age specific prevalence of risk factor associated with PBF

The results of age specific prevalence of risk factor associated with PBF among the Rajbanshi male and female individuals is presented in ***Table 3.29***. The results indicated that the age and sex specific distribution of lean individuals was higher among the males (16.35%) and the females (2.51%) in the 40-49 years and 20-29 years age groups respectively. The higher and lower prevalence of optimal risk status was observed in the age group of 20-29 years (males: 81.99%; females: 78.39%) and 40-49 years (males: 71.07%; females: 68.87%) among both the sexes (***Figure 3.43***). The prevalence of slightly overweight and obese risk groups were also found to be higher among both sexes in the age groups of 30-39 years (males: 10.58%; females: 18.92%) and 40-49 years (males: 3.77%; females: 16.04%) respectively. The sex differences within the age groups with respect to the prevalence of these risk factor groups were statistically significant in the age groups of 30-39 years (χ^2-value = 23.72; d.f.5; $p<0.01$) and 40-49 years (χ^2-value = 25.91; d.f.5; $p<0.01$). The difference was statistically not significant in the age group of 20-29 years (χ^2-value = 13.60, d.f.4; $p>0.01$). Among the female individuals, statistically significant differences were observed in all the age groups (χ^2-value = 21.82, d.f.10; $p<0.05$). However, among the males, these differences were not statistically significant (χ^2-value= 17.82, d.f.10;$p>0.05$).

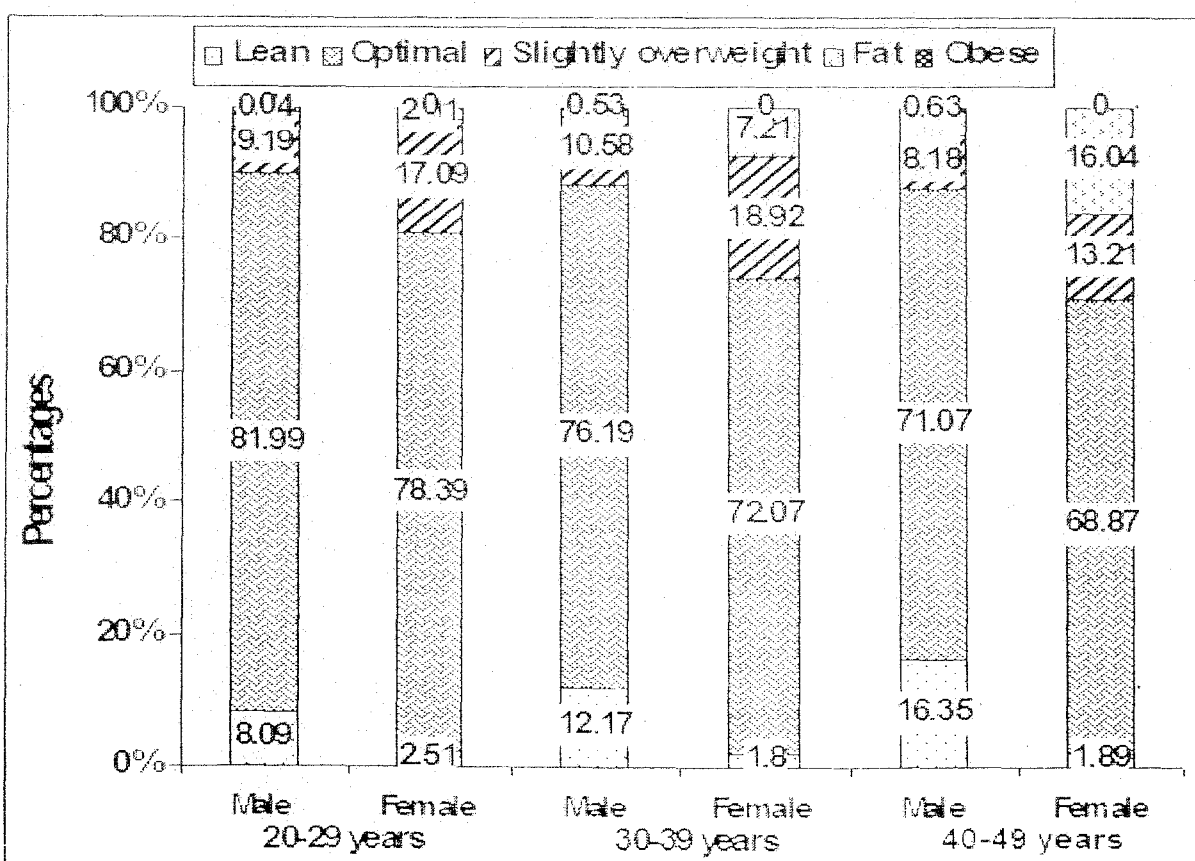


Figure 3.43: Column chart showing the sex and sex specific distribution of risk factors using PBF among the Rajbanshi individuals

Table 3.29. Age and sex specific distribution of risk factor among the Rajbanshi individuals

Risk group	20-29 years		30-39 years		40-49 years		Total	
	Males	Females	Males	Females	Males	Females	Males	Females
Lean	22 (8.09)	5 (2.51)	23 (12.17)	2 (1.80)	26 (16.35)	2 (1.89)	71 (11.45)	9 (2.16)
Optimal	223 (81.99)	156 (78.39)	144 (76.19)	80 (72.07)	113 (71.07)	73 (68.87)	480 (77.42)	309 (74.28)
Slightly overweight	25 (9.19)	34 (17.09)	20 (10.58)	21 (18.92)	13 (8.18)	14 (13.21)	58 (9.35)	69 (16.59)
Fat	2 (0.74)	4 (2.01)	1 (0.53)	8 (7.21)	6 (3.77)	17 (16.04)	9 (1.45)	29 (6.97)
Obese (Over fat)	0 (0)	0 (0)	1 (0.53)	0 (0)	1 (0.63)	0 (0)	2 (0.32)	0 (0)
Total	272 (100)	199 (100)	189 (100)	111 (100)	159 (100)	106 (100)	620 (100)	416 (100)

Figure in parenthesis indicates percentages

3.2.21. Association of the socio-economic, demographic and lifestyle related variables with under-nutrition, regional adiposity among the Rajbanshi male individuals

The association of socio-economic, demographic and lifestyle related variables with the prevalence of under-nutrition and regional adiposity among Rajbanshi male individuals is depicted in ***Table 3.30***. The comparisons with respect to under-nutrition and regional adiposity were made with the respective socio-economic, demographic and lifestyle related counter variables.

Table 3.30. Association of the socio-economic, demographic and lifestyle related variables with under-nutrition and regional adiposity among the Rajbanshi male individuals

Variables	Category	Number of males	BMI (<18.50) (N=129)	WHR(>0.9) (N=248)	WHtR(>0.5) (N=84)
Age (in years)	20-29	272	56 (20.59)	98 (36.03)	32 (11.76)
	30-39	189	29 (15.34)	86 (45.50)	23 (12.17)
	40-49	159	44 (27.67)	64 (40.25)	29 (18.24)
Education	Illiterate	104	25 (24.04)	38 (36.54)	17 (16.35)
	Up to primary	113	22 (19.47)	53 (46.90)	8 (7.08)
	Secondary and above	403	82 (20.35)	157 (38.96)	59 (14.64)
Occupation	Cultivator	326	67 (20.55)	127 (38.96)	48 (14.72)
	Labour	196	39 (19.90)	95 (48.47)	24 (12.24)
	Others	98	23 (23.47)	26 (26.53)	12 (12.24)
Income (in Rupees)	≤4000	198	46 (23.23)	72 (36.36)	18 (9.09)
	4001-6000	288	63 (21.88)	120 (41.67)	34 (11.81)
	6000>	134	20 (14.93)	56 (41.79)	32 (23.88)
Per capita income (in Rupees)	Upto 700	94	23 (24.47)	29 (30.85)	9 (9.57)
	701-1400	410	90 (21.95)	170 (41.46)	48 (11.71)
	1400>	116	16 (13.79)	49 (42.24)	27 (23.28)
Family size	≤ 4	193	40 (20.73)	74 (38.34)	27 (13.99)
	5-6	314	60 (19.11)	129 (41.08)	35 (11.15)
	≥ 7	113	29 (25.66)	45 (39.82)	22 (19.47)
Dependent	0-1	211	40 (18.96)	91 (43.13)	37 (17.53)

children	*2*	213	44 (20.66)	94 (44.13)	27 (12.68)
	≥ 3	196	45 (22.96)	63 (32.14)	20 (10.24)
Family type	*Nuclear*	447	88 (19.69)	166 (37.14)	58 (21.98)
	Joint or extended	173	41 (23.70)	82 (47.40)	26 (15.03)
Marital status	*Unmarried*	178	46 (25.84)	48 (26.97)	15 (8.43)
	Married and Widower	442	83 (18.78)	200 (45.25)	69 (15.61)
Drinking water facility	*Own well/tube well*	470	91 (19.36)	186 (39.57)	54 (11.49)
	Public or shared	150	38 (25.33)	62 (41.33)	30 (20.00)
Toilet facility	*Yes*	362	87 (24.03)	132 (36.46)	38 (10.50)
	No	258	42 (16.28)	116 (44.96)	46 (17.83)
Land holding pattern	*< 2.5 acres*	562	115 (20.46)	224 (39.86)	69 (12.28)
	> 2.5 acres	58	14 (24.14)	24 (41.38)	15 (25.86)
House type	*Bricked*	163	23 (14.11)	84 (51.53)	32 (19.63)
	Non-bricked	457	106 (23.19)	164 (35.89)	52 (11.38)
Socio-economic status	*Low*	289	69 (23.88)	115 (39.79)	30 (10.38)
	Medium	331	60 (18.13)	133 (40.18)	54 (16.31)
Household living condition	*High*	225	35 (15.56)	103 (45.78)	40 (17.78)
	Low to Medium	395	94 (23.80)	145 (36.71)	44 (11.14)
Expenditure groups	*≥ 80% from income*	343	85 (24.78)	137 (39.94)	36 (10.50)
	< 80% from income	277	44 (15.88)	111 (40.07)	48 (17.33)

Figures in parenthesis indicates percentages

3.2.21.1. Association of the socio-economic, demographic and lifestyle related variables with BMI among the Rajbanshi male individuals

The age specific prevalence of under-nutrition was higher among the males comprising the 40-49 years (27.67%) followed by 20-29 years (20.29%) and finally 30-39 years (15.34%) age groups. A higher prevalence of under-nutrition was observed among illiterates (24.04%) and 'others' in the educational and the occupational categories respectively (23.47%). Those comprising the Rs. <3000 (23.23%) and up to Rs.700 (24.47%) per-capita income groups were also more susceptible to under-nutrition. The prevalence of under-nutrition was observed to be higher in the ≥7 members family size (25.66%) and ≥ 3 dependent children (22.96%) categories. Lower prevalence was seen in the 5-6 members family size (19.11%) and 0-1 dependent (18.96%) children category. In case of family type and marital status, the prevalence of under-nutrition was found to be higher among those males belonging to the joint or extended families (23.70%) and comprising the unmarried category (25.84%). The male individuals using 'public or shared' drinking water facilities and having a 'yes toilet facility' exhibited a higher prevalence of under-nutrition (25.33% and 24.03%). The prevalence of under-nutrition was higher among those having a land holding of >2.5 acres (24.14%) and a non-bricked house type (24.11%). The differences in the sub-categories of the different variables on prevalence of under-nutrition showed that the differences were statistically not significant in case of all the variables (p>0.05), except in house type, living conditions and expenditure groups (p<0.05) (***Table 3.31***).

3.2.21.2. Association of the socio-economic, demographic and lifestyle related variables with WHR among the Rajbanshi male individuals

The prevalence of high levels of regional adiposity (WHR) was associated with those male individuals belonging to the 30-39 years age group (45.50%) and those who studied up to the primary level (46.90%). A lower prevalence was found in the 20-29 years age group (36.03%) and those who were illiterate (36.54%). High WHR were observed in case of daily labour (48.47%) followed by cultivator (38.96%) and finally the 'others' (26.53%) in the occupational category. Those comprising the monthly income of Rs. >6000 and Rs. <1400 catogories (41.67% and 42.24%) also had higher levels of adiposity. In case of family size and dependent children, a higher prevalence was noticed in 5-6 members (41.08%) and '2 children' categories (41.08% and 44.13%). Individuals belonging to the joint or extended family type and married and widower groups also exhibited higher levels of adiposity. Those male individuals utilizing public or shared drinking water facilities and with no toilet facility also showed higher levels of adiposity (41.33% and 44.96%). Furthermore, in the land holding and house type categories, those possessing >2.5 acre of land (41.38%) and bricked type of houses also had a higher prevalence (41.38% and 51.53%). In case of socio-economic status, household living conditions and expenditure groups, higher levels of adiposity were found in the medium (40.18%), higher living condition (45.78%) and lower expenditure (40.07%) groups. The differences in the sub-categories of the variables were statistically not significant ($p>0.05$), with marital status (χ^2-value = 8.05; d.f. 1; $p<0.05$) and house type (χ^2-value = 5.00; d.f. 1; $p<0.05$) being the only exceptions (***Table 3.31***).

3.2.21.3. Association of the socio-economic, demographic and lifestyle related variables with WHtR among the Rajbanshi male individuals

Higher levels of adiposity, based on WHtR, were observed among the male individuals comprising the 40-49 years (18.24%) followed by 30-39 years (12.17%) and finally 20-29 years (11.17%) age groups. Illiterate males and cultivators showed high WHtR (16.35% and 14.72% respectively). A higher regional adiposity was found among those in the higher monthly income

(Rs. 6000>) and higher per-capita income groups. The prevalence was also higher in the families having ≥7 members (19.47%) and those having 0-1 dependent children (17.53%). Higher adiposity was also documented among the males in the nuclear family and those married and widowed. Those individuals using public or shared water facilities and having no toilet facilities (17.83%) also exhibited higher levels of adiposity (20.00% and 17.83%). Male individuals owning >2.5 acres of land and having brick houses had higher levels of adiposity (25.86% and 19.63%). The results also indicated that those belonging to the medium socio-economic group, high living condition and lower expenditure groups also exhibited higher levels of adiposity. The differences on the prevalence of higher adiposity in sub-categories of the variables were found to be statistically significant in income, per-capita income, marital status, drinking water facility, toilet facility, landholding pattern, house types, household living condition and expenditure groups ($p<0.05$). The differences were not statistically significant in age, education, occupation, family size, dependent children, family type and socio-economic status ($p>0.05$) using χ^2 analysis (***Table 3.31***).

3.2.22. Association of the socio-economic, demographic and lifestyle related variables with under-nutrition, regional adiposity among the Rajbanshi female individuals

The association of socio-economic, demographic and lifestyle related variables with under-nutrition and regional adiposity based on BMI, WHR and WHtR among the Rajbanshi female individuals are depicted in ***Table 3.32***. The comparisons with respect to under-nutrition and regional adiposity were made with their respective socio-economic, demographic and lifestyle related counter variables.

3.31. Differences between different sub-categories of socio-economic, demographic and lifestyle-related variables, with BMI, WHR and WHtR among the male Rajbanshi individuals

Variable	*BMI (<18.5 kg/m²)*		*WHR (>0.9)*		*WHtR (>0.5)*	
	χ^2-value	*p*	*χ^2-value*	*p*	*χ^2-value*	*p*
Age	5.177	0.075	1.773	0.412	2.992	0.224
Education	0.536	0.764	1.256	0.533	4.085	0.129
Occupation	0.344	0.842	5.944	0.051	0.618	0.734
Income	2.522	0.283	0.697	0.706	11.76	0.002
Per capita income	3.108	2.114	1.761	0.415	8.49	0.014
Family size	1.386	0.500	0.162	0.922	3.675	0.159
Dependent children	0.648	0.723	3.280	0.194	3.681	0.158
Family type	0.788	0.374	2.274	0.132	0.339	0.560
Marital status	2.460	0.117	8.050	0.004	4.379	0.036
Drinking water	1.574	0.209	0.062	0.803	5.159	0.0231
Toilet facility	3.646	0.056	1.924	0.165	5.213	0.022
Land holding pattern	0.276	0.599	0.022	0.882	5.754	0.016
House type	4.095	0.043	5.000	0.025	5.148	0.023
Socio-economic status	2.023	0.155	0.004	0.949	3.456	0.059
Household living condition	3.952	0.047	2.071	0.150	4.045	0.044
Expenditure group	4.870	0.027	0.000	1.00	4.625	0.032

Table 3.32. Association of the socio-economic, demographic and lifestyle related variables with under-nutrition and regional adiposity among the female Rajbanshi individuals

Variables	*Category*	*Frequency (N=416)*	*BMI (<18.5 kg/m²) (N=111)*	*WHR (>0.8) (N=340)*	*WHtR (>0.5) (N=135)*
Age (in years)	*20-29*	199	39 (19.60)	177 (88.94)	71 (35.68)
	30-39	111	37 (33.33)	87 (78.38)	29 (26.13)
	40-49	106	35 (33.02)	76 (71.70)	35 (33.02)
Education	*Illiterate*	117	38 (32.48)	105 (89.74)	38 (32.48)
	Upto primary	77	16 (20.78)	63 (81.82)	33 (24.86)
	Secondary and above	222	57 (25.68)	172 (77.48)	64 (28.83)
Occupation	*Cultivator*	88	25 (28.41)	64 (72.73)	16 (18.18)
	Labour	60	16 (26.67)	49 (81.67)	12 (20.00)
	Housewife & others	268	70 (26.12)	227 (84.70)	107 (39.93)
Income (in Rupees)	*Upto 4000*	148	51 (34.46)	123 (83.11)	36 (24.32)
	4001-6000	180	47 (26.11)	146 (81.11)	55 (30.56)
	6000>	88	13 (14.77)	71 (80.68)	44 (50.00)
Per capita income (in Rupees)	*Upto 700*	91	24 (26.37)	75 (82.42)	22 (24.18)
	701-1400	225	70 (31.11)	182 (80.89)	64 (28.44)
	1400 >	100	17 (17)	83 (83)	49 (49)
Family size	*≤ 4*	146	47 (32.19)	118 (80.82)	45 (30.82)
	5-6	196	48 (24.49)	160 (81.63)	66 (33.67)
	7 ≥	74	16 (21.62)	62 (83.78)	24 (32.43)
Dependent	*0-1*	158	37 (23.42)	132 (83.54)	55 (34.81)

Children	*2*	120	39 (32.50)	92 (76.67)	41 (34.17)
	≥ 3	138	35 (25.36)	116 (84.06)	39 (28.26)
Family type	*Nuclear*	301	89 (29.57)	249 (82.72)	93 (30.9)
	Joint & Extended	115	22 (19.13)	91 (79.13)	42 (36.52)
Marital status	*Unmarried*	101	28 (27.72)	77 (76.24)	22 (21.78)
	Married & Widow	315	83 (26.35)	263 (83.49)	113 (35.87)
Drinking water facility	*Own well or Tube well*	384	104 (27.08)	314 (81.77)	126 (32.81)
	Public or shared	32	7 (21.88)	26 (81.25)	9 (28.13)
Toilet facility	*Yes*	173	37 (21.39)	141 (81.50)	61 (35.26)
	No	243	74 (30.45)	199 (81.89)	74 (30.45)
Land holding Pattern	*< 2.5 acres*	363	97 (26.72)	293 (80.72)	111 (30.58)
	> 2.5 acres	53	14 (26.42)	47 (88.68)	24 (45.28)
House type	*Bricked*	92	15 (16.3)	74 (80.43)	49 (53.26)
	Non-bricked	324	96 (29.63)	266 (82.10)	86 (26.54)
Socio-economic status	*Low*	361	105 (29.09)	297 (82.27)	102 (28.25)
	Medium	55	6 (10.91)	43 (78.18)	33 (60.00)
Household living condition	*High*	154	31 (20.13)	126 (81.82)	58 (37.66)
	Low to Medium	262	80 (30.53)	214 (81.68)	77 (29.39)
Expenditure group	*≥ 80% from income*	222	68 (30.63)	181 (81.53)	57 (25.68)
	< 80% from income	194	43 (22.16)	159 (81.96)	78 (40.21)

Figure in parenthesis indicates percentages

3.2.22.1. Association of the socio-economic, demographic and lifestyle related variables with BMI among the Rajbanshi female individuals

The age specific prevalence of under-nutrition based on BMI was observed to be higher among females comprising the 30-39 years (33.33%) followed by 40-49 years (33.02%) and finally 20-29 years (19.60%) age groups. Illiterate females and those engaged as cultivators showed a higher prevalence of under-nutrition (32.48% 28.41%). In case of income and per-capita family income, a higher prevalence was observed in the categories of up to Rs.4000 (34.46%) and Rs.700-1400 (31.11%) respectively. The results also showed that individuals having a family size of ≤4 members (32.19%) and '2' (32.50) dependent children exhibited a prevalence of under-nutrition (32.19% and 32.50% respectively). The prevalence was also found to be higher among the individuals belonging to a nuclear family (29.57%) and unmarried marital status (27.72%). Female individuals having their own drinking water facilities and 'no toilet' facilities (30.45%) facility also showed higher incidences of under-nutrition status (27.08% and 30.45% respectively). The prevalence was also noticed to be higher among those owning <2.5 acres of land (26.45%) and possessing non-bricked houses (29.63%). Higher prevalence was among those females having a high living condition (30.53%) and high expenditure (30.63%). Using χ^2 analysis the differences in sub-categories on the prevalence of under-nutrition was observed to be statistically not significant in all respective variables ($p>0.05$), except in case of house type (χ^2-value= 4.01; d.f. 1; $p<0.05$) and socio-economic status (χ^2-value= 5.23; d.f. 1; $p<0.05$) (*Table 3.33*).

3.2.22.2. Association of the socio-economic, demographic and lifestyle related variables with WHR among the Rajbanshi female individuals

Higher levels of adiposity using WHR were observed among females aged 20-29 years (88.94%) and illiterate (89.74%). Occupation specific prevalence of adiposity was found to be higher among housewives and 'others' (84.7%) followed by labour (81.67%) and finally cultivators (72.73%). Female individuals comprising the up to Rs.4000 income group (83.11%) and Rs.>1400 per capita income (83%) exhibited higher prevalence of adiposity. Higher adiposity was also noticed among those having ≥7 member family size (83.78%) and ≥3 dependent children (84.06%). The results further suggested that females in the nuclear family (82.72%) and married and widow (83.49%) marital status categories showed higher prevalence of under-nutrition. High prevalence was also observed among those possessing their own water sources (81.77%) and having 'no toilet' facilities (81.89%). In case of the land holding pattern and house type, higher adiposity was found in the >2.5 acre (88.68%) and non-bricked (82.1%) categories respectively. Higher level of adiposity was also observed in the low socio-economic category (82.27%), high living condition (81.82%) and low income group (81.96). Lower adiposity was found in the medium socio-economic category (82.27%), low to medium living condition (81.82%) and high expenditure (81.53%) category. The differences in the prevalence of higher adiposity in the sub-categories were statistically not significant in all socio-economic, demographic and lifestyle related variables using χ^2 analysis ($p>0.05$) (*Table 3.33*).

3.2.22.3. Association of the socio-economic, demographic and lifestyle related variables with WHtR among the Rajbanshi female individuals

The prevalence of higher level of adiposity using WHtR in terms of socio-economic, demographic and lifestyle related factors showed that age specific values are found to be higher among females aged 20-29 years (35.68%) followed by those aged 40-49 years (33.02%) and finally by those 30-39 years (26.13%). A higher adiposity was also observed among 'illiterate' (32.48%) and 'housewife and 'other' (39.93%) in the variables of education and occupation respectively. A higher prevalence of adiposity was also documented among those with a monthly income of >Rs.6000 (50%) and a per-capita income of Rs.1400 (49%). In case of family size and dependent children, higher and lower prevalence was observed in the 5-6 members and $\leq$4 members family size 33.67% and 30.82%) and 0-1 dependent and $\geq$3 children (34.81% versus 28.26%). Individuals belonging to the joint or extended family type (26.52%) and married and widow (35.87%) marital status exhibited higher prevalence of adiposity. Those having their 'own well' as the drinking water facilities and 'yes' as toilet facilities showed higher prevalence of adiposity (32.81% and 35.26%). The females belonging to the >2.5 acre land holding category and bricked house type also showed higher levels of adiposity (45.28% and 53.26%). The results further suggested that females belonging to the medium socio-economic status, high household living condition and low expenditure groups had higher prevalence of adiposity (60%, 37.66% and 40.21% respectively). The differences in the prevalence of high adiposity in the different sub-categories of the socio-economic, demographic and lifestyle-related variables showed that significant statistical differences existed in occupation, income, per-capita income, house type, socio-economic status and expenditure categories ($p<0.05$). The differences were not statistically significant in age, education, family size, dependent children, family type, marital status, drinking water facility, toilet facility, landholding pattern and household living condition ($p>0.05$) (***Table 3.33***).

3.2.23 *Multinomial logistic regression model fitted on the socio-economic, demographic and lifestyle related variables among the male Rajbanshi individuals*

A multinomial logistic regression analysis model was fitted on the socio-economic, demographic and lifestyle related variables to estimate the odds of being a male individual undernourished and over nourished. The association of BMI, WHR and WHtR with the different predictor variables among the male Rajbanshi individuals is presented in ***Table 3.34***. The results indicated that several variables had significant influences in determining whether an individual was under and/or over-nourished

3.2.23.1. BMI vs. socio-economic, demographic and lifestyle related variables among the male Rajbanshi individuals

A higher odd for under-nutrition was observed in the age group of 40-49 years (odds: 1.48; 95% CI 0.94-2.33). Illiterate individuals and those in the 'others occupation' group also showed higher odds than their references (odds: 1.23; 95% CI 0.74-2.07 and odds: 1.19; 95% CI 0.69-2.03 respectively). Those from the <Rs.4000 monthly income and <Rs. 700 per-capita income brackets exhibited higher odds of 1.73 (95% CI 0.97-3.08) and 2.03 (95% CI 1.00-4.11) respectively. Family size of ≥7 individuals and ≥3 dependent children had higher odds than their respective references (odds: 1.32; 95% CI 0.76-2.28 and odds: 1.27; 95% CI 0.79-2.06). Higher odds have also been observed among individuals from joint or extended families (odds: 1.27; 95% CI 0.83-1.93) as compared to those from the nuclear families. The results also indicated that married males and widowers had lower odds (odds: 0.66; 95% CI 0.44-.00) than the unmarried individuals. Individuals using public or shared drinking water facilities and possessing 'no toilet' facilities showed 1.42 (95% CI 0.92-2.18) and 1.63 (95% CI 1.08-2.45) times higher odds than the reference variables respectively. In case of house types, a higher odd was noticed in the non-

bricked house type (odds: 1.84; 95% CI 1.12-3.01) than the reference group respectively. Individuals having lower socio-economic status and lower-medium household living conditions exhibited higher odds of 1.42 (95% CI 0.96-2.09) and 1.70 (95% CI 1.10-2.6) respectively. Those individuals belonging to a higher expenditure group had significantly higher odds of 1.75 (95% CI 1.16-2.62) than the reference category ($p<0.01$).

*3.2.23.2. **WHR** vs. socio-economic, demographic and lifestyle related variables among the male Rajbanshi individuals*

The association of WHR with the different variables showed that male individuals in the age group of 30-39 years and having an education level up to the primary standard had higher odds of 1.48 (95% CI 1.02-2.16) and 1.38 (95% CI 0.91-2.11) respectively than their respective variables. Those individuals engaged in labour as their occupation, also showed a significantly higher odds (odds: 1.48; 95% CI 1.03-2.11) with WHR. Lower odds were associated with monthly family and per-capita income groups as compared with the reference category (>Rs. 6000 and >Rs. 1400). The results further indicated that individuals from a family size of 5-6 members and having 2 dependent children had higher odds of 1.12 (95% CI 0.78-1.62) and 1.04 (95% CI 0.71-1.53) than the respective counter variables. The odds of joint or extended family were significantly lower (odds: 0.66; 95% CI 0.46-0.94) than the nuclear family. Those individuals who were married and using public or shared drinking water facilities had odds of 2.24 times (95% CI 1.53-3.27) and odds of 1.08 times (95% CI 0.74-1.56) higher than the reference categories. Individuals having a land holding of <2.5 acres and 'no toilet' facilities exhibited lower odds (odds: 0.94; 95% CI 0.54-1.63 and odds: 0.7; 95% CI 0.51-0.97 respectively) as compared to the references. The odds for non-bricked house type was significantly lower (odds: 0.53; 95% CI 0.37-0.76) than the bricked type. Lower odds were associated with those individuals comprising the low socio-economic status (odds: 0.98; 95% CI 0.71-1.34), low to medium household living condition (odds: 0.69; 95% CI 0.49-0.96) and high expenditure (odds: 0.99; 95% CI 0.72-1.37) groups than their respective references (*Table 3.34*).

Table 3.33. Differences between the different sub-categories of socio-economic, demographic and lifestyle-related variables, with BMI, WHR and WHtR among the female Rajbanshi individuals

Variables	*BMI (<18.5 kg/m²)*		*WHR (>0.8)*		*WHtR (>0.5)*	
	χ^2-value	*p value*	*χ^2-value*	*p value*	*χ^2-value*	*p value*
Age	5.709	0.057	1.516	0.468	1.564	0.457
Education	2.012	0.365	0.761	0.683	2.495	0.287
Occupation	0.102	0.950	0.662	0.718	10.358	0.005
Income	5.228	0.073	0.030	0.985	10.52	0.005
Per capita income	4.267	0.118	0.024	0.988	8.077	0.017
Family size	2.124	0.346	0.029	0.986	0.159	0.923
Dependent children	1.732	0.421	0.297	0.862	0.864	0.649
Family type	2.788	0.095	0.073	0.787	0.601	0.438
Marital status	0.042	0.837	0.277	0.598	3.746	0.053
Drinking water	0.246	0.619	0.001	0.974	0.156	0.692
Toilet facility	2.490	0.115	0.001	0.975	0.540	0.462
Land holding pattern	0.001	0.974	0.191	0.662	2.151	0.142
House type	4.007	0.045	0.013	0.909	10.76	0.000
Socio-economic status	5.229	0.022	0.055	0.815	9.567	0.001
Household living condition	3.179	0.075	0.000	1.000	1.521	0.217
Expenditure group	2.207	0.137	0.001	0.974	5.063	0.024

Table 3.34. Multinomial logistic regression model fitted on the socio-economic, demographic and lifestyle related variables and nutritional status among the Rajbanshi male individuals

Variable	*Category*	*BMI*			*WHR*			*WHtR*		
		B	*Odds*	*95% CI*	*B*	*Odds*	*95% CI*	*B*	*Odds*	*95% CI*
Age (in years)	*20-29®*	-	-	-	-	-	-	-	-	-
	30-39	-0.36	0.7	0.42-1.44	0.39	1.48	1.02-2.16	0.04	1.04	0.59-1.84
	40-49	0.39	1.48	0.94-2.33	0.18	1.2	0.8-1.79	0.52	1.68	0.97-2.89
Education	*Illiterate*	0.21	1.23	0.74-2.07	-0.1	0.9	0.58-1.41	0.13	1.14	0.63-2.05
	Up to primary	-0.06	0.94	0.56-1.60	0.33	1.38	0.91-2.11	-0.81	0.44	0.21-0.96
	Secondary and above®	-	-	-	-	-	-	-	-	-
Occupation	*Cultivator ®*	-	-	-	-	-	-	-	-	-
	Labour	-0.04	0.96	0.62-1.49	0.39	1.48*	1.03-2.11	-0.21	0.81	0.48-1.37
	Others	0.17	1.19	0.69-2.03	-0.57	0.57	0.34-0.93	-0.21	0.81	0.41-1.59
Income (in Rupees)	*<4000*	0.55	1.73	0.97-3.08	-0.23	0.80	0.51-1.25	-1.14	0.32	0.17-0.60
	4001-6000	0.47	1.60	0.92-	-	1.00	0.66-	-	0.43	0.25-

				2.77	0.01		1.51	0.85		0.73
	6000>®	-	-	-	-	-	-	-	-	-
Per capita Income (in Rupees)	***Upto 700***	0.71	2.03	1.00-4.11	-0.49	0.61	0.34-1.08	-1.05	0.35	0.16-0.79
	701-1400	0.56	1.75	0.99-3.13	-0.03	0.97	0.67-1.47	-0.83	0.44	0.26-0.74
	1400>®	-	-	-	-	-	-	-	-	-
Family size	***≤ 4®***	-	-	-	-	-	-	-	-	-
	5-6	-0.1	0.9	0.57-1.41	0.12	1.12	0.78-1.62	-0.26	0.77	0.45-1.32
	≤7	0.28	1.32	0.76-2.28	0.06	1.06	0.66-1.71	0.4	1.49	0.8-2.76
Dependent children	***0-1®***	-	-	-	-	-	-	-	-	-
	2	0.11	1.11	0.69-1.8	0.04	1.04	0.71-1.53	-0.38	0.68	0.4-1.17
	≥3	0.24	1.27	0.79-2.06	-0.47	0.63*	0.42-0.94	-0.63	0.53	0.3-0.96
Family type	***Nuclear ®***	-	-	-	-	-	-	-	-	-
	Joint or extended	0.24	1.27	0.83-1.93	-0.42	0.66*	0.46-0.94	0.17	1.19	0.7-1.96
Marital status	***Unmarried ®***	-	-	-	-	-	-	-	-	-
	Married and Widower	-0.41	0.66	0.44-1	0.81	2.24**	1.53-3.27	0.70	2.01*	1.12-3.62
Drinking water	***Own well/tube well®***	-	-	-	-	-	-	-	-	-

Facility	***Public or shared***	0.35	1.42	0.92-2.18	0.07	1.08	0.74-1.56	0.66	1.93	1.18-3.15
Toilet facility	***Yes®***	-	-	-	-	-	-	-	-	-
	No	0.49	1.63*	1.08-2.45	-0.35	0.70	0.51-0.97	-0.62	0.54	0.34-0.86
Land holding pattern	***< 2.5 acres***	-0.21	0.81	0.43-1.53	-0.06	0.94	0.54-1.63	-0.91	0.40	0.21-0.76
	> 2.5 acres ®	-	-	-	-	-	-	-	-	-
House type	***Bricked ®***	-	-	-	-	-	-	-	-	-
	Non-bricked	0.61	1.84	1.12-3.01	-0.64	0.53**	0.37-0.76	-0.64	0.53	0.32-0.85
Socio-economic status	***Low***	0.35	1.42	0.96-2.09	-0.02	0.98	0.71-1.34	-0.52	0.59*	0.37-0.96
	Medium ®	-	-	-	-	-	-	-	-	-
Household living Condition	***High ®***	-	-	-	-	-	-	-	-	-
	Low to Medium	0.53	1.70*	1.1-2.60	-0.38	0.69	0.49-0.96	-0.55	0.58*	0.37-0.92
Expenditure groups	***≥ 80% from income***	0.56	1.75**	1.16-2.62	-0.01	0.99	0.72-1.37	-0.58	0.56*	0.35-0.89
	< 80% from income ®	-	-	-	-	-	-	-	-	-

® ***Reference category, *p<0.05, **p<0.01***

3.2.22.3. WHtR vs. socio-economic, demographic and lifestyle related variables among the male Rajbanshi individuals

The results of multinomial logistic regression analysis with the different variables showed that the individuals in the age group of 30-39 years exhibited higher odds of 1.68 (95% CI 0.97-2.89). In case of literacy, higher odds was in the category of illiterate level (odds: 1.14; 95% CI 0.63-2.05). For occupation, lower odds was observed among those engaged in 'labour' and 'Other' occupation group than cultivator. Lower odds were documented for monthly income and per capita income. For family size, a higher odds value (odds: 1.49; 95% CI 0.80-2.76) was obtained in the family size of >7 individuals. The categories of joint or extended family, married and widower, public or shared water facility also showed higher odds (odds: 1.19; 95% CI 0.7-1.96, odds: 2.01; 95% CI 1.12- 3.62 and odds: 1.93; 95% CI 1.18-3.15 respectively). The odds values in case of 'no toilet facility' (odds: 0.54; 95% CI 0.34-0.86), <2.5 acres land holding pattern (odds: 0.4; 95% CI 0.21-0.76) and non-bricked house type (odds: 0.53; 95% CI 0.32-0.85) were lower than their respective counter variables. There were also significant lower odds values found to be observed in low socio-economic status (odds: 0.59; 95% CI 0.37-0.96), low to medium household living condition (odds: 0.58; 95% CI 0.37-0.92) and high expenditure groups (odds: 0.56; 95% CI 0.35-0.89) (***Table 3.34***).

3.2.23. Multinomial logistic regression model fitted on the socio-economic, demographic and lifestyle related variables among the female Rajbanshi individuals

A multinomial logistic regression analysis model was fitted on the socio-economic, demographic and lifestyle related variables to estimate the odds of being a female individual undernourished and over nourished. The association of BMI, WHR and WHtR with the different predictor variables among the female Rajbanshi individuals is presented in ***Table 3.35***. The results indicated that several variables had significant influences in determining whether an individual was under and/or over nourished.

3.2.23.1. BMI vs. socio-economic, demographic and lifestyle related variables among the female Rajbanshi individuals

It was observed that females in the age groups of 30-39 years and 40-49 years exhibited very high significant associations with under-nutrition (odds: 2.05; 95% CI 1.21-3.48 and odds: 2.02; 95% CI 1.18-3.45 respectively). The results of the multinomial model also showed that illiterate females and those engaged in cultivation had 1.39 (95% CI 0.85-2.27) and 1.12 (95% CI 0.66-1.92) times higher odds than the reference groups. There were very significant higher odds in the <Rs. 4000 family income (odds: 3.03; 95% CI 1.54-5.98) and the Rs. 700-1400 per-capita income (odds: 2.21; 95% CI 1.22-3.99) categories. The odd values for family size comprising of 5-6 and ≥7 individuals were lower at 0.68 (95% CI 0.42-1.10) and 0.58 (95% CI 0.30-1.12). In case of dependent children, the odds values were higher in case of those with 2 children (odds: 1.57; 95% CI 0.93-2.68) followed by those with ≥3 children (odds: 1.12; 95% CI 0.65-1.89). The results also indicated that females from the joint or extended family type, married and widow marital status and having access to public or shared drinking water facilities showed lower odds values than their respective reference categories. However, in case of 'no toilet' facility, non-bricked house type and lower socio-economic group, 1.61 (95% CI 1.02-2.54), 2.16 (95% CI 1.18-3.95) and 1.74 (95% CI 1.09-2.80) times higher odds were obtained. The odds for <2.5 acre land holding pattern and high expenditure group also showed 1.02 (95% CI 0.53-1.95) and 1.55 (95% CI 1-2.12) times higher odds (***Table 3.35***).

3.2.23.2. WHR vs. socio-economic, demographic and lifestyle related variables among the female Rajbanshi individuals

The association of WHR with socio-economic, demographic and lifestyle related factors showed that several variables were significantly associated with higher level of adiposity patterns among the female individuals. Age had a significant lower effect on WHR as the odds were lower in the age group of 30-39 years (odds: 0.45; 95% CI 0.24-0.85) and 40-49 years (odds: 0.32; 95% CI 0.17-0.58). Illiterate female individuals showed a significantly high odds (odds: 2.54; 95% CI 1.30-5.00) followed by those who studied up to the primary level (odds: 1.31, 95% CI 0.68-2.53). The results further suggested that occupation and per capita income categories showed lower associations in terms of odds ratio than the reference groups. Females belonging to the <Rs. 4000 monthly income group, a family size of ≥7 members and ≥3 dependent children exhibited 1.18 (95% CI 0.6-2.33), 1.23 (95% CI 0.53-2.58) and 1.04 (95% CI 0.56-1.93) times higher odds. Those individuals in the categories of joint or extended family types, having access to public or shared drinking water facilities and <2.5 acre land holding pattern exhibited 0.79 (95% CI 0.46-1.36), 0.97 (95% CI 0.38-2.44) and 0.53 (95% CI 0.22-1.30) times respectively lower odds. Higher odds than the reference groups were obtained in the 'married and widow' categories (odds: 1.58; 95% CI 0.91-2.77), 'no toilet' facility (odds: 1.03; 95% CI 0.62-1.70) and non-bricked house types (odds: 1.12; 95% CI 0.62-2.01). The results of the multi-logistic regression model further depicted that <2.5 acre (odds: 0.53; 95% CI 0.22-1.30), lower socio-economic group (odds: 0.77; 95% CI 0.39-1.55), low to medium living condition (odds: 0.99; 95% CI 0.59-1.66) and high expenditure groups (odds: 0.97; 95% CI 0.59-1.6) showed lower odds (*Table 3.35*).

3.2.23.3. WHtR vs. socio-economic, demographic and lifestyle related variables among the female Rajbanshi individuals

The association of the socio-economic, demographic and lifestyle related variables with WHtR among the female Rajbanshi individuals showed that the age groups have lower influence with WHtR, with the odds being 0.64 (95% CI 0.38-1.07) and 0.89 (95% CI 06.54-1.4) in the 30-39 years and 40-49 years age groups respectively. Those individuals who studied up to the primary level showed a significant higher odds (odds: 1.85; 95% CI 1.08-3.17) followed by those who were illiterate (odds: 1.19; 95% CI 0.73-1.93). The results also indicated that occupation, income and per-capita income have very lower associations. The odds in case of family size were 1.14 (95% CI 0.72-1.8) and 1.08 (95% CI 0.59-1.96) times higher in the 5-6 members and the ≥7 member categories. In case of dependent children, the odds were lower in 2 children (odds: 0.97; 95% CI 0.59-1.6) and ≥3 children (odds: 0.74; 95% CI 0.45-1.21) categories. The odds values for those in the joint or extended family and married and widow categories exhibited higher odds of 1.29 (95% CI 0.82-2.02) and 2.01 (95% CI 1.19-3.40) respectively. Female individuals using 'public or shared' drinking water facility, with 'no toilet' facility and living in a 'low to medium' household living condition showed lower insignificant associations. Those individuals belonging to the <2.5 acre land holding pattern (odds: 0.53; 95% CI 0.3-0.96), non-bricked house type (odds: 0.32; 95% CI 0.20-0.51), lower socio-economic (odds: 0.26; 95% CI 0.15-0.47) and high expenditure (odds: 0.51; 95% CI 0.34-0.78) categories had significant lower odds (***Table 3.35***).

Table 3.35: Multinomial logistic regression model fitted on the socio-economic, demographic and lifestyle related variables and nutritional status among the Rajbanshi female individuals

Variables	*Category*	*BMI*			*WHR*			*WHtR*		
		B	*Odds*	*95% CI*	*B*	*Odds*	*95% CI*	*B*	*Odds*	*95% CI*
Age (in years)	*20-29®*	-	-	-	-	-	-	-	-	-
	30-39	0.72	2.05**	1.21-3.48	-0.80	0.45*	0.24-0.85	-0.45	0.64	0.38-1.07
	40-50	0.7	2.02**	1.18-3.45	-1.56	0.32**	0.17-0.58	-0.12	0.89	0.54-1.46
Education	*Illiterate*	0.33	1.39	0.85-2.27	0.93	2.54**	1.3-5	0.17	1.19	0.73-1.93
	Up to primary	-0.28	0.76	0.41-1.42	0.27	1.31	0.68-2.53	0.62	1.85*	1.08-3.17
	Secondary and above®	-	-	-	-	-	-	-	-	-
Occupation	*Cultivator*	0.12	1.12	0.66-1.92	-0.73	0.48*	0.27-0.86	-1.1	0.33**	0.17-0.61
	Labour	0.03	1.03	0.55-1.94	-0.22	0.81	0.39-1.68	-0.98	0.38**	0.19-0.74
	Housewife and Others®	-	-	-	-	-	-	-	-	-
Income (in Rupees)	*<4000*	1.11	3.03**	1.54-5.98	0.16	1.18	0.6-2.33	-1.14	0.32**	0.18-0.56
	4001-6000	0.71	2.03*	1.04-	0.03	1.03	0.54-	-	0.44**	0.26-

				4.01			1.97	0.82		0.74
	6000>®	-	-	-	-	-	-	-	-	-
Per capita Income (in Rupees)	***Upto 700***	0.56	1.75	0.87-3.52	-0.04	0.96	0.45-2.03	-1.1	0.33**	0.18-0.62
	701-1400	0.79	2.21**	1.22-3.99	-0.14	0.87	0.47-1.61	-0.88	0.41**	0.25-0.67
	1400>®	-	-	-	-	-	-	-	-	-
Family size	*≤ 4®*	-	-	-	-	-	-	-	-	-
	5-6	-0.38	0.68	0.42-1.1	0.05	1.06	0.61-1.83	0.13	1.14	0.72-1.8
	≥7	-0.54	0.58	0.3-1.12	0.2	1.23	0.58-2.58	0.07	1.08	0.59-1.96
Dependent children	*0-1®*	-	-	-	-	-	-	-	-	-
	2	0.45	1.57	0.93-2.68	-0.44	0.65	0.36-1.18	-0.03	0.97	0.59-1.60
	≥3	0.11	1.12	0.65-1.89	0.04	1.04	0.56-1.93	-0.3	0.74	0.45-1.21
Family type	*Nuclear ®*	-	-	-	-	-	-	-	-	-
	Joint or extended	-0.57	0.56*	0.33-0.95	-0.23	0.79	0.46-1.36	0.25	1.29	0.82-2.02
Marital status	*Unmarried ®*	-	-	-	-	-	-	-	-	-
	Married and Widow	-0.07	0.93	0.56-1.54	0.46	1.58	0.91-2.77	0.70	2.01**	1.19-3.40
Drinking water	*Own well/tube well®*	-	-	-	-	-	-	-	-	-

Facility	***Public or shared***	-0.28	0.76	0.32-1.8	-0.04	0.97	0.38-2.44	-0.22	0.80	0.36-1.78
Toilet facility	***Yes®***	-	-	-	-	-	-	-	-	-
	No	0.48	1.61*	1.02-2.54	0.03	1.03	0.62-1.70	-0.22	0.8	0.53-1.22
Land holding pattern	***< 2.5 acres***	0.02	1.02	0.53-1.95	-0.63	0.53	0.22-1.3	-0.63	0.53*	0.3-0.96
	> 2.5 acres ®	-	-	-	-	-	-	-	-	-
House type	***Bricked ®***	-	-	-	-	-	-	-	-	-
	Non-bricked	0.77	2.16*	1.18-3.95	0.11	1.12	0.62-2.01	-1.15	0.32**	0.2-0.51
Socio-economic status	***Lower***	1.21	3.35**	1.39-8.06	-0.26	0.77	0.39-1.55	-1.34	0.26**	0.15-0.47
	Medium ®	-	-	-	-	-	-	-	-	-
Household living Condition	***High ®***	-	-	-	-	-	-	-	-	-
	Low to Medium	0.56	1.74*	1.09-2.80	-0.01	0.99	0.59-1.66	-0.37	0.69	0.45-1.05
Expenditure groups	***≥ 80% from income***	0.44	1.55	1-2.42	-0.03	0.97	0.59-1.60	-0.67	0.51**	0.34-0.78
	< 80% from income ®	-	-	-	-	-	-	-	-	-

® Reference category, *p<0.05, **p<0.01

3.3. ASSESSMENT OF NUTRITIONAL STATUS USING DIETARY INTAKE

The dietary intake survey has been conducted in order to assess the dietary consumptions of the different food groups and nutrients consumptions in terms of both qualitative and quantitative measures among the adult individuals.

The Rajbanshi are basically agriculturists. They sustain their livelihood by obtaining the food items from 3 major sources. These sources were the food grown in their agricultural land, those purchased from the nearby market and those collected, especially the green leafy vegetable (GLVs), from the nearby areas. Rice was the predominant crop and it dominated the daily dietary habitd of the individuals. In general, the dietary intakes of the Rajbanshi individuals in the present study were observed to be inadequate and deficient. The results were also found below the RDA values for Indian populations as specified by the ICMR (2004).

3.3.1. Food habits of the Rajbanshi individuals

The staple food of the Rajbanshi individuals are rice and the different types of food prepared from it. The individuals usually consumed 3 major meals in a day. They took the morning meal between 8.00 a.m. and 10.00 a.m., the afternoon meal between 12.00 noon and 2.00 p.m. and the evening meal between 7.30 p.m. and 9.00 p.m. Rice was an integral portion of these meals. The consumption of pulses was in the form of lentil, bengal gram and black gram. Most of the individuals regularly consumed tea in the morning and evening as well as during social visits. The Rajbanshi individuals also consumed non-vegetarian foods such as goat, chicken and pigeon meat at least once every week. The consumption of beef and pork was completely absent in their regular food habits. The consumption of fish was however, less among them. The main sources of fish were the local village markets and the streams. The consumption of cow and goat milk was very common. Curd was however, taken occasionally.

The consumption of vegetables included brinjal, ladies finger, cluster bean, snake gourd and tomato. Onion, garlic and potato comprised of a major part of the root and tubers in the daily diet. The GLV component consisted of gogu (*Hibiscus cannabinus*), drumstick leaves (*Moringa oleifera*), curry leaves (*Murraya koenigii*), ipomoea leaves (*Ipomoea aquatic)* and pui saag (*Basella alba*). The intake of arum leaves (*Calacasia esculenta)* was very frequent. Condiments such as chilies, coriander, garlic and turmeric, along with mustard oil also were an integral part of the diet. After rice, wheat occupied the next important position in the diet. Handmade unleavened bread was made wheat flour. *Poori* or *Paratha* made out of wheat flour was occasionally consumed and mostly during festivals and special occasions. The consumption of liquor was conspicuously absent in their food habits. The consumption of areca nut was very common and constituted an integral part in their dietary practices.

The consumption of fresh fruits appeared to be scarce in the diet. There have been sporadic instances of seasonal fruit consumption in the diet. The consumption of fruits was mainly reported during the summer and rainy seasons. The fruits consumed were mango, jackfruit, different kind of berries, guava, pineapple, date, cucumber and palm. The habit of chewing betel leaves with slated lime (*calcium hydroxide*) was a usual practice. The practice was more common among the Rajbanshi females than the males.

3.3.2. Consumption of different kinds of food among the Rajbanshi individuals

The overall and sex specific consumption of different food groups (cereals, pulses, GLVs, other vegetables, root and tubers, milk and milk products, meat and flesh, nut and seeds, fat and oils, condiments and sugar) among the Rajbanshi individuals using the 24-HR method is depicted in ***Table 3.36.*** Consumption of the different food groups was observed to be markedly inadequate when compared with suggested RDA levels for different Indian populations.

Deficiencies were found in almost all the different food groups, except on root and tubers. The results of the sex specific consumptions of different food groups among the Rajbanshi individuals as compared with the RDA specified by the ICMR (2004) are shown in ***Table 3.37.***

The overall and sex specific distribution of consumption patterns of the different food groups and comparison with RDA level is described below:

a) Cereals

The overall consumption of cereals was 472.47 ± 83.69 gms/day. Rice constituted the predominantly source of cereals. Different food stuffs prepared from rice such as rice puff, rice flakes and rice bran were also consumed. Wheat was the next most important source of cereals after rice. The sex specific consumption of cereals was found to be significantly higher among the males (504.13 ± 90.12 gm/day) than the females (439.96 ± 61.69 gm/day). The consumption of cereals was deficit among the male individuals but the values were very close to the RDA. There was a significant sex difference in the consumption of cereals (F ratio= 51.878; d.f.1,301; $p<0.01$) (***Table 3.36***).

When the mean consumption level was compared with recommended RDA level, it was observed that the mean consumption of cereals was almost adequate among the females (99.99%) and less among the males (96.95%). Almost half of the individuals (males: 49.67%, females: 49.66%) exhibited adequate level of cereal consumption as compared to the RDA. The results also showed that 35.29% and 21.48% of the male and female individuals attained 60%-89.99% of the suggested RDA levels respectively. The sex difference in the distribution of different RDA levels was found to be statistically significant (χ^2 value= 11.854; d.f. 4; $p<0.05$) (***Table 3.37***).

*b) **Pulses and legumes***

The intake of pulses and legumes was observed to be less in the diet. The mean overall consumption of pulses and legumes was 22.67 ± 21.07 gm/day. The males reported a higher consumption (24.12 ± 22.89 gm/day) than the females (21.19 ± 18.98 gm/day). The sex difference was statistically insignificant (F ratio= 1.461; d.f. 1,301; $p>0.05$) (***Table 3.36***).

The sex specific consumption of pulses and legumes was observed to be inadequate when compared with the RDA level. The mean consumption was below the half-way mark of the RDA level in both sexes. The male and female individuals had the consumption levels 48.24% and 42.38% of the RDA respectively. Moreover, 38.56% of the males and 40.94% of the females were below 30% of the RDA. It was also observed that only 16.34% of the male and 8.04% of the female individuals achieved adequate levels of the RDA. The sex difference in the different levels of RDA was observed to be statistically not significant (χ^2 value= 6.839; d.f. 5; $p>0.05$) (*Table 3.37*).

c) Green leafy vegetables (GLVs)

The consumption of GLVs was less than the RDA level in both sexes. The overall consumption of GLVs was 13.82 ± 25.89 gm/day. The consumption of GLVs was higher among the females (15.47 ± 27.99 gm/day) than the males (12.21 ± 23.64 gm/day). The sex difference was not statistically significant (F ratio= 1.20; d.f. 1,301; $p>0.05$) (***Table 3.36***).

The comparison of the mean consumption of GLVs was observed to be 30.53% among the males and 15.47% among the females when compared with the RDA (***Figure 1***). The data suggested that majority of the individuals were below 30% of the RDA level (males: 75.16%; females: 74.50%). Adequate levels of GLVs consumption with respect to the RDA was achieved by only 16.99% of the males and 2.68% of the females. The consumption of GLVs above the

90% level of RDA was also observed to be less among both sexes. The sex difference in the consumption of GLVs with the different levels of RDA was statistically significant (χ^2 value= 50.731; d.f. 5, p<0.01) (***Table 3.37***).

*d) **Other Vegetables***

The overall consumption of other vegetables was 63.98 ±53.68 gm/day. The mean consumption was higher among the male (66.08 ± 56.39 gm/day) than the female (61.83 ± 50.86 gm/day) individuals. The sex difference was not statistically significant (F ratio= 0.473; d.f. 1,301; p>0.05) (***Table 3.36***).

The consumption was well above the RDA among the females (154.58%), although it was comparatively lower among the males (94.4%). The results further indicated that 60.78% and 64.43% of the males and the females achieved the adequate level of RDA (≥100%). A lower level of consumption (30% of the RDA) was documented among 25.49% of the male and 21.48% of the female individuals respectively. The sex differences in the consumption with respect to the RDA was not statistically significant (χ^2 value = 5.912; d.f. 5, p>0.05) (***Table 3.37***).

e) ***Root and tubers***

The consumption of root and tubers was a major component in the Rajbanshi diet. The consumption was found to be well above the RDA. The mean overall consumption was 123.15 ± 45.41 gm/day. The consumption was higher among the males (127.05 ± 47.12 gm/day) than the females (127.05 ± 47.12 gm/day). The sex differences was not statistically significant (F ratio= 2.302; d.f. 1,301; p>0.05) (***Table 3.36***).

Table 3.36. Average (mean ±SD) intake of foodstuffs (gm/day) among the Rajbanshi individuals

Foodstuff (in gm)	*Overall (N=302) (Mean ± SD)*	*Males (N=153)*		*Females (N=149)*		*Difference*		
		Mean ± SD	*RDA*	*Mean ± SD*	*RDA*	*F-value*	*d.f.*	*p value*
Cereals	472.47 ± 83.69	504.13 ± 90.12	520	439.96 ± 61.69	440	51.878	1,131	0.000
Pulses and legumes	22.67 ± 21.07	24.12 ± 22.89	50	21.19 ± 18.98	50	1.461	1,131	0.228
GLVs	13.82 ± 25.89	12.21 ± 23.64	40	15.47 ± 27.99	100	1.2	1,131	0.274
Other vegetables	63.98 ± 53.68	66.08 ± 56.39	70	61.83 ± 50.86	40	0.473	1,131	0.492
Root and Tubers	123.15 ± 45.41	127.05 ± 47.12	60	119.14 ± 43.39	50	2.302	1,131	0.130
Milk and Milk product	32.06 ± 35.90	33.58 ± 36.89	200	30.5 ± 34.89	50	0.553	1,131	0.458
Meat and Flesh	23.14 ± 35.19	23.17 ± 36.31	30	23.1 ± 34.13	30	0.001	1,131	0.986
Nut and seeds	9.15 ± 3.77	9.37 ± 3.88	-	8.93 ± 3.64	-	1.029	1,131	0.311
Fat and oils	17.43 ± 3.12	17.66 ± 3.05	45	17.19 ± 3.18	25	1.712	1,131	0.192
Condiments	11.05 ± 6.11	11.54 ± 8.08	-	10.54 ± 2.89	-	2.034	1,131	0.155
Sugar	18.22 ± 3.99	18.60 ± 4.12	35	17.83 ± 3.85	20	2.882	1,131	0.091

RDA- Recommended Dietary Allowance

Table 3. 37. Comparative evaluation of the mean consumption pattern of food intake (%) with the RDA among the Rajbanshi individuals

Foodstuff	Males (N=153)						Females (N=149)					
	<30%	30-59.99%	60-89.99%	90-99.99%	≥100%	Mean % of RDA	<30%	30-59.99%	60-89.99%	90-99.99%	≥100%	Mean % of RDA
Cereals	0 (0)	1 (0.65)	54 (35.29)	22 (14.38)	76 (49.67)	96.95	0 (0)	1 (0.67)	32 (21.48)	42 (28.19)	74 (49.66)	99.99
Pulses and legumes	59 (38.56)	26 (16.99)	37 (24.18)	6 (3.92)	25 (16.34)	48.24	61 (40.94)	35 (23.49)	32 (21.48)	9 (6.04)	12 (8.05)	42.38
GLVs	115 (75.16)	0 (0)	11 (7.19)	1 (0.65)	26 (16.99)	30.53	111 (74.50)	30 (20.13)	3 (2.01)	1 (0.67)	4 (2.68)	15.47
Other vegetables	39 (25.49)	4 (2.61)	16 (10.46)	1 (0.65)	93 (60.78)	94.4	32 (21.48)	11 (7.38)	9 (6.04)	1 (0.67)	96 (64.43)	154.58
Root and Tubers	1 (0.65)	0 (0.00)	3 (1.96)	2 (1.31)	147 (96.08)	211.75	1 (0.67)	0 (0.00)	1 (0.67)	1 (0.67)	146 (97.99)	238.28
Milk and Milk products	129 (84.31)	16 (10.46)	6 (3.92)	0 (0)	2 (1.31)	16.79	10 (6.71)	111 (74.50)	3 (2.01)	3 (2.01)	22 (14.77)	61
Meat and Flesh	100 (65.36)	1 (0.65)	0 (0)	3 (1.96)	49 (32.03)	77.23	93 (62.42)	1 (0.67)	3 (2.01)	0 (0)	52 (34.9)	77
Fat and oils	12 (7.84)	141 (92.16)	0 (0.00)	0 (0.00)	0 (0.00)	39.24	0 (0.00)	20 (13.42)	122 (81.88)	1 (0.67)	6 (4.03)	68.76
Sugar	8 (5.23)	123 (80.39)	21 (13.73)	0 (0.00)	1 (0.65)	53.14	0 (0)	12 (8.05)	23 (15.44)	77 (51.68)	37 (24.83)	89.15

The mean and individual consumptions of root and tubers were also compared with the suggested RDA in order to assess dietary adequacy. The results showed that consumption of root and tubers was higher than the RDA among both the sexes (males: 211.75%; females: 238.28%). When the individual consumption levels were considered, majority of the males (96.08%) and the females (97.99%) attained the adequate level of RDA consumption ($\geq$100%). The sex difference in the different levels of RDA consumption was not statistically significant (χ^2 value= 1.284; d.f. 4, $p>0.05$) (***Table 3.37***).

f) Milk and milk products

The overall mean consumption of milk and milk products was 32.06 ± 35.90 gm/day and did not constitute a major part of the diet. Males had a higher consumption than the females (33.58 ± 36.89 gm/day versus 30.5 ± 34.89 gm/day). The sex difference was however, not statistically significant (F ratio 0.553; d.f. 1,301; $p>0.05$) (***Table 3.36***).

The consumption of milk and milk products was found to be very low when compared with the RDA (ICMR, 2004). The mean consumptions with respect to the RDA were lower among the males (16.79%) than the females (61%). It was also observed that 84.31% of the males and 6.71% of the females were able to achieve <30% of the RDA. The adequate level ($\geq$100% of RDA) of consumption was observed to be very low among the males (1.31%) as compared to the females (14.77%). The sex difference in the different levels of RDA attainment was statistically significant (χ^2 value= 193.588; d.f.5, $p<0.05$) (***Table 3.37***).

g) Meat and flesh products

The consumption of meat and flesh products was occasional in nature. The mean overall consumption of meat and flesh products was 23.14 ± 35.19 gm/day. The meat and flesh products included mutton, poultry, pigeon and different types of fishes. The mean consumption was 23.14

± 35.19 gm/day and 23.10 ± 34.13 gm/day among the male and the female individuals respectively. The sex difference was not statistically significant (F ratio= 0.001; d.f. 1,301; p>0.05) (***Table 3.36***).

When compared with the RDA, the sex specific mean consumption was 77.23% and 77% among the male and the female individuals respectively. The results further indicated that 32.03% of the males and 34.9% of the females achieved the adequate consumption level (≥100%) of the RDA. The sex difference in the different levels of RDA was not statistically significant (χ^2 value= 6.291; d.f.5: p>0.05) ***(Table 3. 37.)***.

h) Nuts and seeds

The overall mean consumption of nuts and seeds was 9.15 ± 3.77 gm/day. The male individuals exhibited a higher consumption the females (9.37 ± 3.88 gm/day versus 8.93 ± 3.64 gm/day). The sex difference was found to be statistically not significant (F ratio= 1.029; d.f. 1,301; p>0.05) (***Table 3.36***).

i) Fats and oils

The mean overall consumption of fat and oils was 17.43 ± 3.12 gm/day. Mustard oil was used as a cooking medium. The use of hydrogenated fats and *ghee* was occasional and/or restricted in the diet. The sex specific consumption of fat and oils was observed to be higher among the males (17.66 ± 3.05 gm/day) than the females (17.19 ± 3.18 gm/day). The sex difference was not significant in the mean consumption patterns of fat and oils (F ratio= 1.712; d.f. 1,301; p>0.05) (***Table 3.36***).

The mean percentages of the consumption of fats and oils were well below the RDA. The mean percentages of consumption values of RDA level were observed to be distinctly higher among the females (68.76%) than the males (39.24%). The result also indicated that the majority of the males (92.16%) and the females (81.88%) were in the 30%-59.99% and 60%-89.99% of RDA respectively. The sex difference in the different levels of RDA was statistically significant (χ^2 value= 231.93; d.f. 5; p<0.05) (***Table 3.37***).

i) Condiments

The overall mean consumption of condiments was low (11.05 ± 6.11 gm/day). The sex specific difference was observed to be higher among the males (11.54 ±8.08 gm/day) than the females (10.54 ± 2.89 gm/day). The sex differences was not statistically significant (F ratio= 2.034; d.f. 1,301; p>0.05) (***Table 3.37***).

j) Sugar

The overall mean consumption of sugar was 18.22 ± 3.99 gm/day. The consumption was higher among the males (18.6 ± 4.12 gm/day) than the females (17.83 ± 3.85 gm/day). Sugar was chiefly used in the preparation of tea. The sex differences in the consumption pattern was not statistically significant (F ratio= 2.882; d.f.1,301; p>0.05) (***Table 3.36***).

The mean overall consumption was documented to be very low than the RDA. The results also showed that 0.65% and 24.83% of the male and the female individuals attained the adequate level of RDA. The results also suggested that the majority of the males (80.39%) and females (51.68%) comprised 30%-59.99% and 90%-99.99% of the RDA levels respectively. The sex difference in the different RDA levels was statistically significant (χ^2 value= 210.447; d.f. 5; p<0.01).

The comparison of the mean consumption (%) of the different food groups with the RDA values and sex specific consumption of different levels of RDA achievements are shown in ***Figures 3.44 and 3.45*** respectively.

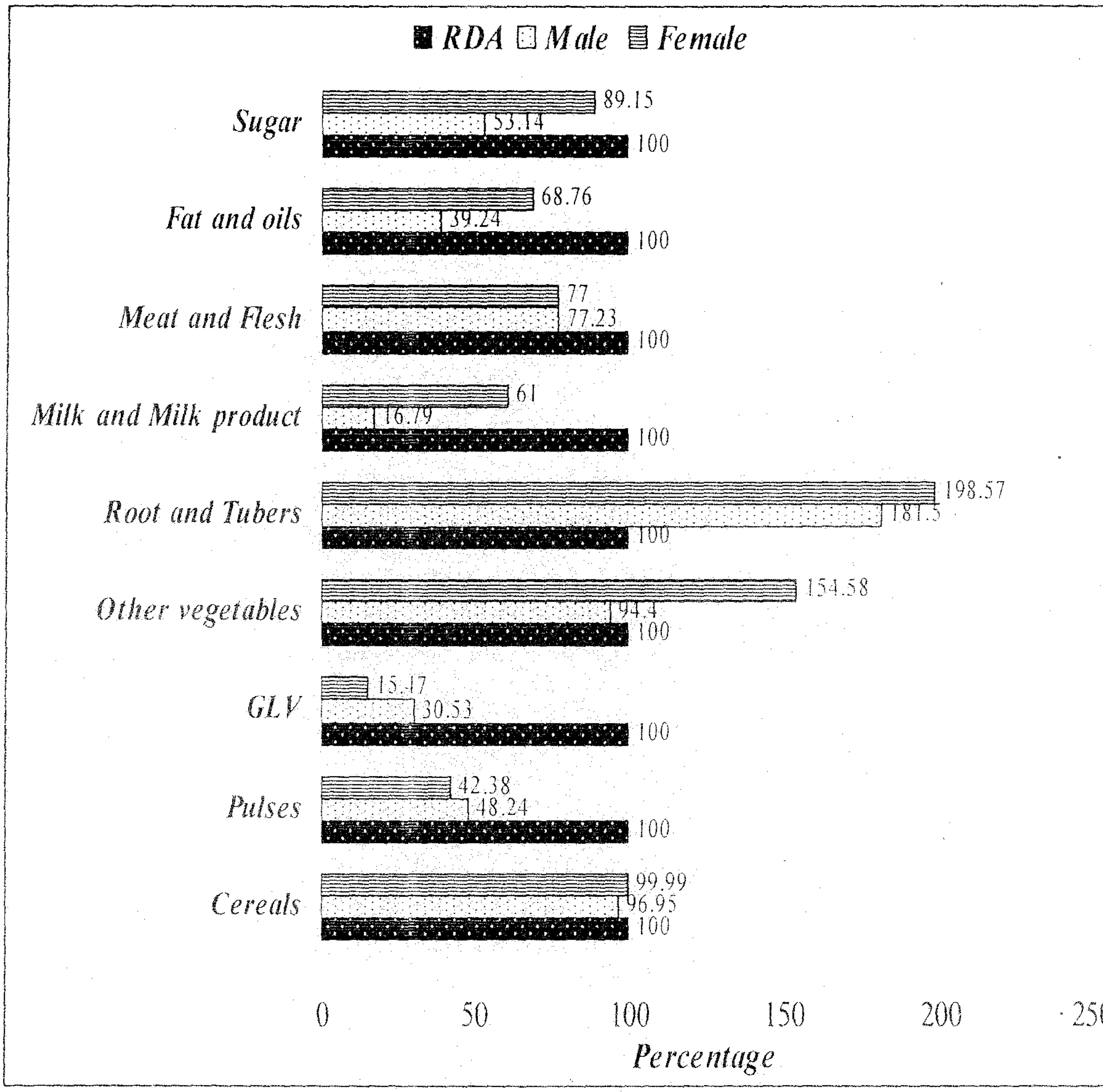


Figure 3.44: Bar diagram showing the mean consumption pattern (%) of different foodstuffs with the RDA

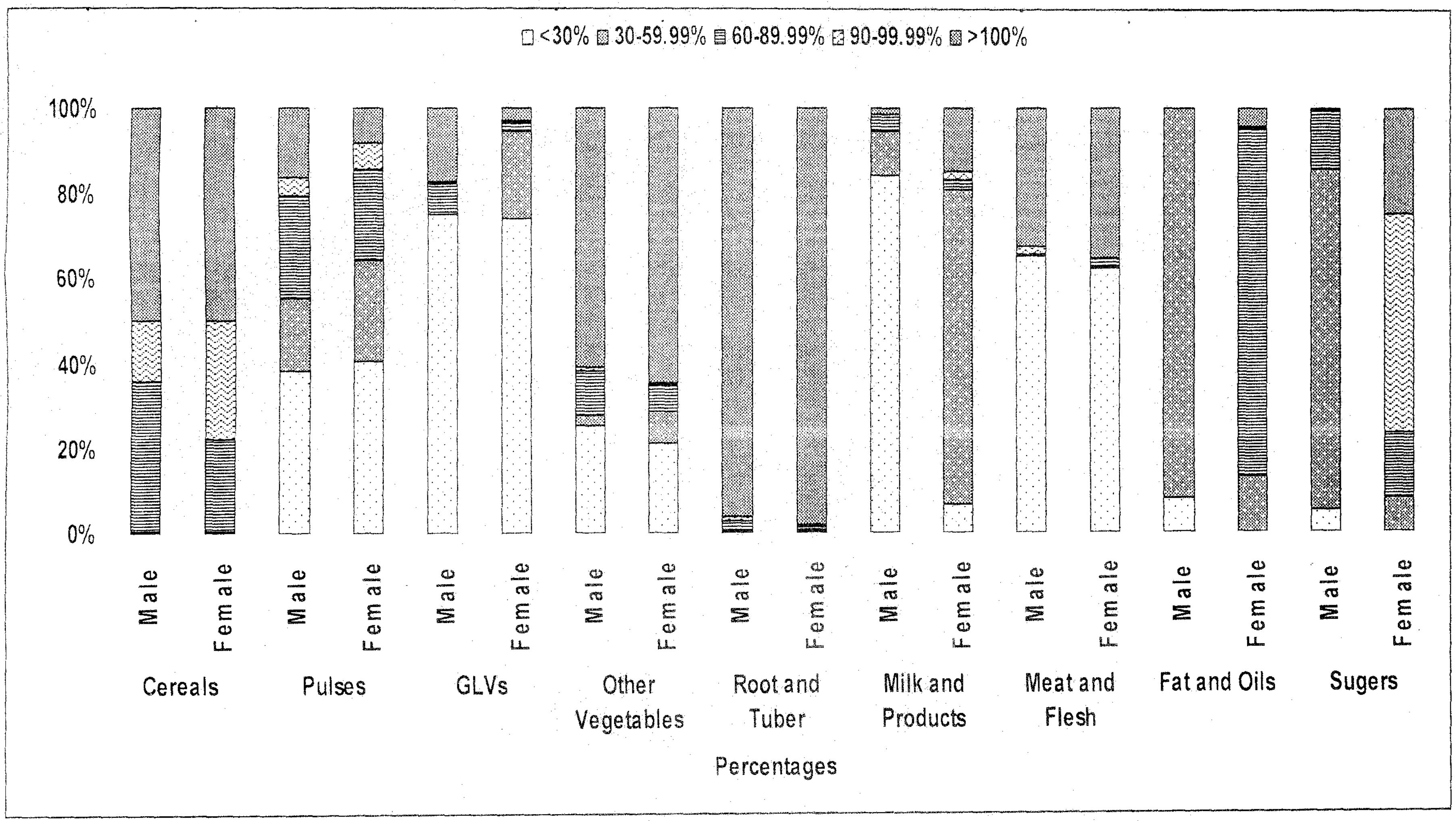


Figure 3.45. Column chart showing the sex specific food consumption of different levels of RDA achievement among the Rajbanshi individuals

3.3.3. Consumption of energy and different nutrients among the Rajbanshi individuals

The mean consumption of nutrients intake of the Rajbanshi male and female individuals is depicted in ***Table 3.38.*** The dietary intake of the different foodstuffs was analyzed in terms of energy, protein, fats, calcium, iron, vitamin-A, thiamin, riboflavin, niacin and vitamin-C in order to assess nutritional status. The nutrients consumption patterns of the individuals was calculated from the monograph entitled *"Nutritive value of Indian Foods"* authored by Gopalan *et al.* (2007). The RDA levels of the different nutrients as suggested for Indian populations by the ICMR (2004) have been given in ***Table 3.38***.

Nutritional status based on the nutrient intake assessment was assessed by comparing the mean and individual dietary intakes with the suggested RDA for Indian populations. Nutrient consumption was observed to be markedly deficit when compared with the suggested RDA level for the Indian populations. ***Table 3.39*** shows the mean consumption and comparison with the percentage of the RDA among the male and female individuals.

The consumptions of different nutrients and their comparison with the RDA are described below:

*a) **Energy***

The overall mean consumption of energy was 2235.11 ± 353.86 Kcal/day. The predominant sources of the energy were rice, rice-based products and roots and tubers. The sex specific mean consumption of energy was higher among the males (2333.99 ± 327.05 Kcal/day) than the females (2159.39 ± 352.63 Kcal/day). A statistically significant sex difference existed in energy consumption (F ratio = 26.249; d.f. 1,301; $p<0.01$) (***Table 3.38***).

The comparison of the mean energy consumption with suggested RDA was observed to be deficit among both sexes. The results showed that the consumption was 81.18% and 97.05%

of the recommended level among the males and the females respectively. When the individual consumptions were compared with the RDA, only 3.92% and 32.89% of the males and the females were able to achieve the adequate RDA. A high proportion of the individuals (males: 74.51%, females: 34.23%) comprised the 60%-89.99% and 90%-99.99% of the RDA respectively. The sex difference in the different levels of RDA was statistically significant (χ^2 value= 67.942; d.f. 4; $p<0.001$) (*Table 3.39*).

b) Protein

The consumption of dietary protein among the Rajbanshi individuals was chiefly in the form of cereals and pulses. Protein-rich food such as mutton, poultry and fish were low in their diet. The overall mean consumption of protein was 50.55 ± 38.38 gm/day. Males and females exhibited almost similar mean consumptions (50.57 ± 10.79 gm/day versus 50.53 ± 53.63 gm/day). The sex difference was statistically not significant (F ratio= 0.001; d.f. 1,301; $p>0.05$) (*Table 3.38*).

When the consumption of proteins was compared with the RDA, it was noticed that a deficit existed among the males (84.28%), while among the females the consumption was adequate (101.06%) (*Figure 3.46*). The results also portrayed that 12.42% and 29.53% of the males and the females showed adequate levels of RDA ($\geq$100%). It was also observed that the majority of the males (62.09%) and the females (46.61%) belonged to 60%-89.99% of the RDA consumption level. The sex difference in the different levels of RDA was statistically significant (χ^2 value= 20.822; d.f. 5; $p<0.05$) (*Table 3.39*).

c) Fat

The main source of dietary fat was cooking oils. The consumption of milk and milk products was low. The overall mean consumption was 26.06 ± 9.31 gm/day. The male individuals showed a higher mean consumption of fat than the female individuals (27.40 ± 11.87 gm/day versus 24.68 ± 5.27 gm/day). The sex difference in the consumption of fat was seen to be statistically significant (F ratio= 6.573; d.f. 1,301; $p<0.05$) (***Table 3.38***).

The consumption of the mean dietary fat was sufficient among both the male (137%) and female (123.4%) individuals when compared to the RDA. It was also observed that 92.16% and 85.91% of the male and the female individuals achieved adequate fat consumption (≥100% of RDA) respectively. The sex difference in the different levels of RDA in respect to fat consumption was not statistically significant (χ^2 value= 4.97; d.f. 5; $p>0.05$) (***Table 3.39***).

d) Calcium

The overall mean intake of the diet calcium among Rajbanshi was 333.05 ± 244.16 mg/day. The consumption was observed to be inadequate when compared with the RDA. The main sources of calcium intake were milk and milk products and nuts. The mean consumption was found to be higher among the males (338.03 ± 246.04 mg/day) than the females (327.94 ± 242.93 mg/day). The sex difference in the consumption of calcium was not statistically significant (F ratio= 0.129; d.f. 1,301; $p<0.05$).

When the calcium consumption was compared with the suggested RDA, it was observed that the level of consumption was inadequate in both sexes. The males exhibited a higher consumption than the females (84.51% versus 81.99%). It was also seen that 24.18% and 25.50% of the male and female individuals were able to achieve the adequate level of calcium consumption (≥100% of RDA). The sex difference in the different RDA levels consumption was not statistically significant (χ^2 value = 4.29; d.f. 5; $p>0.05$).

e) Iron

The overall mean consumption was 12.84 ± 9.89 mg/day. The overall consumption was found to be inadequate among both sexes. The consumption of iron-rich foods was very low. The consumption was higher among the males (13.98 ± 13.26 mg/day) than the females (11.68 ± 3.98 gm/day). The sex difference in iron consumption was found to statistically significant (F ratio= 4.129; d.f. 1,301; $p<0.05$).

The consumption of iron was lower than the suggested RDA in both sexes. Iron consumption was higher among the males (49.93%) than the females (38.93%). The majority of them exhibited an iron consumption of 30%-59.99% of the RDA level (males: 84.97%; females: 73.15%). The higher and adequate levels (90%-99.99% and ≥100%) were observed to be lower among both sexes. The sex difference in different levels of the RDA in iron consumption was statistically significant (χ^2 value= 14.686; d.f. 5; $p<0.05$).

f) Vitamin-A

The consumption of vitamin-A was very low among the Rajbansi individuals (480.41 ± 490.96 μg/day). The mean consumption of vitamin-A was observed to be higher among the females (493.78 ± 513.38 μg/day) than the males (467.39 ± 469.43 μg/day). However, sex difference was not statistically significant (F ratio= 0.217; d.f. 1,301; $p>0.05$).

The consumption of vitamin-A was found to be markedly inadequate in both sexes when compared with the RDA. It was higher among the females (82.30%) than the males (77.90%). The individual levels of consumption showed that only 28.10% and 29.53% of the males and females were able to achieve the adequate level of RDA (≥100% of the RDA). The consumption of vitamin-A at <30% of the RDA was higher among both sexes (males: 38.56%; females:

39.6%). The sex difference in the different levels of RDA in vitamin-A consumption was not statistically significant (χ^2 value= 0.475; d.f. 5; $p<0.05$).

g) Thiamin

The overall mean consumption of thiamin (1.33 ± 0.29 mg/day) was observed to be satisfactory in both sexes. The consumption of thiamin was higher among the males (1.41 ± 0.31 mg/day) than the females (1.25 ± 0.23 mg/day). The sex difference was statistically significant (F ratio= 26.294; d.f. 1,301; $p<0.01$).

The consumption with RDA was higher among the females than the males ((113.64% versus 100.71%). The results also showed that >95% of the individuals exhibited >60% of the RDA in both sexes. The adequate level of RDA (≥100%) in thiamin consumption was higher among the females (81.88%) than the males (50.33%). The sex difference in different levels of RDA was statistically significant (χ^2 value= 34.519; d.f. 5; $p<0.01$).

h) Riboflavin

The main sources of riboflavin in the diet were cereals and pulses. The overall mean intake (0.54 ± 0.24 mg/day) was inadequate and lower that the RDA. The mean consumption was slightly higher among the males (0.57 ± 0.27mg/day) when compared to the females (0.51 ± 0.2 mg/day). However, the sex difference was not statistically significant (F ratio= 3.663; d.f. 1,301; $p>0.05$). The attainment of riboflavin was higher among the females (39.23%) than the males (35.63%) when compared with the RDA. About 45.75% of the males and 28.19% of the females exhibited >30% of the RDA. The consumption at 30%-59.99% of the RDA level was higher among the females when compared with the males (65.77% versus 48.37%). The sex difference in the different levels of RDA in riboflavin consumption was observed to be statistically significant (χ^2 value=20.071; d.f. 5; $p<0.05$).

i) Niacin

The overall mean consumption of niacin was 23.45 ± 6.79 gm/day. The consumption was observed to be adequate when compared with the RDA. The mean consumption was higher among the males (23.84 ± 6.92 mg/day) than the females (23.04 ± 6.66 mg/day). The sex difference in consumption of niacin consumption was however, not statistically significant (F ratio = 1.056; d.f. 1,301; $p>0.05$).

The consumption of niacin was higher among the females (113.64%) than the males (100.71%). Nearly 83.01% of the males and 95.97% of the females exhibited an adequate level (≥100% of RDA). The sex difference in different levels of RDA was statistically significant (χ^2 value= 15.558; d.f. 5; $p<0.05$).

j) Vitamin C

The overall mean consumption of vitamin-C was 38.79 ± 17.48 gm/day. GLVs were the major source of vitamin C in the diet. The consumption was observed to be higher among the males (40.25 ± 18.44 mg/day) than the females (37.28 ± 16.36 mg/day). The sex difference was not statistically significant (F ratio 2.187; d.f. 1,301; $p>0.05$). Although the consumption of vitamin-C was unsatisfactory when compared with the RDA among the females (93.20%), it was observed to be adequate for the males (100.63%). When the individual consumption of different levels of the RDA in vitamin-C was considered, 47.71% of the males and 40.27% of the females achieved the adequate level (≥100 of the RDA). The consumption at the 60%-89.99% level of the RDA was higher among both sexes (males: 24.18%, females: 26.85%). The sex difference in the different levels of the RDA in vitamin-C consumption was not statistically significant (χ^2 value=2.043; d.f. 5; $p>0.05$).

Table 3.38: The average (mean ±SD) intake of nutrient (per/day) among the Rajbanshi individuals

Nutrient	*Overall (N=302)*	*Males (N=153)*		*Females (N=149)*		*Difference*		
	(Mean ±SD)	*Mean ±SD*	*RDA*	*Mean ±SD*	*RDA*	*F-value*	*d.f.*	*p value*
Energy (Kcal)	2235.11 ± 353.86	2333.99 ± 327.05	2875	2159.39 ± 352.63	2225	26.249	1, 301	0.000
Protein (gm)	50.55 ± 38.38	50.57 ± 10.79	60	50.53 ± 53.63	50	0.001	1, 301	0.994
Fat (gm)	26.06 ± 9.31	27.4 ± 11.87	20	24.68 ± 5.27	20	6.573	1, 301	0.011
Calcium (mg)	333.05 ± 244.16	338.03 ± 246.04	400	327.94 ± 242.93	400	0.129	1, 301	0.720
Iron (mg)	12.84 ± 9.89	13.98 ± 13.26	28	11.68 ± 3.98	30	4.129	1, 301	0.043
Vitamin A (µg)	480.41 ± 490.96	467.39 ± 469.43	600	493.78 ± 513.38	600	0.217	1, 301	0.641
Thiamin (mg)	1.33 ± 0.29	1.41 ± 0.31	1.4	1.25 ± 0.23	1.1	26.294	1, 301	0.000
Riboflavin (mg)	0.54 ± 0.24	0.57 ± 0.27	1.6	0.51 ± 0.20	1.3	3.663	1, 301	0.057
Niacin (mg)	23.45 ± 6.79	23.84 ± 6.92	18	23.04 ± 6.66	14	1.056	1, 301	0.305
Vitamin C (mg)	38.79 ± 17.48	40.25 ± 18.44	40	37.28 ± 16.36	40	2.187	1, 301	0.140

RDA- Recommended Dietary Allowance

Table 3.39: Mean consumption pattern (%) of nutrient intake with the RDA among the Rajbanshi individuals

Nutrients	*Males (N=153)*						*Females (N=149)*					
	<30%	*30-59.99%*	*60-89.99%*	*90-99.99%*	*≥100%*	*Mean % of RDA*	*<30%*	*30-59.99%*	*60-89.99%*	*90-99.99%*	*≥100%*	*Mean % of RDA*
Energy	0 (0.00)	3 (1.96)	114 (74.51)	30 (19.61)	6 (3.92)	81.18	0 (0)	0 (0)	49 (32.89)	51 (34.23)	49 (32.89)	97.05
Protein	1 (0.65)	8 (5.23)	95 (62.09)	30 (19.61)	19 (12.42)	84.28	0 (0.00)	1 (0.67)	69 (46.31)	35 (23.49)	44 (29.53)	101.06
Fats	0 (0)	0 (0)	2 (1.31)	9 (5.88)	141 (92.16)	137	1 (0.67)	1 (0.67)	5 (3.36)	14 (9.40)	128 (85.91)	123.40
Calcium	3 (1.96)	68 (44.44)	38 (24.84)	7 (4.58)	37 (24.18)	84.51	8 (5.37)	70 (46.98)	29 (19.46)	4 (2.68)	38 (25.50)	81.99
Iron	12 (7.84)	130 (84.97)	6 (3.92)	2 (1.31)	3 (1.96)	49.93	33 (22.15)	109 (73.15)	5 (3.36)	2 (1.34)	0 (0.00)	38.93
Vitamin-A	59 (38.56)	44 (28.76)	6 (3.92)	1 (0.65)	43 (28.10)	77.9	59 (39.60)	38 (28.50)	7 (4.7)	1 (0.67)	44 (29.53)	82.30
Thiamin	1 (0.65)	4 (2.61)	39 (25.49)	32 (20.92)	77 (50.33)	100.71	0 (0.00)	2 (1.34)	11 (7.38)	14 (9.40)	122 (81.88)	113.64
Riboflavin	70 (45.75)	74 (48.37)	1 (0.65)	6 (3.92)	2 (1.31)	35.63	42 (28.19)	98 (65.77)	6 (4.03)	0 (0.00)	3 (2.01)	39.23
Niacin	1 (0.65)	1 (0.65)	17 (11.11)	7 (4.58)	127 (83.01)	132.44	0 (0)	0 (0)	2 (1.34)	4 (2.68)	143 (95.97)	164.57
Vitamin-C	5 (3.27)	29 (18.95)	37 (24.18)	9 (5.88)	73 (47.71)	100.63	4 (2.68)	34 (22.82)	40 (26.85)	11 (7.38)	60 (40.27)	93.20

Values in parenthesis indicates percentages

The mean consumption pattern (%) of nutrient intake with the RDA and sex specific nutrient consumption of different levels of RDA achievement among the Rajbanshi individuals is shown in ***Figures 3.46 and 3.47*** respectively.

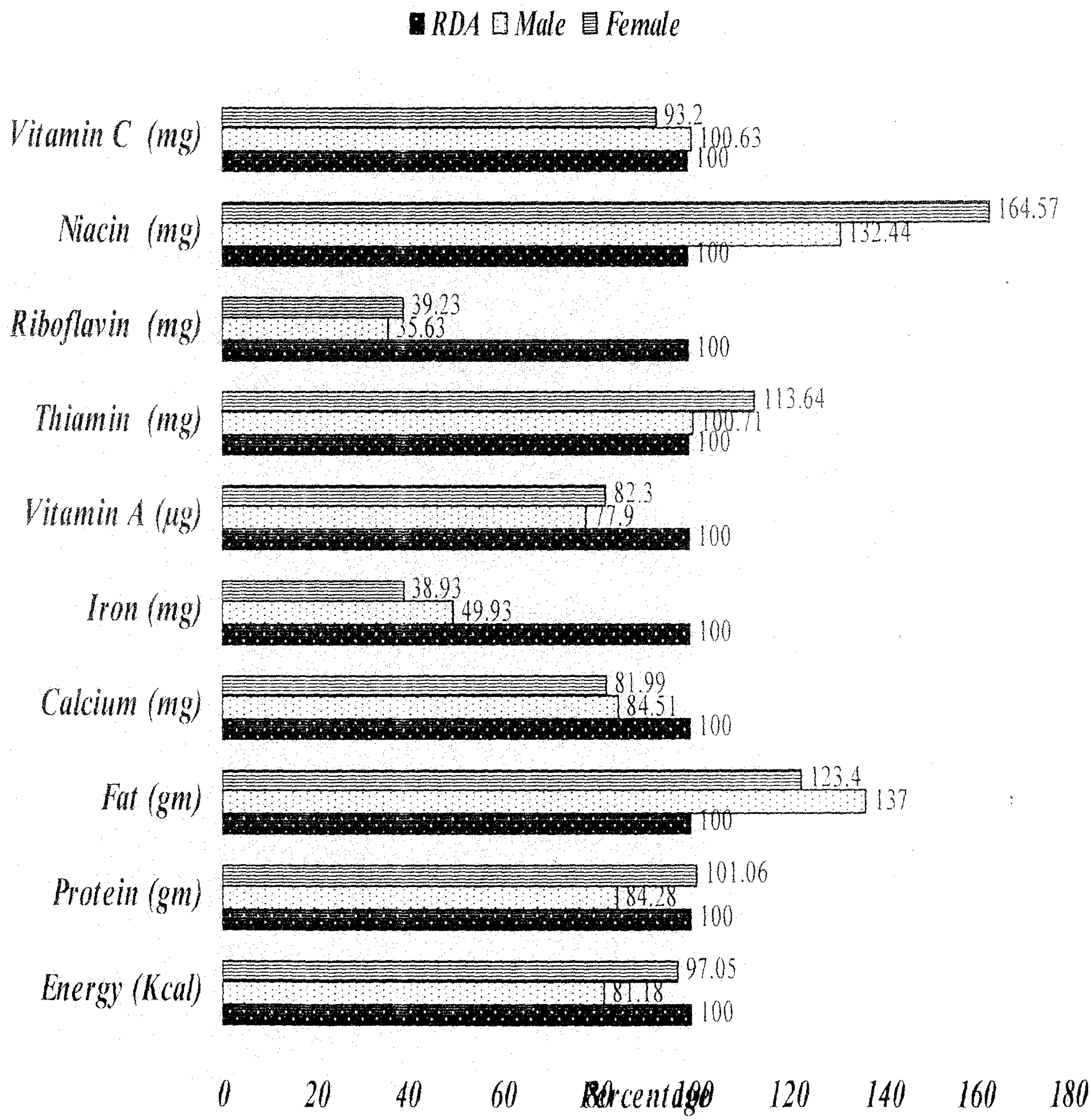


Figure 3.46: Bar diagram showing the mean consumption pattern (%) of nutrient intake with the RDA

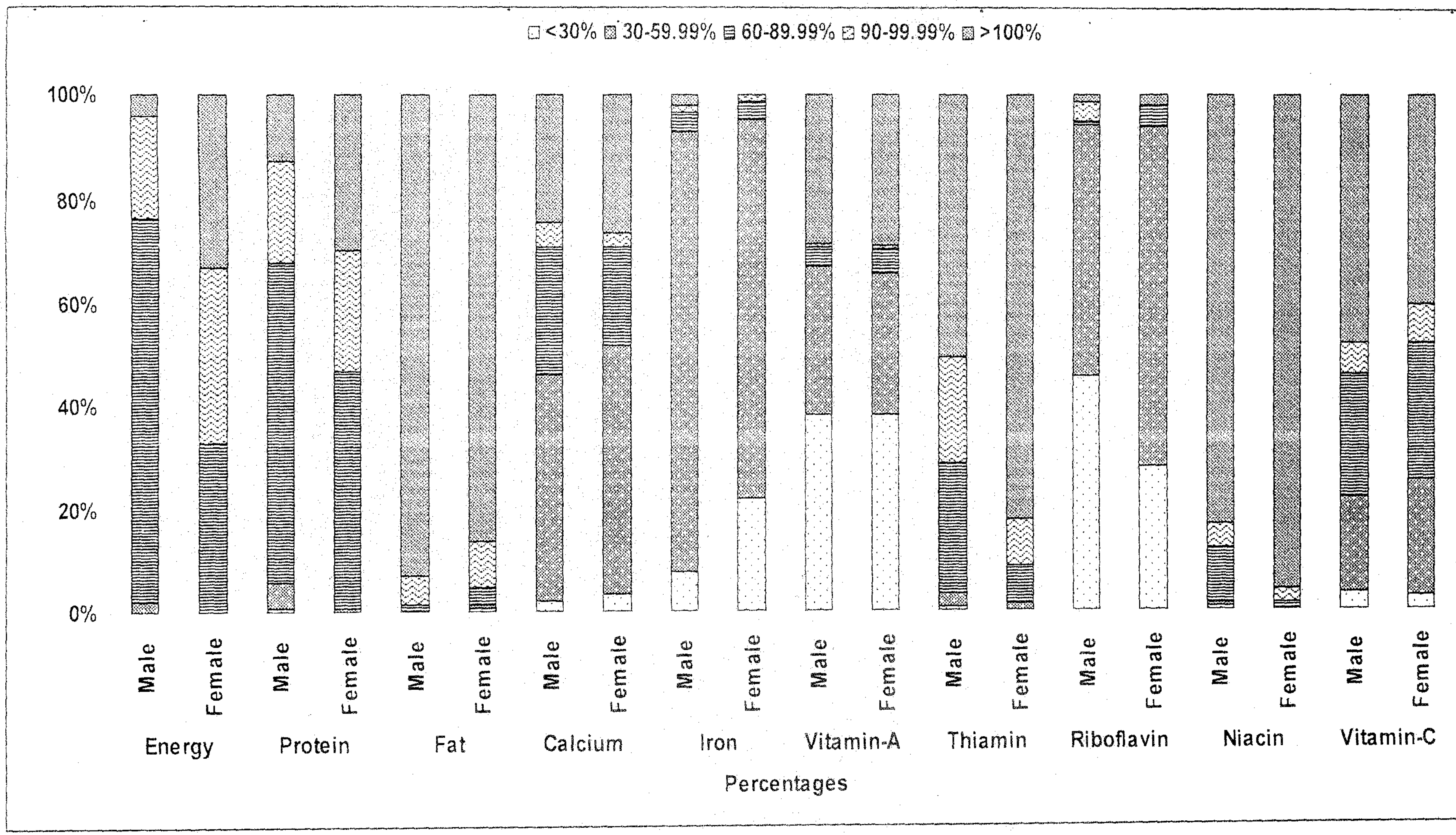


Figure 3.47: Column chart showing the sex specific nutrient consumption of different levels of RDA achievement among Rajbanshi individuals

3.3.4. Protein-caloric adequacy among the Rajbanshi individuals

The protein-caloric adequacy of the Rajbanshi individuals was derived using the Gaussian distribution with co-efficient of variation of 15%. The results are outlined in ***Table 3.40.*** The majority of the individuals exhibited inadequate protein and caloric (P– C–) intakes among both sexes. The overall prevalence of protein-caloric (P – C–) inadequacy was 39.07%. About 28.48% of the individuals consumed adequate calories and proteins (P+ C+). Adequate proteins but inadequate calories (P+ C–) and inadequate proteins and adequate calories (P– C+) were exhibited by 29.8% and 2.65% of the individuals respectively. The overall prevalence of the protein-caloric adequacy is depicted in ***Figure 3.48.*** The female individuals were more affected by protein-caloric deficiency than the males. The protein-caloric inadequacy was higher among the females (48.32%) than the males (30.07%). The protein-caloric adequacy was higher among the males (41.18%) than the females (15.44%). Adequacy in protein and inadequacy in caloric consumption was observed to be higher among the females (34.9%) than the males (24.84%). Adequacy in caloric and inadequacy in protein was higher in the males (3.92%) than the females (1.34%).

The sex differences in the prevalence of different protein-caloric adequacies are shown in ***Table 3.40.*** It was statistically significant in protein-caloric (P– C–) inadequacy (χ^2 value= 4.64; d.f.1; $p<0.05$) and adequate caloric and protein (P+ C+) (χ^2 value= 13.85; d.f.1; $p<0.05$). However, the sex differences in the prevalence of adequate protein and inadequate caloric (P+ C–) (χ^2 value= 1.98; d.f. 1; $p>0.05$) and inadequate protein and adequate in caloric (P– C+) (χ^2 value= 1.85; d.f.1; $p>0.05$) were not statistically significant. The prevalence of different categories of protein-caloric adequacy among the male and the female individuals is depicted in ***Figure 3.49.***

Table 3.40: Prevalence of Protein-Caloric malnutrition among the Rajbanshi individuals

Category	*P + C+*	*P + C–*	*P – C+*	*P – C–*	*P –*	*C–*
Males	63 (41.18)	38 (24.84)	6 (3.92)	46 (30.07)	52 (33.99)	84 (54.90)
Females	23 (15.44)	52 (34.90)	2 (1.34)	72 (48.32)	74 (49.66)	124 (83.22)
Total	86 (28.48)	90 (29.80)	8 (2.65)	118 (39.07)	126 (41.72)	208 (68.87)
χ^2- *value*	13.846	1.977	1.848	4.642	3.143	5.23
d.f.	1	1	1	1	1	1
p value	0.000	1.597	0.174	0.031	0.762	0.022

Values in parenthesis indicates percentages

P + C+ = protein adequacy-calorie adequacy

P + C– = protein adequacy-calorie inadequacy

P – C+ = protein inadequacy-calorie adequacy

P – C– = protein inadequacy-calorie inadequacy

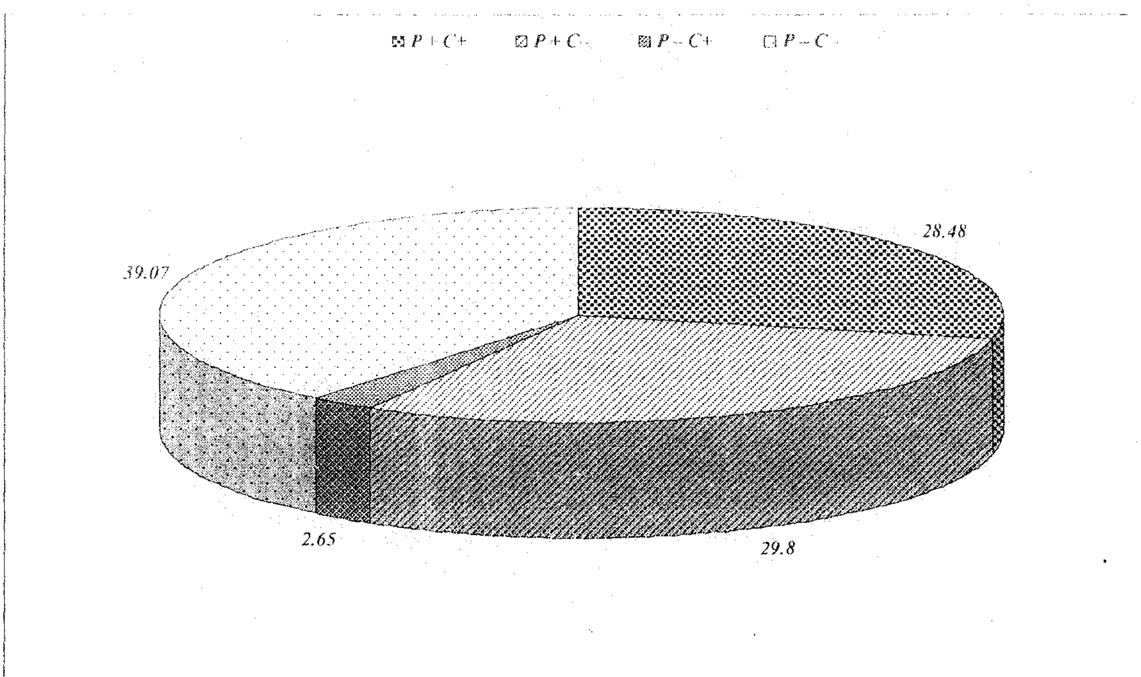


Figure 3.48: Pie chart showing the prevalence of protein-caloric adequacies among the Rajbanshi individuals

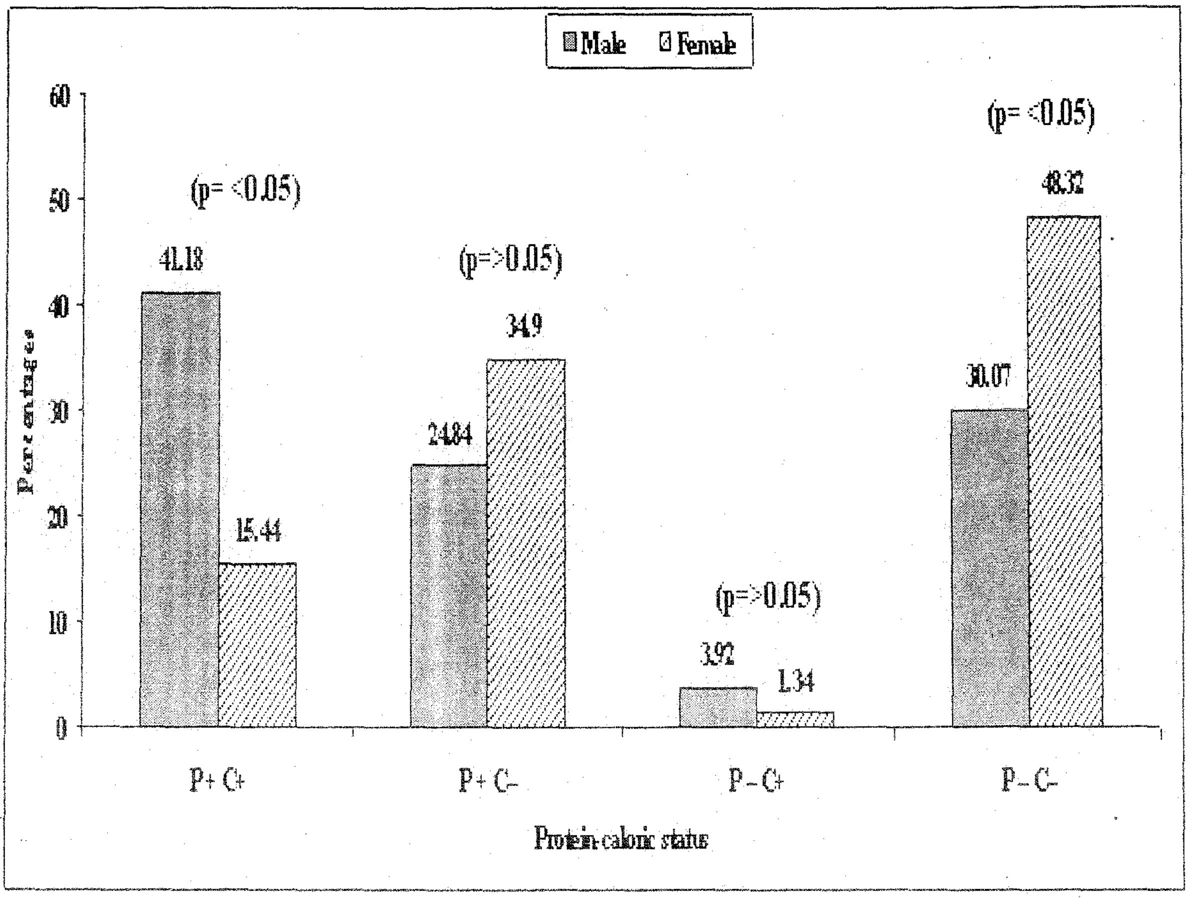


Figure 3.49: Bar diagram showing the prevalence of protein-caloric adequacies among the Rajbanshi male and female individuals

3.3.5. Multinomial logistic regression model fitted on the socio-economic, demographic and lifestyle related variables among the Rajbanshi individuals

A multinomial logistic regression model was fitted to assess the influence of socio-economic, demographic and lifestyle-related variables on the protein-caloric adequacy and the protein-energy deficiency. The deficiency was assessed by utilizing the cut-off values considered to be consuming inadequate calories or proteins when the intakes were less than the mean −2 SD of the RDA using a Gaussian distribution. The cut-offs values were, thereby, suggested to be

2425 Kcal of energy and 46 gm of protein as the daily requirement of an individual. Those individuals below these values were considered to be having an inadequate intake and thus being undernourished ***(Table 3.41)***. The results of multinomial logistic regression model are briefly summarized below:

3.3.5.1. Protein and Caloric inadequacy vs. socio-economic, demographic and lifestyle related variables among the Rajbanshi individuals

The results of the multinomial logistic regression model revealed that the inadequacy in terms of caloric and protein consumption was strongly related to sex. The odd values were 4 times higher (odds: 4.07; 95% CI 2.38-6.96) and almost double (odds: 1.92; 95% CI 1.21-3.05) in case of caloric and protein inadequacy among the females when compared with the males ($p<0.01$). Age also exhibited higher odd values in the 40-49 years age group in both caloric (odds: 1.51; 95% CI 0.79-2.87) and protein inadequacy (odds: 1.19; 95% CI 0.69-2.08) ($p>0.05$) than the 20-29 years and 30-39 years age groups. However, lower odd values were obtained for the higher family (≥5 individuals) and dependent children (≥2 children) for both caloric and protein inadequacies. Monthly income had a significant effect in inadequate protein' intake, where the odd values were higher in ≤Rs.4000 (odds: 1.28; 95% CI 0.72-2.27; $p>0.05$) and Rs. 4001-6000 (odds: 2.36; 95% CI 1.26-4.42; $p<0.01$) categories. Individuals belonging to the 'labour group' exhibited lower odds (odds: 0.94 95% CI 0.58-1.54) and higher odds (odds: 1.22 95% CI 0.77-1.94) for an individual being undernourished in caloric and protein inadequacy respectively. Higher odd values were obtained from individuals belonging to the lower monthly expenditure, per-capita expenditure and per-capita income for both caloric and protein inadequacy status.s The per-capita expenditure and per-capita income showed higher effects in caloric and protein inadequacies among individuals belonging to the ≤Rs.750 category ***(Table 3.41)***.

3.3.5.2. Protein-energy deficiency vs. socio-economic, demographic and lifestyle related variables among the Rajbanshi individuals

The results of the multinomial logistic regression analysis for the combined protein and energy deficiency status indicated that sex was a major variable. The odds was significantly double (odds: 2.18; 95% CI 1.36-3.49) for the females being undernourished than the males ($p<0.01$). The individuals belonging to the higher age group (40 years-49 years), joint family and lower education showed higher odds for protein-caloric deficiency. However, lower odd values were obtained for individuals belonging to the ≥5 family size and ≥2 dependent children categories ($p>0.05$). The multinomial logistic regression analysis further revealed that individuals belonging to the lower monthly income (≤ Rs. 4000, odds: 1.13; 95% CI 0.63-2.01), lower monthly expenditure (≤ Rs. 3000, odds: 1.60; 95% CI 0.87-2.93), low per-capita expenditure (≤ Rs. 750-1000, odds: 1.63; 95% CI 0.90-2.97) and low per-capita income (≤ Rs. 750, odds: 1.01; 95% CI 0.57-1.77) ($p>0.05$) categories exhibited higher odds ***(Table 3.41)***..

*Table 3.41: **Multinomial logistic regression model fitted on the on the socio-economic, demographic and lifestyle related variables, and the protein-caloric adequacy and protein-energy (PEM) adequacy among the Rajbanshi individuals***

Variable		*Frequency (N=302)*	*Caloric inadequacy (N=208)*			*Protein inadequacy (N=126)*			*Protein-energy deficiency (N= 118)*		
			N	*B*	*odds (95%CI)*	*N*	*B*	*odds (95%CI)*	*N*	*B*	*odds (95%CI)*
Sex	***Male ®***	153 (50.66)	84 (40.38)	-	- -	52 (51.52)	-	- -	46 (38.98)	-	- -
	Female	149 (49.34)	124 (59.62)	1.41	4.07** (2.38-6.96)	74 (58.73)	0.65	1.92** (1.21-3.05)	72 (38.98)	0.78	2.18** (1.36-3.49)
Age (in year)	***20-29 ®***	131 (43.38)	42 (20.19)	-	- -	55 (43.65)	-	- -	53 (44.92)	-	- -
	30-39	89 (29.47)	52 (25.00)	- 0.52	0.60 (0.34-1.05)	33 (26.19)	0.21	0.81 (4.69-1.42)	28 (23.73)	- 0.39	0.68 (0.38-1.19)
	40-50	82 (27.15)	64 (30.77)	0.41	1.51 (0.79-2.87)	38 (30.16)	0.18	1.19 (0.69-2.08)	37 (31.36)	0.19	1.21 (0.6-2.11)

Family Type	***Nuclear*** ®	193 (63.91)	128 (61.54)	-	- -	73 (57.94)	-	- -	68 (57.63)	-	- -
	Joint	109 (36.09)	80 (38.46)	0.34	1.40 (0.83-2.35)	53 (42.06)	0.44	1.56 (0.97-2.50)	50 (42.37)	0.44	1.56 (0.96-2.51)
Family size	≥ *4* ®	129 (42.72)	90 (43.27)	-	- -	57 (45.24)	-	- -	52 (44.07)	-	- -
	5 ≥	173 (57.28)	118 (56.73)	-0.07	0.93 (0.56-1.52)	69 (54.76)	-0.18	0.84 (0.53-1.33)	68 (57.63)	0.09	0.91 (0.57-1.45)
Dependent children	***0-1*** ®	143 (47.35)	101 (48.56)	-	- -	69 (54.76)	-	- -	63 (53.39)	-	- -
	2 ≥	159 (52.65)	107 (51.44)	-0.16	0.86 (0.53-1.4)	57 (45.24)	-0.51	0.60* (0.38-0.95)	55 (46.61)	-0.4	0.67 (0.42-1.07)
Education of Head	≤ *4*	142 (47.02)	98 (47.12)	0.01	1.01 (0.62-1.65)	59 (46.83)	-0.01	0.99 (0.62-1.56)	58 (49.15)	0.14	1.15 (0.72-1.83)
	5 ≥ ®	160 (52.98)	110 (52.88)			67 (53.17)			60 (50.85)		
Income	≤ ***4000***	136 (45.03)	92 (44.23)	-0.19	0.83 (0.45-	53 (42.06)	0.25	1.28 (0.72-	49 (41.53)	0.12	1.13 (0.63-

					1.51)			2.27)			2.01)
	4001-6000	85 (28.15)	58 (27.88)	- 0.16	0.85 (0.44-1.66)	46 (36.51)	0.86	2.36** (1.26-4.42)	42 (35.59)	0.67	0.04 (1.04-3.66)
	6001≥ ®	81 (26.82)	58 (27.88)	-	- -	27 (21.43)	-	- -	27 (22.88)	-	- -
Earning Head	*1-2*	229 (75.83)	159 (76.44)	0.11	1.11 (0.63-1.95)	89 (70.63)	- 0.48	0.62 (0.36-1.05)	82 (69.49)	- 0.56	0.57* (0.34-0.98)
	3 ≥ ®	73 (24.17)	49 (23.56)	-	- -	37 (29.37)	-	- -	36 (30.51)	-	- -
Monthly expenditure	***≤ 3000***	77 (25.5)	52 (25)	0.04	1.04 (0.55-1.95)	37 (29.37)	0.53	1.7 (0.93-3.1)	35 (29.66)	0.47	1.6 (0.87-2.93)
	3001-4500	123 (40.73)	88 (42.31)	0.23	1.26 0.71-2.22	53 (42.06)	0.33	1.39 (0.81-2.38)	48 (40.68)	0.2	1.23 (0.71-2.12)
	4501≥ ®	102 (33.77)	68 (32.69)	-	- -	36 (28.57)	-	- -	35 (29.66)	-	- -
Nature of Occupation	***Cultivator®***	167 (55.3)	116 (55.77)	-	- -	66 (52.38)	-	- -	61 (51.69)	-	- -
	Labour	135	92	-	0.94	60	0.2	1.22	57	0.24	1.27

		(44.70)	(44.23)	0.06	(0.58-1.54)	(47.62)		(0.77-1.94)	(48.31)		(0.8-2.02)
Per-capita expenditure	***≤ 750***	119 (39.4)	87 (41.83)	0.11	1.11 (0.6-2.07)	47 (37.3)	0.09	1.1 (0.62-1.95)	45 (38.14)	0.18	1.2 (0.67-2.13)
	751-1000	97 (32.12)	60 (28.85)	-0.41	0.67 (0.36-1.24)	47 (37.3)	0.46	1.59 (0.88-2.87)	44 (37.29)	0.49	1.63 (0.9-2.97)
	1001 ≥ ®	86 (28.48)	61 (29.33)	-	- -	32 (25.4)	-	- -	29 (24.58)	-	- -
Per-capita income	***≤750***	73 (24.17)	53 (25.48)	0.2	1.22 (0.66-2.27)	31 (24.6)	0.02	1.01 (0.58-1.78)	29 (24.58)	0.04	1.04 (0.59-1.84)
	751-1000	77 (25.50)	51 (24.52)	-0.1	0.91 (0.51-1.62)	31 (24.6)	-0.08	0.93 (0.53-1.62)	30 (25.42)	0.01	1.01 (0.57-1.77)
	1001≥ ®	152 (50.33)	104 (50)	-	- -	64 (50.79)	-	- -	59 (50)	-	- -

*Values in parenthesis indicates percentages, *p<0.05, **p<0.01, ® Reference Category*

CHAPTER-IV:

DISCUSSION

DISCUSSION

4.1. THE COMPARATIVE EVALUATION OF SOCIO-ECONOMIC AND DEMOGRAPHIC AND LIFE STYLE RELATED FACTORS

In the present cross-sectional study several socio-economic, demographic and lifestyle variables were also taken into consideration for the understanding of nutrition and health of the indigenous Rajbanshi population of North Bengal. As per the 2001 Census, the total population of the districts under North Bengal was 14.72 million, which was 18.35 percent of the state of West Bengal. The decennial population growth of the region (1991-2001) was 22.31% as against 17.84% in the case of the state as a whole. The region is predominantly a rural one. The districts of Cooch Bihar, Jalpaiguri and West Dinajpur are characterized by a of higher proportion of scheduled caste populations (well above the average for the state). In the districts of Jalpaiguri, and Darjeeling, 21% and 13.8% of the populations are composed of scheduled tribes as compared to the state's average of 5.60%.

In West Bengal, 27.97% and 72.03% of the populations reside in the urban and rural areas respectively (Census, 2001). The Rajbanshi constitute the second largest caste population of state of West Bengal (3,386,617 individuals; 18.4% of the scheduled caste populations) (Sen and Ghosh, 2008). In the present study, the results showed that 59.85% and 40.15% of the Rajbanshi individuals were males and females respectively ***(Table 3.1).*** According to the Census 2001, the sex ratio of the districts of Darjeeling was 943, Cooch Behar was 949, Jalpaiguri was 941, Malda was 948 and Dinajpur was 942. In the present study, 70.65 % (males: 69.23; females 70.08%) and 28.71% (males: 24.28%; females: 26.93%) of the Rajbanshi individuals were married and unmarried respectively (***Figure 3.12)***. According to the Census of 2001, 48.9% and 45.9% of the total scheduled caste populations of the state were unmarried and married (Census, 2001).

Among all the scheduled caste populations, 59% was literate, which was higher than the aggregated national average for scheduled castes in West Bengal (54.7%). The gender gap in literacy among the scheduled castes has been quite conspicuous in literacy rates with the males being more literate than the females (70.5% versus 46.9%) (Census, 2001). The districts of North Bengal were characterized by lower literacy levels (50.13% in 2001) whereas in the rest of West Bengal it was 61.7%. The Darjeeling district recorded a literacy of over 64%. The literacy rate of the Rajbanshi individuals was 60.1% (males: 72.3%; females: 47.3%) (Census, 2001). The results of the present study has however, documented a higher literacy rate of 78.67% (males: 83.23%; females: 71.87%) among the Rajbanshi individuals (***Table 3.1***). The result was also higher than the overall literacy rate of India that was 64.8% (Census, 2001) and 74% (Census, 2011). The sex specific literacy rate was however, observed to be lower than total literacy rate of the country (males: 82.1%; females: 65.5%; Census, 2011). It is evident that North Bengal is characterized by lower literacy levels (50.13% in 2001) whereas in the rest of Bengal it was 61.7%. In addition to low levels of literacy there is also marked gender disparity. The existing literature also suggested that the literacy rate was found to be low in coastal, peripheral and metropolitan areas and is high in inland and mountainous areas. These regional disparities are the products of differences in the length of educational background, age at marriage, level of urbanisation, standard of living and proportion of socially conservative and backward sections of the population (Sagar, 1989). When the level of education was taken into consideration, 11.6% total scheduled castes in West Bengal are having educational level above matriculation. In the present study, 3.38% (males: 4.84%; females: 1.2%) have higher education levels (e.g., graduation) that was lower than the Sunri (29.3%), Bagdi (4.9%) and Bauri (4.7%) of West Bengal (Census, 2001). The educational composition of main workers in the districts of North Bengal revealed a large preponderance of illiterate workers in comparison to the state of West

Bengal. The relative proportion of educated individuals (matriculate and above) in the districts of North Bengal (excluding Darjeeling) was far below the state's average. In the present study the gender disparity in education as been observed among the Rajbanshi males and females especially in the higher education level of secondary and above (60.16% vs. 52.16%) and graduation (4.84% vs. 1.20%) ***(Table 3.1 and Figure 3.3).***

According to the Census of 2001, a total of 31.9% of individuals were engaged as agricultural labourers and 20.3% as cultivators. Almost a third of their total main workers among the Paliya (38.9%), the Rajbanshi (35.1%), the Sunri (excluding Saha) (33.3%), and the Kadar (29.7 per cent) were cultivators in West Bengal. In the present study, a majority of the individuals were engaged in cultivation (39.96%) and daily labourer (24.71%) (Figure 3.5). The percentage of scheduled caste workers to total population is 38.8%, which is lower than the aggregated figure for scheduled caste at the national level (40.4%), where a total of 74% and 26% of the workers have been recorded as main workers and marginal workers respectively. It is evident that the region North Bengal has substantially larger proportion of workers in agriculture-related occupations as compared to the rest of the state. This coupled with the effect of increasing number of land-less agricultural labourers (Census 1991-2001) as compared to land-owning cultivators inhibited agricultural productivity (IAMR, 2002). The Rajbanshi is a predominantly agriculturist ethnic community. The results of the present study showed that a significant proportion of the individuals are cultivators (39.96%), followed by wage labourer (24.71%) (***Table 3.1 and Figure 3.5***). The female workers had a percentage of only 22.30%, which is quite low when compared with the males (54.4%) (Census, 2001). The results showed that the gender specific engagement of women was significantly lower than male counterparts in cultivator (21.15% vs. 52.58%) and daily labourer (14.42% vs. 31.61%) ($p<0.01$) ***(Table 3.1 and Figure 3.5)***.

Among the infrastructures that contribute to better health and quality of life, the proportion of the rural and urban households that have access to safe drinking water, toilet facilities, electricity connection and transportation facilities bear significance. Available data indicate that with respect to the 3 main civic amenities of electricity, safe drinking water and sanitation facilities, the districts of North Bengal were poorly placed in comparison to other districts of West Bengal. Being predominantly rural, the access to the infrastructural facilities remains even more limited in North Bengal. In the present study, 82.43% (males: 75.81%; females: 92.31%) and 17.57% (males: 24.19%; females: 7.69%) of the adult individuals had their own tube well or well and public and shared drinking facilities respectively ***(Table 3.1 and Figure 3.13).*** The present study has also indicated that that 51.64% and 48.36% of the Rajbanshi individuals have 'yes' and 'no' toilet facilities respectively ***(Table 3.1 and Figure 3.14)***. According to the Census of 1991, the proportion of rural and urban households with access to drinking water (rural: 36.1%; urban: 39.22%) and toilet (rural: 27.23%; urban: 69.03%) of the district of Darjeeling was poor (IAMR, 2002). A similar situation existed when the region was considered in terms of human development indicators.

In comparison to the state as a whole, the level of industrialization in North Bengal remains very low. As per the income estimates available for the year 1995-96, the per capita income in all the districts of North Bengal was far below the state's average. However, in Darjeeling, it was just below the state's average. The results of the present also suggested that the most of the individuals belonged to the Rs. 4001-6000 income category (45.17%), followed by up to Rs. 4000 income category (33.4%) and finally the >Rs. 6000 income category (21.43%) ***(Table 3.1 and Figure 3.6)***. Furthermore, the highest number of individuals comprised the Rs. 701 1400 category (61.29%) followed by the >Rs. 1400 category (20.85%) and finally up to the Rs. 700 income category (17.86%) ***(Table 3.1 and Figure 3.7)***. It has also been reported that during the period from 1990-91 to 1995-96, the per capita incomes in all the districts of North Bengal including Darjeeling have increased in the region but at a slower pace than that of West Bengal ((IAMR, 2002).

4.2. ANTHROPOMETRIC ASSESSMENT AND NUTRITIONAL STATUS AMONG THE RAJBANSHI INDIVIDUALS

4.2.1. Anthropometric variables and the assessment of nutritional status and body composition

The present study was conducted among 1036 adult Rajbanshi individuals aged 20-49 years and residing in the Darjeeling district of the state of West Bengal, India. The assessment of body composition and nutritional status was evaluated using a set of anthropometric and skinfolds measurement ***(Table 3.2)***. The mean values of weight, height, MUAC, WC were documented to be significantly higher among the males than the females ($p<0.01$), while HC, BSF, TSF, SSF, SISF were observed to be higher among the females than the males ($p<0.01$) ***(Table 3.2)***. Similar trends among the males and the females in the anthropometric measurements were reported in the existing literature. Bakr *et al.* (2002) reported the mean MUAC and TSF values to be significantly higher among the females than the males ($p<0.05$). A similar trend was reported among the Kora-Munda tribal population of Bankura district, West Bengal (Bose *et al.*, 2006c). Bose (2007) further reported that while the older Bengalee males had significantly higher mean values in height, weight and WC than the females ($p<0.001$), the mean HC was significantly higher among the females than the males $p<0.05$). In their study among the adult Santals of Birbhum district, West Bengal, Mukhopadhyay *et al.* (2009) observed the mean values of height, weight, WC, HC, MUAC and SISF to be higher among the males, while that of BSF, TSF and SSF was higher among the females. In another study among the Savar population of Odisha, Chakrabarty and Bharati (2010) reported the mean height, height, MUAC and WC to be higher among the males while the BSF, TSF, SSF and SISF was higher among the female individuals. Similar sex specific higher adiposity in skinfold measurements were also reported among adult females by Bisai *et al.* (2008) and Silva and Padez (2010).

It is evident from the results that the sex specific mean height and weight was observed to be higher among the males (162.13 ±5.65 cm and 53.43 ±6.98 kg) than the females (150.03 ±5.42 cm and 46.20 ±7.58 kg) ($p<0.01$) (***Table 3.2***). When the mean height and weight data obtained in the present study was compared with the available data from different Indian populations, it was seen that the Rajbanshi individuals exhibited significantly higher mean values. Here the studies among the Bhumij of Paschim Medinapur (males: 159.4 cm, 47.4 kg; females: 148.4 cm, 40.5 kg) by Bose and Bisai (2008), the Kora-Mudi of Bankura (males: 159.1 cm, 46.8 kg; females: 147.5 cm, 39.5 kg) by Bisai *et al.* (2008), the Lodha of Paschim Medinapur (males: 161.4 cm, 50.8 kg; females: 149.2 cm 42.9 kg) by Bisai and Bose (2008), the Oraon of Jalpaiguri (males: 158 cm, 47 kg; females: 144 cm 41 kg) by Mittal and Srivastava (2006) and the Santal of Paschim Medinapur (males: 160.5 cm, 51.7 kg; females: 149.8 cm, 43.4 kg) by Bose *et al.* (2006d). A comparative evaluation of mean height and weight of the individual belonging to different Indian populations with that obtained in the present study are depicted in ***Tables 4.1 and 4.2.*** The results of the present study suggested the existence of sexual dimorphism in height and weight ($p<0.01$). These whole body differences are complemented by major differences in tissue distribution among adults (Wells. 2007). The results further suggested that the Rajbanshi males exhibited higher UMA than the females, while the females had more peripheral distribution of fat (BSF, TSF, SSF and SISF) ($p<0.01$). Such sexual dimorphisms in anthropometric and body composition characteristics are primarily attributable to the action of sex steroid hormones, which drive the dimorphisms during pubertal development among individuals (Wells, 2007).

The measurements of weight, height and the circumferences showed a tendency to increase during the middle ages (30-39 years) and then decline in the later ages (40-49 years) ***(Table 3.3)***. It has been opined in a number of studies that such decreases were prominent in the latter age groups (Rosmond, 2004; Arlappa *et al.*, 2005; Pardo Silva *et al.*, 2006; Chakrabarty and Bharati, 2010). The decline in the stature among adult individuals is considered to be a common phenomenon (Khosla and Lowe, 1968; Brahmam, 1994). Such age-related phenomena has been shown in various anthropometric measurements and indices, and they reflected the aging process in action. This, in fact, seemed to be a universal phenomenon and not related to the differences in socio-economic status (Nikolic *et al.*, 2005; Bhardwaj *et al.*, 2006). Decline in stature is attributed to the thinning of inter-vertebral disc and flabbiness of the muscles and is manifested as change in posture and loss of collagen between the spinal vertebrae. This in turn, causes the spine to bow and shrink, leading to decrease in stature (Aiken, 1995). The existing literature also suggested that individuals belonging to higher age groups show higher mean values and more frequently higher levels of adiposity in both sexes as the amount of fat-free tissue decreases and the proportion of adipose tissue increases (Flegal *et al.*, 1998; Rosmond, 2004). The decline in body weight may be attributed to a decrease in muscle mass in response to a reduction in protein intake and is also partly due to the bones becoming lighter because of gradual mineral mass loss due to age (Verma *et al.*, 1987). Among the Rajbanshi individuals, the age specific mean values in skinfold measurements showed an increasing trend in case of BSF, TSF, SSF and SSF among both the males and the females. The age specific differences among the ages were statistically not significant among the males ($p>0.05$) but statistically significant among the females ($p<0.05$) ***(Table 3.3)***. Such increases in mean adiposity measures (e.g., BSF, TSF, SSF and SSF) can be attributed to reduced physical activity, higher intake of fat in the diet and lower energy expenditure among the individuals concerned, as opined by Ahmed *et al.* (1998), Tur *et al.* (2005), Das and Bose (2006) and Mungreiphy and Kapoor (2010).

The mean values of TUA and UMA in the present study was observed to be significantly higher among the males (44.39 ± 4.90 cm^2) that the females (40.6 ± 7.58 cm^2) (<0.01) but the UFA was significantly higher among the females (7.55 ± 2.67 cm^2) than the males (6.16 ± 1.74 cm^2) ($p<0.01$) ***(Table 3.4)***. Zverev and Chisi (2004) reported higher UMA values among rurâl Malawian females than the males, and this was attributed to the heavy agricultural and household labour done by the females. Studies have further reported significant sex differences in the upper arm indices (e.g., UMA and UFA) among different ethnic populations engaged in agriculture and non-agricultural works (Bishop, 1984; Bowen and Custer, 1984; Falciglia *et al.*, 1988; Pelletier *et al.*, 1991; Dettwyler, 1992; Chong *et al.*, 1995; Bakr *et al.*, 2002; Ghosh, 2004; Menezes and Marucci Mde, 2007; Bisai *et al.*, 2008).

Bakr *et al.* (2002) reported that the mid-arm muscle circumference of the males was significant higher than that of the females. In the present study, the mean values of TUA were documented to be higher among the males (44.39 ± 4.9 cm^2) than the females (40.6 ± 7.58 cm^2) ($p<0.01$). The upper arm composition and associated body composition suggested that the Rajbanshi female individuals were thinner when compared with the males in respect to TUA and UMA ($p<0.01$) ***(Table 3.4)***. The lower body composition among these females was probably due to the heavy agricultural works which are traditionally practiced by the Rajbanshis. The significant sex differences in the upper arm composition indices (e.g., TUA, UMA and UFA) also suggested the females to be constantly under a nutritional stress and heavy physical activity relating to agriculture ***(Table 3.4)***. The age specific mean TUA and UMA decreased with the advancement of age and was documented to be distinctly lower in. The reduction in the age specific mean TUA and UMA was observed to be

Table 4.1. Comparison of mean height and weight of the male Rajbanshi individuals with those reported from different Indian populations

Ethnic group	*N*	*Area*	*Height (cm)*	*Weight (kg)*	*BMI (kg/m²)*	*Reference*
Rajbanshi	*620*	Darjeeling, West Bengal	162.1 ± 5.7	53.4 ± 6.9	20.3 ± 2.3	Present study
Santal	*168*	Birbhum, West Bengal	160.9 ± 6.6	53.2 ± 8.6	20.5 ± 2.6	Mukhopadhyay, 2010
Mech	*141*	Darjeeling , West Bengal	164.9 ± 0.5	59.5 ± 0.7	21.8 ± 0.2	Banik *et al*., 2009
Lodha	*157*	Paschim Medinipur, West Bengal	161.4 ± 6.1	50..8 ± 7.9	19.5± 2.7	Bose *et al*., 2008
Bhumij	*161*	Paschim Medinipur, West Bengal	159.4 ± 6.7	47.4 ± 6.9	18.65 ± 2.4	Bose *et al*., 2008
Bhuiya	*50*	Odisha, Eastern India	155.9 ± 4.6	47.2 ± 4.9	19.4 ± 1.8	Chakrabarty *et al*., 2008
Gond	*99*	Odisha, Eastern India	160.6 ± 5.1	46.7 ± 4.2	18.1 ± 1.5	Chakrabarty *et al*., 2008
Khond	*100*	Odisha, Eastern India	156.3 ± 4.7	46.8 ± 4.6	19.2 ± 1.9	Chakrabarty *et al*., 2008
Munda	*50*	Odisha, Eastern India	157.2 ± 5.2	47.3 ± 4.9	19.11 ± 1.7	Chakrabarty *et al*., 2008

Ethnic group	*N*	*Area*	*Height (cm)*	*Weight (kg)*	*BMI (kg/m²)*	*Reference*
Paroja	*50*	Odisha, Eastern India	160.1 ± 5.8	44.3 ± 4.6	17.3 ± 1.8	Chakrabarty *et al.*, 2008
Ho	*50*	Bihar, Eastern India	160.2 ± 4.4	45.6 ± 5.4	17.8 ±1.7	Chakrabarty *et al.*, 2008
Dhimal	*159*	Darjeeling, West Bengal	163.3 ± 6.2	52.2 ± 70	19.5 ± 2.0	Banik *et al.*, 2007
Bhil	*401*	Central India	161.4 ± 5.5	47.6 ± 5.8	18.3 ± 1.9	Adak *et al.*, 2006
Gond	*9.4*	Central India	162.3 ± 5.6	49.0 ± 5.5	18.6 ± 1.7	Adak *et al.*, 2006
Kora-Mudi	*250*	Bankura, West Bengal	158.9 ± 6.2	47.3 ± 6.4	18.7 ± 1.8	Bose *et al.*, 2006c
Savar	*300*	Keonjhar, Odisha	159.6 ± 6.5	49.1 ± 6.5	19.3 ± 2.1	Bose *et al.*, 2006b
Santal	*213*	West Medinipur, West Bengal	160.5 ± 6.4	51.7 ± 8.6	20.0 ± 2.6	Bose *et al.*, 2006a
Oraon	*200*	Jalpaiguri, West Bengal	158 ± 6.9	47.0 ± 5.1	18.8 ± 2	Mittal and Srivastava, 2006
Bathudi	*183*	Keonjhar, Odisha	159.4 ± 6.4	46.9 ± 6.3	18.4 ± 1.9	Bose and Chakraborty, 2005

Ethnic group	*N*	*Area*	*Height (cm)*	*Weight (kg)*	*BMI (kg/m²)*	*Reference*
Dibongiya Deori	***98***	Assam, India	164.2 ± 6.4	54.1 ± 7.2	20 ± 2.1	Gogoi and Sengupta, 2002
Kalita	***100***	North East India	163.1 ± 5.7	50.5 ± 6.8	18.9 ± 2.2	Khongsdier, 2001
Kaibarta	***100***	North East India	160 ± 6.5	47 ± 6.7	18.3 ± 2	Khongsdier, 2001
Ahom	***100***	North East India	162 ± 5.6	49.3 ± 5.5	18.7 ± 1.5	Khongsdier, 2001
Kochs	***100***	North East India	162.6 ± 6.2	50.7 ± 7.7	19.2 ± 2.5	Khongsdier, 2001
Lalungs	***49***	North East India	160.1 ± 6.4	49.3 ± 6.2	19.2 ± 1.4	Khongsdier, 2001
Miris	***50***	North East India	159.3 ± 5.8	49.6 ± 5.1	19.6 ± 1.9	Khongsdier, 2001

Table 4.2. Comparison of mean height and weight of the female Rajbanshi individuals with those reported from different Indian populations

Ethnic group	*N*	*Area*	*Height (cm)*	*Weight (kg)*	*BMI (kg/m²)*	*Reference*
Rajbanshi	*416*	Darjeeling, West Bengal	150 ± 5.4	46.2 ± 7.6	20.5 ± 3.1	Present study
Santal	*317*	Purulia, West Bengal	147.5 ± 5.7	39.5 ± 5.9	18.1 ± 2.2	Das and Bose, 2012
Santal	*183*	Birbhum, West Bengal	150.5 ± 6	44.18 ± 6.9	19.5 ± 2.5	Mukhopadhyay, 2010
Mech	*142*	Darjeeling, West Bengal	152.7 ± 0.4	51.3 ± 0.8	21.9 ± 0.3	Banik *et al.*, 2009
Rajput	*150*	Uttrakhand	154 ± 5.3	46.5 ± 7.9	19.4± 3.2	Gautam and Thakur, 2009
Brahmin	*60*	Uttrakhand	152.9 ± 5.6	43.4 ± 6.3	18.6± 2.5	Gautam and Thakur, 2009
Arya	*52*	Uttrakhand	152.4 ± 4.9	46.1 ± 9.2	19.8± 3.8	Gautam and Thakur, 2009
Thakur	*100*	Madhya Pradesh	154.8 ± 5.2	47.9 ± 9.7	19.9± 5.3	Gautam and Thakur, 2009
Dhimal	*146*	Darjeeling, West Bengal	152.4 ± 6.7	44.6 ± 7.5	19.1 ± 2.6	Banik *et al.*, 2007

Heterogynous	***333***	Midnapur, West Bengal	148.2 ± 6.4	43.2 ± 8.8	19.6 ± 3.6	Bose *et al.*, 2007b
Kora-Mudi	***250***	Bankura, West Bengal	147.7 ± 5.6	40.0 ± 5.4	18.3 ± 2.1	Bose *et al.*, 2006c
Savar	***300***	Keonjhar, Odisha	148.5 ± 5.6	41.6 ± 6.5	18.9 ± 2.7	Bose *et al.*, 2006b
Santal	***197***	West Medinipur, West Bengal	149.8 ± 5.9	43.4 ± 7.1	19.3 ± 2.6	Bose *et al.*, 2006a
Bengalee	***171***	Kolkata, West Bengal	152.8 ± 5.1	49.2 ± 11	20.9 ± 4.2	Ghosh and Bandyopadhyay, 2006
Oraon	***150***	Jalpaiguri, West Bengal	144.0 ± 6.1	41.0 ± 4.8	18.7 ± 2.4	Mittal and Srivastava, 2006
Dalit women	***220***	Andhra Pradesh, South India	150.0 ± 5	40.9 ± 5.7	18.2 ± 2.2	Schmid *et al.*, 2006
Bathudi	***226***	Keonjhar, Odisha	149.2 ± 6.7	39.8 ± 6.2	17.9 ± 2.5	Bose and Chakraborty, 2005

significantly greater among the females (F ratio=11.15; d.f. 2, 415; $p<0.01$ and F ratio= 26.84; d.f. 2, 415; $p<0.01$) than the males (F ratio=1.38; d.f. 2, 619; $p>0.05$ and F ratio=3.57; d.f. 2, 619; $p<0.05$) ***(Table 3.6)***. A similar age and sex specific trend in upper arm composition variables were reported among different adult populations by Bishop (19840, Bowen and Custer (1984), Burr and Phillips (1984), Falciglia *et al.* (1988), Pieterse *et al.* (1998) and Coqueiro *et al.* (2009)

In many of the developing countries, a considerable section of the population may have a BMI below the normal range (Alemu and Lindbjorn, 1995). It was evident that the mean BMI values in the present study were considerably lower in both sexes (males: 20.31 $\pm$ 2.33 kg/m^2; females: 20.50 $\pm$ 3.03 kg/m^2: $p>0.05$) ***(Table 3.4)***. Sex difference in mean BMI values was also observed to be statistically not significant among older Bengalee Hindus (Bose, 2007). Another study (Bose *et al.*, 2006b) has reported that age was significantly negatively correlated ($p<0.001$) with BMI in both sexes among adult Savar tribal individuals of Keonjhar district, Odisha. A similar significant difference in the mean BMI was also observed among adult Kora-Mudi individuals of Bankura, West Bengal ($p<0.05$) (Bisai *et al.*, 2008). It was also been opined by Nubé and van den Boom (2003) that adult BMI values varied strongly with age and in low income countries. BMI tended to increase up to the ages of 45-50 years after which it reached a plateau or started to decrease. In the present study, the age specific mean BMI values were observed to be higher among early (20-29 years) and middle (30-39 years) ages among both sexes ***(Table 3.6)***. Use of RI was considered to be useful for understanding the relationship between different anthropometric and body composition variables and nutritional status of individuals by some researchers (Rolland Cachera, 1989; Rolland Cachera *et al.*, 1991; Omura *et al.*, 1993; Berdasco, 1994; Fujikura *et al.*, 2008; Mei *et al.*, 2002; Manios *et al.*, 2005; Gao *et al.*, 2009; Nishida and Funahashi, 2009). But the major confounding factor was the high correlation RI exhibited with weight (Rolland Cachera, 1989). In the present study, the correlation of RI with weight was also significantly high among both the males (r=0.66; $p< 0.01$) and the females (r=0.76; $p< 0.01$). However, age variations in RI was almost absent among the males (F ratio= 0.85; d.f. 2, 619; $p>0.05$) but was statistically significant among the females (F ratio=10.89; 2, 415; $p<0.01$) ***Table 3.6)***.

Several other anthropometric measures and indices were used to assess the nutritional and body composition characteristics among the Rajbanshi individuals in the present study. The concept of FFMI and FMI has been previously described as indicators of nutritional status among adults and elderly individuals (VanItallie *et al.*, 1990; Bartlett *et al.*, 1991). Traditionally, FM has been normalized by expressing data as a percentage of body mass, whereas FFM was expressed in absolute units (in kg) unadjusted for body size (Wells, 2010). Furthermore, the use of BMI does not distinguish between FM and FFM and it is known that many adults with relatively high BMI did not exhibit excess body fatness (Baumgartner *et al.* 1995; Prentice and Jebb 2001). Hence, the FM and FFM are considered to be two very important indicators for assessing nutritional status and body composition. These have been utilized in the present study. The results indicated that FM and FMI were significantly higher among the females ($p<0.01$), while FFM and FFMI were significantly higher among the males ($p<0.01$) ***(Table 3.4)***. Similar sex specific trends in body composition using FM and FFM were reported among adults of the Bathudi and Savar populations of Keonjhar, Odisha, by Bose *et al.* (2008) and adult Kora-Mudi population of Bankura, West Bengal (Bisai *et al.*, 2008). Higher prevalence of FM and FMI over FFM and FFMI among the females and children were also reported from other Indian populations by Mukhopadhyay *et al.* (2005), Chowdhury *et al.* (2007), Ghosh *et al.* (2009), Datta Banik *et al.* (2011) and Rao *et al.* (2012).

The comparison of body composition characteristics of the Rajbanshi individuals showed that the FM, FFM, FMI and FFMI were higher than those reported by Bose *et al.* (2008) among the Bathudi and the Savar, except in case of FM and FMI (among Savar males) and FMI (among Savar females). The results of the present study further suggested that the female Rajbanshi individuals had significantly higher FM (9.89 ± 2.86 kg vs. 6.16 ± 2.39 kg; $p<0.01$) and lower FFM (4.91 ± 1.03 kg vs. 9.53 ± 2.73 kg; $p<0.01$) ***(Table 3.4).*** The linear regression analysis showed an inverse relation of FM (t value: -1.197; $p>0.05$) and FFM (t value: -2.565; $p<0.05$) among the male and the female individuals respectively ***(Tables 3.11 and 3.12)***. Very low proportions of FM and high percentage of FFM were also reported among adult Oraon and Sarak females of Ranchi district, Jharkhand, India by Banik (2011).

It has been reported that lower values of FFMI among Caucasoid populations were associated with longer hospital stays (Pichard *et al.*, 2004). While considering the lower range of normal FFMI among Caucasoid individuals (Schutz *et al.*, 2002; Kyle *et al.*, 2003), cut off points of 15.1 kg/m^2 for low FFMI was obtained after allowing for height. Thus the normal range of FFMI was adjusted from 15.1 kg/m^2 to 18 kg/m^2. In addition, the corresponding range for normal FMI was adjusted to 2.9 kg/m^2 - 5 kg/m^2 for Indian populations (Khongsdier, 2005). In the present study, the individuals were categorized based on the above mentioned cut-off points. The results indicated that 35.34% of the females and 3.87% of the males in FFMI and 82.9% of the males and 10.34% of the females in FMI were observed to lie below the relevant cut off points. There is, however, the existence of limited data on Asian populations in the issue of lower BMI in respect to FMI and FFMI (Garcia and Kennedy, 1994; Yuan *et al.*, 1998; Khongsdier, 2002). However, Khongsdier (2005) reported that among the War Khasi of north-eastern India, males with a FMI of <2.9 kg/m^2 or >5

kg/m^2 would have higher risks of becoming sick than those with normal FMI (2.9 kg/m^2 - 5 kg/m^2).

Anthropometry has also been extremely useful in identifying age variations in body size and composition (Bose and Das Chaudhuri, 2003; Bose, 2002, 2007; Bisai *et al.*, 2008). Anthropometric measurements provide for an indirect assessment of body composition and are easy, non-invasive, and inexpensive to undertake. These make them ideally suited for field investigations in India (Bose and Das Chaudhuri, 2003; Bose, 2002, 2007; Bisai *et al.*, 2008). Many studies have reported effects of sex on age, anthropometric measurements and body composition characteristics from different population including those from India (Bowen and Custer, 1984; Falciglia *et al.*, 1988; Shimokata *et al.*, 1989; Miccozi and Harris, 1990; Strickland and Ulijaszek, 1993; Kuczmarski *et al.*, 2000; Bose, 2007; Bisai *et al.*, 2008). However, very few studies from India have dealt with age changes in anthropometric measurements and body composition characteristics. Here the studies of Ghosh *et al.* (2001) and Bose and Das Chaudhuri (2003) may be cited. Till date very little is known about the sexual dimorphism in age variations with respect to anthropometric and body composition characteristics among different populations of India. The present study provides unique data on age and sex differences in anthropometric and body composition characteristics and nutritional status of adult Rajbanshi individuals. The age specific mean BMI values were lower among the male and female individuals aged 40-49 years ***(Table 3.6)***. The relationship with age appeared to be in line with the generally observed pattern of increasing BMI and weight over the ages of approximately 20-49 years and decreasing BMI beyond that age, as observed by Durandhar and Kulkarni (1992) and Rotimi *et al.* (1995). Similar trends have been also reported in the studies of Gugelmin and Santos (2006), Mungreiphy and Kapoor (2010) and Livshits *et al.* (2011). The mean values of the anthropometric measures (such as

FFM, FFM, FFMI, BFMA and WHR) declined with age ***(Table 3.6)***. TUA showed a similar decreasing trend with the advancement of age ***(Table 3.6)***. This decline with age is indicative of the reduction of lean body mass among the Rajbanshi individuals.

The results of the present study also suggested that the mean values of several anthropometric measures and indices such as height, MUAC, WHR, TUA, UMA, BFMA, FFM and FFMI decreased with age among the Rajbanshi individuals. Most of the skinfold ratios such as $\sum$4SKF/BMI, BSF/$\sum$4SKF and Log10 $\sum$4SKF among the males and $\sum$4SKF, $\sum$4SKF/BMI, BSF/$\sum$4SKF and Log10 $\sum$4SKF among the females were significantly associated with age and the differences were observed to be statistically significant within the age groups in both sexes ($p<0.05$) ***(Table 3.7)***. Most of the anthropometric variables have shown significant correlations among the male and the female individuals ***(Tables 3.8 and 3.9)***. Age had significant associations with the different anthropometric variables of WHR, WHtR, FFM, weight, WC and CI (among the males) and WHR, UMA, UFA, STR, PBF, FFM, weight, TSF, BSF and RI (among the females). Banik (2007) reported that height, weight, MUAC and BMI were significantly correlated with each other ($p<0.05$). The BMI also showed significant associations with most of adiposity variables among both sexes. In the present study the adiposity indicators of TSF, RI, WHR, WHtR, PBF, FM and FMI were significantly correlated with BMI. Kusuma *et al.* (2008) reported that age was strongly correlated with WHR and CI, but not with BMI and that both WHR and CI were influenced by BMI. In the present study, age also showed significant association with WHR and CI (among the males) and with WHR (among the females. Moreover, BMI showed significant correlations with WHR, WHtR and PBF among both sexes. It was reported by Kusuma *et al.* (2008) that BMI and sex were observed to be significant contributors to variation in WHR.

Linear regression analysis was done to assess the effect of sex on the different anthropometric and body composition measures and indices among the Rajbanshi individuals. The results showed that WHtR, UFA, PBF, FM, TSF, BSF, RI and CI were significantly positively and WHR, UMA, FFM, weight, height, WC and CFR were significantly negatively associated with sex ($p<0.01$) ***(Table 3.10)***. However, STR and BMI did not show such associations with sex. In their study among the adult Kora-Mudi of Bankura, West Bengal Bisai *et al.* (2008) reported that BSF, TSF, SSF, SISF, $\sum$4SKF, FM and FMI showed positive associations ($p<0.001$) and height, weight, MUAC, BMI and UMA showed significantly negative associations ($p<0.001$) with sex.

Linear regression analysis showed significant associations of the anthropometric measures with age in both sexes ***(Tables 3.11 and 3.12)***. In case of the male Rajbanshi individuals, WHR ($p<0.01$), WHtR ($p<0.01$), WC ($p<0.01$), CI ($p<0.01$) and FFM ($p<0.05$) were showing significant positive associations, while height ($p<0.05$) and weight ($p<0.05$) showed statistically significant negative associations with age ***(Table 3.11)***. The linear regression analysis on the different anthropometric variables among adult Kora-Mudi males showed statistically insignificant association in height, weight, MUAC, TSF, SSF, SISF, BMI, PBF, FM, FMI, UMA and UFA ($p>0.05$) (Bisai *et al.*, 2008). The present study also showed statistically insignificant associations in BMI, UMA, UFA, STR, PBF, FM, TSF, BSF, RI and CFR with age among the male Rajbanshi individuals. In case of the females, UFA ($p<0.01$), PBF ($p<0.01$), TSF ($p<0.01$) and BSF ($p<0.01$) were significantly statistically positively associated, while BMI ($p<0.01$), WHR ($p<0.01$), UMA ($p<0.01$), weight ($p<0.01$), PBF ($p<0.01$) and RI ($p<0.01$) were significantly negatively associated with age ***(Table 3.12)***.

Significant linear regression coefficients was reported for age on weight ($p<0.05$), BSF ($p<0.01$), TSF ($p<0.01$), SSF ($p<0.01$), SISF ($p<0.01$), BMI ($p<0.05$), PBF ($p<0.01$), FM ($p<0.01$), FMI ($p<0.01$), and UFA ($p<0.01$) among the females of the Kora-Mudi population of Bankura, West Bengal by Bisai *et al.* (2008). In the present study, insignificant association was observed age on WHtR, STR, FM, height, WC, CI and CFR among the females ($p>0.05$). Bisai *et al.* (2008) also reported insignificant ($p>0.05$) association of age on height, MUAC and UMA among adult Kora-Mudis of Bankura, West Bengal. The significant linear associations of the anthropometric measurements and indices suggested that these were strongly dependent on age among both sexes. The results also demonstrated that age among both the males and the females was significantly negatively related with overall adiposity (BMI; $t= -1.226$ and $t= -3.909$) and all other measures of fat (STR, CFR, RI and weight). This was an indication of a strong tendency of loss in adiposity among the male and the female individuals. Moreover, significant p values (< 0.05) in the regressions of age on the different adiposity measures (BMI, WHR, WHtR, PBF, FM, FMI, UFA, STR, BSF and TSF) were suggestive of significant sexual dimorphism in age variations in anthropometric and body composition variables among these individuals ***(Tables 3.8 and 3.9)***.

Linear regression analysis was also performed to determine the association of BMI on different anthropometric measures and indices among the Rajbanshi individuals ***(Tables 3.13 and 3.14)***. The results showed that WHR, WHtR, UMA, UFA, PBF, FM, weight, TSF, WC, BSF and RI showed significantly positive linear associations with BMI among the males($p<0.01$) ***(Table 3.13)***. Among the female individuals, WHR, WHtR, UMA, UFA, STR, PBF, FM, weight, TSF, WC, BSF, RI and CFR exhibited significantly positive linear associations with BMI ($p<0.01$) ***(Table 3.14)***. Negative associations were observed with FFM (among the males) and FFM and CI (among the females) ($p<0.01$) on BMI. Height was also observed to have insignificant negative association BMI among both sexes ($p>0.05$). The significant linear associations of the anthropometric and body composition measurements and indices with BMI suggested strong dependency on BMI. Bose (2007) has reported BMI had the strongest impact on WC in both sexes but a weaker impact on WHR and CI among adult Bengalee Hindus of Kolkata, India. Similarly, Gautam and Thakur (2009) reported that regression analysis of the anthropometric variables of weight, HC, WC, MUAC and sitting height showed significant associations with BMI. In the present study, a noteworthy point was the presence of a distinct sex specific difference in the strength of the impact of BMI on WHR (t= 10.912), WHtR (t= 22.026), UMA (t= 13.646), UFA (t= 13.071), PBF (t= 11.561), FM (t= 20.427), weight (t= 39.193), TSF (t= 10.834), WC (t= 20.890), and RI (t= 83.348) among the male individuals *(Table 3.13)*, and of BMI on WC (t= 12.953), WHtR (t= 13.228), UMA (t= 11.781), FM (t= 23.731), weight (t= 40.510) and RI (t= 83.079) among the female individuals *(Table 3.14)*. The possible causes of this sexual dimorphism could lie on the differences in fat distribution and body composition induced by hormonal factors, lifestyle or gender related factors.

4.2.2. The Body Mass Index (BMI) and nutritional status

The mean BMI (kg/m^2) among the Rajbanshi individuals was observed to be higher among the females (20.50 ± 3.06 kg/m^2) than the males (20.31 ± 2.33 kg/m^2) ($p>0.05$) ***(Table 3.4)***. Comparative evaluations of mean BMI of the male and the female individual belonging to different Indian populations with that obtained in the present study are depicted in ***Tables 4.1 and 4.2***. It has been observed that the mean BMI values were higher among the Dhimal (Banik *et al.*, 2007), the Kalita (Khongsdier, 2001), the Koch (Khongsdier, 2001), the Dibongiya Deori (Gogoi and Sengupta, 2002) and the Gond (Adak *et al.*, 2006) for the males. The mean BMI values were higher among the Mech (Banik *et al.*, 2009) and the Bengalee (Ghosh and Bandyopadhyay, 2006) among the females. It is also evident that the in general, the mean BMI values were higher among the males than the females. The females exhibited a higher prevalence of thinness due to lower mean BMI values. The variations in these mean values may be attributed to many factors such as age, sex, environmental conditions, genotype, socio-economic and nutritional conditions (Eveleth and Tanner, 1990; Rolland Cachera, 1993; Khongsdier, 2001). It has also been stated that even though human populations show wide variations in height and weight as the major expression of different genetic makeup (Eveleth and Tanner, 1990) at the population level, BMI may be considered as the major expression of nutritional status rather than genetic predisposition (Rolland-Cachera, 1993).

BMI is considered to be an indicator in the assessment of both under-nutrition and over-nutrition. A number of scientific papers have focused on its potential to determine nutritional status among different populations from India (Bharati, 1989; Visweswara Rao *et al.*, 1990, 1995; Naidu and Rao, 1994; Reddy, 1998; Khongsdier, 2001, 2002, 2005; Ghosh and Bharati, 2006; Bose *et al.*, 2006a, b, c, 2007, 2009; Gautam *et al.*, 2006; Chakrabarty *et al.*, 2008; Sarkar *et al.*, 2009; Chakrabarty and Bharati, 2010). There is now a broad international consensus to accept the BMI value of <18.5 kg/m^2 as the cut-off point below which adult individuals are classified as undernourished, irrespective of their ethnic background (Nubé, 2009). This cut-off point for BMI (<18.5 kg/m^2) has been utilized for assessing under-nutrition in a number of studies (Bailey and Ferro-Luzzi, 1995; Ferro-Luzzi *et al.* 1992; Shetty and James, 1994; Naidu and Rao, 1994). Low BMI values among adults have been also associated with adverse health consequences associated with increased mortality and morbidity, and poor birth outcomes (Frisancho *et al.*, 1983; Ferro-Luzzi *et al.*, 1992; Campbell and Ulijaszek 1994; Kusin *et al.*, 1994; Hirve and Ganatra, 1994; Shetty and James, 1994; Rotimi *et al.*, 1999; Khongsdier, 2001, 2002, 2005; Sen *et al.*, 2010c; Chakraborty and Anderson, 2011).

Table 4.3. Comparison of the prevalence of chronic energy deficiency (CED; BMI<18.5 kg/m²) and public health risk assessment of the Rajbanshi individuals with those reported from different Indian populations

Ethnic group	N	Region	Prevalence of CED (%)	Public Health Risk	Reference
Rajbanshi	620	Darjeeling, West Bengal	20.8	Serious Situation	Present study
Santal	168	Birbhum, West Bengal	30.5	Serious Situation	Mukhopadhyay, 2010
Bengalee	1203	Hooghly, West Bengal	23.6	Serious Situation	Bose *et al.*, 2009
Mech	141	Darjeeling, West Bengal	77.3	Critical Situation	Datta Banik *et al.*, 2009
Lodha	157	Paschim Medinipur, West Bengal	45.2	Critical Situation	Bose *et al.*, 2008
Bhumij	161	Paschim Medinipur, West Bengal	48.4	Critical Situation	Bose *et al.*, 2008
Bhuiya	50	Odisha, Eastern India	30	Serious Situation	Chakrabarty *et al.*, 2008
Gond	99	Odisha, Eastern India	64.6	Critical Situation	Chakrabarty *et al.*, 2008
Khond	100	Odisha, Eastern India	35	Serious Situation	Chakrabarty *et al.*, 2008

Munda	50	Odisha, Eastern India	34	Serious Situation	Chakrabarty *et al.*, 2008
Paroja	50	Odisha, Eastern India	80	Critical Situation	Chakrabarty *et al.*, 2008
Ho	50	Bihar, Eastern India	70	Critical Situation	Chakrabarty *et al.*, 2008
Dhimal	159	Darjeeling, West Bengal	27	Serious Situation	Banik *et al.*, 2007
Bhil	401	Central India	61.1	Critical Situation	Adak *et al.*, 2006
Gond	9.4	Central India	51	Critical Situation	Adak *et al.*, 2006
Kora-Mudi	250	Bankura, West Bengal	48	Critical Situation	Bose *et al.*, 2006c
Savar	300	Keonjhar, Odisha	38	Serious Situation	Bose *et al.*, 2006b
Santal	213	West Medinipur, West Bengal	31.5	Serious Situation	Bose *et al.*, 2006a
Oraon	200	Jalpaiguri, West Bengal	47	Critical Situation	Mittal and Srivastava, 2006
Bathudi	183	Keonjhar, Odisha	52.7	Critical Situation	Bose and Chakraborty, 2005

Dibongiya Deori	98	Assam, East India	21.4	Serious Situation	Gogoi and Sengupta, 2002
War Khasi	575	Meghalaya, North east India	35.1	Serious Situation	Khongsdier, 2002
Kalita	100	North east India	55	Critical Situation	Khongsdier, 2001
Kaibarta	100	North east India	61	Critical Situation	Khongsdier, 2001
Ahom	100	North east India	52	Critical Situation	Khongsdier, 2001
Kochs	100	North east India	50	Critical Situation	Khongsdier, 2001
Lalung	49	North east India	34.7	Serious Situation	Khongsdier, 2001
Miri	50	North east India	34	Serious Situation	Khongsdier, 2001

Table 4.4. Comparison of the prevalence of chronic energy deficiency (CED; BMI<18.5 kg/m^2) and public health risk assessment of the Rajbanshi individuals with those reported from different Indian populations

Ethnic group	N	Region	Prevalence of CED (%)	Public Health Risk	Reference
Rajbanshi	416	Darjeeling, West Bengal	26.7	Serious Situation	Present study
Oraon	216	Ranchi, Jharkhand	62.5	Critical Situation	Datta Banik, 2011
Sarak	110	Ranchi, Jharkhand	46.4	Critical Situation	Datta Banik, 2011
Santal	317	Purulia, West Bengal	63.4	Critical Situation	Das and Bose, 2012
Santal	183	Birbhum, West Bengal	38.5	Serious Situation	Mukhopadhyay, 2010
Bengalee	1203	Hooghly, West Bengal	31.7	Serious Situation	Bose *et al.*, 2009
Mech	142	Darjeeling, West Bengal	69	Critical Situation	Datta Banik *et al.*, 2009
Rajput	150	Uttrakhand	41.3	Critical Situation	Gautam and Thakur, 2009
Brahmin	60	Uttrakhand	58.3	Critical Situation	Gautam and Thakur, 2009

Arya	52	Uttrakhand	40	Critical Situation	Gautam and Thakur, 2009
Thakur	100	Madhya Pradesh	44.2	Critical Situation	Gautam and Thakur, 2009
Dhimal	146	Darjeeling, West Bengal	46	Critical Situation	Banik *et al.*, 2007
Heterogynous	333	Midnapur, West Bengal	46.8	Critical Situation	Bose *et al.*, 2007b
Kora-Mudi	250	Bankura, West Bengal	56.4	Critical Situation	Bose *et al.*, 2006c
Savar	300	Keonjhar, Odisha	49	Critical Situation	Bose *et al.*, 2006b
Santal	197	West Medinipur, West Bengal	41.8	Critical Situation	Bose *et al.*, 2006a
Oraon	150	Jalpaiguri, West Bengal	30.7	Serious Situation	Mittal and Srivastava, 2006
Saharia	227	Rajasthan	53.2	Critical Situation	Rao *et al.*, 2006
Dalit females	220	Andhra Pradesh, South India	58	Critical Situation	Schmid *et al*, 2006
Bathudi	226	Keonjhar, Odisha	64.5	Critical Situation	Bose and Chakraborty, 2005

The mean BMI was also very significant in predicting morbidity patterns in a population (Khongsdier, 2002, 2005). Khongsdier (2002) reported that the mean BMI value among the War Khasi was 19.18 kg/m^2 for those who reported illness and 20.06 kg/m^2 for those observed to be ill.

It has been well proved that the influence of nutrition and environment on BMI was more plausible than genetics (Rolland Cachera, 1993; Khongsdier, 2001). Individuals with lean and thin body composition and low weight-surface area ratio were the characteristics of individuals living in the tropical and sub-tropical regions (Schreider, 1968). It has been reported that Asian individuals exhibited lower BMI (23.3 kg/m^2) than the White, Black and Peurto Rican ethnic populations (Wang *et al.*, 1996). In a large-scale survey conducted in 1988-1990, Naidu and Rao (1994) reported a lower mean BMI for Indian adult males (18.9 kg/m^2). Chakrabarty *et al.* (2008) reported the mean BMI values of different populations of Bihar (18.61 kg/m^2) and Odisha (18.8 kg/m^2) irrespective of social groups to be lower than that of the populations of North-eastern India (19.14 kg/m^2). The mean BMI of the Rajbanshi individuals in the present study was higher than those reported from different Indian populations by Bharati (1989), Visweswara Rao *et al.* (1990, 1995) and Reddy (1998). The mean values are also observed to be higher than those reported from different central Indian populations (18.43 kg/m^2) and south Indian adult males (17.7 kg/m^2) by Ferro-Luzzi *et al.* (1992).

The existing literature showed that the prevalence of mortality was higher among males with a BMI <17 kg/m^2 compared with those with a BMI >18.5 kg/m^2 (Khongsdier, 2002; Gautam *et al.*, 2006; Bose *et al.*, 2007; Sauvaget *et al.*, 2008). Shetty and James (1994) were of the opinion that a BMI value >18.5 kg/m^2 was compatible with good health among soldiers and females in the United Kingdom and comprising the high socio-economic class in the developing countries. It was also reported by Shetty (1984) that Indian male labourers with a BMI >17 kg/m^2 were physically fit according to standard text, although their physical capacity remained unknown.

4.2.3. Chronic Energy Deficiency (CED) based on BMI

It has been proposed by Ferro-Luzzi *et al.* (1992) that BMI alone was sufficient to define CED at the population level. The overall prevalence of under-nutrition in the present study was 23.17% ***(Table 3.15 and Figure 3.27)***. The prevalence was higher among the females (26.68%) than the males (20.81%) ($p>0.05$) ***(Figure 3.28)***. The prevalence was observed to be in the high-prevalence category (20% to 39%) and this, according to WHO (1995) is needed to be taken seriously ***(Table 2.4)***. Comparative evaluations of the prevalence of CED (BMI<18.5 kg/m2) and public health risk factors associated with the prevalence of CED among the male and female individual of different Indian populations with those obtained in the present study are depicted in ***Tables 4.3 and 4.4*** respectively. It is evident that the prevalence of CED among individuals of the different populations was quite high. The prevalence of CED was found to be higher among the females than the males. Using the WHO (1995) proposed classification for public health risk factor based on the prevalence of CED, it was observed that the situation remained critical in majority of the Indian populations. The situation among the Dhimal, the Savar, the Santal, the Lalung, the Miri and the Rajbanshi of the present study were serious.

Adak *et al.* (2006) reported the prevalence of CED among individuals belonging to different populations of central India. They documented high prevalence of CED among the scheduled castes (Khati, Koli, Kori and Mahar: 60.3%) followed by the other backward classes (Barala, Kachi, Lohar and Rawal: 51.7%), and finally the scheduled tribes (Bhil, Gond, Kol and Korku: 51.5%). The Muslims and the general caste populations (Brahmin and Rajput) showed comparatively lower prevalence of 47.5% and 43.1% respectively.

Several studies have reported significantly gender differences in the prevalence of CED among different Indian populations (Bose and Chakraborty, 2005; Bose *et al.*, 2006b; Chakrabarty and Bharati, 2010). Bose and Chakraborty (2005) reported a high prevalence of CED among the Bathudi of Keonjhar district, Odisha (57.90%). The prevalence was significantly higher among the females (64.5%) than the males (52.7%) ($p<0.05$). Banik (2007) reported the prevalence to be nearly 30% among the adult Telega males and >30.00% among the adult Telega females from Kharagpur, West Bengal. These were appreciably higher than those reported for the Rajbanshi individuals in the present study.

Banik *et al.* (2007) reported that the overall prevalence of CED to be very high (36.4%) among adult Dhimal individuals of West Bengal. They further suggested that the prevalence was significantly higher among the females (46.40%) than the females (27%) ($p <0.01$). Bose *et al.* (2006b) documented a high prevalence of CED (43.5%) among adult Savar individuals of Keonjhar District, Odisha. Similar sex differences have also been documented in the present study ***(Table 3.15 and Figure 3.28)***.

A higher prevalence of CED (55.3%) was also observed among the Kora-Munda females of West Bengal (Bisai and Bose, 2009). Chakraborty *et al.* (2009) reported the prevalence of CED to be 32.3% among adult Bengalee male slum dwellers of Kolkata. A higher prevalence of 43.5% was reported among adult Bengalees of Hooghly district, West Bengal by Bose *et al.* (2009). The overall prevalence of CED was documented to be 38.2% among adult male slum dwellers of Midnapore, West Bengal, India (Bose *et al.*, 2007).

Several researchers have reported the discrimination made against the girl child in Indian society (Ghosh, 1990; Devendra, 1995; Borooah, 2004). It is probable due to prolonged nutritional deprivation and the nutritional preferences given to the boys. Investigators have also pointed out that the males had better access to food and resources than the females (Kishor 1993; Gopaldas and Gujral, 1995). Studies conducted on rural populations indicated higher gender differences in under-nutrition among the females when compared with the males (Rousham, 1996; Miller, 1997; Yadav and Singh, 1999; Choudhury *et al.*, 2000; Bose *et al.*, 2006a; Gautam *et al.*, 2006; Banik *et al.*, 2007; Chakrabarty and Bharati, 2010).

Other significant studies documenting the nutritional deprivation among the females include those of Okojie (1994), Svedberg (1996) Miller (1997), Haddad (1999) and Adak *et al.* (2006). Osmani (1997) reported that female deprivation might well be a major determining factor for the high levels of CED, particularly in different South-Asian countries, including India. Nubé and van den Boom (2003) had opined that a high level of low BMI existed among the female individuals of South-Asia and this was a major causative factor for high levels of under-nutrition. This reflects a major public health concern and warrants special attention in respect to nutrition and health. The present study also revealed that the prevalence of under-nutrition was higher among the Rajbanshi females when compared with the males ($p>0.05$) ***(Table 3.16 and Figure 3.29)***. This can be attributed to an unequal distribution of food and resources within the family and the cultural preferences to the male child as observed by Kishor (1993). It is evident from the foregoing discussion that the prevalence of under-nutrition was a very serious public health issue among different adult Indian populations, including the Rajbanshi in the present study.

The prevalence of age specific CED grades were seen to increase with age. The prevalence was mostly observed to be higher in the ages of 40-49 years among sexes in CED Grade II and Grade III. ***(Table 3.17 and Figure 3.30)***. Banik (2011) reported that prevalence of under-nutrition and thinness (e.g., CED) increased with age among the Oraon and the Sarak females of Ranchi district. Jharkhand. The studies of Banik (2008) and Delpeuch *et al.* (1994) are also mentionable here. .

4.2.4. Different grades of CED

The majority of the undernourished Rajbanshi individuals comprised CED Grade I (17.37%; BMI 17 kg/m^2 - 18.49 kg/m^2) followed by CED Grade II (4.05%; BMI 16 kg/m^2 - 16.99 kg/m^2) and finally CED Grade III (1.74%; BMI <16 kg/m^2) ***(Table 3.17 and Figure 3.29)***. Adak *et al.* (2006) suggested that apparently healthy individuals affected with CED Grade-I could be thin but physically active and healthy. The results of the present study appear to be in agreement with this conclusion of Adak *et al.* (2006). Several researchers had also concluded that lean linear body build with a low weight-surface area ratio was one of the general features of individuals inhabiting the tropical and sub-tropical regions (Roberts, 1953; Newman and Munro, 1955; Dobzhansky, 1962; Schreider, 1968). This may be one of the reasons behind the high number of individuals with CED Grade-I in most of the Indian populations including the Rajbanshi ***(Figure 3.30)***.

Bose *et al.* (2006a) reported the prevalence of different grades of CED to be 3.3% (Grade III), 3.9% (Grade III) and 19% (Grade I) among adult Santal male individuals from Odisha. Khongsdier (2005) observed that a high prevalence of CED (26%) was still a major concern than overweight (12%) among adult War Khasi individuals of North-east India. However, the prevalence of CED in the present study was slightly lower than the War Khasi. Majority of the nutritional assessment studies in India have reported that significant proportions of the individuals were suffering from CED Grade III and CED Grade II that was significantly lower than the prevalence of CED Grade I. The comparative prevalence of CED Grade II showed that the prevalence was found to be higher among the Oraon (9.5%) (Mittal and Srivastave, 2006), the Lodha (8.3%) (Bose *et al.*, 2008), the Bhumij (6.2%) (Bose *et al.*, 2008), the Gond (13.1%) (Chakrabarty *et al.*, 2008), the Munda (12%) (Chakrabarty *et al.*, 2008), the Shabar (14.02 %) (Chakrabarty and Bharati, 2010) and the Bhil (14.5%) (Adak *et al.*, 2006) than the Rajbanshi males. The prevalence of CED Grade II was observed to be higher among the Dhimal (5.5%) (Banik *et al.*, 2007), the Oraon (8%) (Mittal and Srivastve, 2006), the Savar (18.32%) (Chakrabarty and Bharati, 2010) and the Rajput (10%) (Gautam and Thakur, 2009) when compared with that of the Rajbanshi females.

The prevalence of CED Grade III was documented to be very low among the Rajbanshi individuals (males: 0.81%; females: 3.13%). The existing literature suggested that the prevalence severe thinness was also very high among the different populations of India. The comparative evaluation of CED Grade III was higher among adult individuals belonging to the Oraon (Mittal and Srivastava, 2006), the Dhimal (Banik *et al.*, 2007), the Lodha (Bose *et al.*, 2008), the Mech (Banik *et al.* 2009) and the Savar (Chakrabarty and Bharati, 2010) populations.

4.2.5. Mid-upper arm circumference (MUAC) and nutritional status

The mid upper arm circumference (MUAC) has been extensive used for the assessment of nutritional status mainly due to its portability and universal applicability (James *et al.*, 1994; WHO, 1995). Currently, MUAC has been extensively utilized to assess nutritional status (Harries *et al.*, 1985; Siziya and Matchaba-Hove, 1994; Bern and Nathanail, 1995; James *et al.*, 1994; Collins, 1996; Ferro-Luzzi and James, 1996; Mei *et al.*, 2008). MUAC is potentially suited to screening admission to feeding centers during emergencies and its use has been recommended for different age groups and physical conditions. Here the studies of Ferro-Luzzi *et al.* (1992), James *et al.* (1994), Collins (1996), Ferro-Luzzi and James (1996), Kumar *et al.* (1996), de Onis *et al.* (1997), Roy (2000), Abidoye and Ihebuzor (2001), Gartner *et al.* (2001), Khadivzadeh (2002), Bose *et al.* (2006a), Bisai and Bose (2009), Lemma and Shetty (2009), Chakraborty *et al.* (2009, 2011) and Sen *et al.* (2010) are mentionable.

Several researches have utilized the cut-offs of James *et al.* (1994) for assessment of under-nutrition among different Indian populations. Using MUAC, the overall prevalence of under-nutrition in the present study was documented to be 40.64%. The prevalence of under-nutrition was slightly higher among the males (40.97%) than the females (40.14%) ($p>0.05$) ***(Table 3.18 and Figure 3.33)***. A comparative evaluation of the results of the present study with that reported in other studies is shown in ***Table 4.5***. Using MUAC, Bose *et al.* (2006a) reported the prevalence of under-nutrition to be 33.70% among adult Santal males from Odisha. The value was well below than that obtained for the Rajbanshi individuals in the present study. Bisai and Bose (2009) further documented a high prevalence of CED based on MUAC >22 cm (51.2%) among the female individuals from the Kora-Munda population of West Bengal.

It has now recognized that the combination of BMI with MUAC may provide a more refined classification of CED (James *et al.*, 1994; Ferro-Luzzi and James 1996; Dorlencourt *et al.*, 2000; Gartner *et al.*, 2001; Nair *et al.*, 2006; Chakraborty *et al.*, 2011), even though there may be variations in the cut-off points of MUAC due to geographical locations (Lloyd and Lederman, 2002). However, the differences in the prevalence of CED based on these 2 measurements may have certain public health implications especially when the sample size is very large. Therefore, with limited resources and with the absence of skilled manpower, MUAC still seems to be more appropriate to assess CED in populations, especially in the developing countries such as India. The present study has observed the relative risk of low BMI with low MUAC (18.5 kg/m^2) to be higher among the females (20.67%) as compared to the males (17.25%) ($p > 0.05$) ***(Table 3.19 and Figure 3.34)***.

4.2.6. Prevalence of overweight and obesity

The anthropometric indicators of BMI, WC, WHR, WHtR, PBF and skinfolds were used to assess the prevalence of overweight and obesity among the Rajbanshi individuals ***(Table 3.20)***. The prevalence of overweight and obesity was observed to be higher among the females when compared to the males using BMI ($p<0.01$), WC ($p<0.01$), WHR ($p<0.01$), WHtR ($p<0.01$), PBF ($p<0.05$) and skinfolds ($p<0.01$). Using the WHO (1995) proposed BMI cut-off of >25 kg/m^2, it was also observed that the prevalence of combined overweight and obesity was higher among the females (6.97%) than the males (3.06%) ($p<0.01$) ***(Table 3.35)***. Several researchers have earlier reported the prevalence of overweight and obesity to be higher among the females than the males (Kapoor *et al.*, 1999; Dudeja *et al.*, 2001; Misra *et al.*, 2001; Venkatramana *et al.*, 2005; Das and Bose, 2006; Masoodi *et al.*, 2010; Zargar *et al.*, 2000).

A high prevalence of overweight had been also reported among the Marwari females from Howrah, West Bengal by Das and Bose (2006) and from individuals from North-east India by Dudeja *et al.* (2001). Utilizing the NFHS (1998-1999) data, Bharati *et al.* (2007) reported lower prevalence of overweight (9.4%) and obesity (2.6%) among Indian females. Venkatramana *et al.* (2005) in their study among the Kamma, the Kaikala and the Mala populations of Andhra Pradesh documented an increasing trend of obesity while comparing their results with that reported in the earlier study of Reddy (1998). The prevalence of overweight among the Kamma was 17% (males) and 12% (females), among the Kaikala it was 14% (males) and 9% (females) and finally among the Mala it was 9% (males) and 8% females) (Venkatramana *et al.*, 2005). All these values were well above the prevalence reported among the Rajbanshi in the present study. It was further concluded by Venkatramana *et al.* (2005) that the combined prevalence of overweight and obesity was igher among the Kamma (18%) which was higher in the socio-economical scale than the Kaikala (12%) and the Mala (9%). In the present study, although the majority of the individuals belonged to a lower socio-economic group, the combined overweight and obesity were lower (male: 3.06%; female: 6.97%) than the Kaikala and the Mala individuals.

Table 4.5: Comparison of the prevalence of under-nutrition using MUAC of the Rajbanshi individuals with those reported from different Indian populations

Population	*N*	*Area*	*Under-nutrition (%)*	***Reference***
Rajbanshi	1036	Darjeeling, West Bengal	40.64	Present study
Santal	520	Purulia, West Bengal	60.38	Das and Bose, 2012
Kora Mudi	123	West Bengal, India	51.2	Bisai and Bose, 2009
Heterogeneous	333	Midnapore, West Bengal	43.5	Bose *et al.*, 2007b
Santal	332	Keonjhar District, Odisha	33.7	Bose *et al.*, 2006a

The prevalence of overall overweight and obesity based on BMI (>25 kg/m^2) in the present study was also observed to be lower than those reported for the Kashmiri population (23.69%) by Zargar *et al.* (2000) and a North Indian population (15.6%) by Misra *et al.* (2001). Bhadra *et al.* (2005) reported a higher overall prevalence of obesity and overweight of 17.45% and 37.24% among adult Bengalee Hindu females of Kolkata, India. Very recently, in their study among adult individuals belonging to the Kashmiri population, Masoodi *et al.* (2010) documented the prevalence of overweight (BMI>23 kg/m^2) to be 16.3% (males: 16.2%; females: 16.4%). They further documented the prevalence of obesity (BMI >25 kg/m^2) to be 5.1% (males: 6%; females: 2.9%) in the same population.

The existing literature showed that the prevalence of obesity was higher in the lower socio-economic groups in the developed countries when compared with that of the developing countries (Sobol and Stunkard, 1989; Randrianjohany *et al.*, 1993; Hossain *et al.*, 2007; WHO, 2003). It is being observed that the prevalence of overweight and obesity is now increasing in a rapid rate in many of the developing countries, including India (WHO, 2002, 2003). The experience of the developed countries clearly demonstrates that the cost of morbidity and mortality associated with increasing obesity and related non-communicable diseases would be overwhelming for the developing countries (WHO, 2000). It has been indicated that urbanization, availability of processed and fast foods, less physical activity and consumption of more energy density foods have led to overweight and obesity in the developing countries (WHO, 2002, 2003; Bell *et al.*, 2002; Popkin 2002; Hossain *et al.*, 2007). The Indian urban population is now showing an increased prevalence of obesity when compared with that of the rural areas (Gopinath *et al.*, 1994; Venkatramana and Reddy 2002; Subramanian and Smith, 2006; Bharati *et al.*, 2007; Subramanian *et al.*, 2007). Although the prevalence of under-nutrition remained a major public health concern in India (Visweswara Rao *et al.*, 1990, 1995; Naidu and Rao, 1994; Reddy, 1998; Khongsdier, 2001, 2002, 2005; Bose *et al.*, 2006a,b,c; Bharati *et al.*, 2007; Bisai and Bose, 2009; Chakrabarty and Bharati, 2010). Indian populations have shown increases in the prevalence of overweight and obesity during the last two decades (Gopalan, 1998; Das and Bose, 2006; Bharati *et al.*, 2007; Sadhukhan *et al.*, 2007; Mungreiphy and Kapoor, 2010). The existing literature has also reported that the prevalence of overweight and obesity has been markedly increasing among the female individuals comprising the economically better off segment of the population in urban India (Zargar *et al.*, 2000; Griffith and Bently 2001; Sidhu and Tatla, 2002; Misra *et al.*, 2001; Subramanian and Smith, 2006; Subramanian *et al.*, 2007; Mungreiphy and Kapoor, 2010; Masoodi *et al.*, 2010).

It has been opined by Osmani and Sen (2003) that higher BMI is associated with an increased risk of chronic diseases during adulthood. The co-existence of under-nutrition and over-nutrition in this country could also be attributed to the consequences of the maternal surrounding environment and socio-economic status. Overweight and obesity can also lead to an increase in the prevalence of non-communicable diseases such as hypertension and diabetes (Hossain *et al.*, 2007). These issues have been highly debated at higher ends of the BMI range where overweight and obesity were associated with degenerative disorders (James *et al.*, 2001). Hence, the co-existence of overweight and obesity among the Rajbanshi individuals has the potential to lead to non-communicable diseases during the later ages.

The WHO Regional Office for the Western Pacific Region (WHO, 2000), International Association for the Study of Obesity (IASO) and the International Obesity Task Force (IOTF) have now recommended new cut-offs for defining overweight (BMI $\geq$23 kg/m^2) and obesity (BMI $\geq$25 kg/m^2) for the Asian populations. However, several studies have indicated that at the higher end of the BMI range, significant ethnic differences existed in body composition between individuals of African, Asian and Caucasoid descent (Snehalatha *et al.*, 2003; Wang *et al.*, 2003). Some studies have also questioned the validity of BMI as an indicator of fatness because it lacked the specificity in terms of variations in body composition and effects of age, sex, and ethnicity (Norgan, 1994; Wagner and Heyward, 2000; Frankenfeild *et al.*, 2001; Prentice and Jebb, 2001; Kyle *et al.*, 2003).

4.2.7. The assessment of regional adiposity

Sexual dimorphism in body fatness has important implications for both clinical and epidemiological research in adiposity (Paeratakul *et al.*, 1999). The presence of higher body fatness among the females is a fundamental aspect of sexual dimorphism in humans (Brown and Konner, 1987; Paeratakul *et al.*, 1999). The present study has indicated that with the exception in BMI, the mean adiposity using BMI, UFA, PBF, FM, FMI, PBF-BMI ratio and WHtR was observed to be significantly higher among the females than the males ($p<0.05$) ***(Table 3.4)***. The mean values of these adiposity indicators were observed to be below than that reported from a population from North-eastern India by Dudeja *et al.* (2001) and Howrah, West Bengal by Das and Bose (2006). The mean values of WHR, FFM, UMA, and FFMI were however, higher among the male Rajbanshi individuals. The results also showed that mean FFM was higher among the males as compared to the females. The mean PBF-BMI ratio was also higher among the males than the females ($p<0.05$) ***(Table 3.4)***. In general, the results were in conformity with those reported by Dudeja *et al.* (2001) and Das and Bose (2006). The existence of such trends in body composition and adiposity indicators is related to sexual dimorphism.

The WHR is considered to be a good indicator for the assessment of abdominal fat accumulation and this again has been shown to reflect changes in risk factors for chronic heart disease (CHD) and other forms of chronic non-communicable diseases (Valdez *et al.*, 1993; Gupta and Majumder, 1994; Taylor *et al.*, 1998; Kaur and Mogra, 2006; Ghosh and Bandyopadhyay, 2007; Huxley *et al.* 2008; Mungreiphy *et al.*, 2012). Using the suggested cut-off values (>0.9 cm for males; >0.8 cm for females) (Webb, 2000; Huxley *et al.*, 2008), the present study reported that the prevalence of abdominal obesity to be higher among the females (81.73%) than the males (40%) ($p<0.01$) ***(Tables 3.24 and 3.25)***. Using WHR, a high prevalence (42.39%) of regional adiposity was also reported among the Bengalee Hindu female individuals of Kolkata by Bhadra *et al.* (2005). Masoodi *et al.* (2010) reported the overall prevalence of abdominal obesity among a Kashmiri population to be 9.5%, which was significantly higher among the females as compared to the females (27.6% vs.1.8%; $p<0.01$). Venkatramana *et al.* (2005) observed the prevalence of abdominal obesity to be low (3% to 18%) among both sexes among the Kamma, the Kaikala and the Mala populations of Andhra Pradesh. However, they utilized the higher cut-offs of 1 cm for the males and 0.85 cm for the females as specified by WHO (1998). Recently, Sarkar *et al.* (2009) reported high levels of abdominal obesity among adults belonging to a Kayastha population in North Bengal. The results of the present study have depicted higher levels of adiposity when compared to these studies.

Another convenient simple measure unrelated to height which correlates closely with BMI and WHR (indices of intra-abdominal fat mass and total body fat) is WC. It has been observed in the present study that WC was significantly correlated with BMI and WHR among both the males ($r = 0.64$ and $r = 0.64$) and the females ($r = 0.54$ and $r = 0.62$) ($p<0.01$) ***(Tables 3.8 and 3.9)***. Regional adiposity was evaluated using WC and the cut-off points of >90 cm for the males and >80 cm for the females, as recommended by WHO (2000). The overall prevalence of regional adiposity was 6.56% (males: 1.17%; females: 13.7%) ***(Table 3.20)***. A very high prevalence of regional adiposity (55.15%) was reported among adult Bengalee Hindu females by Bhadra *et al.* (2005). In a recent study, Sarkar *et al.* (2009) documented a significantly high level (96%) of regional adiposity among adults belonging to a Kayastha population of North Bengal. A very low prevalence of regional adiposity (males: 3.8%; females: 12%) was observed by Masoodi *et al.* (2010). All these values were distinctly higher than those obtained for the Rajbanshi males (1.77%) and the females (13.7%).

Excess adiposity was assessed using the cut-offs of PBF, as suggested by Pollock and Wilmore (1990). It has been reported by Deurenberg *et al.* (1991) that adult males and females having a BMI of 30 kg/m^2 exhibited a body fat of 25% (for the males) and 30% (for the females). These cut-off values have been successfully utilized by researchers to assess excess adiposity among different Indian populations (Dudeja *et al.*, 2001; Bhadra *et al.*, 2005; Das and Bose, 2006). It is apparent from present study that the overall prevalence of higher adiposity was 0.87% (N = 9) which was significantly higher among the females (1.68%) than the males (0.32%) ($p<0.05$) ***(Table 3.20 and Figure 3.35)***. Excess PBF, which is a measure of overall obesity, showed a high prevalence of 36.53% among the Bengalee Hindu population (Bhadra *et al.*, 2005). Dudeja *et al.*, (2001) also reported a very high prevalence of obesity using PBF among an adult population of North India. Das and Bose (2006) reported a very high prevalence of adiposity (males: 90.9%; females: 97.3%) among the Marwari population. The overall adiposity in the present study was significantly lower when compared to those obtained in the above-mentioned studies.

4.2.8. Percent of body fatness related to risk factors and body fitness assessed using percent of body fat

Research has indicated that individuals who exhibit excessive body weight and body fat show an increased prevalence of cardiovascular diseases, diabetes and cancer (WHO, 1990; Manson *et al.*, 1995). Several studies have reported the association between body fatness and disease risk factors with BMI among different Indian populations (Zaadstra *et al.*, 1993; Misra *et al.*, 2001, 2003, 2004; Bose *et al.*, 2003; Ghosh and Das Chaudhuri, 2005; Ghosh *et al.*, 2006; Ghosh and Bandyopadhyay, 2007). It has been reported by Durnin and Womersley (1974), Gibson (1990), Neiman (1995) and Lee and Neman (2005) that body composition, anthropometric dimensions and morphological characteristics play vital roles in the determination of body fatness. These parameters are sensitive indicators of growth progress and nutritional status of a population and are ultimately relevant to the specific event in which the individual excels (Chatterjee *et al.*, 2006; Wilmore and Costill, 1999). The observations in the present study reflected lower fatness among the Rajbanshi individuals engaged in agriculture.

Total body fatness as determined by PBF is considered to be a risk indicator of cardiovascular disease in adulthood. Sexual dimorphism in fat patterns that appear to be related to differential changes in body composition is reflected during the onset of puberty. These findings have important public health implications given the recent evidence linking it to increased risks of obesity and morbidity in adulthood. In the present study, gender differences fat distribution based on the PBF was evaluated using the body fitness scale proposed by Neiman (1995) and Lee and Neiman (2005). It has been observed that majority of the individuals comprised the risky body fitness category (males: 64.68%; females: 32.93%) ($p<0.01$) ***(Table 3.26)***. The sex specific prevalence of fair (2.58% versus 16.35%) and good (15.81% versus 27.16%) body fitness was low among the male and the females (***Figure 3.40)***. However, the sex specific prevalence in body fitness in fair and good categories were found to be statistically significant ($p<0.01$) ***(Table 3.26)***. When the age and sex specific body fitness pattern was taken into consideration, the prevalence of risky body fitness was observed to increase in the higher age groups among both sexes. The increase of risky body fitness pattern is attributed the corresponding decrease of PBF with the advancement of age among both sexes. Several studies have reported the similar trends showing the decreasing of PBF with age among adults in developing countries including India (Flegal *et al.*, 1998; Rosmond, 2004; Das and Bose, 2006).

4.2.9. Effect of the socio-economic, demographic and lifestyle-related variables on nutritional status

The poor demographic, socio-economic and environmental conditions are related to under-nutrition, which is defined as BMI < 18.5 kg/m^2 (James *et al.*, 1988; Ferro-Luzzi *et al.*, 1992; James *et al.*, 1994; WHO, 1995; Ferro-Luzzi and James, 1996; Ahmed *et al.*, 1998; James *et al.*, 1999; Khongsdier, 2001, 2005; Subramanian and Smith, 2006; Subramanian *et al.*, 2007; Azmi *et al.*, 2009; Chakrabarti and Bharati., 2010). In the present study, multinomial logistic regression analysis was done to assess the effect of different socio-economic, demographic and life style related variables with CED (BMI<18.5 kg/m^2) among the Rajbanshi male and female individuals ***(Tables 3.34 and 3.35)***. Several studies have reported that the females residing in rural environments were more vulnerable to under-nutrition than the males (Ferro-Luzzi *et al.*, 1990; Zerihun *et al.*, 1997; Nubé *et al.*, 1998; Teller and Yimar 2000; Arlappa *et al.*, 2005). It has also been observed that in India 31% of the females exhibit a high prevalence of nutritional deficiency (BMI < 18.5 kg/m^2) and that most of them resided in the rural areas and belonged to illiterate scheduled caste and schedules tribe populations with low standards of living indices (IIPS and ORC Macro, 2000). The present study has also observed that the prevalence of under-nutrition was higher among the females when compared to the males ($p>0.05$) ***(Table 3.15 and Figure 3.28)***. The results of the present study has showed that age had a significant effect on the prevalence of CED as the odd values were observed to be higher among the male individuals aged 40-49 years (odds: 1.48; 95% CI: 0.94-2.33; $p>0.05$). The two time higher odds values were found to be higher in 30-39 years (odds: 2.05; 95% CI: 1.21-3.48; $p<0.01$) and 40-49 years (odds: 2.02; 95% CI: 1.18-3.45; $p<0.01$) among the females. Ahmed *et al.* (1998) reported that rural females aged more than 35 years were twice as likely to have a BMI < 18.5 kg/m^2 compared with younger females from Bangladesh. Kabir *et al.* (2006) reported that age had a negative impact on nutritional status among adult individuals of Bangladesh (Kabir *et al.*, 2006).

Subramanian and Smith (2006) suggested a positive association between nutrition and socio-economic status. This is a characteristic of the early stages of socio-economic and nutritional transitions in the developing countries such as India. The results in the present study support the fact that the prevalence of CED is of primary significance among the tribal and rural populations of India, as opined by Naidu and Rao (1994) and Reddy (1998). This can be attributed to the country's immense population size, socio-economic disparities insufficient resources, faulty feeding practices, poor economic conditions and poor health care facilities (Mondal and Sen, 2010a). It has also been suggested that higher adiposity and BMI were associated with income and standard of living in the developing countries such as India (Delpeuch *et al.*, 1994; Nubé *et al.*, 1998; Khongsdier, 2002; Subramanian *et al.*, 2007; Chakraborty *et al.*, 2009). The multinomial logistic regression analysis suggested that lower monthly income was strongly associated with a higher prevalence of CED in both sexes among the Rajbanshi individuals ***(Tables 3.34 and 3.35)***. The association was significantly three-fold (odds: 3.03; 95% CI: 1.54-5.98; $p<0.01$) and two-fold (odds: 2.03; 95% CI: 1.04-4.01; $p<0.01$) among the female individuals belonging to lower (<Rs.4000/-) and middle (Rs.4000/- - Rs.6000/-) income groups ***(Table 3.35)***. The results further suggested that the odds values were more than 1.5 times higher among the male individuals belonging to lower (odds 1.73; 95%CI 0.97-3.08; $p>0.05$ in <Rs.4000/-) and middle (odds 1.60; 95%CI 0.92-2.77; $p>0.05$ in Rs.4000/- - Rs.6000/-) income groups. Bose *et al.* (2009) reported that adult individuals belonging to the lowest family income group had the lowest mean BMI (19.1 kg/m^2) and the highest rate of CED (46.3%), while those comprising the highest family income group had the largest mean BMI (20.8 kg/m^2) and lowest rate of CED (30.2%).

Similar conclusions were also made for adult slum dwellers of Kolkata (Chakraborty *et al.*, 2009) and Malaysian adults (Azmi *et al.*, 2009). The present study is also in agreement with other studies (Bose *et al.*, 2007a) with respect to the fact that the prevalence of CED was observed to be higher among the individual belonging to lower income groups (males: 23.23%; females: 34.46%) than those in the higher income groups (males: 14.93%; females: 14.77%) ***(Table 3.30 and 3.32)***.

It has also been observed that the Rajbanshi individuals comprising the high monthly expenditure category (>80% from income) were more susceptible to under-nutrition. The association was statistically significant in case of the males (odds: 1.75; 95% CI: 1.16-2.62; $p<0.05$), but insignificantly among the females (odds: 1.55; 95% CI: 1.00-2.42; $p>0.05$) ***(Tables 3.34 and 3.35)***. Those male and female individuals belonging to the lower and middle monthly income and per capita income groups showed higher risk factors to being affected by under-nutrition than those from the higher monthly income and per-capita income groups. In fact, the females constituted a significant double risk factor group (Rs. 701-1400; odds: 2.21; 95% CI: 1.22-3.99; $p<0.01$). It has been reported by Nubé *et al.* (1998) that per capita income and expenditure exhibited highly significant positive associations with BMI among adults ($p<0.001$) and that the cash expenditures were stronger correlated with adult BMI than the total expenditures. Therefore, monthly per capita income and high expenditure were very important in the assessment of under-nutrition among the Rajbanshi population.

The multinomial logistic regression analysis indicated that occupation had a pronounced effect on the prevalence of under-nutrition among the Rajbanshi individuals. The results suggested that the 'others' occupation category (odds: 1.19; 95% CI 0.69-2.03 $p>0.05$) and 'cultivator' (odds: 1.00; reference group) among the males and 'cultivator' (odds: 1.12; 95% CI 0.66-1.92; $p>0.05$) and labour (odds: 1.03; 95% CI 0.55-1.94) among the females exhibited higher odds for under-nutrition. The heavy agricultural work of the Rajbanshi individuals required more daily energy among both sexes. As a consequence, the individuals of the 'cultivator' group were more nutritionally vulnerable than the others. Gautam (2008) reported that the prevalence of CED was the highest (72%) among the different caste earning groups living as daily wage labourers in central India. In the present study, a significant proportion of the individuals (males: 19.9%; females: 26.67%) belonging to the labourer groups were suffering from CED ***(Tables 3.30 and 3.32)***. Arlappa *et al.* (2009) reported that the prevalence of CED was higher among the agricultural and non-agricultural labour and for marginal or small farmers among the Indian adults. Naidu and Rao (1994) reported that the mean BMI values were lower among the landless agricultural occupational groups and in the low per capita income households when compared with the artisans and the higher income groups in India. The females were more affected by under-nutrition as they had to perform both the heavy agricultural duties and also the household chores. Lukmanji (1992) had aptly described the rural female in the developing countries as bearing the burden of a 'double day' in order to fulfill both their working roles. Rao *et al.* (2010) went on to report that in India, females engaged in farming had a similar domestic workload as that of non-farming females. Barker *et al.* (2006) observed that the male and the female individuals from farming households in India were thinner than those who were engaged in other occupations. They further stated that the females engaged in farming or agricultural-related work, spent more time than their male counterparts and in addition also performed a majority of the household chores. A study conducted in Ghana also showed that farming had a strong negative effect on female BMI (Higgins and Alderman, 1997).

The present study has also observed that land holding pattern had a significant effect on CED. Female individuals belonging to the '<2.5 acre' and '>2.5 acre' land holding categories showed almost similar odds values with respect to under-nutrition. It was concluded by Barker *et al.* (2006) that the females belonging to larger land holding group were thinner than those who owned less land and that land holding patterns seemed to have a negative effect on their BMI. It has also been documented that joint families were associated with adverse health outcomes in children and young females (Das Gupta, 1999, Bloom *et al.*, 2001). The present study has observed that female individuals belonging to the joint or extended families had a significantly lower odd value with CED (odds: 0.56; 95% CI: 0.33-0.95; $p<0.05$) than those from the nuclear families. However, a higher odds value was found among the males belonging to the joint or extended families (odds: 1.26; 95% CI: 0.83- 1.93; $p>0.05$) ***(Table 3.34)***. It was reported that in rural India, males and females belonging to the joint families were thinner than those from the nuclear families (Barker *et al.*, 2006). The present study has also observed that family size appears to also be a determinant factor for under-nutrition in both sexes among the Rajbanshi population. The odd values for the individuals belonging to the large family size (≥ 7 members) showed significantly higher association among the males (odds: 1.32; 95% CI: 0.76- 2.28; $p>0.05$). It has been reported by Gautam and Thakur (2009) that family size had a significant impact on low BMI status among adults.

It has also been suggested that SES appeared to be an important determinant for under-nutrition in populations (Delpeuch *et al*, 1994; Reddy, 1998; Ahmed *et al.*, 1998; Subramanian and Smith, 2006; Faruque *et al.*, 2006; Bharati *et al.*, 2007; Subramanian *et al.*, 2007; Bose *et al.*, 2009; Chakabarty and Bharati, 2010). The SES of the individuals in the present study was evaluated using the modified scale of Kuppuswami (Mishra and Singh, 2003; Kumar *et al.*, 2007). The results reported a 3-times higher odds value (odds: 3.35; 95% CI 1.39-8.06; $p<0.01$) associated with under-nutrition among the female Rajbanshi individuals belonging to a lower SES. This indicated that the females of the lower SES were significantly at risk to suffer from under-nutrition ***(Table 3.35).*** A study from Bangladesh showed that better-off females were observed to have 0.77 times lower odds to be affected by CED when compared with the females from poor households (Ahmed *et al.*, 1998). Furthermore, the odds value in the present study was also higher among the male individuals belonging to a lower SES (odds: 1.42; 95% CI 0.96-2.09; $p>0.05$). Studies have reported that the mean BMI values were higher among individuals belonging to a higher SES than a lower SES (Reddy 1998; Faruque *et al.*, 2006; Subramanian *et al.*, 2007). Subramanian and Smith (2006) and Subramanian *et al.* (2007) have reported very clear associations of SES with nutritional status among females of low socio-economic positions in India. The pattern found in the present study was also consistent with the studies of Reddy (1998) and Shukla *et al.* (2002) which showed similar associations between SES and under-nutrition.

The present study also assessed the standard of living conditions using house types and living conditions. It has been reported by Nubé *et al.* (1998) that adult BMI was considered to be a useful indicator for the standard of living. Chakraborty *et al.* (2009) reported that the prevalence of CED was significantly higher in the bamboo-fenced houses (i.e., non-bricked) among the adult slum dwellers of Kolkata. In the present study, higher proportions of the adult individuals (males: 23.19%; females: 29.63%) having non-bricked house type were suffering from under-nutrition (***Table 3.30 and 3.32***). Those individuals belonging to low to medium household living conditions exhibited significantly higher odds for the males (odds: 1.7; 95% CI: 1.1-2.6) and the females (odds: 1.74; 95% CI: 1.09-2.8) to be undernourished (e.g., with CED) than those from the higher living condition category ($p<0.05$). The results of logistic regression analysis further indicated that the odds value for individuals living in non-bricked houses were higher among the males (odds: 1.48; 95% CI

1.12-3.01; p>0.05) and the females (odds: 2.16; 95% CI: 1.18-3.95; p<0.05) ***(Tables 3.34 and 3.35)***. The results further suggested that the Rajbanshi individuals having 'no toilet facility' had significantly higher odds values among the males (odds: 1.63; 95% CI: 1.08-2.45; p<0.05) and the females (odds: 1.61; 95% CI: 1.02-2.54; p<0.05) ***(Table 3.34 and 3.35)***. Hence, house type, living conditions and toilet facilities play a significant role in the prevalence of under-nutrition.

It had been suggested that there was a negative relationship between a female's higher level of education and the proportion of undernourished females (Berdasco, 1994; Ahmed *et al.*, 1998; Teller and Yimar 2000). Bharati *et al.* (2007) also reported that education, especially among females, was one of the regulatory factors enhancing the awareness of health and hygiene in the society and that the nutritional status of females went together with the enhancement of their educational status and standard of living. In the present study, higher prevalence of CED was observed in the 'illiterate' education category (males: 24.04%; females: 32.48%) (***Tables 3.30 and 3.32***). It was also observed that the Rajbanshi individuals comprising the 'illiterate' education category were more susceptible to under-nutrition (*e.g.*, CED) than those of the higher educational levels. The odd values were documented to be higher among both the males (odds: 1.23; 95% CI: 0.74-2.07; p>0.05) and the females (odds: 1.39; 95% CI: 0.85-2.27; p>0.05) (***Tables 3.34 and 3.35***). Bose *et al.* (2009) reported significantly higher rates of CED (p< 0.001) associated with individuals having 'no formal education' among Bengalee males and females. Berdasco (1994) reported that the lower educational levels were directly related to higher percentages of CED among Cuban female individuals. A similar study showed that rural females who received one or more years of formal education were nearly half as likely to suffer from CED as those with no schooling in Bangladesh (Ahmed *et al.*, 1998).

4.2.10. Effect of socio-economic, demographic and lifestyle-related variables on overweight and obesity

Overweight and obesity continues is considered to be serious chronic conditions that contribute to numerous preventable non-communicable diseases such as hypertension and diabetes. During the last few decades, obesity has been increasing at an alarming rate in both the developed and developing nations (Popkin, 2001, 2002; York *et al.*, 2004; Tur *et al.*, 2005; Hossain *et al.*, 2007). The development of obesity is usually attributed to genetic predisposition, although the development of epidemics among populations around the world suggested that environmental risk factors were also some of the promoting variables (Tur *et al.*, 2005). A number of biological, demographic, socio-cultural and behavioural factors are associated with overweight and obesity but their determinants in particular populations are often different. The important factors influencing body fatness are demographic (*e.g.*, sex and ethnic origin), biological (*e.g.*, genetic background and menopausal effect), socio-cultural (*e.g.*, education, marital status and number of children) and behavioural (*e.g.*, dietary habit, alcohol intake, smoking habit and physical activity) (Seidell and Flegal, 1997). These are apart from the most frequently presented factors of unemployment, long term physiological and socio-economic stress, smoking during pregnancy and television watching (Lobstein *et al.*, 2004; Rosmond, 2004; Tur *et al.*, 2005).

It has also been suggested that individuals from both the developed and developing countries consume more quantities of high energy foods and have less physical activity. This has resulted in a substantial increase in the number of overweight and obese individuals (WHO, 2002). It has been also observed that susceptible individuals were often exposed to a lifestyle characterized by less physical activity, an abundant availability of energy dense, high fat and palatable foods and inappropriate meal patterns (WHO, 2000). A review of the different cross-sectional studies that focused on effect of socio-economic status with obesity showed that obesity was a health problem mostly among individuals of the higher socio-economic groups in the developed countries and also remained the highest among the lower socio-economic groups (Sobal and Stunkard, 1989). However, the picture has changed radically during the past two decades as the rates of obesity have tripled in the developing countries (Hossain *et al.*, 2007). Data from the developing countries suggested that the shift in the incidence of obesity was more towards the poorer groups and tended to be greater among the females than the males (Subramanian and Smith, 2006; Monteiro *et al.*, 2007; Subramanian *et al.*, 2007). A substantial amount of studies have been shown a positive effect of SES on weight gain, overweight and obesity among the adult populations of both the developed and the developing countries (Grol *et al.*, 1997; Griffiths and Bentley, 2001; Sichieri *et al.*, 2003; Subramanian and Smith, 2006; Bharati *et al.*, 2007; Shafique *et al.*, 2007; Subramanian *et al.*, 2007)

The prevalence of overweight and excessive thinness have also been simultaneously reported among the populations from India Brazil, China and Russia, countries that constitute the 4 largest economically developed nations (Kapoor and Anand, 2002). All these nations had presented several levels of transitions in health, economy, demography, society and environment. The economic transition has its effect on all segments of the population and was likely be the strongest factor involved in the rise of overweight and obesity. Of course, there were specific factors that differed from one region or nation to another. Using WHtR, the present study has reported significant lower odd values the females belonging to the 'cultivator' (odds: 0.33; 95% CI 0.17-0.61; $p<0.01$) and 'labour' (odds: 0.38; 95% CI 0.19-0.74; $p<0.01$) occupational groups when compared to the 'housewife' category ($p<0.01$) ***(Table 3.35)***. In the developing countries such as India, lower education levels may be associated with high unemployment or low paid jobs that are labour extensive. It has been postulated that in the countries in transition, less educated individuals people were engaged in labour intensive occupations and those having higher education exhibited a more sedentary lifestyle (Shukla *et al.*, 2002; Tur *et al.*, 2005).

The present study has explored the effects of different related factors with the prevalence of overweight and obesity utilizing two regional adiposity indices (WHR and WHtR). The BMI was not taken into consideration because of the prevalence of a lower level (4.63%) of central adiposity (BMI $\geq$25 kg/m^2) than the regional adiposity (56.76% and 21.14% using WHR and WHtR respectively) among the Rajbanshi individuals ***(Table 3.20)***. It is conjectured that for an effective management of the overweight and obesity, the needs were to establish the social, cultural, environmental, economic, and educational factors involved in the populations concerned (Martínez *et al.*, 1999). The independent effects of SES on overweight and obesity has been reported among adults by Proper *et al.* (2007). Subramanian and Smith (2006) have highlighted that the higher prevalence of overweight among higher socio-economic groups could be partially explained by the possible indifferent body composition among the younger adults, and socio-economic status was positively related to being pre-overweight, overweight, and obese among the individuals. It has also been observed that the consumption of energy from fats was significantly more in the higher income groups (32%) as compared with the lower income groups (17%) (Shetty, 2002). Grol *et al.* (1997) reported that the comparison to women of higher SES, the lower SES women have a two to three times higher risk of regional adiposity (e.g., WHR or WC) exceeding the cut-off points.

A multinomial logistic regression analysis was performed to assess the risk factors associated with higher levels of adiposity among the Rajbanshi individuals. Several socio-economic, demographic and lifestyle-related factors were significantly associated with regional adiposity in both sexes ***(Tables 3.34 and 3.35)***. The odds in the 'labour', '≥3 dependent children', 'joint or extended family', 'married' and 'non-bricked house type' categories were significantly associated with higher levels of adiposity assessed using WHR ($p<0.05$). Significant associations in respect to the odd values were also observed in 'married', 'lower socio-economic', 'high monthly income' and 'high expenditure' categories among the male Rajbanshi individuals using WHtR. A higher educational level has been associated with healthier dietary pattern and a decrease in the prevalence of obesity (Rasheed, 1998). Bharati *et al.* (2007) had observed that female occupation and education status had strong roles to play in the family health. The present study also suggests that higher odds were associated with individuals belonging to lower education levels ('illiterates' and 'literate to primary') among both sexes. Studies have also reported that education had an inverse effect with weight gain and prevalence of obesity (Martínez *et al.*, 1999; Machado and Sichieri, 2002; Gutiérrez-Fisac *et al.*, 2002; Olinto *et al.*, 2006). Shafique *et al.* (2007) reported that rural females with at least 14 years of education showed an 8.1 fold increased risk of being overweight as compared with non-educated women in Bangladesh. In the present study, utilizing WHR and WHtR, the odds of being overweight and obese were significantly higher among the females belonging to the 'illiterate' (odds: 2.54; 95% CI: 1.3-5; $p<0.01$) and 'upto primary' (odds: 1.85; 95% CI: 1.08-3.17; $p<0.05$) categories. An increase in the prevalence of obesity was observed as the level of education decreased. Recently Azmi *et al.* (2009) reported that the prevalence of higher adiposity (e.g., overweight) was the highest for those individuals with primary education. Utilizing WHtR, it has been reported that lower prevalence of regional adiposity existed among the adult females with >12 years of education (odds: 0.63; 95% CI: 0.47-0.85) (de Sousa *et al.*, 2011). A similar study with regard to education among the Korean females showed significantly decreased odds with inverse trends for abdominal obesity across all education levels (Yoon *et al.*, 2006). A higher proportion of the individuals belonging to the 'upto primary' education showed higher adiposity using WHR in the present study. There was a significant inverse association between the WHR and educational level among middle-aged females living in northern Italy ($p<0.001$) (Cota *et al.*, 2001). A significant lower prevalence towards obesity was associated with higher educational levels among adult female individuals in Jamaica (Ichinohe *et al.*, 2005). This has been attributed to the fact that education had a direct effect particularly among those individuals with lower levels of education, since the poorly educated have been shown to have a less healthy diet and a greater prevalence of overweight (Woo, 1998; Mokhtar *et al.*, 2001; Machado and Sichieri, 2002).

It has also been observed that using WHtR, the Rajbanshi female individuals belonging to the lower income groups (>Rs.4000/= and Rs.4000-6000/=) exhibited significantly lower odd ratios (odds: 0.33; 95% CI: 0.18-0.56 and odds: 0.41; 95% CI: 0.26-074) to being overweight and obese than those belonging to the higher income group (<Rs.6000) ($p<0.01$) ***(Table 3.35)***. It was also reported using WHtR that a lower prevalence of regional adiposity existed among the female individuals with higher income (odds: 0.64; 95% CI: 0.47-0.86) among adult population from Florianópolis, Santa Catarina (Sousa *et al.*, 2011). Among Brazilian females, income was inversely associated with abdominal obesity (Olinto *et al.* 2006). A similar result was also obtained in the per capita income group, where the odds were significantly lower in the lower per-capita income groups ($p<0.01$).

Subramanian *et al.* (2007) suggested that the average levels of economic development were strongly associated with degrees of over-nutrition (overweight and obesity) among married Indian females. The results of the logistic regression model in the present study also showed that marital status had a significantly higher odds effect for the manifestation of overweight and obesity utilizing both WHR (odds: 2.44; 95% CI: 1.53-3.27 and odds: 1.58; 95% CI: 0.91-2.77) and WHtR (odds: 2.01; 95% CI: 1.12-3.62 and odds: 2.01; 95% CI: 1.19-3.40) among the married males and females respectively ***(Tables 3.34 and 3.35)***. Similar associations were reported by Tur *et al.* (2005) and Jeffery and Rick (2002) in the adiposity levels among adults, but all these researchers had utilized BMI. Rguibi and Belahsen (2004) reported that the prevalence of obesity was significantly higher among the married females when compared with the unmarried females of South Morocco. Utilizing the regional adiposity indicators, it has also been observed in the present study that the married individuals were more likely to fall in a double risk factor category for obesity when compared with the unmarried ones.

4.3. DIETARY INTAKE ASSESSMENT AND FOOD AND NUTRIENT CONSUMPTION AMONG THE RAJBANSHI INDIVIDUALS

The diet of a population is influenced by many factors. These factors are income, cost of the foodstuff, individual preferences, beliefs and cultural traditions as well as environmental, social and economic factors. Furthermore, the consumption patterns related to the dietary consumption in India is diverse in nature. These vary from region to region and ethnic populations to population groups in the Indian subcontinents. All these interact in a complex manner to shape the dietary consumption of a population. The growth in world food consumption has been accompanied by significant structural changes and a shift in diet away from staple foods such as root and tubers towards more livestock products, vegetables and oil. This shift has been more prominent in the developing countries such as India. Current energy intakes have ranged from 2681 Kcal per capita per day in the developing countries to 2906 kcal per capita per day in the transitional countries and 3380 kcal per capita per day in the industrialized countries.

The result of the dietary assessment among the adult Rajbanshi individuals was evaluated using the 24-HR method. It may be appended here that a number of studies have utilized the 24-HR method to report the dietary patterns of Indian populations (Shobana *et al.*, 1998; Mehta and Shringarpure, 2000; Reddy and Rao, 2000; Goyal and Grewal, 2004; Arlappa *et al.*, 2005; Mittal and Srivastava, 2006; Gupta *et al.*, 2010; Bowen *et al.*, 2011; Radhika *et al.*, 2011; Venkaiah *et al.*, 2011). The assessment of nutritional status was evaluated in terms of both food and nutrient consumption by comparing recommended dietary allowance (RDA) suggested for Indian population (ICMR, 2004) ***(Tables 2.7 and 2.8)***. It was observed in the present study that the consumption of major food groups was found to be deficient among both sexes in Rajbanshis ***(Table 3.36 and Table 3.37)***.

4.3.1. Comparative evaluation of different food groups intakeS among different indian populations

The results of the dietary evaluation showed that the prevalence of higher amount of inadequacy exist in food and nutrient consumption among the adult Rajbanshi individuals in the present study. This could be attributed mainly to the inadequate dietary intake, lower SES, low purchasing power and faulty feeding habits. In India, a large proportion of the populations residing in the rural areas exhibit lower SES and social backwardness, apart from having access to inadequate infrastructural facilities and experiencing lack of basic amenities.

The consumption of different food groups was compared with the RDA as suggested for Indian population for the assessment of nutritional status by the ICMR. The results showed that the consumption of other cereals (in women), vegetables, roots and tubers were found to be satisfactory when compared with the RDA values (ICMR, 2004) ***(Table 3.36 and Figure 3.44)***. However, the sex specific consumption was found to be inadequate in the different food groups (pulses and legumes, GLVs, milk and milk products, meat and flesh, fats and oil and sugar) in both sexes when compared with the RDA values ***(Table 3.36 and Figure 3.44)***.. The sex differences in the consumption of these different food groups was not significant using ANOVA ($p>0.05$), except in the consumption of cereals ($p<0.05$). The existing literature suggested that most of the diets were predominantly cereal-based among different Indian ethnic tribal and non-tribal rural populations.

The dietary habit of the Rajbanshi population was observed to be chiefly cereal-based. However, the mean consumption of cereals was lower than those reported from studies conducted among different Indian ethnic population such as the Oraon (Chandrasekhar *et al.* 1997; Mittal and Srivastava, 2006), the Maria Gond (Hanumantha Rao *et al.*, 1992), the Janu Kuruba (Hanumantha Rao *et al.*, 1993), the scheduled caste population of Assam (Borooah and Dutta, 2006) and the Baiga (Chakma *et al.*, 2009), but slightly higher than those reported by the NNMB among different tribal and rural Indian populations (Rao *et al.*, 2010).

The consumption of adequate food that includes vegetables plays a vital role in providing a diverse and nutritious diet. A lower consumption of fruits and vegetables in of the developing countries is a persistent problem. This has been confirmed by the finding of number of food consumption surveys. A Nationally representative survey in India (NFHS-2) showed that there was a steady consumption of only 120-140 gm per capita per day from vegetables, with about another 100 gm per capita coming from roots and tubers and some 40 gm per capita from pulses.

The present study revealed that the consumption of root and tubers among the Rajbanshi population was double than the RDA as specified by the ICMR and that root and tubers occupied a dominant place after rice in their dietary habits. This is probably due to the abundance of such food items in locally grown fields. On an average, the Rajbanshi individuals consumed a high number of food servings of cost effective food items such as potatoes, arum and GLVs which were grown in local agricultural fields and very occasionally also collected fishes from the nearby rivers. The consumption of pulses was found to be slightly higher than the reported levels in NHFS-2, but the dietary intake was less than half of the RDA (ICMR, 2004). The results of the present study suggested that only 12.25% of the Rajbanshi individuals (males: 16.34%; females: 8.05%) met the adequate levels of dietary requirements as specified by the ICMR (2004) ***(Table 3.37)***. There appears to be an increase in the consumption of roots, tubers and other vegetables in their diet. This may be due to the sufficient availability of these foods in the area. However, the consumption of pulses and legumes decreased and this can be attributed to their rising costs. Dietary intake assessment studies from India have reported that the consumption of roots and tubers were adequate and satisfactory with respect to the RDA among many rural and tribal populations (Kumar *et al.*, 2005; Rao *et al.*, 2010). However, lower intakes of roots and tubers were also reported by a number of studies. In this case, the studies of Borooah and Dutta (2006) among the scheduled caste populations of Assam, that of Mittal and Srivastava (2006) among the Oraon and that of Chakma *et al.* (2009) among the Baiga are mentionable. The mean consumption in almost all these studies was observed to be lower than that of the Rajbanshi in the present study.

The results in the present study further suggested that the consumption of milk and milk products was inadequate and the consumption was found to be well below the RDA levels (ICMR, 2004) ***(Figure 3.44)***. The results thus were in agreement with those reported from various Indian tribal and rural populations. Here the studies of Mittal and Srivastava (2006), Chakma *et al.* (2009) and Rao *et al.* (2010) may be cited. Very few of the adult Rajbanshi individuals were able to achieve adequate levels of the RDA for milk and milk products and only a small segment (males: 1.31%; females: 14.77%) preferred to consume milk during family dinners and morning meals ***(Table 3.37)***. Those families who have domesticated cows in their residences frequently consumed milk. The RDA values obtained in the present study were observed to be higher than those reported in the studies of Mittal and Srivastava (2006), Chakma *et al.* (2009), Rao *et al.* (2010). However, the values were lower than those reported in the studies of Kumar *et al.* (2005), Borooah and Dutta (2006) and Rao *et al.* (2010).

Pulses (legumes, lentil and green gram) and flesh foods (meat and poultry) are generally considered to be a very good source of dietary protein. However, the consumption of flesh foods was observed to be inadequate among the Rajbanshi individuals when compared to the RDA levels (ICMR, 2004). The consumption of flesh foods was observed to be almost negligible. The major sources of dietary protein among them were the plant foods and pulses. The sex specific consumption of protein was found to be slightly higher among the males when compared with the females ($p>0.05$) ***(Table 3.38)***. Several dietary assessment studies among rural and tribal populations have reported that the consumption of protein rich diet which includes pulse, legumes and flesh food were found to be markedly unsatisfactory when compared with the RDA. Reddy and Rao (2000) have reported poor levels of protein-rich diet that included pulse, legumes and flesh food among the Sugali population of Andhra Pradesh. Similar results were reported among the Oraon of North Bengal by Mittal and Srivastava (2006), the scheduled caste population of Assam by Borooah and Dutta (2006), the Baiga of Madhya Pradesh by Chakma *et al.* (2009) and various other rural and tribal populations by Rao *et al.* (2010). The mean consumption of pulses and legumes in the present study was noticed to be almost half of the RDA ***(Figure 3.44)***. However, the mean intake of pulses and legumes were observed to be higher than those reported from similar studies. Here the studies among the Baiga by Chakma *et al.* (2004), Gujrati by Kumar *et al.* (2005), Oraon by Mittal and Srivastava (2006) are mentionable. But again the mean values were lower than those reported among the Sugali by Reddy and Rao (2000) and the scheduled caste population of Assam by Borooah and Dutta (2006). This inadequacy could be attributed to the lower purchasing ability and affordability of the individual, including those belonging to the Rajanshi population in the present study.

The consumption of protective food (fruits and GLVs) was observed to be markedly inadequate when compared to the RDA among the Rajbanshis ***(Table 3.36 and Figure 3.44)***. Fruit consumption was almost negligible in their dietary habits and it was only observed during the summer season. A majority of the individuals did not consume adequate amounts of GLVs. Several dietary assessment studies have reported inadequate levels of fruit consumption as compared to the RDA among a number of Indian ethnic populations. Here the studies among the Sugali (Reddy and Rao, 2000), the Gujrati (Kumar *et al.*, 2005), the Oraon (Mittal and Srivastava, 2006), the scheduled caste population of Assam (Borooah and Dutta, 2006) and the Baiga (Chakma *et al.*, 2009) may be cited. The mean intake of GLVs was lower than that reported among the Sugali by Reddy and Rao (2000) and different rural tribal populations by Rao *et al.* (2010). Lower intakes of GLVs were reported among the Oraon of North Bengal by Mittal and Srivastava (2006) and the Raika of Rajasthan by Singh *et al.* (2009). Inadequate levels of GLVs as compared with the RDA, as specified by the ICMR (2004) were also reported by Kumar *et al.* (2005) among the Gujrati and by Chakma *et al.* (2009) among the Baiga. However, Borroah and Dutta (2006) reported a higher amount of GLV consumption among a scheduled caste population of Assam.

The consumption of sugar was also observed to be inadequate when compared to the RDA ***(Table 3.36 and Figure 3.44)***. Existing studies have revealed that sugar consumption of sugar was higher among individuals belonging to the high income families as compared to those from the lower income families. Almost negligible mean sugar consumption has been reported among the Sugali (Reddy and Rao, 2010), the Gujrati (Kumar *et al.,* 2005), the Oraon (Mittal and Srivastava, 2006), the Baiga (Chakma *et al.*, 2009) and some rural tribal populations of the country (Rao *et al.,* 2010). However, Borooah and Dutta (2006) reported higher sugar consumption among the scheduled caste population of Assam.

4.3.2. Comparative evaluation of different nutrient among different Indian populations

The consideration of nutrient requirements and availability from the diet bears more significance than an individuals' food because of the interactions between food consumption and absorption. The sex specific consumption of different nutrients among the Rajbanshi individuals in the present study was evaluated using the dietary assessment tables given in '*Nutritive Value of Indian Foods*' for Indian populations by Gopalan *et al.* (1993). The results revealed that the mean proportion of protein and carbohydrate intakes were lower than that the RDA. The mean fat intake was adequate and the dietary fat consumption pattern was balanced and the mean intake did not exceed the RDA ***(Table 3.38)***. The dietary intake results revealed that the diet of the Rajbanshi individuals was monotonous and chiefly based on cereals. Most of the dietary intake studies in India have reported the major source of energy to be cereal-based (Gopalan *et al.*, 1993; Reddy and Rao, 2000; Kumar *et al.*, 2005; Borooah and Dutta, 2006; Mittal and Srivastava, 2006; Harinarayan *et al.*, 2007; Chakma *et al.*, 2009; Singh *et al.*, 2009 Rao *et al.*, 2010).

When compared to the RDA, the consumptions of major nutrients were observed to be inadequate among the Rajbanshi individuals. The sex specific mean consumptions of dietary fat, thiamin and niacin were observed to be adequate, but the consumptions of energy, protein, calcium, iron, vitamin-A, riboflavin and vitamin-C were inadequate ***(Figure 3.46)***. A sex specific consumption pattern existed among these different nutrients. The differences were statistically significant in case of energy, fat, iron and thiamin consumptions ($p<0.05$).

However, the differences were not statistically significant in case of proteins, calcium, vitamin-A, riboflavin, niacin and vitamin-C ($p>0.05$) (***Table 3.38)***. The overall mean consumption of dietary fat showed an adequate level of the RDA. The distributions of individual levels of energy and protein consumptions were observed to be unsatisfactory among both sexes and very few of them were able to achieve the adequate level of consumption when compared with the RDA ***(Figure 3.46)***. The results of the present study appears to be in conformity with similar studies done among different Indian rural and tribal populations (Reddy and Rao, 2000; Kumar *et al.*, 2005; Harinarayan *et al.*, 2007; Borooah and Dutta, 2006; Mittal and Srivastava, 2006; Chakma *et al.*, 2009; Singh *et al.*, 2009; Rao *et al.*, 2010).

The results of the present study also suggested that 92.16% of the Rajbanshi males and 85.91% of the Rajbanshi females exhibited adequate levels (100%) of total fat intake that were within the RDA ***(Table 3.39)***. There was an improvement or achieved adequate levels in intake of cereal products, vegetables, root and tubers, total fat and protein among the females when compared with the males ($p>0.05$). Moreover, the main protein sources in the diet of the Rajbanshi were fish, meat, poultry and milk and milk products and all these were markedly inadequate ***(Figure 3.44)***. The mean consumption was observed to be lower among both sexes although it exceeded the recommendations for consumption of total fat. The mean consumption of fat was found to be lower than reported values from a population of north India (Chadha *et al.*, 1995), the scheduled caste population of Assam (Borooah and Dutta, 2006) and the Oraon of North Bengal (Mittal and Srivastava, 2006).

The analysis of the dietary intake data showed that the proportions of macronutrient intakes among the Rajbanshi individuals were widely inadequate as compared with the RDA. The study revealed that the consumption of iron and calcium were observed to be markedly inadequate among them *(Figure 3.46)*. The sex specific mean consumptions of both these essential elements were distinctly lower than the RDA. The mean consumption in iron was 49.93% of the RDA among the males and 38.93% of the RDA among the females. For calcium the corresponding values were 84.51% for the males and 81.99% for the females. The results clearly indicate that for iron and calcium, the sex specific consumption pattern was higher among the males when compared to the females. The sex difference was, however, statistically significant for iron ($p<0.05$) but not for calcium ($p>0.05$) *(Table 3.38)*. The higher consumption of cereals could be a leading cause for the low intake of iron and calcium among the Rajbanshi. The inadequate consumption of dietary calcium among them could also be attributed to the low consumptions of milk and milk products, and GLVs as it has been observed that the intake of these were deficient when compared with the RDA. The animal sources of protein were also consumed at a weekly or fortnightly basis and there were no other sources of calcium in their diet. It has been reported by Harinarayan *et al.* (2004) that cereal-based diets were unlikely to provide enough calcium in the diet until and unless plenty of milk and milk products were consumed. It has also been opined that individuals having a background diet high in phytates also inhibited the absorption of these elements (Gopalan *et al.*, 1996; ICMR, 2000). In India, there has been a strong indication of a high phytate/calcium ratio in the rural diet that in turn retarded calcium absorption (Harinarayan *et al.*, 2004). The poor intake of calcium among the Rajbanshi individuals in the present study could lead to an increase in the risk of fractures, especially among post-menopausal females and the elderly. This can be further rectified to a greater degree with calcium supplementation. The shortcoming of the inadequate dietary calcium intake associated with the reduced bioavailability of calcium in the gut due to phytates and age-related calcium conservation on the gut can be overcome by up-revising the RDA for calcium restricting phytate foods. The mean dietary intake of different nutrients indicates that dietary consumption chiefly encompasses cereals, roots and tubers and other vegetables products. It has been also been pointed out that the RDA values for calcium intake among Indian populations as recommended by the ICMR (2004) were lower than the recently revised recommendations by the United States of America and Canada (Swaminathan, 1981; Gopalan *et al.*, 1996). An inadequate intake of dietary iron, its poor bio-availability and concurrent inadequate intake of dietary micronutrients appear to be the primary factors responsible for the high prevalence iron deficiency in the present population. Studies have indicated that a significant proportion of individuals suffered from dietary iron deficiencies in India (Kumar *et al.*, 2005; Singh *et al.*, 2009). This deficiency can lead to the manifestation of anemia which becomes more marked among the females (Chakma *et al.*, 2009; Singh *et al.*, 2009).

The consumption of vitamins (vitamin-A, riboflavin and vitamin-C) was mostly observed to be grossly inadequate among in the Rajbanshi population when compared to the RDA (ICMR, 2004) ***(Figure 3.46)***. Only the male individuals exhibited adequate vitamin-C consumption. The deficiencies in these nutrients in the diet could be attributed to the low consumption of milk and milk products, GLVs and fruits. It has already been shown that the diet of these Rajbanshi individuals were predominantly cereal-based with rice constituting their staple diets. Vitamin-A is considered to be an important micronutrient for maintaining normal growth, regulating cellular proliferation and differentiation, controlling development, and maintaining visual and reproductive functions. National diet surveys have shown that the intake of vitamin-A was significantly lower than the RDA in all populations over decades and that there has not been hardly any improvement in its intake (NNMB, 1979-2002). Deficiency in vitamin-A and riboflavin consumptions were also reported among the Maria Gond (Hanumantha Rao *et al.* 1992), the Jenu Kuruba (Hanumantha Rao *et al.* 1993), the Oraon (Chandrasekhar *et al.*, 1997; Mittal and Srivastava, 2006) and the Baiga (Chakma *et* *al.*, 2009). The lower levels of vitamin-A and thiamin in a population have been attributed to a lower intake of GLVs and negligible amount of milk in their dietary habits (Hanumantha Rao *et al.* 1993). Lower levels of vitamin and calcium consumption were also reported from both rural and urban Indian populations by Harinarayan *et al.* (2004).

The sex specific consumption of thiamin and niacin was observed to be adequate when compared with the RDA (ICMR, 2004) ***(Figure 3.46)***. The Rajbanshi male individuals exhibited higher levels of thee two nutrients than the females ($p>0.05$). When compared with the RDA, the mean consumption was found to be 100.71% and 113.64% (in case of thiamin) and 132.44% and 164.57% (in case of niacin) among both male and female Rajbanshi individuals respectively ***(Table 3.39)***. The adequacy in these two nutrients is due to consumption high proportion of cereals in the diet, especially rice. The consumption of rice is considered to be very good source and helps the individuals to achieve adequate levels of thiamin and niacin (Gopalan *et al.*, 2007). The comparison of mean consumption of thiamin and niacin with the different Indian ethnic population showed higher intake pattern than those reported for the rural and tribal population of India (Rao *et al.*, 2010), the Baiga (Chakma *et al.*, 2009), but lower than those reported for the Sugali (Reddy and Rao, 2000), the Gujrati (Kumar *et al.*, 2005) and the scheduled caste population of Assam (Borooah and Dutta, 2006).

4.3.3. Gender related nutritional status, diet and nutrient consumption

In the developing countries, there is considerable number of evidence indicating the prevalence of under-nutrition is a primary concern among the poor while over-nutrition is a problem of wealthy individuals (Subramanian and Smith, 2006). The assessment of nutritional status revealed that the prevalence of under-nutrition was documented to be very high in both sexes among the Rajbanshi and that the prevalence of CED was observed to be higher among the females than the males (p>0.05) ***(Table 3.15 and Figure 3.28)***. Also the consumptions of food, nutrients, dietary preferences and food habits among them showed a gender specific pattern. Osmani and Sen (2003) reported the gender inequality contributes to the inter-generational transmission of poor health through poor intrauterine and early life exposure. The existing literature has suggested that the relations between different factors and low energy reporting have been mixed. Studies have observed low energy reporting to be more common among the adult females than the males in both mean food and nutrient consumptions (Reddy and Rao, 2000; Agudo *et al.*, 2002; Rajeshwari *et al.*, 2004; Tur *et al.*, 2005; Mirmiran *et al.*, 2006; Mittal and Srivastava, 2006; Morimoto *et al.*, 2008; Castro *et al.*, 2009; Sudo *et al.*, 2009).

Utilizing the classification of the WHO (1995) for assessing the under-nutrition, it was observed that the situation warranted immediate intervention. The food preferences were usually given to the male rather than the female Rajbanshi individuals during meals (food intake). The food habit also distinctly showed a gender related consumption pattern of nutrients among them. In most cases, the consumption of foods was found to be significantly higher among the males than the females. The consumption of higher foods and nutrients among the males were due to the intake of higher quantities of food and food preference, not to any other specific dietary factor. A decreasing proportion of food and nutrient consumption were also observed among the females when compared with the males. The high level of physical activity agricultural field-related activities and poor achievements related to the RDA level led a higher prevalence of under-nutrition in both sexes especially among the female Rajbanshi individuals. This would affect the female individuals in the long run. It has been reported that female individuals suffering from poor health and under-nutrition were more likely to give births to infants with LBW (Shannon *et al.*, 2008; Muthayya, 2009; Sen *et* *al.*, 2010b). They are less likely to be able to provide food and adequate care for their children. Finally, a female's health can affect the household's economic well being, and as a female individual with poor health would be less productive in the labour force of the society (Nubé and van den Boom, 2003; Baker *et al.*, 2006). Gender studies in India have pointed out that female children exhibited greater micronutrient deficiencies and growth retardation. At times of natural disasters or crises, the girls were observed to be more affected by malnutrition than the boys. Cultural stereotyping and restrictions on movement subjected the girls to the authority and control of the male children and adult males. In the public sphere, girls were used by families to help in the household and production needs of the family and other relatives (Punalekar, 1995). Furthermore, the poor intake of food and nutrients leads to prolong nutritional deprivation as manifested as under-nutrition among females in later life.

4.3.4. Prevalence of Protein-caloric adequacy status

The present study suggested that the prevalence of protein-caloric inadequacy status among the Rajbanshis were observed to be significantly higher among the females (48.32%) than the males (30.07%) ($p<0.05$) ***(Table 3.40 and Figure 3.49)***. It has been reported by Reddy and Rao (2000) that the Sugali males and females had higher percentages of deficiency in calories (66.9% and 59.3%, respectively) than in proteins (48.2% and 43.5% respectively). The values were lower than the overall deficiency in calories (68.87%) but higher than protein deficiency (41.72%) obtained in the present study. The caloric deficiency in the present study lower than that reported among the Raika of Rajasthan (50.5%) by Singh *et al.* (2009). It is evident from the earlier studies that in India the primary bottleneck in the diets of individuals belonging to the poor economic groups were calories and not proteins (ICMR, 1984; Gopalan and Jaya Rao, 1984). Rao *et al.* (2010) reported the prevalence of protein-caloric adequacy status utilizing the data of National Sample Survey Organization

(NSSO) from different districts of India and observed that the protein-caloric status was 80% among the non-pregnant and non-lactating females and 58% to 60% of the pregnant and lactating females consumed both protein and energy. In their study, the results also showed that the inadequacy status was higher among the pregnant and lactating women in India.

4.3.5. Effect of Socio-economic, demographic and life-styLe variables ON THE prevalence of protein and caloric inadequacy status

In most of the developing countries having high population density, large sections of the populations' exhibit low consumption levels and the per-capita intake of nutrient, calories, vitamins and minerals remain poor. The present study shows variations based on age, gender, nature of occupations and physical activity levels among both the male and the female Rajbanshi individuals. The multinomial logistic regression analysis showed inverse associations of dietary protein, energy and fat intake with family size, family income, per capita income and number of dependent children in the households ***(Table 3.41)***. Thus, inverse associations have been documented between dietary energy, protein and fat intake and the socio-economic and demographic and life-style variables. The consumption of calories and percentages in the diet were proportionately lower in the higher age groups among them. The multinomial logistic regression analysis also showed the sex specific nutritional deprivation to be strongly associated with the caloric, protein and protein-caloric inadequacy statuses. The odds value was four times (odds: 4.07; 95% CI 2.38-6.96; $p<0.01$) and two times (odds: 2.18; 95% CI 1.36-3.49; $p<0.01$) in caloric and protein-caloric deficiencies respectively among the Rajbansi females.

Several Indian studies have corroborated the issue of the females being deprived and comprising a nutritionally risk group in terms of protein and caloric inadequacy statuses (Reddy and Rao, 2000; Mittal and Srivastava, 2006; Singh *et al.*, 2009; Rao *et al.*, 2010).

Inadequate level of calorie consumption among the females could be related to either a lower physical activity or to the fact that the male individuals are given most of the food. The present study further confirms the existence of gender related nutritional deprivation. Furthermore, the results showed that the higher odds values for the caloric, protein and protein-caloric inadequacies were in the higher age group (40 years to 49 years) ($p>0.05$). Several studies have pointed out such age-related trends in caloric deficiencies (Reddy and Rao, 2000; Kumar *et al.*, 2005). However the results of the multinomial logistic regression analysis showed that odds values for protein adequacy status was higher in lower monthly family income (≤ Rs. 4000 and Rs. 4001-6000) and per-capita income group (≤ Rs. 750) ***(Table 3.41)***. The results suggested that odds values for protein inadequacy status were found to be distinctly higher in low income families, but an inverse relationship was noticed with odds values with higher income families for both caloric and protein-caloric inadequacy status. The results suggested that protein intake, fat intake, percentage of energy provided by fat, percentage of energy and protein coming from animal foods and some micro-nutrients intake had increasing trends with the increase of family income in both rural and urban populations, a fact also observed by Wang *et al.*, 2008.

CHAPTER-V:

SUMMARY AND CONCLUSION

CONCLUSIONS AND RECOMMENDATIONS

The assessment of nutritional status is considered to be the measure of health status and standard of living of an individual or population. It is necessary to mentions that these data would be more helpful for policy planners and public health professional to better understand the current nutritional situation in relation to food and nutritional and to improve the situation for vulnerable segments of the population. The present cross-sectional study has conducted to assess the nutritional status of adult Rajbanshi population aged 20- 49 years of North Bengal, India. The nutritional status was evaluated using different derived anthropometric measurements, dietary intake assessment and food related habits. The socio-economic, demographic and lifestyle related factors were also obtained to describe the possible association with nutritional status and dietary intake. The results would be very useful in the formation and/or implement of appropriate development and nutritional supplementary programmes to promote the health condition of the population under study. The present study assessed the nutritional status of the Rajbanshi individuals utilizing different anthropometric indices that appeared to be reliable indicators for the assessment of both under-nutrition (e.g., CED) and over nutrition (e.g., overweight and obesity) among them. The use of BMI and MUAC depicted the existence of a high prevalence of undernourishment. The results further confirmed the pronounced gender-related undernourishment. It was evident that the proposition of nutritional deprivation was the major nutritional concern among the female than the male Rajbanshi individuals.

Despite the increasing prevalence of overweight and obesity among the Indian populations the prevalence of under-nutrition continues to be a major problem in most of the rural populations in India including the Rajbanshi as documented in the present study. The existing literature further revealed that the under-nutrition was considered to be a major problem in the low socio-economic populations than the high socio-economic populations in India. The results of the present study support the inference that in the Indian rural populations, CED remained of primary significance rather than obesity or overweight, which was in contrast with the populations of the western countries. The results further suggested that an urgent nutritional support programmes should be launched focusing to the females for reducing the magnitude of under-nutrition in the population concerned. Further studies should be conducted to determine the effects of nutritional supplementations on the anthropometric parameters and functional ability among the Rajbanshi population. The following conclusions could be derived from the present study:

5.1. ANTHROPOMETRY AND NUTRITIONAL STATUS

- The results indicated the mean weight, height, MUAC and WC were considerably higher among the male individuals when compared with the female individuals. The mean HC was observed to be slightly higher among the females (84.93 ± 6.29 cm) when compared with the males (83.52 ± 5.64 cm). The skinfold adiposity measurements of BSF, TSF, SSF and SISF were higher among the female individuals. Age variations in the anthropometric variables among these Rajbanshi individuals were found to be strongly associated with the age groups (20-29 years; 30-39 years; 40-49 years).

- The derived anthropometric indices showed that BMI and RI were higher among the females than the males. However, the male individuals had higher mean values of WHR, TUA, UMA, BFMA, FFM and FFMI than the females. In case of the nutritional and body composition variables of WHtR, CI, UFA, AFI%, PBF%, FM, FMI and PBF-BMI ratio, mean values were higher among the females than the males. When age specific effect was taken into consideration, the results indicate that most of anthropometric variables were observed to be higher in age group of 30-39 years in case of the males and in the age group of 40-49 years in case of the females.

- The results of the Pearson's correlation analysis between the anthropometric variables showed that most of anthropometric variables were significantly correlated with each other ($p<0.05$). Age was significantly higher correlated with WHR, WHtR, FFM, WC and CI. Height and weight were significantly correlated with all the anthropometric variables.
- Linear regression analysis showed that anthropometric and body composition variables were significantly associated with BMI, WHR, WHtR, UMA, UFA, PBF, weight, TSF, BSF, RI, STR and FFM ($p<0.05$).
- Linear regression analysis of BMI as the dependent characteristic showed that several anthropometric and body composition characteristics is significantly associated with BMI among both the male and the female Rajbanshi individuals.
- In countries like India and the many developing countries the appropriate health care and nutritional strategies should be implemented to improve the nutritional status especially in the populations where prevalence of thinness and chronic energy deficiency (CED) were very high. This includes the Rajbanshi population of North Bengal. Utilizing the WHO (1995) proposed criteria based on BMI, it was shown that the adult Rajbanshi individuals comprised a high undernourishment group (CED >20 %) and suffering from different grades of CED. The overall prevalence of overweight (BMI: >25 kg/m^2) and obesity (BMI: >30 kg/m^2) were 38 (3.67%) and 10 (0.97%) respectively. It has been observed that using BMI to assess overweight and obesity, only 4.63% of the individuals had BMI values >25 kg/m^2. The female were more overweight and obese than the males (6.97% versus 3.06%) ($p<0.01$).

- The sex specific prevalence of different grades of under-nutrition or CED among the Rajbanshi individuals was assessed using BMI showed that most of the undernourished individuals comprised mild under-nutrition (CED Grade I: 17.37%) followed by moderate under-nutrition (CED Grade II: 4.05% and finally severe under-nutrition (CED Grade III: 1.74%) among the Rajbanshi.
- Nutritional status was also assessed using the sex specific cut-off points of MUAC <23 cm for males and <22 cm for females, as specified by James *et al.* (1994). The results are shown that the overall prevalence of under-nutrition was 40.64%. The sex specific prevalence of under-nutrition was observed to be slightly higher among the males than the females (40.97% versus 40.17%) ($p>0.05$).
- When the nutritional status of the Rajbanshi individuals were classified using the combination of MUAC with BMI, it was observed that 17.26% and 20.67% of the male and female individuals were affected by under-nutrition. The sex difference was however, found to be statistically not significant ($\chi 2$-value= 1.31; d.f.1; $p>0.05$).
- When regional adiposity was assessed using WC, WHR and WhtR, the prevalence of overall obesity was 6.56%, 56.76% and 21.14% respectively. The prevalence high PBF and $\sum$SKF were 0.87% and 2.12% among the individuals. A total of 6 male and 16 female individuals (0.97% versus 3.85 %) exhibited high skinfold thickness. The levels of adiposity were significantly higher among the females as compared to the males for all the anthropometric measures and derived indices.
- When the Rajbanshi individuals were categorized in terms of fitness status based on PBF, more than half of the individuals exhibited risky fitness status (51.93%), followed by good (20.37%), then excellent (19.59%) and finally fair fitness status (8.11%). Risky fitness status were exhibited by 64.68% and 32.93% of the males and the females ($p<0.01$). The amount of risk factor associated with PBF among the Rajbanshi

individuals showed that the majority of them had an optimal risk (76.16%). The individuals comprising the slightly overweight and lean categories were observed to be 12.26% and 7.72% respectively.

- A multinomial logistic regression analysis model was fitted on the socio-economic, demographic and lifestyle related variables to estimate the odds of being a male individual undernourished and over-nourished. The association of BMI, WHR and WHtR with the different predictor variables among the male Rajbanshi individuals indicated that several variables had significant influences in determining whether an individual was under and/or over-nourished. The results further suggested that toilet facility, household living condition and expenditure (in male) and age, income, per-capita income, family type, toilet facility, house type, socio-economic status and household living condition (among the females) were significantly ($p<0.05$) associated with CED.
- The association of WHR and WhtR with the socio-economic, demographic and lifestyle related factors showed that several variables were significantly associated with higher level of adiposity patterns among the male and the female individuals.

5.2. DIETARY INTAKE, FOOD HABIT AND NUTRITIONAL STATUS

The dietary intakes were evaluated using 24-HR method. The dietary intake was observed to be markedly inadequate in qualitative and quantitative analyses when compared to the suggested RDA values. The consumption of different food groups tended to show reasonably inadequate intakes than suggested RDA among the Rajbanshi. The amount of food and nutrient consumptions was varied and deficiencies were more pronounced in the female than the male individuals.

- The intakes of different food groups suggest that consumption of 'meat and poultry products' and 'milk and milk products' were found to be very less in the regular diet when compared with the RDA. The consumption of fruits were very negligible than recommended RDA level.

- The dietary analysis of the consumption of essential nutrients showed that energy, protein, fat, calcium, iron, vitamin-A, riboflavin and vitamin-C were found to be grossly inadequate among both sexes when compared to the RDA. However, thiamin and niacin intakes were observed to be satisfactory to a certain extent in both sexes. The age specific consumption of foods and nutrients were observed to be higher in the early (20-29 years) and the middle (30-49 years) age groups than the higher age group (40-49 years). The age specific dietary intake food and nutrients decreased with age.

- The consumption of meat, fish, and poultry products were found very inadequate when compared to the RDA, although fish and meat products were purchased.

- The consumption of calcium, iron and riboflavin was found to be markedly deficit in both sexes compared to RDA (ICMR, 2004). A generous intake of green leafy vegetables (GLV) and milk and milk products are recommended to overcome the deficiencies of these nutrients among Rajbanshi's. The inclusion of the daily diet about 50 gm GLV is the reach source of iron, calcium, riboflavin and thiamin could help to meet a fair proportion of iron need beside providing calcium, vitamin-A and vitamin-C respectively in the regular dietary intake.

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5.3. RELATION OF SOCIO-ECONOMIC,DEMOGRAPHIC AND LIFESTYLE FACTORS WITH NUTRITIONAL STATUS

- The majority of Rajbanshi individuals in the present study were from a rural region of North Bengal that lacked the basic infrastructural and health facilities. The lower consumption of food and nutrients could be attributed to low income and less affordability of adequate food stuffs. .

- Rice was the predominant cereal. The food was mainly dependent on locally available agricultural products that included GLVs, roots and tubers, and vegetables. The results showed that majority of the individuals have small land holdings. The production of agricultural products was also grossly inadequate due to the practice of traditional methods of cultivation that increased the burden of higher family dependency and low level of land and per-capita yield.

5.4. RECOMMENDATIONS AND PROPOSED SUGGESTIVE MEASURES

The present study revealed a poor nutritional status among the adult Rajbanshi individuals. There are some recommendations and suggestive measures to improve the nutritional status, and therefore the health of these individuals. The recommendations or suggestive measures are as follows:

- ✓ The nutritional status should be improved by introducing the good quality of locally available foods. The supplementation of good amounts of protective food and nutrients (e.g., iron, zinc and calcium) should be introduced in the diet especially among the females.

- ✓ The supplementations of nutritional trace elements especially zinc, selenium should be provided.

- ✓ The installations of hygienic toilets are required to improve the health conditions.
- ✓ Furthermore, the Government should play a proactive role in reducing the prevalence of under-nutrition among the population under study. Nutritional intervention programmes are needed to be implemented among the adults.
- ✓ There was also the prevalence of regional and abdominal adiposity among adult Rajbanshi's. Therefore appropriate strategies should be initiated to reduce such prevalence and also improve the public health conditions by checking the manifestation of non-communicable diseases include hypertension, diabetes and chronic heart disease among them.
- ✓ Appropriate awareness should be imparted among the individuals in respect to ill-health conditions caused by thinness and CED. The individuals comprising the less educated, lower socio-economic background, poor income group and high dependency ratio family groups should be targeted. There is also a need for integrated health policy to alleviate thinness and CED.
- ✓ The health care facilities must be expanded and found to be within the reach of the individuals. The proper utilization of health care facilities should be ensured in terms of health cheek up camps in regular basis and health personnel should encouraged and motivated within the community. The Government and Non-Government Organizations (NGOs) should be strives hard to popularized the utilization of existing health care facilities in order to combat ill-health and under-nutrition condition.
- ✓ The rapid treatment of nutritional diseases would be helpful to minimize the nutritional burden among Rajbanshi's. Well trained health professionals and medicine practitioners should be encouraged to hold health camps.

- ✓ The necessary nutritional and health related educations should be imparted for a better understanding of the problems and adoption of redial measures.
- ✓ Proper education should be provided to make the individuals aware of the major issues relating to nutrition, health and disease.
- ✓ The effective orientation programmes relating to the importance of proper nutritional status should be organized.

5.5. GENERAL OBSERVATION AND CONCLUDING REMARKS:

Finally, the promotion of healthy diet and lifestyle to reduce the burden of under-nutrition (e.g., CED) and its consequences requires a multi-dimensional approach. The agriculture and food sector figure predominantly in this endeavor and must be given their due importance. These strategies must not merely be directed at ensuring food security for all individuals, but must also achieve the consumption of adequate quantities of safe and good quality foods that together make up a healthy diet for the community. The results have established a high prevalence of under-nutrition and inadequate dietary food and nutrients consumption among the adult Rajbanshi individuals. The results further revealed significant associations between dietary related patterns with socio-economic and demographic factors were observed. The results also showed a sex specific nutritional consumption and female nutritional deprivation. More importance should be given to improve the nutritional status of the adult females. One well-known fact is the adverse health effect of low BMI or under-nutrition has to increase the risk of low birth weight babies.

The prevalence of overweight and obesity has been increasing among the individuals belonging to the higher income and education group. So the burden of diseases associated with the higher levels of adiposity shall continue to increase. To meet this public health challenge related to the double nutritional burden in the population, there lies an opportunity to formulate appropriate policies in respect to an integrated health improvement. Food and nutritional professionals could use this information to assess unhealthy food choices observed in the dietary patterns and to guide nutritional recommendations to help to reduce the incidence of under-nutrition and protein and energy-protein related risk factors among the Rajbanshi. Future research should aim to evaluate dietary intake utilizing the complementary methods for a better understanding of the nutrition-diet relationship.

Increasing the intake of whole grain, fruits, vegetable and dairy products and increasing physical activity could improve nutrient intakes and BMI status thereby prevalence of under-nutrition. The nutrient contribution in terms of dietary supplements increased the prevalence of nutrient adequacy for several nutrients. This study has emphasized a critical need for implementation of nutritional and health interventions in a rural community with a special attention to inadequate nutrient consumptions. The adult individuals were suffering from the lack of macronutrients, vitamins and energy intakes as compared with the RDA. The results of the present study emphasize the importance of a multi-disciplinary approach combat nutritional problem. These are the importance of empowering women through engagement and education, and of maintaining the healthy physical environment (e.g., water and sanitation). The study highlights the importance of supporting initiatives that address these issues not only for their core benefit, but also for the potential benefit to nutritional status.

The present study warrant interdisciplinary approaches from researchers, policy makers and extension health workers in popularizing the beneficial effects of vegetables and fruits, encouraging their wide use which would ensure nutritional security to rural populations. It may be concluded that to reduce the problem of under-nutrition among the adult Rajbanshi indiiduals of North Bengal, both the Government and Non-Government Organizations (NGO's) should adopt initiatives so as to improve nutritional status with specific planning and policies. There is an urgent need for an attention to improve nutritional status by appropriate health and nutritional intervention programmes so as to ameliorate the under-nutrition among them.

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