CHAPTER-II:

MATERIAL AND METHOD

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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.

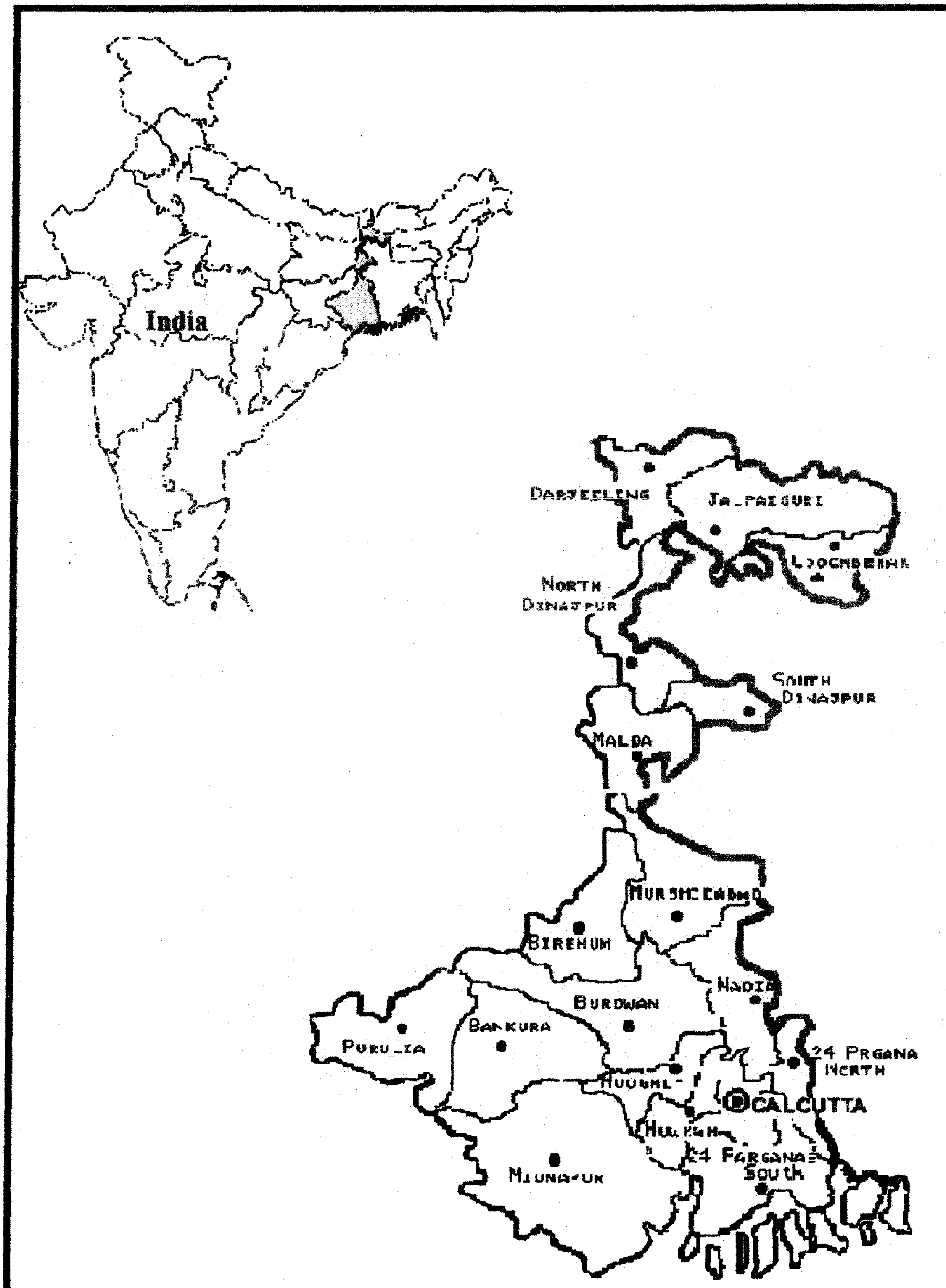

Figure 2.1: Figure showing the geographical location of Darjeeling district, West Bengal, India

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):

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

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:

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

2.5.3.3. Waist-Hip Ratio (WHR)

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

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

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/m^2)
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/m²)*
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: $\geq$ 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:

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

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

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.

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

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:

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

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

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* ($\sum 4SKF$) $= BSF+TSF+SSF+SSIF$
2. $\sum 4SKF$*-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. $BSF\text{-}\sum 4SKF = BSF/ \sum 4SKF$
9. $TSF\text{-}\sum 4SKF = TSF\text{-}\sum 4SKF$
10. $SSF\text{-}\sum 4SKF = SSF\text{-}\sum 4SKF$
11. $SISF\text{-}\sum 4SKF = SSIF\text{-}\sum 4SKF$
12. $Log_{10} \sum 4SKF = Log_{10} (BSF+TSF+SSF+SSIF)$

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

Age (in years)	Male			Female		
	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, ≤ 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.