RISK FACTORS ASSOCIATED WITH OVERWEIGHT AND OBESITY AMONG 18-59 YEARS MALE AND FEMALE RESIDING IN ITAHARI SUB-METROPOLITAN CITY

by

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Risk Factors Associated with Overweight and Obesity Among 18-59 years Male and Female Residing in Itahari Sub-metropolitan City

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Approval Letter

This ***dissertation*** entitled ***Risk Factors Associated with Overweight and Obesity Among 18-59 Years Male and Female Residing in Itahari Sub-metropolitan City,*** presented by **Binod Khanal** has been accepted as the partial fulfillment of the requirement for the degree of **Bachelors of Science in Nutrition and Dietetics**.

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(Binod Khanal)

Abstract

The study was intended to assess risk factors associated with overweight and obesity among 18-59 years male and female residing in Itahari Sub-metropolitan city. A cross sectional study was conducted on 207 adults residing in Itahari Sub-metropolitan city with a structure questionnaire. Weight, height, waist, and hip circumference were measured to determine indicators related to overweight and obesity. The indicators of overweight and obesity were body mass index, waist circumference, and waist –to-hip ratio. A Chi-square test was used to establish the association between variables. Data were analyzed using the Statistical Package for Social Sciences (SPSS) version 20 and Microsoft package 16 (Excel and Word).

The study revealed 29.5% of respondents were overweight and 15% were obese; 58.5% of them were abdominally obese by WC and 69.6% by WHR. Here, mean BMI was 25.56±3.57 kg/m^2 and mean WC was 89.49±9.41 cm with mean WHR of 0.92±0.08. Age, physical activity, sleep, consumption of fast foods, carbohydrate intake, protein intake, fat intake and calorie intake were factors found significantly associated ($p<0.05$) with overweight and obesity. While, marital status, consumption of paneer/cheese were common factors significantly associated ($p<0.05$) with abdominal obesity. However, Factors like consumption of alcoholic drinks and salt intake were only significantly associated ($p<0.05$) with BMI. Factors like, consumption of roots & tuber and other vegetables were only significantly associated ($p<0.05$) associated with WHR. The study depicted the prevalence of overweight and obesity among 18-59 years male and female residing in Itahari sub-metropolitan city. Thus, overweight and obesity should be viewed as serious problems/issue.

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List of abbreviations

Abbreviation	Full form
ADIPOQ	Adiponectin
BIA	Bioelectrical Impedance
BMI	Body Mass Index
CBS	Central Bureau of Statistics
CDC	Centers for Disease Control and Prevention
CHD	Coronary Heart Disease
CKD	Chronic Kidney Disease
CT	Computed Tomography
CVD	Cardiovascular Disease
DEXA	Dual-energy X-ray Absorptiometry
DFTQC	Department of Food Technology and Quality Control
FAO	Food and Agriculture Organization
FFQ	Food Frequency Questionnaire
GON	Government of Nepal
HC	Hip Circumference
HDL	High Density Lipoprotein
ICMR	Indian Council of Medical Research
IDF	International Diabetes Federation
IPAQ	International Physical Activity Questionnaire
LEPR	Leptin Receptor
MET	Metabolic Equivalent
MetS	Metabolic Syndrome
MOHP	Ministry of Health and Population
MRI	Magnetic Resonance Imaging
NCD	Non-communicable Disease
NDHS	Nepal Demographic and Health Survey
PA	Physical Activity

RDA	Recommended Dietary Allowances
SPSS	Statistical Package for Social Sciences
ST	Skinfold Thickness
T2DM	Type 2 Diabetes Mellitus
UNICEF	United Nations Children's Fund
WC	Waist Circumference
WOF	World Obesity Federation
WHO	World Health Organization
WHtR	Waist-to-Height Ratio
WHR	Waist-to-Hip Ratio

Part I

Introduction

1.1 General introduction

Overweight and obesity are defined as abnormal or excessive fat accumulation that may impair health (WHO, 2022). Body mass index (BMI) is a simple index of weight-for-height that is commonly that is commonly used to classify overweight and obesity in adults. It is defined as person's weight in kilograms divided by square of its height in meters (kg/m^2). For adults, overweight is BMI greater than or equal to 25 kg/m^2 and obesity is BMI greater than or equal to 30 kg/m^2 (WHO, 2022). The fundamental cause of obesity and overweight is an energy imbalance between calories consumed and calories expended. An increased intake of energy dense food and increasingly sedentary nature of life style and work, and increasing urbanization have led to global epidemic of overweight and obesity (WHO, 2021).

Body mass index (BMI) is a simple index of weight-for-height that is commonly used to classify overweight and obesity in adults. It is defined as a person's weight in kilograms divided by the square of his height in meters (kg/m^2) (Shahi *et al.*, 2013b) . In 2015,41% of CVD-related death, 9.5% of diabetes-related death and 10% of death from CKD and neoplasms were attributed to obesity (Afshin *et al.*, 2017). Compared with adults of normal weight, adults with BMI >40 kg/m^2 have an approximately 64% higher risk of T2DM, a 54% higher risk of high blood pressure, a 9% higher risk for high cholesterol, a 17% higher risk for asthma, a 34% higher risk for arthritis, and a 32% higher risk for generally fair or poor health (Must *et al.*, 2012).

Recently, evidence has been growing to suggest that an additional indicator of central obesity, waist circumference (WC), may be more closely associated with metabolic risks

compared to BMI because it reflects regional body fat distribution and upper body adiposity (Sahakyan *et al.*, 2015).

In 2016, more than 1.9 billion (39%) adults aged 18 years and older were overweight and of these over 650 million (13%) adults were obese. The overweight population consists of 39% men and 40% women whereas the obese population consists of 11% men and 15% women. The worldwide prevalence of obesity nearly tripled between 1975 and 2016 (WHO, 2022). In developing countries with under-nutrition, obesity is a complex condition, with serious social and psychological dimensions, affecting virtually all ages and socio-economic groups (WHO, 2004).

In case of Nepal, it was found that 24.3% of adult population were overweight or obese which consists of 23.4% of male and 25.1% of female population. Also, percentage of adults who were obese was 4.3% including 3.2% of male and 5.3% of female. The mean waist to hip ratio of male and female was found to be 0.93 and 0.90 respectively. 63.6% adults (56.3% male and 70.2% female) have high prevalence of WHR (Dhimal *et al.*, 2020).

Itahari is a sub-metropolitan city in the Sunsari District of Province No. 1 of Nepal. Itahari city is business hub of eastern Nepal. It is the second most populous city in Eastern Nepal after Biratnagar. Situated at a distance of 25 kilometres north of the provincial capital of Biratnagar, 16 kilometres south of Dharan and 92 kilometres west of Kakarbhitta, Itahari serves as a junction point of the east-west Mahendra highway and the north–south Koshi highway. Itahari has an estimated city population of 1,98,098 living in 40,207 households as per 2021 Nepal census. It is one of the fastest growing cities of Eastern Nepal.(Wikipedia, 2022)

1.2 Statement of problem

Nepal's increasing trend towards urbanization and leads health challenges, whose consequences are seen as overweight and obesity. Changing dietary habits can shift a society's disease pattern from infectious, communicable diseases' dominance towards a status of double-disease burden with increasing prevalence of obesity and non-communicable diseases (Vaidya *et al.*, 2010). Overweight and obesity is a significant public health concern affecting more than half a billion people worldwide (Gakidou, 2014).

Nepal is experiencing nutrition transition in recent decades because of which there is increase consumption of high fat and high sugar foods. Rapidly growing economies of the country has resulted in the globalization of food markets, fast food chains and the increasing availability of street vendors who offer products at very competitive value due to economical acquisition of inputs such as raw and processed foods which increases the consumption of energy dense food (Bhurosy and Jeewon, 2014).

The obesity burden would certainly cost heavy in low and middle income countries. Many low and middle income countries have been neglecting overweight and obesity as major health treats, with policies in place to tackle undernutrition, but lack policies to halt the given burden of diseases due to rise of overweight and obesity (WHO, 2013). An enabling environment is of paramount importance to increase awareness about the risk factors for overweight and obesity in general population to decrease the prevalence of overweight associated NCDs in the upcoming generations of Nepal (S. Piryani *et al.*, 2016b). It is the responsibility of policy makers and all the other concerned authorities to address this issue.

Looking at the urbanization rate in Itahari sub-metropolitan city and the observed high prevalence of risk factors in adults it becomes necessary to assess the nutritional status of adults to find out over nutritional status. Thus, assessment of overweight and obesity in male and female is must needed in order to know the prevalence of overweight and obesity along with its risk factors. Such an assessment will help policy maker and developer to address the fast growing problem appropriately and in a timely manner to reduce the chronic health impact of overweight and obesity among male and female as well as associated consequences of NCDs in the upcoming generations of Nepal.

1.3 Conceptual framework

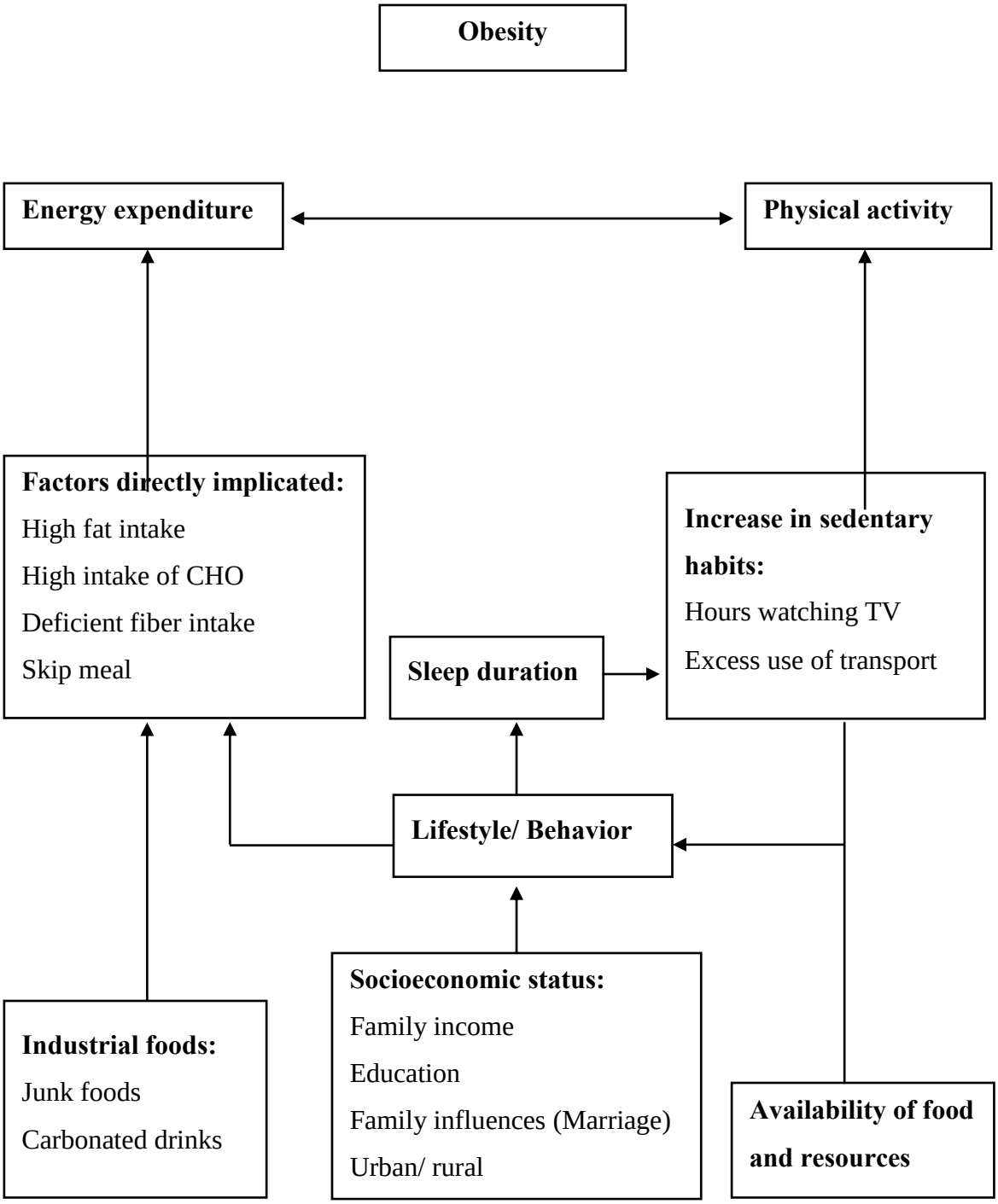


Figure 1.1 Conceptual framework for overweight and obesity

(Jiménez, 2013; Sartorius *et al.*, 2015)

1.4 Objectives

1.4.1 General objectives

The general objective of this study was to identify the prevalence of overweight and obesity among 18-59 years male and female residing in Itahari sub-metropolitan city.

1.4.2 Specific objectives

The specific objectives of this study were to:

i. Assess overweight and obesity among 18-59 years male and female residing in Itahari sub-metropolitan city.
ii. Assess physical activity level, behavioral factors and dietary factors with the help of questionnaire.
iii. Identify risk factors directly and indirectly associated with overweight and obesity.

1.5 Research questions

This research aimed to answer the following questions:

i. What is the prevalence of overweight and obesity among 18-59 years male and female residing in Itahari sub-metropolitan city?
ii. What are the risk factors associated with overweight and obesity among 18-59 years male and female residing in Itahari sub-metropolitan city?

1.6 Significance

i. This study will be helpful in highlighting the distribution of overweight and obesity and its associated contributing factors.
ii. The result of this study will be helpful for the adults to improve their dietary habits and physical activity level.
iii. As health problems associated with obesity and overweight are increasing more often now a day; these findings will be helpful in informing the health sector and the public health planners in mobilization and allocation of resources for the prevention and control of NCDs.

1.7 Limitations

i. Obesity was not assessed by the body fat percentage due to limited resources.
ii. Salt intake through different packaged foods cannot be calculated.

PART II

Literature review

2.1 Overweight and obesity

Obesity is a medical condition described as excess body weight in the form of fat. Overweight and obesity are defined as abnormal or excessive fat accumulation that may impair health (WHO, 2022). Body mass index (BMI) is a simple index of weight-for-height that is commonly that is commonly used to classify overweight and obesity in adults. It is defined as person's weight in kilograms divided by square of its height in meters (kg/m^2). For adults, overweight is BMI greater than or equal to 25 kg/m^2 and obesity is BMI greater than or equal to 30 kg/m^2 (WHO, 2022). BMI is a measure of generalized obesity whereas central obesity can be measured on the basis of waist circumference and waist to hip ratio (WHR). An adult who has a BMI of 25-29.9 is considered overweight, and an adult who has a BMI over 30 is considered obese. A BMI of (18.5-24.9)kg/m^2 is considered normal weight. In general, overweight and obesity indicate a weight greater than what is considered healthy. Obesity is a chronic condition defined by an excess amount of body fat. According to WHO waist to hip ratio above 0.90 for male and 0.85 for female is considered as central obesity whereas WC above 90 cm for male and 80 cm for female is considered as being centrally or abdominally obese (IDF.2005).

When energy intake equals energy expenditure, the body is in positive energy balance and body energy is stable. Over the many years, when body remains in positive energy balance, that is, the intake of calories is more than the expenditure of energy, this leads to obesity. The generalized accumulation of excess adipose tissue in the body with body weight more than 20% of the desirable body weight is called obesity whereas overweight is body weight 10-20% more than the mean standard weight for age, height and sex (Srilakshmi, 2019). Obesity is a complex issue related to lifestyle, environment, and genes. Environmental and genetic factors have a complex interaction with psychologic, cultural, and physiologic influences (L Kathleen Mahan and Raymond, 2016).

Obesity is characterized by high cholesterol and fatty acid levels, imbalance in metabolic energy, insulin desensitization, lethargy, gallstones, high blood pressure, shortness of breath, emotional and social problems, and excessive adipose mass accumulation with hyperplasia and hypertrophy (Kushner and Ryan, 2014).

When energy intake equals energy expenditure, the body is in positive energy balance and body energy is stable. Over the many years, when body remains in positive energy balance, that is, the intake of calories is more than the expenditure of energy, this leads to obesity. The generalized accumulation of excess adipose tissue in the body with body weight more than 20% of the desirable body weight is called obesity whereas overweight is body weight 10-20% more than the mean standard weight for age, height and sex (Srilakshmi, 2019). The positive energy balance is a broad aspect for increase in adiposity; there are various internal factors to be blamed. Neurochemicals, body fat stores, protein mass, hormones, and post-ingestion factors, all play their roles in regulating intake and weight maintenance. Short term regulation governs hunger, appetite and satiety related to consumption of food from meal to meal and long term regulation of body weight is controlled by the availability of adipose stores and hormone responses involving insulin and leptin (L.K. Mahan and Raymond, 2017).

2.2 Measurement of overweight and obesity

Body mass index (BMI), waist circumference (WC), waist-to-hip ratio (WHR) and waist-height ratio (WHtR) are different measures used to estimate the body fat content; however, comparison to a gold standard test is practically difficult (Baioumi, 2019).The most accurate measures of body weight and composition are underwater weighing, dual-energy x-ray absorptiometry (DEXA) scanning, computed tomography (CT), and magnetic resonance imaging (MRI) but are impractical for use in everyday clinical encounters as well as in research settings (Purnell, 2018). The practicable, inexpensive and routine measurement includes anthropometric measurement of body weight, height, waist and hip circumference required to construct indicators of adiposity namely, body mass index (BMI), Waist circumference and Waist-to-hip ratio (Kushner, 2012).

2.2.1 Body mass index

Body Mass Index (BMI), also known as Quetlet Index, is a measure combining the weight and height of an individual. It can be calculated by dividing the weight(in kg) by the square of the height (WHO, 2022).

The BMI cut-offs are given by WHO and are categorized as follows:

Table 2.1: WHO BMI Classification

Classification	BMI (kg/m^2)	Risk of comorbidities
Underweight	<18.5	Low
Normal	18.5-24.9	Average
Overweight/ Pre-obese	25-29.9	Increased
Obese I	30-34.9	Moderate
Obese II	35-39.9	Severe
Obese III	≥40	Very severe

However due to high body fat content in Asians, they develop negative health consequences at a lower BMI than western populations. South-Asians have an increased body fat percentage (BF %), both total and in the abdominal region, lesser lean mass, skeletal muscle and bone mineral content along with a higher risk for CVD. The significant variability in body composition between ethnic groups may not be truly reflected by measuring only BMI or other markers as each has its own limitations. Therefore, WHO recommended lower cut-off points of BMI for high risk populations including South Asians (Amin *et al.*, 2015).

Table 2.2: Classification of Asian BMI cut-offs

Classification	BMI(kg/m^2)	Risk of comorbidities
Underweight	<18.5	Low risk
Normal	18.5-23	Acceptable risk
Overweight	23-27.5	Increased risk
Obese	≥27.5	High risk

BMI provides the most useful population level measure of overweight and obesity as it is the same for both sexes and for all ages of adults. However, it should be considered a rough guide because it may not correspond to the same degree of fatness in different individuals (WHO, 2022). It measures excess body weight for a particular height and has been shown to

correlate with body fat although it is not a direct measure of body fat. It does not measure overweight or obesity risk and mortality risk with the same accuracy in all target populations due to variations in body fat composition and distribution (Bhurosy and Jeewon, 2014).

2.2.2 Fat percentage

Body fat is composed of cells that contain triglyceride stores. Body fat can be divided into two main compartments: subcutaneous and intra-abdominal. Fat may also accumulate at ectopic sites such as muscle, including the heart, pancreas, and liver (Depres and Lemieux, 2006; Ronti *et al.*, 2006). Body fat percentage is total body fat expressed as a percentage of total body weight. The generally accepted definition of obesity, based on total body fat, uses cut-points as >25% in men, and >30% in women (Okorodudu *et al.*, 2010). Percent body fat provides a more accurate body assessment for being overweight or obese in compared with BMI (Trang *et al.*, 2019). Excessive ectopic fat distribution in sites such as the viscera leads to abnormal fat metabolism and aggravates the development of diabetes and obesity (Hwang *et al.*, 2015).

The determination of the accuracy of any anthropometric measure to determine body fat is gauged by the method of fat identification to which it is compared as all these anthropometric measures are indirect measures of fat distribution. The direct methods are those which have the ability to identify fat droplets all over the body with particular relevance to visceral fat and ectopic fat, for example, in skeletal muscle, liver, pancreas, heart (Baioumi, 2019).

Computed Tomography (CT) or dual-energy X-ray absorptiometry (DEXA), continue to be the gold standard for evaluating the distribution of body fat (Rollins *et al.*, 2017). Nevertheless, the high cost and low availability have made it difficult to use in large population studies. Recently, more research has examined the potential role of body composition measurements in health monitoring (Mazzocoli, 2016; Ramirez-Velez *et al.*, 2017). Bioelectrical impedance analysis (BIA) is the method that is most frequently used to assess body composition and calculate body fat composition and calculate body fat percent in clinical practice, given its accuracy, simplicity, low cost, and excellent correlation with DEXA, CT, or magnetic resonance imaging (MRI) (Xiaoguang *et al.*, 2011). In addition to them, body fat percentage estimated by skin fold thickness (ST) is widely practiced indirect measure in health researches (Sangachin *et al.*, 2018). According to age the adjusted body fat percentage of women can be categorized as follows:

Table 2.3: Percent body fat charts for male and female

Gender	Age in years	Low Fat	Normal	Overweight	Obese
Male	20-39	<8%	8-19.9%	20-24.9%	≥25%
	40-59	<11%	11-21.9%	22-27.9%	≥28%
	60-79	<13%	13-24.9%	25-29.9%	≥30%
Female	20-39	<21%	21-32.9%	33-38.9%	≥39%
	41-60	<23%	23-33.9%	34-39.9%	≥40%
	60-79	<24%	24-35.9%	36-41.9%	≥42%

(Gallagher *et al.*, 2000)

2.2.3 Waist circumference

Waist circumference is an indicator of health risk associated with excess fat around the waist. It is an anthropometric measure at waist line that provides a simple and practical measure for assessing central adiposity. It has been shown that mesenteric adipose tissue inflammation is more related to metabolic consequences of obesity (Kranendonk *et al.*, 2015). Waist circumference has been increasingly used as a convenient measure of adipose tissue in epidemiological studies as well as in weight loss intervention trials (Filgueiras *et al.*, 2019). It has been suggested that waist circumference is more practical and superior to BMI in case of predicting obesity-related mortality (Jacqui, 2017). This is largely based on the rationale that increased visceral adipose tissue is associated with a range of metabolic abnormalities, including decreased glucose intolerance, reduced insulin sensitivity and adverse lipid profiles, which are risk factors for type 2 DM, cancers and CVD (Seidell, 2010).

Waist circumference is measured at the midpoint between the lowest palpable rib and top of iliac crest, using a non-stretchable measuring tape that provides a constant 100g tension; at the end of several consecutive breaths (WHO, 2011). The WHO stated cut offs for waist circumference and risk of metabolic complications are as follows:

Table 2.4: WHO waist circumference cut-offs in male and female

Gender	Classification	Cut-offs	Metabolic risk
Male	Centrally overweight	>94 cm	Increased
	Centrally obese	>102 cm	Substantially increased
Female	Centrally overweight	>80 cm	Increased
	Centrally obese	>88 cm	Substantially increased

(WHO, 2011)

However, the recommended cut off values of waist circumference for central obesity vary among different ethnic groups. Asians tend to have more body fat per BMI than Caucasians, which indicates greater potential for them to develop hypertension, diabetes, and dyslipidemia at lower BMIs (W.-Y. Ma *et al.*, 2013). Therefore, the recommended cut off values for defining abdominal obesity among South Asians are ≥90cm for males and ≥80 cm for females (IDF, 2006).

2.2.4 Waist to hip ratio

The waist-to-hip ratio (WHR) is obtained by dividing the waist circumference by the hip circumference (HC) using the same units of measurements for both. The HC is measured using a non-elastic tape held horizontally without constricting it at the point that yields the maximum diameter over the buttocks (Baioumi, 2019). For the WC and the HC, each measurement should be done twice and if both measurements differ by >1cm, each measurement should be repeated(WHO, 2005). The role of WHR as a surrogate measure of both visceral and subcutaneous fat was established following convincing evidence from longitudinal studies that showed significant associations between abdominal obesity and adverse cardiovascular outcomes (Umuerri, 2019).

Abdominal obesity is defined as waist-to-hip ratio above 0.90 for males and above 0.85 for females. These values indicate abdominal obesity and reflect substantially increased cardio-metabolic risks (WHO, 2011). The ratios are defined as one of the decisive benchmarks for metabolic syndrome and is consistent with findings of research predicting all cause and cardiovascular disease mortality (L.K. Mahan and Raymond, 2017).

Measuring hip circumference may be more difficult than measuring waist circumference alone; this could limit the potential use of waist hip ratio as an alternative to either waist circumference alone or BMI (WHO, 2011). WHR can also be harder to interpret than waist circumference and have little implications with those who have a BMI of 35 or higher (Watson and Bubnis, 2017).

2.3 Types of obesity

2.3.1 Based on BMI

Based on increasing BMI, obesity can be categorized into following three different grades (Srilakshmi, 2019):

i. Grade I obesity

People with this type of obesity have body mass index more than 25 kg/m^2 but less than 29.9 kg/m^2. Overweight does not affect their health; they may lead normal health and life expectancy is above normal. They may reduce on their own (Srilakshmi, 2019).

ii. Grade II obesity

The body mass index is between (30-39.9) kg/m^2. Though they appear to be in good health, they have reduced tolerance to exercise with shortness of breath on exertion and they are unduly fatigued. This is due to the burden of increased weight they always carry and have reduced capacity of the circulatory and respiratory systems that are handicapped by masses of internal fat and fatty infiltration of muscle. For metabolic and mechanical reasons these patients are at increased risk of diabetes, atherosclerosis, hypertension, fatty liver, gall bladder diseases, osteoarthritis, hernias and varicose veins. Mortality rate also increases (Srilakshmi, 2019).

iii. Grade III obesity

The body mass index is above 40 and these patients are in pathetic conditions. Their day to day activities are restricted due to their enormous mass and more susceptible to diseases mentioned in Grade II. They are susceptible to atherosclerosis, prone to accidents and have serious psychological disturbances (Srilakshmi, 2019).

2.3.2 Based on age of Onset of obesity

Patients with early onset of obesity had a higher total body fat mass, and higher body fat percentage, and a 1.84 times higher risk of BMI above 40 kg/m^2 than patients with adult onset of obesity (≥ 20 years) (Wrzosek and Wisniewska, 2018). On the basis of age of onset, obesity can be categorized into two ways (Srilakshmi, 2019):

i. Juvenile-onset obesity

Juvenile obesity occurs due to hyperplasia and most rapidly in the first few years of life. It appears most frequently in the first year of life, at 5-6 years of age and during adolescence (Srilakshmi, 2019). Too many calories fed in infancy and early childhood leads to an overproduction of fat cells (hyperplasia) followed by hypertrophy (enlargement of fat cells) (Sheth and Shah, 2006). Overweight and obese children are likely to stay obese into adulthood and more likely to develop non-communicable disease like diabetes and cardiovascular diseases at a younger age (Sahoo *et al.*, 2015). Childhood obesity can profoundly affect children's physical health, social, and emotional well-being, and self-esteem. It is also associated with poor academic performance and a lower quality of life experienced by the child. Many co-morbid conditions like metabolic, cardiovascular, orthopedic, neurological, hepatic, pulmonary, sleep apnea and renal disorders are also seen in association with childhood obesity (Sahoo *et al.*, 2015).

ii. Adult -onset obesity

It occurs from hypertrophy of fat cells alone; the size of the individual cell is greatly enlarged. A distended adipose cell leads to further physiological, biochemical, anatomic aberrations in individual's organs and organ systems. In addition to this fact, increased number of fat cells may also occur in adult life which is to be expected when BMI is above 40 kg/m^2 (Bray and Bouchard, 2019). A pharmacology intervention coupled with other management strategies will work better in treating such cases than juvenile obesity (Srilakshmi, 2019). High energy density diet, increased portion size, low physical activity and adoption of a sedentary lifestyle as well as eating disorders are considered as important risk factors for the development of obesity (James, 2008). These behavioral and environmental factors lead to alterations in adipose tissue structure (hypertrophy and hyperplasia of adipocytes, inflammation) and secretion (e.g. adipokines) leading to development of metabolic syndrome (Tilg and Moschen, 2006).

2.3.3 Based on distribution of Fat storage

Fat mass is distributed differently in men and women. The pattern of body's adipose tissue deposition, independent of total body fat, alters health risk in human body despite of their age and gender. There are two types of regional fat distribution as follows (McArdle *et al.*, 2010):

i. Android-type obesity

In central or android-type obesity, there is increased health risk from fat deposition, particularly internal visceral deposits, resulting from active lipolysis from the adipose tissue with catecholamine stimulation. Fat stored in this region shows greater metabolic responsiveness that fat deposited below waist line; as reflected by altered metabolic profile such as insulin resistance, hyperinsulinemia, non-insulin dependent diabetes mellitus, hyperlipidemia and hypertension (McArdle *et al.*, 2010).

Android obesity is commonly related to male body and is also called as apple-type body however, this can be related to menopause in case of females. The underlying mechanism might be due to the lipolytically sensitive abdominal depots providing excess free fatty acids to muscle tissues that has a decreased capacity for their oxidation. This excessive exposure of fatty acids impairs the insulin function of tissues and increase blood insulin levels leading to reduced insulin sensitivity and ultimately making a person insulin resistant. The hyperinsulinemia might be the starting point for most of other metabolic derangements (Srilakshmi, 2019). Also, increase in central fat more readily support processes that cause heart disease (McArdle *et al.*, 2010).

ii. Gynoid-type obesity

Gynoid-type obesity is related to weight gain around hips and flank area; thigh and bottom. It is typically related to obesity in women and is also known as pear-type or peripheral fat distribution (Srilakshmi, 2019). Individuals with a gynoid fat distribution are at a greater risk of mechanical problems like osteoarthritis (Sheth and Shah, 2006). The lower body fat deposition is usually by hyperplasia. Reducing the number of fat cells in lower hyperplastic depot is difficult than android obesity. This explains the weight loss difficulties faced by many women with gynoid obesity (Srilakshmi, 2019).

Gynoid fat deposition in women during child bearing years is utilized to support the demands of pregnancy and lactation. Women with the gynoid-type obesity do not develop

the impairments of glucose metabolism as compared with an android deposition (L.K. Mahan and Raymond, 2017).

2.4 Theories on obesity

Obesity arises in a person when the size or the number of fat cells increases in the body. A normal person has got about 30-35 billion fat cells (Sheth and Shah, 2006). When a person tries to lose fat, then it is possible to reduce the size of fat cells rather than their numbers. Hence with initial increase in number of fat cells, weight loss becomes difficult (Hopkin, 2008). Different theories have been postulated to understand the body weight regulation mechanism and subsequent obesity. These include:

i. Fat cell theory

The number of fat cells are determined early in life which once have formed, have a tendency to form full fat. The fat cells increase early in life (juvenile-onset hyperplasia) which indicates that adult-onset obesity is caused by an increase in the size of fat cells (hypertrophy). When a person starts losing weight, the cells decrease in size but the number generally stays the same. Thus, people having large number of fat cells have more difficulty in maintaining body weight than those with fewer fat cells (Srilakshmi, 2019). However, the obesity related health problems occur due to the enlarged fat cells which are metabolically active rather than the number of fat cells or the person's weight. The number of fat cells increase as a result of positive energy balance but can decrease only with sustained weight loss for a prolong period of time (Spalding *et al.,* 2008).

ii. Set point theory

According to the set point theory, body weight remains remarkably stable from the internal regulatory mechanisms that are genetically determined. A deliberate efforts to starve or overfeed are followed by a rapid return to the original body weight called a 'set point' (L.K. Mahan and Raymond, 2017). Thus, once a body weight reaches this point, a whole set of signals is produced that influences the person's food intake to maintain in set point (Srilakshmi, 2019).

The set point mechanism is not regulated on a meal-to-meal basis. During the recovery from illness, food intake is increased in a catch-up fashion until lost weight is regained. Similarly, when the weight of the person exceeds the set point, then the hypothalamus recognizes the need to lose weight (Sheth and Shah, 2006).

iii. Enzyme and hormone theories

When there is hyperinsulinemia, then the lipogenesis takes place which leads to conversion of glucose into triglycerides (fat). The resulting high serum triglycerides are stored in fat cells i.e., in the adipose tissue, and make the fat cells distended. This defect of chemical imbalance has been described as syndrome "X". It makes you fat and becomes difficult to lose weight (Sheth and Shah, 2006).

When the fat cells absorb more of triglycerides, they emit a biochemical protein into bloodstream called leptin. When there is too much of leptin, it signals to restrict feeding behavior; the fat storage is inhibited and stimulates lipolysis with corresponding energy expenditure. Hence, leptin is regarded as a bodyweight regulatory hormone (Srilakshmi, 2019). In obesity, though leptin levels remain elevated, their receptors in the hypothalamus are desensitized. So, the hypothalamus continues the triglyceride storage in adipose cells with reflex of hunger beyond need and ultimately results in weight gain. Also, an increase in lipoprotein lipase enzyme is known to deposit fat into fat cells and has probable role in raising the appetite (Sheth and Shah, 2006).

2.5 Risk factors associated with overweight and obesity

Obesity is a complex multifactorial chronic disease developing from interactive influences of numerous factors including - social, behavioral, psychological, metabolic, cellular and genetic. The various influencing factors on energy intake and expenditure that are considered to be important in weight gain and the development of obesity are as follows (L.K. Mahan and Raymond, 2017):

2.5.1 Genetics

Obesity tends to run in families. It is likely that some individuals are genetically more susceptible to the effects of an obesogenic environment (Gandy *et al.*, 2006). Many hormonal and neural factors involved in weight regulation are determined by heredity and genetics. Small defects in their expression or interaction could contribute significantly to weight gain. Genetic inheritance influences 50-70 percentage a person's chance of becoming fat more than any other factor (L.K. Mahan and Raymond, 2017). Within a family, the chance of being obese is 80 percent if both parents are obese and 50 percent if one parent is

obese. A mutation in the human gene coding for the B3 receptor in adipose tissue, involved in lipolysis and thermogenesis markedly increase the risk of obesity (Srilakshmi, 2019).

Genes interact with the diet and activity patterns that lead to obesity and the metabolic pathways that influence satiety and energy balance. Researchers have identified an obesity gene called 'Ob' that is expressed primarily in the adipose tissue and codes for the protein leptin (Whitney and Rolfes, 2011). Although numerous genes are involved, several have received much attention- the 'Ob' gene, the adiponectin (ADIPOQ) gene, the "fat mass and obesity associated" gene or FTO gene, and the beta3-adrenoreceptor gene. The Ob gene produces leptin. Mutation in the Ob gene, leptin receptor (LEPR), or ADIPOQ genes can result in obesity or metabolic syndrome (MetS) (L.K. Mahan and Raymond, 2017).

2.5.2 Age

The aging process brings about many changes in body composition, often without concomitant changes in body weight and body mass index. In general as individual's age increases, percentage body fat increases whereas lean mass and bone mineral density decrease (Choi *et al.*, 2012). Advancing age is associated with an increase in abdominal white adipose tissue and fat deposition in skeletal muscle, due to hormonal changes and a less active lifestyle which may increase the risk of obesity with significantly affecting insulin sensitivity (Jura and Kozak, 2016). The body fat distribution also changes during aging, such as increased fat accumulation from the subcutaneous area to visceral organs (Öztürk *et al.*, 2018). Hales *et al.* (2018) found that age standardized prevalence of severe obesity in adults increased from 5.7% (95%-CI) in (2007-2008) to 7.7% (95%-CI) in (2015-2016). The prevalence increased in men, women and adults aged 20 to 39 years and 40-59 years.

2.5.3 Marital status

Marital status affects body weight. In particular, living without partner, either being divorced or never married is associated with lower body weight. Cohabitors and married respondents tend to weigh more. There are three perspectives linking body weight to marital status (Teachman, 2016). The first perspective, the resource model, emphasizes different resources, social and economic, available to individuals possessing different marital status. Married individuals are more likely to have a confident with whom to eat and may therefore eat more

regularly and of larger portion sizes, as well as decreased physical activity, leading to weight gain (Dinour *et al.*, 2012).

The second model, the attractiveness model, links body weight to differences in emphasis people place on their physical attractiveness. Married men and women are less likely to be conscious or concerned about their body weight because they are not actively seeking a mate. As a consequence, married individuals are more likely to experience greater increase in body weight when compared to non-married individuals (Wilson, 2012). The third model is the crisis model and it focuses on stresses associated with marital status, particularly marital dissolution. Stress linked to marital disruption have been related to psychological, physiological and social consequences that can lead to weight loss (Teachman, 2016).

2.5.4 Socioeconomic factors

Socioeconomic status is an important factor associated with obesity. It can be determined using variables such as education, income, and occupation, with education considered to be the most stable variable over time (Anekwe *et al.*, 2020). The prevalence of obesity varies with socioeconomic status. In developed countries, poverty is associated with increase prevalence, whereas in developing countries it is the relative affluence that carries the greater risk (Yeung and Laquatra, 2003). The growing urbanization and globalization of food production and marketing, changing socioeconomic status of population has a profound effect on energy balance with introduction of low-cost, energy-dense foods in the domestic food market (Bhurosy and Jeewon, 2014).

The specific factors such as social identity, social status, social trends and influences of the built, industrial, and social environments are closely associated with the prevalence or incidence of obesity or that impacts efforts to prevent and treat this disease (Lee *et al.*, 2000). Socioeconomic factors contribute to obesity on an individual and community level, and any viable approach to sustainably addressing the obesity epidemic must take these factors into account (Anekwe *et al.*, 2020).

2.5.5 Physical activity

Lack of physical activity, through its impact on energy balance, has been identified as an important modifiable risk factor for obesity (Bryan and Walsh, 2004). There has been increasing evidence over the past decades of the importance of physical exercise in

maintaining cardiovascular health and preventing diseases (Blair and Moriss, 2009). When sedentary individuals undertake exercise, the activity provides a massive stimulus with widespread physiological implications. The precise metabolic regulation brought about by exercise is expressed at many levels of regulatory processes, be it by stimulating the effect of key enzymes, by increasing cell sensitivity to numerous hormones, by facilitating substrate transport through membranes, by influencing cell receptors in a tissue-specific manner, and much more. With the generalized sedentariness observed in modern societies, the human body needs to compensate for the lack of exercise stimulation to maintain energy and macronutrient balance. Fat gain and the metabolic syndrome are unfortunately the price to pay to maintain this balance (Chaput *et al.*, 2011).

Most of the research clearly report the prevalence of overweight and obesity being higher among the individuals with low levels of physical activity as compared to those with high levels of physical activities (Dabrowska *et al.*, 2015). However, the physical activity interventions had a positive effect on adiposity measures (Baker *et al.*, 2016). It is recommended that adults aged 18-64 years should do at least 150 minutes of moderate intensity aerobic physical activity throughout the week, or do at least 75 minutes of vigorous intensity aerobic physical activity throughout the week, or an equivalent combination of moderate and vigorous intensity physical activity (WHO, 2010). Also, the intensity of physical activity is measured in metabolic equivalents or METs. One MET is defined as the calories burned while an individual sit quietly for one minute. For the average adult, this is about one calorie per every 2.2 pounds of body weight per hour (IPAQ, 2005).

One of the methods for the assessment of physical activity level in community level is ‘International Physical Activity Questionnaire (IPAQ)’. From the questionnaire, total MET minutes/week and physical activity level can be determined as following (Ashok *et al.*, 2016; IPAQ, 2005):

Table 2.5: MET values computation

MET values	Formula for computation
Walking MET minutes/week	3.3 × walking minutes × walking days
Moderate MET minutes/week	4 × moderate intensity activity minutes × moderate days
Vigorous MET minutes/week	8 × vigorous intensity activity minutes × vigorous days
Total MET minutes/week	Walking + Moderate + Vigorous MET minutes/week scores

(Ashok *et al.*, 2016; IPAQ, 2005)

After the calculation of total MET score of each participants, the physical activity level can be categorized according to IPAQ scoring protocol as follows:

i. Low:

This is the lowest level of physical activity. Those individual who do not meet criteria for moderate and high level or with MET scores less than 600 MET minutes/week are considered of having low level of physical activity.

ii. Moderate:

The pattern of activity having following criteria can be classified as moderate:

- 3 or more days of vigorous intensity activity of at least 20 minutes per day. OR
- 5 or more days of moderate intensity activity and/or walking of at least 30 minutes per day. OR
- 5 or more days of any combination of walking, moderate intensity or vigorous intensity activities achieving a minimum total physical activity of at least 600 MET minutes/week.

iii. High:

Individuals meeting following criteria can be classified of having high physical activity level:

- Vigorous intensity activity on at least 3 days achieving a minimum total physical activity of at least 1500 MET minutes/week. OR

• 7 or more days of any combination of walking, moderate intensity or vigorous intensity activities achieving a minimum total physical activity of at least 3000 MET minutes/week. Moderate intensity physical activity is defined as activities that are strenuous enough to burn three to six times as much energy per minute when sitting quietly, or 3 to 6 METs. Vigorous intensity activities burn more than 6 METs.

2.5.6 Dietary intake

Diet plays an important role in obesity. Excess calorie intake along with overconsumption of specific nutrients and foods such as saturated fat, added sugars, high sodium food, and refines grain contribute to obesity (Jensen *et al.*, 2014). Carbohydrates, fat and protein all contribute to the body's energy needs. To meet the need for these macronutrients without increasing risk of chronic disease requires that people eat a balance diet. The recommendations for population nutrient intake goals include 55-75% total carbohydrate intake as adequate, total fat consumption of 15-30% and protein ingestion of 10-15% (WHO/FAO, 2010).

i. Energy dense foods

Energy density is the amount of energy (in kilocalories) per given weight of food (in grams). Energy dense foods, often high in refined grains, added sugars, and added fats (Bechthold, 2014), are palatable, inexpensive, and convenient (Mendoza *et al.*, 2007). A single group of researchers have identified dietary fats, sugars and corn sweeteners, soft drinks, fast foods, snacks, and larger portion sizes as potential culprits in the obesity epidemic (Drewnowski, 2007). Dietary fat has higher energy density (9 kcal/g) than other macronutrients; either carbohydrate or protein (4 kcal/g), and excess dietary fat is readily stored in adipose tissue depots with a very high efficiency. Disruptions in fat balance has become a clear perspective of weight changes following challenges to body weight regulation (WHO, 2003).

Lower food costs may be associated with more energy-dense diets, and total energy intake may actually increase. Lower food costs may be associated with more energy-dense diets, and total energy intake may actually increase (Drewnowski, 2009).The etiology of obesity increasingly reflects excessive calorie intake matched with higher levels of sedentary activity that occur in the face of a worldwide urban migration. In this scenario, traditional diets are often replaced with low cost energy dense foodstuffs produced by the industrialized food

(Gluckman *et al.*, 2015; Hill and Peters, 1998). Nepalese diet is shifting away from agricultural staple foods to modern processed foods with higher total energy, total fat, and sugar resulting in increased prevalence of overweight/obesity and diet related non-communicable diseases (Subedi *et al.*, 2017).

ii. Protein intake

The word protein is derived from the Greek word "proteios", meaning prime or primary. This term is very appropriate in nutrition, because protein is the most fundamental component of tissues in animals and human. A protein contains various amount of different amino acid linked via peptide bonds (G. Wu, 2016). An adequate level of protein consumption is essential for every individual, and the World Health Organization (WHO) has established an international dietary protein recommendation of 0.83 g/kg/day (WHO, 2015).

Protein has long been regarded for its ability to assist in weight management, increase high-density lipoprotein (HDL) cholesterol, increase thermogenesis and satiety, and enhance bone mineralization (Ahnen *et al.*, 2019). In the 7 year follow up study, Bujnowski *et al.* (2011) reported that animal protein intake was positively related and vegetable protein intake inversely associated with overweight/obesity in apparently healthy middle-aged American men. The results of this study indicate that protein sources may be important with respect to weight, independent of energy, carbohydrate, alcohol, and fat intake (Bujnowski *et al.*, 2011). A cross-sectional study conducted in multiethnic population concluded that high dietary protein intake protects against the effects of risk variants in the FTO gene on BMI and waist circumference (Merritt *et al.*, 2018).

iii. Fruits and vegetables

Fruits and vegetables have historically held a place in dietary guidance because of their concentrations of vitamins, especially vitamins A and C; minerals, especially electrolytes; and more recently phytochemicals, especially antioxidants. They are also good source of dietary fibers (Slavin and Lloyd, 2012). It is suggested to consume more than 400 grams (five servings) of fruits and vegetables per day to improve overall health and reduce the risk of certain NCDs excluding tubers like potato, cassava, etc (WHO, 2020). In Nepal, low

consumption of fruits and vegetables was found which can be directly attributed to prevailing non-communicable diseases (Shahi *et al.*, 2013a).

Consequently replacing some added sugars and saturated fat with more fruits and vegetables may benefit health. Some research indicates that fruit and vegetable consumption reduces the risk of major diseases and possibly delays the onset of age-related disorders (Vincente *et al.*, 2014). Fruits and vegetables are high in water and fiber, incorporating them in the diet can reduce energy density, promote satiety and decreased energy intake (Rolls *et al.*, 2004). Research shows that some bioactive components in fruits and vegetables, such as carotenoids, could contribute to the prevention and treatment of obesity. Some of these carotenoids are responsible for vitamin A production, a hormone-like vitamin with pleiotropic effects in mammals. Among these effects, vitamin A is a potent regulator of adipose tissue development, and is therefore important for obesity (Coronel *et al.*, 2019).

iv. Milk and Milk products

Milk products play an important role in daily human nutrition, as milk contains a balanced composition of amino acids, vitamins, and minerals (Smolnikova *et al.*, 2021). It is a source of anti-oxidative peptides, Vitamins, organic acids, calcium and pro-biotic bacteria with other biologically active peptides that are liberated from milk proteins by different hydrolytic methods. Besides milk, many dairy products including butter, yoghurt, cream, cheese, and kefir, have been manufactured and consumed worldwide (Patil *et al.*, 2021). Milk and dairy products constitute the best dietary source of calcium due to the bioavailability of the calcium they contain (Rovira, 2015).

Greater consumption of total dairy products may be of importance in the prevention of weight gain in middle aged and elderly women who are initially normal weight. Epidemiologic data suggest that people with greater dairy product (high calcium) intake have a lower prevalence of overweight and obesity (Rautiainen *et al.*, 2016). The possible anti-obesity mechanisms of calcium includes regulation of adipogenesis, fat metabolism, adipocyte (precursor) proliferation and apoptosis, thermogenesis, fat absorption and excretion, and gut microbiota (Zhang *et al.*, 2019).

v. Salt intake

The recommended salt intake for adults is less than 5 gram of salt per day which is 2 grams of sodium per day (WHO, 2012). High sodium intake is significantly associated with an increased risk of obesity and metabolic syndrome in the general population (Oh *et al.*, 2015). Recently, several lines of evidence have also shown that high salt intake is associated with an increased risk of obesity. One reason for this association is that high salt intake stimulates thirst and increases fluid intake and thereby increasing sugar-sweetened beverage consumption (Y. Ma *et al.*, 2015).

Sodium intake also stimulates appetite, and subsequently increases energy intake and extracellular volume (Oh *et al.*, 2017). In addition, the association between salt and obesity may also be partially caused by excessive consumption of processed food that is high in both calorie and salt (Y. Ma *et al.*, 2015). A diet with a high salt content may have a negative influence on development in body composition by expanding body fat and reducing fat free mass (Larsen *et al.*, 2013).

2.5.7 Behavioral factors

The behavioral influences on obesity include specific behaviors that may contribute to weight gain thorough overeating or reduced physical activity and the mechanisms by which the environment can affect health (Affenito *et al.*, 2012).

i. Watching T.V. while eating

Television watching appears to encourage snacking during viewing and also influences food choices both during viewing and at other times. In controlled interventions, decreased television watching reduced weight gain in children, and effect that was mediated more by improvements in dietary habits than by a change in physical activity (Mozaffarian *et al.*, 2011). The association between watching television with overweight and obesity was evidenced by a different explanation such as hours spent in front of the television, decrease in the physical activity, a television based food advertising influencing what and how people eat, and watching television leads to mindless eating or lack of attention paid to consume due to external cues in the environment (Ahmed *et al.*, 2020).

The more television people watch, the more likely they are to gain weight or become overweight or obese (Thorp *et al.*, 2011). Different studies revealed that watching television is positively associated with an overall increase in food intake, particularly pizza, fast food, and high-calorie snacks and is inversely associated with intakes of vegetables and fruits (Ahmed *et al.*, 2020). A research among adolescents in Nepal, reports that watching TV for longer time is one of the major risk factors for developing overweight (S. Piryani *et al.*, 2016b).

ii. Skipping breakfast

"Breakfast is the most important meal of the day" is a consensus in public. However, the definition of breakfast varies across studies. Here are two standard definitions as follows: Firstly, Eating the first meal of the day before or at the beginning of the activity within 2 hours of waking up, usually no later than 10 am, the calorie content is 20% to 35% of the total daily energy requirement. Secondly, the consumption of food or beverage (excluding water) between 5 and 9 am (X. Ma *et al.*, 2020).

Breakfast skipping is associated with changes in appetite and decreased satiety, which may lead to subsequent overeating and impaired insulin sensitivity (Önnerfält *et al.*, 2018). Chowdhury *et al.* (2016) conducted a randomized controlled trial and demonstrated that in obese adults, daily breakfast leads to more significant physical activity during the morning, whereas morning fasting results in partial dietary compensation (i.e. higher energy intake) later in the day. Skipping breakfast have become more prevalent among school-age children, adolescents and working adults (X. Ma *et al.*, 2020). Skipping breakfast was significantly correlated with waist circumference and BMI (Y. Watanabe *et al.*, 2014).

iii. Sleep

Sleep plays a crucial role in human's endocrine, metabolic and neurologic functions (Liu *et al.*, 2019). Sleep is an important modulator of neuroendocrine function and glucose metabolism and sleep loss has been shown to result in metabolic and endocrine alterations, including decreased glucose tolerance, decreased insulin sensitivity, increased evening concentrations of cortisol, increased levels of ghrelin, decreased levels of leptin, and increased hunger and appetite (Beccuti and Pannain, 2011). Experimental sleep restriction was associated with increased salt retention and inflammatory markers as well. Many

epidemiological studies have shown that decreased sleep duration and quality (<7 hours per night) is significantly associated with increased obesity incidence (Cooper *et al.*, 2018). Thus, quantity and quality of sleep can also prevent a risk factor for overweight and obesity through dysfunctional eating behaviors, decreased physical activity, and metabolic changes (Bonanno *et al.*, 2019).

iv. Eating outside once in a day

Eating outside may lead to overconsumption and increase risk of obesity in part because of larger portion sizes, high energy dense foods, and increased variety and preferred taste of the foods (Anderson *et al.*, 2011). Food choices when eating out are usually high in energy content, which contributes to excessive energy intake (Bezerra *et al.*, 2012). Studies have found a positive association between the intake of food away from home and person's body mass index (BMI) or weight gain (Seguin *et al.*, 2016). Even one-meal per week consumption outside home, in fast food and sit-down restaurant, was associated with increase in BMI (Bhutani *et al.*, 2016). Fast foods typically have an extremely high energy density, which leads to excessive energy intake that contributes to weight gain and obesity (Prentice and Jebb, 2003).

v. Alcohol intake

Alcohol drinking is a component of lifestyle in many regions and, recently, has been raised in some developed countries. It contains high energy (7.1 kcal/g) and also, by disrupting energy balance, leads to accumulation of fat mass and development of overweight or obesity (Golzarand *et al.*, 2021). Increased energy intake through alcohol consumption can promote an energy imbalance, where intake exceeds output, and ultimately contribute to weight gain if not compensated for (Traversy and Chaput, 2015).

Regular heavy episodic drinking in young adulthood is associated with higher risk of gaining excess weight and transitioning to overweight/obesity (Fazzino *et al.*, 2017). Light-to-moderate alcohol intake, especially wine, may be more likely to protect against weight gain, whereas consumption of spirits has been positively associated with weight gain (Carmen *et al.*, 2011). Alcohol has numerous complex effects on, for instance, food intake regulation, psychosocial well-being, sleeping, and depression symptoms, all of which may influence body weight (Traversy and Chaput, 2015). Beer intake > 500 mL/day has been associated with abdominal obesity ("beer belly") (Bendsen *et al.*, 2013).

2.6 Comorbidities of overweight and obesity

Understanding the pathophysiology of obesity related disease will allow providers to better manage the suite of diseases that affect an individual. Keeping obesity as the central focus and basis of all treatment strategies for obesity related diseases is essential for the management of current disease as well as the prevention of future diseases (Andolfi and Fisichella, 2018). Health consequences of obese people fall into two broad categories: those attributable to the effect of increased fat mass (such as osteoarthritis, obstructive sleep apnea, social stigmatization) and those due to the increased number of fat cells (diabetes, cancer, cardiovascular disease, non-alcoholic fatty liver disease) (Gupta *et al.*, 2011).

Obesity may be associated with hypertension, dyslipidemia, diabetes, or insulin resistance, and elevated levels of fibrinogen and C-reactive protein, all of which increase the risk of CVD mortality and morbidity, particularly with central deposition of adipose tissues (Akhil and Ahmad, 2011). The relative risk of mortality from cancer, attributable to obesity, was approximately 14.2% in men and 19.8% in women. The most highly associated with obesity include breast cancer in postmenopausal women, colon cancer (especially among men), endometrial, esophageal adenocarcinoma, gall bladder and renal cancers (Stone *et al.*, 2018). The long term risk of type 2 diabetes increases significantly with increasing weight. More than 6 fold increase in diabetes risk for class III obese (BMI≥40) individuals was observed, compared to normal weight individuals (Leung *et al.*, 2017). In obesity, there is insulin resistance especially in muscle and there is hyperinsulinemia because of impaired insulin uptake by receptors in target tissue (Srilakshmi, 2019).

Obesity is characterized by a state of chronic and low-grade inflammation and obese patients are affected at various levels of their innate and adaptive immune responses. Obese patients have chronically lowered concentration of adiponectin (an anti-inflammatory adipokines) and higher levels of leptin (a pro-inflammatory adipokines) (Ouchi *et al.*, 2011). Obesity is a well-recognized cause of respiratory function compromise which might make these group of patients at risk of a more severe clinical course if they contract COVID-19. We have also concluded that obese subjects are potentially more vulnerable to become infected with COVID-19, and are more contagious when they do so with a prolonged period of viral shedding (Albashir, 2020). A rise in 10 kg body weight increases the risk of coronary artery disease by 12% and at the same time, systolic blood pressure rises by 3 mmHg and diastolic by 2.3 mmHg as a consequence (Csige *et al.*, 2018).

2.7 Prevalence and trends of overweight and obesity

2.7.1 Global trends of overweight and obesity

The prevalence of overweight and obesity has increased dramatically during the past four decades posing a major public health challenge both in developing and developed countries. Worldwide obesity has nearly tripled since 1975 (WHO, 2022). Between 1975 and 2016, the prevalence of obesity increased in every country in the world. In 1995, there were an estimated 200 million obese adults worldwide which increased to over 300 million in 2000 (Agha and Agha, 2017). The obesity pandemic has continued to rise since then; it had reached 600 million in 2014 and over 650 million in 2016 (WHO, 2022). It these trends continue, by 2025, global obesity prevalence will reach 18% in men and surpass 21% in women (NCD-RisC, 2016). In 2016, more than 1.9 billion (39%) adults aged 18 years and older were overweight and of these over 650 million (13%) adults were obese. The overweight population consists of 39% men and 40% women whereas the obese population consists of 11% men and 15% women (WHO, 2022). Globally 8% of deaths in 2017 were the result of obesity which represents an increase from 4.5% in 1990 (Ritchie and Roser, 2020).

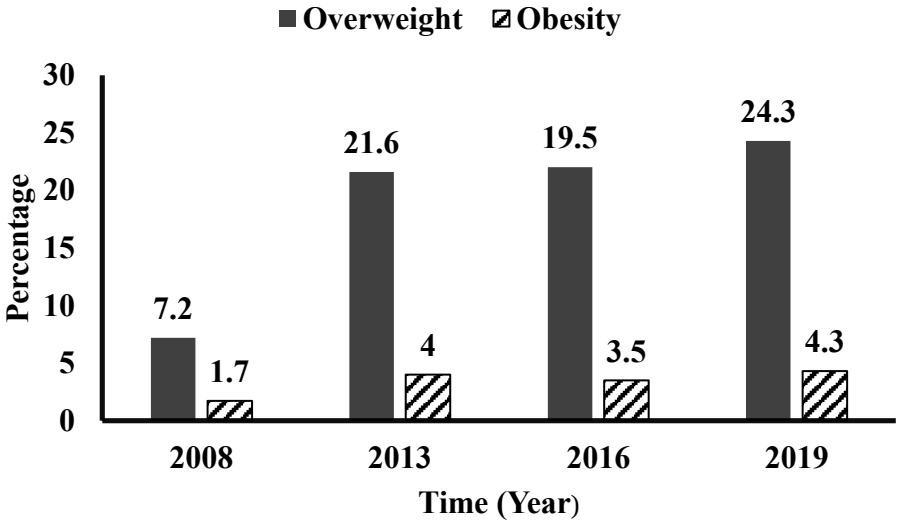
The prevalence of overweight has increased in almost all Asia-Pacific countries and territories since 2010. The increase was observed to be faster in lower –middle and low income countries and territories – 38% for children and adolescents (from 10.8% to 14.9%) and 15% for adults (from 26.9% to 30.8%) (OECD and WHO, 2020). Two out of every five adults are either overweight or obese in the Asia-Pacific regions (Helble and Francisco, 2017). The obesity burden is greater for South Asia, due to differences in fat patterning and body composition and the cardio-metabolic effects of body mass index (BMI) at levels far below standard BMI overweight cut-offs of 25 (Popkin *et al.*, 2012). Deaths attributed to obesity for South-Asian population increased from 2.03% in 2000 to 5.59% in 2017 (Ritchie and Roser, 2020).

2.7.2 Overweight and obesity in Nepal

According to the STEPS Survey Nepal 2008, 7.2% adults were overweight or obese and 1.7% obese. The mean BMI was 20.6 kg/m^2 (MOHP *et al.*, 2009). The trend of overweight and obesity increased to 21.6% overweight or obese and 4% obese in 2013 with the mean BMI of 22.4 kg/m^2 (Aryal *et al.*, 2014). A survey in 2016 estimated that nearly 19.5%

Nepalese adults were overweight or obese which includes 22% of female and 17% male population. The percentage of obese population was 3.5% (5% women and 2% men) (MOHP and ICF, 2017). According to the STEPS Survey Nepal 2019, the percentage of overweight or obese population was 24.3% (23.4% male and 25.1% female) and that of obese population was 4.3% (3.2% male and 5.3% female). The mean BMI was found to be 22.7 kg/m^2 (Dhimal *et al.*, 2020).

The prevalence of overweight and obesity was 22.9% in Province 1 and 3.8% of population were obese. Province 3 had the highest prevalence of overweight and obesity when compared with other provinces of Nepal (Dhimal *et al.*, 2020). A STEPS survey conducted in Nepal found that 7.2% and 1.7% of adults were overweight and obese respectively in 2007 which increased to 17.7% and 4% in 2013 respectively (MOPH, 2013). A study related Prevalence of Hypertension, Obesity, Diabetes, and Metabolic Syndrome in Nepal, the result found out that 28% were overweight, and 22% were obese (Sharma *et al.*, 2011a). Likewise another study done in Lalitpur sub metropolitan city described that almost 12.2% adolescents were overweight (Piryani *et al.*, 2016a). Overweight/obesity prevalence of 33.4% was found in a study conducted among civil servants in Nepal (Simkhada *et al.*, 2011). The study done in Ramdhuni municipality described that almost 26.9% and 14.3% adults residing in Ramdhuni municipality were overweight and obese respectively (Chaudhary, 2020).



(Aryal *et al.*, 2014; Dhimal *et al.*, 2020; MOHP and ICF, 2017; MOHP *et al.*, 2009)

Figure 2.1: Trends of overweight and obesity in Nepal

PART III

Materials and methods

3.1 Study area

This study was conducted at Itahari sub-metropolitan city of Sunsari district, Koshi zone, which is situated in Province no. 1 of Nepal. The total area of Itahari sub-metropolitan city was 93.79 sq km^2. It has total population of 1,98,098 population of which 94308 are males and 103790 are females living in 50,743 households (CBS, 2021; Municipality, 2079).

3.2 Study population

The population under study were adults of age 18-59 years residing in Itahari sub-metropolitan city.

3.3 Selection criteria

3.3.1 Inclusion criteria

18-59 years male and female residing in Itahari sub-metropolitan city were included in the study.

3.3.2 Exclusion criteria

i. Respondents who were not available at household during the time of survey.
ii. Those who with lifestyle diseases (such as Diabetes, Hypertention), mentally unfit, pregnant and lactating in case of females.
iii. Those who denied to give informed consent.

3.4 Research Design

A community based cross-sectional study was conducted among 18-59 years adults from different wards of Itahari who were available at the time of field work. The field work consisted of survey with the help of structured questionnaire followed by anthropometric measurements.

3.5 Sampling technique

The study was conducted on 7 ward of Itahari sub-metropolitan city. Out of 20 wards in Itahari a total of 7 wards were selected for sample selection by using lottery method. Number

of households to be surveyed from each ward was calculated on the basis of probability proportionate sampling technique to improve precision of sampling strategy. Random households were chosen for sample selection. Only one female/male from each household were chosen for study.

3.6 Sample size

The sample size was determined by using a single proportional formula where the combined prevalence rate of overweight and obesity was taken to be 22.9% in the survey area (Dhimal *et al.*, 2020), along with 95% confidence interval (CI), 6% margin of error (d) and 10% non-response rate.

We have, the sample size for infinite population as:

Sample size (N) = $z^2 \times \frac{p(1-p)}{d^2}$

where,

z = confidence level at 95% (standard value of z is 1.96)

p = baseline prevalence of overweight or obesity in Province 1

d = margin of error

Now, z = $1.96^2 \times \frac{0.229(1-0.229)}{(0.06)^2}$ = 188.408 ≃ 188

According to the population Census of 2078, the total population of Itahari was 198098. Thus we apply finite population sample formula to obtain new sample size to conduct survey in Itahari.

Therefore,

New SS = N / [1+ (N-1) / POP]

Where,

New SS = New sample size for finite population

N = Sample size in infinite population

POP = Total number of population

New sample size obtained as

= N / [1+ (N-1) / POP]

= 188 / [1+ ((181-1) / 198098)]

= 187.82≃ 188

Thus, calculated sample size is adjusted for non-response. Considering non-response rate as 10%, the adjusted sample size is calculated to be 207.

3.7 Research instruments

i. Weighing machine: Weighing machine manufactured by Microlife Pvt. Ltd, with the capacity of 180kg and having the least count of 0.1Kg (1piece) was used.
ii. Stadiometer: Stadiometer was used to measure height with the capacity of 197 cm and having the least count of 0.1cm.
iii. Measuring tape: A non-stretchable flexible measuring tape was used to measure waist and hip circumference.
iv. Questionnaire: A well designed, structured and pretested set of questionnaire was used to collect information on socio-demographic and economic data, physical activity, dietary intake and behavioral characteristics.
v. Measuring utensils: Standardized utensils were used for taking 24 hour dietary recall.

3.8 Study variables

3.8.1 Independent variables

The independent variables included in this study were as follows:

i. Socio-economic and demographic variables

Age, ethnicity, religion, marital status, education, occupation, family size.

ii. Physical activity

Physical activity was classified into different levels as low, moderate and high according to the calculated score of each individual from the IPAQ-short questionnaire. Similarly, the adequacy of physical activity for each individual was also determined as per the global recommendations on physical activity for health (WHO, 2010).

iii. Dietary intake

To assess the dietary intake, 24-hour dietary recall was used. The information collected was transformed to nutrient intake, namely, macronutrients. The nutrient adequacy was determined based on recommended dietary allowance (RDA) for Nepalese adults (DFTQC,

2017; ICMR, 2010). While salt intake (WHO, 2012) and fruits and vegetables intake (WHO, 2020) was based on WHO recommendations.

iv. Behavioral characteristics

Watching TV while eating foods, skipping breakfast, smoking, alcohol intake, and sleep

v. Health related characteristics

Use of contraceptives, menstrual disorders and thyroid problems.

3.8.2 Dependent variables

Following were the dependent variables included in this study:

i. Body Mass Index (BMI): BMI is defined as person's weight in kilograms divided by square of its height in meters (kg/m^2). Participants with a BMI greater or equal to 25 and less than $30kg/m^2$ is considered as overweight and obese if BMI is greater than or equal to $30kg/m^2$ (WHO, 2022).
ii. Waist circumference: Male participants with waist circumference above 90 cm and female participants with waist circumference above 80 cm were identified as abdominally obese (Alberti *et al.*, 2006)
iii. Waist to Hip ratio (WHR): Male respondents with waist to hip ratio greater than 0.9 and female respondents with WHR greater than 0.85 were considered as abdominally obese (WHO, 2011).

3.9 Pre-testing

The set of questionnaire was prepared and reviewed by the supervisor. It was then pre-tested among 10 adults for the practicability of the tool. This helped to have better understanding of the questions, estimation of the time consumed by each set of questions, and have clear view about the standardization procedures for anthropometry. After the completion of pretesting, all the misleading and wrongly interpreted questions were omitted and revised to obtain the final set of questionnaire.

3.10 Validity and reliability

Validity refers to the degree to which the data collection instruments will measure what they intent to measure. Validity of weighing balance was ascertained by comparing the data provided by the weighing balance with the standard weights. Similarly, the validity of the

stadiometer was ascertained by comparing the measurement with the UNICEF stadiometer. The measuring tape was calibrated against the standard stadiometer. The instruments were checked and reset daily to validate the data. For 24 hour recall, different foods were standardized in measuring cups used for data collection.

Reliability refers to the degree to which the result of a measurement, calculation, or the specification can be depended on to be accurate. It refers to how consistently a method measures something. The questionnaire was pre-tested prior to data collection to ascertain the reliability and was checked daily for completeness and consistency. The test re-test method was used and close supervision was done in the field.

3.11 Data collection techniques

Data collection was done on the month of February, 2022, in two steps which consists of initial interview with the participants to complete the semi-structured questionnaire, followed by anthropometric assessment. An informed consent was obtained prior to data collection. Participants were asked about their general information, socio-demographic and economic information followed by anthropometry, physical activity level and dietary details.

i. Socio-demographic information:

The socio-demographic information involved asking the participants about their age, ethnicity, marital status, education, family annual income.

ii. Anthropometric assessment:

Each anthropometric measurement was repeated thrice.

a. Weight: A portable digital weighing scale was used to measure weight. The instrument was placed on a firm, flat surface. Participants were requested to remove their footwear and socks, wear light clothes and stand in the scale with one foot on each side of the scale, face forward, place arms idly at their side and wait until asked to step off. Weight was measured in kilograms (Dhimal *et al.*, 2020; WHO, 2005)
b. Height: A portable standardized stadiometer was used to measure height. The participants were asked to remove the footwear and any hat or hair ties. They were requested to stand on the flat board facing the interviewer, heels against the back board with their feet together and knees straight. They were asked to look straight ahead and not tilt their head up, making sure that their eyes are at the same level as ears. Height was measured in centimeters (Dhimal *et al.*, 2020; WHO, 2005)

c. Waist circumference and Hip circumference: Waist circumference was measured at the mid-point between the lower margin of the least palpable rib and the top of the iliac crest, while, hip circumference was taken at the maximum over the buttocks; using a non-stretchable tape that provided a constant 100 g tension and at a level parallel to the floor. The tape was snugged around the body, but not pulled so tight that it was constricting. Also, the subjects were made stand erect with arms at the sides, feet positioned close together, and weight distribution across the feet and relaxed with measurement taken at the end of normal respiration. The measurement was read at the level of the tape to the nearest 0.1 cm (Dhimal *et al.*, 2020; WHO, 2011)

iii. Physical activity:

Information on physical activity of the participants included its type, intensity, duration and frequency in a week for the purpose of work, transportation and recreational activities. The short form of 'International Physical Activity Questionnaire (IPAQ)' was used for the data collection. IPAQ short form is an instrument designed primarily for population surveillance of physical activity among adults (IPAQ, 2005). It is a valid instrument of measuring physical activity (PA) which allows the international comparisons and which studies PA in its totality (at work, at home, and in the context of transports and hobbies) (Ashok *et al.*, 2016).

iv. Dietary information:

Dietary assessment was done using a food frequency questionnaire (FFQ) and dietary recall (24-hour) method. The FFQ was used to estimate the usual diet pattern and understand the diet quality and obesity outcome based on the frequency of consumption of predetermined food list for a week. While, the 24-hour food recall involved asking participants to recall their food intake in the previous 24 hours (the previous day). This method assessed the food quantity in household standardized measure of measuring cups and table spoon. The gram equivalents of those foods were calculated which was used to calculate amount of nutrients consumed.

3.12 Data analysis

The questionnaire was checked at the end of the day for completeness. The collected data sets were first coded and entered manually in database using Microsoft Excel 2016. Here,

the qualitative data were transcribed and coded by assigning labels to various categories. The date was then transferred to IBM SPSS Statistics software (version 20) for further analysis. Descriptive analysis was used to describe percentage and distribution of respondents by socio-demographic variables, physical activity, dietary patterns, medical characteristics and behavioral characteristics. Chi square test was used to establish the relationships with explanatory variables in the assigned data set.

3.13 Logistic and Ethical considerations

This research study was conducted with the permission received from the Department of Nutrition and Dietetics, Central Campus of Technology along with the ethical approval obtained from Itahari sub-metropolitan city. The objectives of research were explained in simple language and an informed written and verbal consent was obtained from all the participants. Privacy and confidentiality of collected data was ensured.

Part IV

Result and Discussion

The result of this cross-sectional study to assess the prevalence and risk factors associated with overweight and obesity among18-59 years male and female residing in Itahari sub-metropolitan city are presented and explained under following headings:

4.1 Demographic and Socio-economic characteristics

4.1.1 Gender wise distribution

The gender wise distribution of the study population shows that the majority of the participants were male. Out of total 207 participants 53.6% (111) were male and 46.4% (96) were female. The gender- wise distribution of the study population is shown in Table 4.1:

Table 4.1: Gender wise distribution of the surveyed population (n=207)

Variable		Frequency(n)	Percent (%)
Gender	Male	111	53.6
	Female	96	46.4

4.1.2 Age wise distribution

The age group with highest share of population was 40-49 years of age with 33.3% (69) whereas the age group 18- 20 years were least in number with the share of 1.9% (4). The age wise distribution of the study population is shown in Table 4.2:

Table 4.2: Distribution of age in the surveyed population (n=207)

Variable	Frequency (n)			Percentage (%)
	Male	Female	Total	
Age				
18-20	1(0.9%)	3(3.1%)	4	1.9
20-29	10(9%)	24(25%)	34	16.4
30-39	22(19.8%)	30(31.3%)	52	25.1
40-49	45(40.5%)	24(31%)	69	33.3
50-59	33(29.7%)	15(15.6%)	48	23.3

4.1.3 Religion and caste

The majority of the participants were Hindu with 78.7% (163) followed by Buddhist with 8.2% (17), 6.9% (14) Kirat, 4.3% (9) Christian and 1.9% (4) Muslim. According to the distribution by ethnic group, the highest share of participants were *Chhetri* 37.7% (78), followed by *Brahmin* with 20.8% (43), 17.4% (36) *Janajati*, 16.9% (35) *Chaudhary* and 7.2% (15) others. The distribution by caste and religion is shown in Table 4.3:

Table 4.3: Distribution of religion and caste of surveyed population (n=207)

Variable	**Frequency (n)**			**Percentage (%)**
	Male	**Female**	**Total**	
Religion				
Hindu	94(84.7%)	69(71.9%)	163	78.7
Buddhist	10(9%)	7(7.3%)	17	8.2
Muslim	1(0.9%)	3(3.1%)	4	1.9
Christian	2(1.8%)	7(7.3%)	9	4.3
Kirat	4(3.6%)	10(10.4%)	14	6.9
Caste				
Brahmin	21(18.9%)	22(22.9%)	43	20.8
Chhetri	54(48.6%)	24(25%)	78	37.7
Janajati	12(10.8%)	24(25%)	36	17.4
Chaudhary	20(18%)	15(15.6%)	35	16.9
Others	4(3.7%)	11(11.5%)	15	7.2

4.1.4 Marital status

The majority of the participants were married with 85% (176) whereas 15% (31) were unmarried. The distribution of marital status of the study population is shown in Table 4.4:

Table 4.4: Distribution of marital status of surveyed population (n=207)

Variable	Frequency (n)			Percentage (%)
	Male	Female	Total	
Marital status				
Unmarried	10(9%)	21(21.9%)	31	15
Married	101(91%)	75(78.1%)	176	85

4.1.5 Socio-economic factors

Socio economic status (SES) refers to an individual's position within a hierarchical social structure, which is one of the important determinants of health status. Evaluation of SES of a family mean the categorization of the family in respect of defined variables such as, education, occupation, economic status, physical assets, social position etc. (Ghosh and Ghosh, 2009). Considering the estimated annual income depicted in Table 4.5, of all respondents, those with annual income between NRs two hundred fifty thousand to five hundred thousand had the highest percentage i.e. 45.9% (95) and the household that earn below fifty thousand, between fifty thousand to one hundred fifty thousand, between one hundred fifty thousand to two hundred fifty thousand, between two hundred fifty thousand to five hundred thousand and above five hundred thousand annually were 1% (2), 11.1% (23),35.3%(73),45.9%(95),6.7%(14) respectively. Labour and Foreign employment were the major source of income for most of the respondents with both share 16.4% (34). However, 6.8% (14) of respondents were unemployed. The distribution of educational status among adults showed that 15.5% (32) of them were illiterate, 21.7% (45) had completed their primary schooling, 41.5% (86)adults had completed their SLC level, 14.5%(30) adult had completed their High school and 6.8% (14) of them had completed their bachelor and above level. Annual income levels are on the basis of Itahari-submetropolitan city household survey 2075 B.S. (Municipality, 2079) The distribution of socio-economic factors is shown in Table 4.5:

Table 4.5: Distribution of socio-economic factors of surveyed population (n=207)

Variables	Frequency(n)			Percent (%)
	Male	Female	All	
Annual income				
<50k		2(2.1%)	2	1
(50-150)k	12(10.8%)	11(11.5%)	23	11.1
(150-250)k	37(33.3%)	36(37.5%)	73	35.3
(250-500)k	51(45.9%)	44(45.8%)	95	45.9
>500k	11(9.9%)	3(3.1%)	14	6.7
Occupation				
Agriculture	11(9.9%)	12(12.5%)	23	11.1
Service	14(12.6%)	11(11.5%)	25	12.1
Labour	22(19.8%)	12(12.5%)	34	16.4
Business	17(15.3%)	3(3.1%)	20	9.7
Foreign employment	34(30.6%)		34	16.4
Unemployed	4(3.6%)	10(10.4%)	14	6.8
Education				
Illiterate	13(11.7%)	19(19.8%)	32	15.5
Primary school	23(20.7%)	22(22.9%)	45	21.7
SLC level	44(39.6%)	42(43.8%)	86	41.5
High school	21(18.9%)	9(9.4%)	30	14.5
Bachelor & above	10(9%)	4(4.2%)	14	6.8

4.1.6 Family type and family size

This study showed that most of the participants i.e. 75.8% (157) were living in nuclear family while 24.2% (50) of them had joint family. Nuclear-type family was found to be promoted among the participants. The result from recent national census found that average family size to be 4.32 (CBS, 2021). The study being consistent to it, found that the majority of the participants 64.3% (133) had a family size of four to five members. On the other hand 24.1% (50) of the participants had larger family size. The distribution of type and size of family is shown in the table below:

Table 4.6: Distribution of family type and family size (n=207)

Variable	Frequency (n)			Percentage (%)
	Male	Female	Total	
Type of family				
Nuclear	89(80.2%)	68(70.8%)	157	75.8
Joint	22(19.8%)	28(29.2%)	50	24.2
Family size				
<4	17(15.3%)	7(7.3%)	24	11.6
4-5	70(63.1%)	63(65.6%)	133	64.3
>5	24(21.6%)	26(27.1%)	50	24.1

4.2 Behavioral characteristics

Majority of the participants did not have the habit of eating in front of TV with a share of 75.8% (157). However 9.2% (19) watched TV daily, 12.6% (26) ate meals while watching TV twice a week and 2.4% (5) watched 3-4 times a week. Similarly, 34.3% (71) skipped their breakfast daily, 23.7% (49) had the habit of skipping twice/thrice a week. 15% (31) had the habit of skipping breakfast once a week followed by 27% (56) of them never skipping breakfast.

In context of sleep, 37.2% (77) slept less than 6 hours while 51.2% (106) attained the adequate sleep of 6-8 hours a day and rest of them 11.6% (24) slept more than 8 hours daily. Similarly 38.6% (80) of the participants ate only one time away from home, 12.6% (26) ate twice or thrice away from home and majority of participants i.e. 48.8% (101) didn't eat away from home. It was also found that 72.9% (151) of the participants did not drink alcohol and 27.1% (56) of them used to drink alcohol either occasionally or on the regular basis. Also,

89.4% (185) did not have the habit of smoking or tobacco use of any kind but 10.6% (22) claimed about doing so. The distribution of behavioral characteristics of the surveyed population is shown in the Table 4.7:

Table 4.7: Distribution of behavioral characteristics (n=207)

Variable	Frequency (n)			Percentage (%)
	Male	Female	Total	
Eating in front of TV				
Daily	9(8.1%)	10(10.4%)	19	9.2
Twice a week	12(10.8%)	14(14.6%)	26	12.6
3-4 times a week	3(2.7%)	2(2.1%)	5	2.4
Never	87(78.4%)	70(72.9%)	157	75.8
Skipping breakfast				
Daily	37(33.3%)	34(35.4%)	71	34.3
Twice/Thrice a week	17(15.3%)	32(33.3%)	49	23.7
Once a week	21(18.9%)	10(10.4%)	31	15
Never	36(31.4%)	20(20.8%)	56	27
Sleep				
<6 hours	41(36.9%)	36(37.5%)	77	37.2
6-8 hours	62(55.9%)	44(45.8%)	106	51.2
>8 hours	8(7.2%)	16(16.7%)	24	11.6
Meals away from home				
Once	53(47.7%)	27(28.1%)	80	38.6
2-3 times	23(20.7%)	3(3.1%)	26	12.6
Rarely	35(31.5%)	66(68.8%)	101	48.8
Alcohol intake				
Yes	37(33.3%)	19(19.8%)	56	27.1
No	74(66.7%)	77(80.2%)	151	72.9
Smoking/Tobacco				
Yes	21(18.9%)	1(1%)	22	10.6
No	90(81.1%)	95(99%)	185	89.4

4.3 Physical activity pattern

The physical activity of the participants was assessed on the basis of scoring protocol of IPAQ where the subjects were categorized into three levels of physical activity. The three levels of physical activity were low, moderate and high. It was found that 40.1% (83) were engaged in low level of physical activity followed by 48.3% (100) and 11.6% (24) engaged in moderate and high physical activity respectively. The alternative analysis done according to WHO recommendation to estimate the adequacy of physical activity found that 59.9% (124) of the participants have adequate physical activity of more than 150 minutes/week. The distribution of physical activity is shown in the Table 4.8 below:

Table 4.8: Distribution of physical activity pattern of surveyed population (n=207)

Variable	Frequency (n)			Percentage (%)
	Male	Female	Total	
Physical activity level				
Low	41(36.9%)	42(43.8%)	83	40.1
Moderate	55(49.5%)	45(46.9%)	100	48.3
High	15(13.5%)	9(9.4%)	24	11.6
Adequacy of physical activity				
Adequate	70(63.1%)	54(56.3%)	124	59.9
Inadequate	41(36.9%)	42(43.8%)	83	40.1

4.4 Health related factors

5.8% (12) of the participants used contraceptives which consists of 7.3% (7) females and 4.5% (5) males. 94.2% (195) of the participants did not use contraceptives. Out of total 96 females, 12.5% (12) females were found of having menstrual irregularities whereas the remaining 87.5% (84) of them did not have menstrual irregularities. The distribution of contraceptive use and menstrual irregularities are shown in the Table 4.9:

Table 4.9: Distribution of health related factors of surveyed population (n=207)

Variable	Frequency (n)			Percentage (%)
	Male	Female	Total	
Contraceptive use				
Yes	5(4.5%)	7(7.3%)	12	5.8
No	106(95.5%)	89(92.7%)	195	94.2
Menstrual irregularities				
Yes		12(12.5%)	12	12.5
No		84(87.5%)	84	87.5

4.5 Dietary intake

4.5.1 Dietary characteristics

The study found that most of the participants 81.6% (169) were non-vegetarian. However, 9.7% (20) of them followed vegan diet and 3.4% (7) of them followed lacto-vegetarian diet and 5.3% (11) of them followed lacto-ovo-vegetarian diet. Salt consumption pattern of the participants shows that only 16.4% (34) were having optimum salt intake as per recommendation given by WHO. 83.6% (173) of them were consuming excess amount of salt per day.

Majority of the participants, 45.4% (94) followed the consumption pattern of 3 meals per day followed by 43% (89) following the consumption pattern of 4 meals per day. 3.9% (8) of them had 2 meals per day, 6.3% (13) had 5 meals per day and 1.4% (3) had 6 meals per day respectively The distribution of dietary characteristics is shown in Table 4.10:

Table 4.10: Distribution of dietary characteristics (n=207)

Variable	Frequency (n)			Percentage (%)
	Male	Female	Total	
Vegetarianisms				
Vegan	8(7.2%)	12(12.5%)	20	9.7
Lacto-vegetarian	2(1.8%)	5(5.2%)	7	3.4
Lacto-ovo-vegetarian	8(7.2%)	3(3.1%)	11	5.3
Non-vegetarian	93(83.8%)	76(79.2%)	169	81.6
Salt intake				
Optimum	20(18%)	14(14.6%)	34	16.4
Excess	91(82%)	82(85.4%)	173	83.6
No. of meals				
2	8(7.2%)		8	3.9
3	43(38.7%)	51(53.1%)	94	45.4
4	52(46.8%)	37(38.5%)	89	43
5	7(6.3%)	6(6.3%)	13	6.3
6	1(0.9%)	2(2.1%)	3	1.4

4.5.2 Dietary intake in preceding day

The result of the study showed that 55.1% (114) participants had consumed excess calories in their previous day. 11.6% (24) of them had inadequate calorie intake and 33.3% (69) were found to have consumed adequate calorie in the previous 24 hour. The mean calorie intake of the participants was found to be 2082±271.14 kilocalories which was slightly more than the minimum average adequate requirement of 2220 kilocalories set by Government of Nepal (National Planning Comission and Central Beureu of Statistics, 2013).The result was lower than as compared to the males and females of southern Terai where mean calorie consumption was 2137±532 kilocalorie (Sato *et al.*, 2010).

47.8% (99) participants had adequate carbohydrate intake whereas 13% (27) of them had low carbohydrate intake and 39.1% (81) of them had high carbohydrate intake than the

recommended amount. The mean carbohydrate intake was found to be 345.80±70.45 grams. This was slightly lower than the mean consumption of 404±100 gm/day among rural population of southern Terai (Ohno *et al.*, 1997). The study revealed that 41.1% (85) participants had adequate intake of protein in their diet whereas 49.3% (102) had high intake of protein. Similarly, the mean protein intake was found to be 63.20±16.83 grams. The mean protein intake was greater than per capita protein intake of 51 gm/day in urban households of Nepal (Kumar *et al.*, 2016).

In case of fat consumption, it was found that 59.9% (124) of the participants had adequate intake of fat in their diet whereas 29.5% (61) had high fat intake. Also, 10.6% (22) of them had low fat intake. The mean fat intake was found to be 49.59±14.46 grams. This result was greater when compared with consumption of 24.5±12 gm/day in rural households of southern Terai region (Ohno *et al.*, 1997). The distribution of dietary intake of preceding day is shown in Table 4.11:

Table 4.11: Distribution of dietary intake in preceding day (n=207)

Variable	**Frequency (n)**			**Percentage (%)**
	Male	**Female**	**Total**	
Calorie				
Inadequate	18(16.2%)	6(6.3%)	24	11.6
Adequate	34(30.6%)	35(36.5%)	69	33.3
Excess	59(53.2%)	55(57.3%)	114	55.1
Carbohydrates				
Low	7(6.3%)	20(20.8%)	27	13
Adequate	59(53.2%)	40(41.7%)	99	47.8
High	45(40.5%)	36(37.5%)	81	39.1
Protein				
Low	9(8.1%)	11(11.5%)	20	9.7
Adequate	50(45%)	35(36.5%)	85	41.1
High	52(46.8%)	50(52.1%)	102	49.3
Fat				
Low	10(9%)	12(12.5%)	22	10.6
Adequate	68(61.3%)	56(58.3%)	124	59.9
High	33(29.7%)	28(29.2%)	61	29.5

4.5.3 Food consumption pattern

The consumption of food items were considered “regular” if consumed daily for at least once, “frequent” when ingested 3-4 times a week, “rare” if consumed once a week or less and “never” if not consumed at all. It was found that rice was consumed daily by all the participants. This might be due to the fact that rice is our staple cereal grain. 35.7% (74) of the participants consumed wheat on regular basis and 32.4% (67) of them consumed wheat on frequent basis. Only 5.3% (11) of the participants consumed maize or millet or barley regularly whereas majority of them were found consuming them rarely or never.

In the context of pulses and legumes, majority of the participants i.e. 54.1% (112) was found to have consumed whole daal on regular basis. Also, 31.4% (65) consumed whole daal on frequent basis. Similarly, 23.2% (48) consumed grams or beans or peas on regular basis and 51.7% (107) i.e. majority of them consumed these food items frequently.

In this study, 72% (149) and 75.4% (156) participants have claimed to have regular consumption of green leafy vegetables and other vegetables respectively. It was seen that 27.5% (57) had consumed green leafy vegetables frequently. 54.1% (112) of the participants claimed to consume roots and tubers on regular basis. In terms of fruits consumption it was found that 58% (120) had regular consumption pattern and 21.3% (44) of them consumed frequently. However, 20.8% (43) rarely consumed fruits.

The consumption pattern of milk and milk products found that 53.6% (111) of the participants consumed milk regularly whereas 15% (31) of them consumed milk frequently or 3-4 times a week. Meanwhile, 19.8% (41) did not consumed milk and 11.6% (24) of them consumed in rare occasion. Similarly, 18.8% (39) and 8.7% (18) of the participants consumed curd and ghee or butter respectively on regular basis. Majority of the participants rarely consumed paneer or cheese or did not consumed at all.

The meat consumption pattern found chicken meat was more popular among the participants which comprises 49.3% (102) consuming it on frequent basis. Red meat was found to be less preferred by the participants. Only 0.5% (1) consumed red meat on regular basis and 12.6% (26) consumed it frequently. A large portion of study population had been found to consume red meat rarely and 38.2% (79) did not consume red meat at all. Likewise, intake of calorie dense fast foods and fast foods was also done and was found that 26.1% (54) of the participants regularly consumed either calorie dense foods or fast foods. 39.6%

(82) consumed frequently and 34.3% (71) of them consumed rarely. The distribution of food consumption pattern is shown in Table 4.12:

Table 4.12: Distribution of food consumption pattern of surveyed population (n=207)

Variable	Frequency (n)			Percentage (%)
	Male	Female	Total	
Wheat				
Regular	48(43.2%)	26(27.1%)	74	35.7
Frequent	41(36.9%)	26(27.1%)	67	32.4
Rare	22(19.8%)	44(45.8%)	66	31.9
Maize/millet/barley				
Regular	10(9%)	1(1%)	11	5.3
Frequent	15(13.5%)	4(4.2%)	19	9.2
Rare	62(55.9%)	65(67.7%)	127	61.4
Never	24(21.6%)	26(27.1%)	50	24.2
Whole daal				
Regular	69(62.2%)	43(44.8%)	112	54.1
Frequent	30(27%)	35(36.5%)	65	31.4
Rare	12(10.8%)	18(18.8%)	30	14.5
Grams/beans/peas				
Regular	34(30.6%)	14(14.6%)	48	23.2
Frequent	59(53.2%)	48(50%)	107	51.7
Rare	18(16.2%)	31(32.3%)	49	23.7
Never		3(3.1%)	3	1.4
Green leafy vegetables				
Regular	82(73.9%)	67(69.8%)	149	72
Frequent	28(25.2%)	29(30.2%)	57	27.5
Rare	1(0.9%)		1	0.5
Other vegetables				
Regular	81(73%)	75(78.1%)	156	75.4
Frequent	28(25.2%)	20(20.8%)	48	23.2
Rare	2(1.8%)	1(1%)	3	1.4
Roots and tubers				

Regular	53(47.7%)	59(61.5%)	112	54.1
Frequent	20(18%)	17(17.7%)	37	17.9
Rare	30(27%)	19(19.8%)	49	23.7
Never	8(7.2%)	1(1%)	9	4.3
Fruits				
Regular	65(58.6%)	55(57.3%)	120	58
Frequent	17(15.3%)	27(28.1%)	44	21.3
Rare	29(26.1%)	14(14.6%)	43	20.8
Milk				
Regular	69(62.2%)	42(43.8%)	111	53.6
Frequent	14(12.6%)	17(17.7%)	31	15
Rare	11(9.9%)	13(13.5%)	24	11.6
Never	17(15.3%)	24(25%)	41	19.8
Curd				
Regular	26(23.4%)	13(13.5%)	39	18.8
Frequent	33(29.7%)	18(18.8%)	51	24.6
Rare	40(36%)	40(41.7%)	80	38.6
Never	12(10.8%)	25(26%)	37	17.9
Ghee/Butter				
Regular	9(8.1%)	9(9.4%)	18	8.7
Frequent	16(14.4%)	14(14.6%)	30	14.5
Rare	40(36%)	42(43.8%)	82	39.6
Never	46(41.4%)	31(32.3%)	77	37.2
Paneer/cheese				
Regular	3(2.7%)		3	1.4
Frequent	5(4.5%)	7(7.3%)	12	5.8
Rare	48(43.2%)	59(61.5%)	107	51.7
Never	55(49.5%)	30(31.3%)	85	41.1
White meat				
Frequent	57(51.4%)	45(46.9%)	102	49.3
Rare	32(28.8%)	29(30.2%)	61	29.5
Never	22(19.8%)	22(22.9%)	44	21.3
Red meat				

Regular		1(1%)	1	0.5
Frequent	12(10.8%)	14(14.6%)	26	12.6
Rare	61(55%)	40(41.7%)	101	48.1
Never	38(34.2%)	41(42.7%)	79	38.2
Fast foods				
Regular	30(27%)	24(25%)	54	26.1
Frequent	37(33.3%)	45(46.9%)	82	39.6
Rare	44(39.6%)	27(28.1%)	71	34.3

4.6 Prevalence of overweight and obesity

4.6.1 According to international BMI classification

The BMI of the participants was analyzed according to the classification given by WHO and it was found that 54.1% (112) were normal, 29.5% (61) were overweight , 15% (31) were obese and only 1.4% (3) were underweight. The result suggested that among male population 58.6% (65) were normal, 25.2% (28) overweight and 13.5% (15) were obese whereas among female 49% (47), 34.4% (33) and 16.7% (16) were normal, overweight and obese respectively. The combined prevalence of overweight or obesity was found to be 44.5% among 18-59 years male and female residing in Itahari Sub-metropolitan City. This result was found to be higher than prevalence of 24.3% overweight or obese and 4.3% obese obtained from STEPS Survey Nepal 2019 (Dhimal *et al.,* 2020) and than the combined prevalence of overweight and obesity 41.3% obtained from survey done in Ramdhuni municipality (Chaudhary, 2020). A study done on Kathmandu reported that 44.68% males and 30.48% females were overweight (Shrestha, 2017). The prevalence of overweight/obesity was 33.4% among civil servants in Nepal which was higher than our study (Simkhada *et al.,* 2011). The Prevalence of overweight and obesity in 18-59 aged male and female residing in Itahari sub-Metropolitian city is depicted in Figure 4.1:

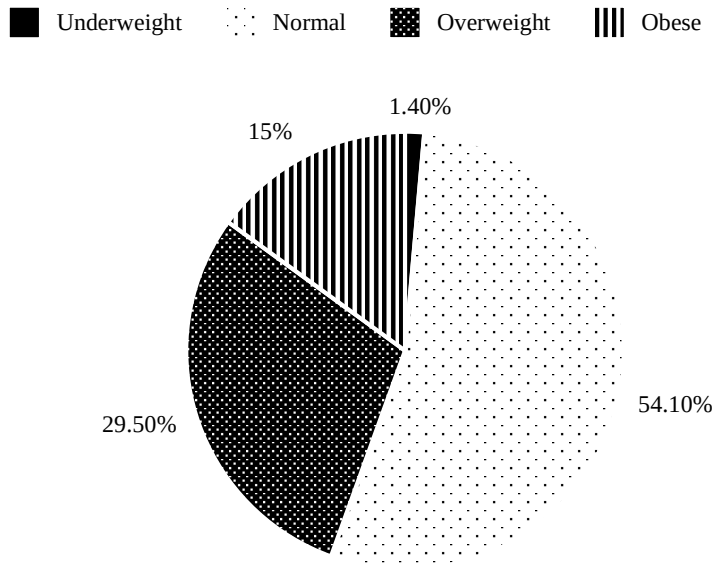


Figure 4.1: Prevalence of overweight and obesity in 18-59 aged male and female residing in Itahari sub-Metropolitan city.

The mean BMI among study population was 25.56±3.57 kg/m^2 (24.97±3.51 kg/m^2 for male and 26.25±3.51 kg/m^2 for female) which was higher than 22.7 kg/m^2, mean BMI from national survey (Dhimal *et al.*, 2020).

4.6.2 According to Asian BMI cut off

The result based on Asian BMI cut-off found that only 19.8% (41) were normal with 53.6% (111) overweight, 25.1% (52) obese and 1.4% (3) underweight. Out of total participants, 49% (47) females were overweight with 35.4% (34) of them obese. Among males 57.7% (64) were overweight and 16.2% (18) were obese. This result was higher than proportion of overweight or obese of 49.8% among adult population in rural villages of Udaypur, a district in south-eastern Nepal (Pyakurel *et al.*, 2019). The prevalence of overweight and obesity according to Asian classification is depicted in Figure 4.2:

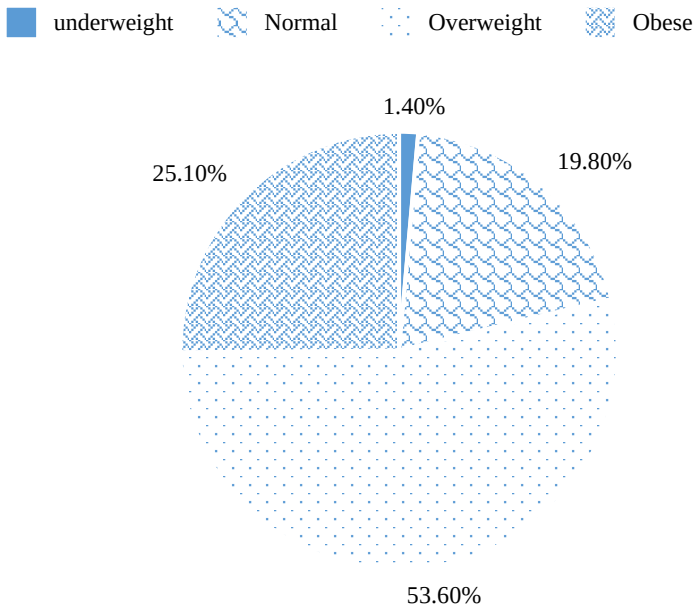


Figure 4.2: Prevalence of overweight and obesity by Asian BMI cut-offs

4.6.3 According to waist circumference

According to waist circumference measurement, 58.5% (121) were abdominally obese while 41.5% (86) had their waist circumference at normal range (below 80 cm for female and below 94 cm for male). Among them 60.4% (58) females and 56.8% (63) males were abdominally obese. This result was more than prevalence of central obesity among adult population in Kathmandu which was 56.35% (63.09% for females and 45.06% for males) (Silvanus *et al.*, 2018). It was found that 70.2% female and 87 % male at Kavre (Shah *et al.*, 2009) were abdominally obese which is more than the study done in Itahari sub-metropolitan city where as it was found 56.8% in male and 60.4%.in female. It was found that 59.9% adults residing in Ramdhuni mulipicality were found to be abdominally obese which was slightly higher than our study (Chaudhary, 2020). The prevalence of abdominal obesity according to WC is depicted in Figure 4.3:

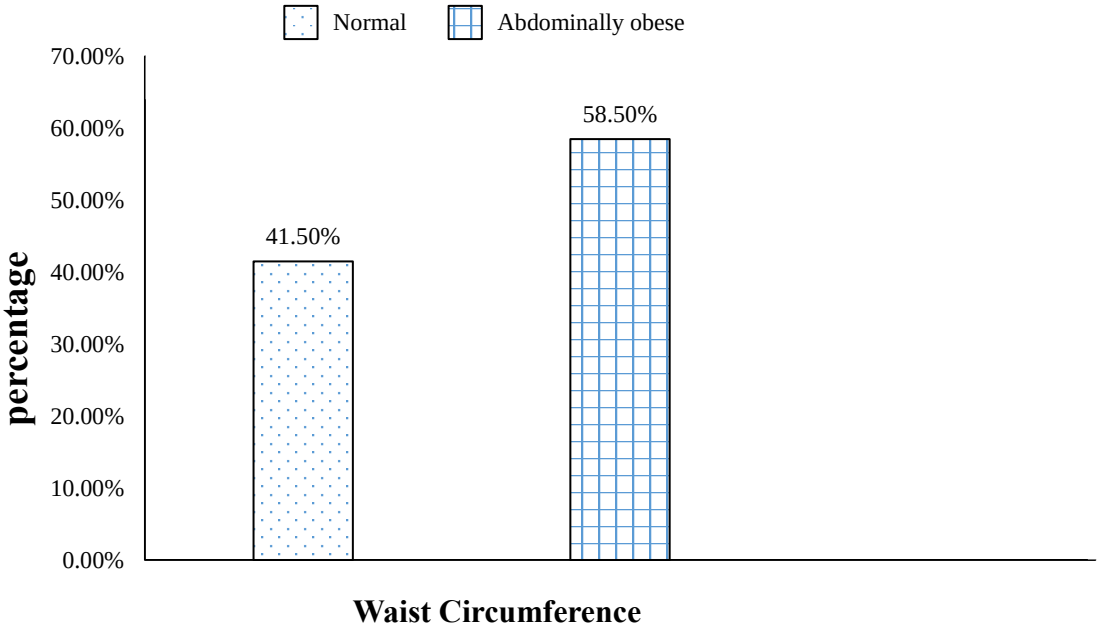


Figure 4.3: Prevalence of obesity with respect to waist circumference

The mean waist circumference was found to be 92.86±8.51 cm in males and 85.60±8.93 cm in females (overall 89.49±9.41 cm).which was higher than mean waist circumference of Nepalese adults i.e. 79.7 cm (Dhimal *et al.*, 2020). It was also found to be lower in case of female and higher in case of male in the result of the recent study. The mean waist circumference of that study was 91.90±7.38 cm in males and 87.86±8.712 cm in females (Joshi *et al.*, 2019)

4.6.4 According to waist-to-hip ratio measurement

The prevalence of abdominal obesity was found to be 69.6% (144) according to waist-to-hip ratio while the remaining 30.4% (63) had normal WHR ratio (less than 0.85 for females and less than 0.90 for males). 70.8% (68) female were abdominally obese whereas in case of males 68.5% (76) were obese. This result was higher than 63.6% adults having high WHR according to STEPS survey (Dhimal *et al.*, 2020). It was also higher than the prevalence of central obesity of 47.56% among adult population of Kathmandu (Silvanus *et al.*, 2018). The prevalence of abdominal obesity according to WHR is depicted in Figure 4.4

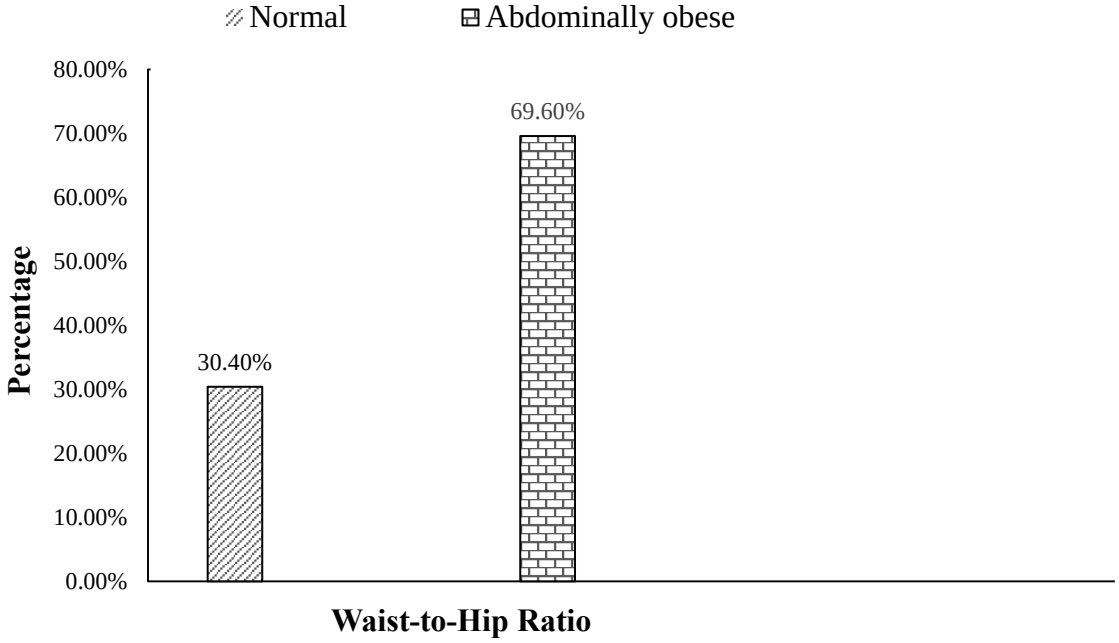


Figure 4.4: Prevalence of obesity with respect to waist-to-hip ratio

The mean WHR was found to be 0.92±0.08 (male=0.95±0.08 and female=0.88±0.06) which was higher than national data of 0.90 among Nepalese adults (Dhimal *et al.*, 2020). In the recent study, the mean waist-to-hip ratio of male and female population was 0.99±0.03 and 0.92±0.04 respectively. When compared, it was found that mean WHR among males and females were lower in this study (Joshi *et al.*, 2019). The prevalence of total abdominal obesity was found to be 69.6% which was higher than the prevalence of abdominal obesity 66% obtained from survey done in Ramdhuni municipality (Chaudhary, 2020)

4.7 Factors associated with overweight and obesity

4.7.1 Factors associated with BMI (WHO cut off)

The chi-square analysis was used to identify the factors associated with overweight and obesity. The analysis showed that age, physical activity, sleeping hours, calorie intake, protein intake, fat intake, salt intake, consumption of wheat, whole daal, fruits, alcohol and fast foods were significantly associated with BMI. The association is shown in Table 4.14:

The study suggested that the prevalence of overweight and obesity increased as people age. The result of a survey conducted in US concluded that age significantly affect the BMI of adults i.e. increase in age is directly proportional (Canning *et al.*, 2014). Similar result was observed in the study done in Tanzania (George *et al.*, 2021). Short sleep duration was found significantly associated with increased risk of obesity (M. Watanabe *et al.*, 2010). Short sleep may influence weight gain through different pathways. One mechanism is that short sleep duration leads to increased food intake (Ogilvie and Patel, 2017).

Table 4.13: Factors associated with overweight and obesity based on BMI of WHO cut-off (n=207)

Factors	Category	Overweight and obesity frequency	Normal and underweight frequency	P-value
Age	18-20	1(25%)	3(75%)	0.000*
	20-29	5(14.7%)	29(85.3%)	
	30-39	28(53.9%)	24(46.1%)	
	40-49	36(52.2%)	33(47.8%)	
	50-59	32(45.8%)	26(54.2%)	
Physical activity	Low	(75.5%)	12(24.5%)	0.000*
	Moderate	36(36%)	64(64%)	
	High	3(12.5%)	21(87.5%)	
Sleep	<6 hours	62(80.5%)	15(19.5%)	0.000*
	6-8 hours	20(18.9%)	86(81.1%)	
	>8 hours	10(41.7%)	14(58.3%)	
Wheat	Regular	19(25.6%)	55(74.4%)	0.007*
	Frequent	34(50.7%)	33(49.3%)	
	Rare	39(59.1%)	27(40.9%)	

Calorie intake	Inadequate	9(37.5%)	15(62.5%)	
	Adequate	22(31.8%)	47(68.2%)	0.006*
	Excess	61(53.5%)	53(46.5%)	
Carbohydrate	Low	8(29.6%)	19(70.4%)	
intake	Adequate	38(38.4%)	61(61.6%)	0.023*
	High	46(56.8%)	35(43.2%)	
Protein intake	low	6(30%)	14(70%)	
	Adequate	30(35.2%)	55(64.8%)	0.035*
	High	56(54.9%)	46(45.1%)	
Fat intake	Low	5(20.8%)	19(79.2%)	0.011*
	Adequate	58(41.7%)	81(58.3%)	
	High	29(65.9%)	15(34.1%)	
Alcoholic	Yes	25(44.7%)	31(55.3%)	0.039*
product	No	67(44.4%)	84(55.6%)	
Fast foods	Regular	44(81.5%)	10(18.5%)	0.000*
	Frequent	37(45.1%)	45(54.9%)	
	Rare	11(15.5%)	60(84.5%)	
Salt intake	Optimum	14(41.2%)	20(58.8%)	
	Excess	78(45.1%)	95(54.9%)	0.024*

*statistically significant ($p<0.05$)

The study found that consumption of whole cereal grains (like wheat) had a significant association with the prevalence of overweight and obesity. Insoluble dietary fibers derived from cereal sources, may activate the release of gut hormones involved in regulating food intake (McKeown *et al.*, 2009). A study conducted in Korea reported that dietary protein intake, whether animal or plant source, was negatively correlated with BMI (Byeong *et al.*, 2018) Epidemiological evidence suggests that a high-fat diet promotes the development of obesity and that there is a direct relationship between the amount of dietary fat and the degree of obesity (Golay and Bobbioni, 1997). Likewise the increase consumption of fast foods was found to be significantly associated with increased BMI in east Sikkim, India (Kar and Khandelwal, 2015). Salt is not a direct cause of obesity but it is a major influencing factor (S. K. Sharma *et al.*, 2011b). Eating an extra gram of salt each day increased the risk of

obesity in children by 28% and in adults by 26% (McMillen, 2017). This study showed that 44.7% who consumed alcoholic drinks were found to be overweight or obese. Alcohol drinking is a component of lifestyle in many regions and, recently, has been raised in some developed countries. It contains high energy (7.1 kcal/g) and also, by disrupting energy balance, leads to accumulation of fat mass and development of overweight or obesity (Golzarand *et al.*, 2021). A study done in Spain found that abdominal obesity is directly associated with PA of respondents. high PA was associated with lower risk of overweight or abdominal obesity (López-Sobaler *et al.*, 2016).

Other factors such as, marital status, education level, types of family, occupation, skipping breakfast, eating in front of T.V, eating pattern, meals a day, annual income, smoking, consumption of root tuber, fruits and vegetables, whole daal, meats were not significantly associated with prevalence of overweight and obesity.

4.7.2 Factors associated with waist circumference

Age, marital status, sleeping hours, consumption of wheat, fast foods, and paneer/cheese, calorie intake, protein intake, fat intake and carbohydrate intake, physical activity were significantly associated with waist circumference measurements.

A study done in Brazil found that incidence of abdominal obesity increases with age as well as dependent on marital status (Barzin *et al.*, 2018). Sleep duration and abdominal obesity were found interdependent (Alkerwi *et al.*, 2015). Wheat consumption was also significantly associated with abdominal obesity. A randomized double-blind study concluded that whole wheat diet contribute to preventing visceral fat obesity (Kikuchi *et al.*, 2018). The consumption of processed and fast foods was significantly associated with increased abdominal obesity in adults and the readymade meal consumers were less likely to achieve the nutritional recommendation (Alkerwi *et al.*, 2015). A study done in Spain found that abdominal obesity is directly associated with PA of respondents. high PA was associated with lower risk of overweight or abdominal obesity (López-Sobaler *et al.*, 2016). The association between these factors is shown in Table 4.14:

Table 4.14: Factors associated with abdominal obesity of surveyed population (n=207)

Factors	Category	Overweight and obese frequency	Normal and underweight frequency	P-value
Age	18-20	1(25%)	3(75%)	0.000*
	20-29	8(23.5%)	26(76.5%)	
	30-39	33(63.5%)	19(36.5%)	
	40-49	45(65.2%)	24(34.8%)	
	50-59	34(70.8%)	14(29.2%)	
Marital status	Unmarried	11(35.5%)	20(64.5%)	0.005*
	Married	110(62.5%)	66(37.5%)	
Sleep	<6 hours	50(72.5%)	19(27.5%)	0.000*
	6-8 hours	28(39.4%)	43(60.6%)	
	>8 hours	11(64.7%)	6(35.3%)	
Wheat	Regular	33(44.6%)	41(55.4%)	0.010*
	Frequent	45(67.2%)	22(32.8%)	
	Rare	43(65.2%)	23(34.8%)	
Fast foods	Regular	41(75.9%)	13(24.1%)	0.004*
	Frequent	47(57.3%)	35(42.7%)	
	Rare	33(46.5%)	38(53.5%)	
Calorie intake	Inadequate	8(33.3%)	16(66.7%)	0.000*
	Adequate	31(44.9%)	38(55.1%)	
	Excess	82(71.9%)	32(28.1%)	
Protein intake	Low	6(30%)	14(70%)	0.000*
	Adequate	39(45.9%)	46(54.1%)	
	High	76(74.5%)	26(25.5%)	
Fat intake	Low	14(63.6%)	8(36.4%)	0.019*
	Adequate	63(50.8%)	61(49.2%)	
	High	44(72.1%)	17(27.9%)	
Carbohydrate intake	Low	12(44.4%)	15(55.6%)	0.007*
	Adequate	51(51.5%)	48(48.5%)	
	High	58(71.6%)	23(28.4%)	

Paneer/cheese	Regular		3(100%)	0.031*
	Frequent	6(50%)	6(50%)	
	Rare	71(66.4%)	36(33.6%)	
	Never	44(51.8%)	41(48.2%)	
Physical activity	Low	60(72.3%)	23(27.7%)	0.003*
	Moderate	51(51%)	49(49%)	
	High	10(41.7%)	14(58.3%)	

*statistically significant ($p<0.05$)

4.7.3 Factors associated with waist-to-hip ratio

The factors which were significantly associated with waist-to-hip ratio of the participants were age, marital status, sleep, consumption of other vegetables, roots and tubers, fast foods, paneer/cheese, protein intake, fat intake, carbohydrate intake, calorie intake and physical activity were also associated with WHR.

Abdominal obesity and age was positively associated in the study conducted in Iranian adults (Dalvand *et al.*, 2015). A population based cross-sectional study among Chinese adults also concluded that the prevalence of abdominal obesity increased with age throughout adulthood (Xu *et al.*, 2016). Marital status and income were found to be associated with WHR in the population based study in China (S. Wu *et al.*, 2014). Fast foods consumption was related with WHR in a study done in Iran (Mohammadbeigi *et al.*, 2018).

This study found that the respondents taking adequate/more calorie were overweight or obese. Carbohydrate intake was inversely associated with obesity or overweight when the multivariate model was additionally adjusted for intakes of fiber, protein, total fat, monounsaturated fat, polyunsaturated fat, saturated fat, magnesium, fruit, and vegetables (Merchant *et al.*, 2009). Similarly, a study conducted among premenopausal women in Korea reported significant association of higher body weight and higher BMI prevalence with short sleep duration of less than 7 hours/day (Doo and Kim, 2017) which was even complied by the study findings.

The association is shown in Table 4.15:

Table 4.15: Factors associated with abdominal obesity based on WHR (n=207)

Factors	Category	Obese frequency (%)	Non-obese frequency (%)	P-value
Age	18-20	2(50%)	2(50%)	0.000*
	20-29	10(29.4%)	24(70.6%)	
	30-39	32(61.5%)	20(38.5%)	
	40-49	57(82.6%0	12(17.4%)	
	50-59	43(89.6%)	5(10.4%)	
Marital status	Unmarried	10(32.3%)	21(67.7%)	0.000*
	Married	134(76.1%)	42(23.9%)	
Sleep	<6 hours	67(87%)	10(13%)	0.000*
	6-8 hours	64(60.4%)	42(39.6%)	
	>8 hours	13(54.2%)	11(45.8%)	
Other vegetables	Regular	115(73.7%)	41(26.3%)	0.019*
	Frequent	26(54.2%)	22(45.8%)	
	Rare	3(100%)		
Roots & tubers	Regular	74(66.1%)	38(33.9%)	0.002*
	Frequent	33(89.2%)	4(10.8%)	
	Rare	28(57.1%)	21(42.9%)	
	Never	9(100%)		
Paneer/Cheese	Regular		3(100%)	0.029*
	Frequent	10(83.3%)	2(16.7%)	
	Rare	78(72.9%)	29(27.1%)	
	Never	56(65.9%)	29(34.1%)	
Fast foods	Regular	50(92.6%)	4(7.4%)	0.008*
	Frequent	52(63.4%)	30(36.6%)	
	Rare	42(59.2%)	29(40.8%)	
Protein	Low	11(55%)	9(45%)	0.019*
	Adequate	53(62.4%)	32(37.6%)	
	High	80(78.4%)	22(21.6%)	
Physical activity	Low	67(80.7%)	16(19.3%)	0.006*

	Moderate	65(65%)	35(35%)	
	High	12(50%)	12(50%)	
Fat intake	Low	13(59.1%)	9(40.9%)	0.002*
	Adequate	78(62.9%)	46(37.1%)	
	High	53(86.9%)	8(13.1%)	
Carbohydrate	Low	17(63%)	10(37%)	0.011*
intake	Adequate	61(61.6%)	38(38.4%)	
	High	66(81.5%)	15(18.5%)	
Calorie intake	Low	16(66.7%)	8(33.3%)	0.009*
	Adequate	39(56.5%)	30(43.5%)	
	Excess	89(78.1%)	25(21.9%)	

*statistically significant ($p<0.05$)

Part V

Conclusions and recommendations

5.1 Conclusions

This study was intended to identify the risk factors associated with prevalence of overweight and obesity among obesity in 18-59 years male and female residing in Itahari sub-metropolitan city. Following are the conclusions of this study:

i 29.5% respondents were overweight and 15% were obese as defined by BMI among them 25.2% of males were overweight and 13.5% were obese whereas among females 34.4% were overweight and 16.7% were obese. The mean BMI was found to be 25.56±3.57 kg/m².The mean BMI was 24.97±3.51kg/m² for males and 26.25±3.51kg/m² for females.

ii Based on WC, 58.5%(60.4% female and 56.8% male) were abdominally obese, and based on WHR, the prevalence of abdominal obesity was 69.6%(70.8% female and 68.5% male).The mean waist circumference was found to be 92.86±8.51 cm in males and 85.60±9.32 in females (overall 89.49±9.41 cm). Likewise, the mean WHR was 0.95±0.08 among males and 0.88±0.06 among females(overall 0.92±0.08)

iii The study showed that age, physical activity, sleep, consumption of fast foods, carbohydrate intake, protein intake, fat intake and calorie intake was common factors for all of the three dependent variables. In addition, marital status, paneer/cheese were common factors associated with WC and WHR respectively. While consumption of wheat is associated with BMI and WC respectively.

iv Factors like consumption of alcoholic drinks and salt intake were only associated with BMI. While, consumption of roots & tuber and other vegetables were only associated with WHR.

v In today's time every individual is in the risk of being overweight and obese due to various associated factors such as high calorie intake, increase in sedentary habits, lack of balance foods etc. So, taking in concern with every associated factors, problem of overweight and obesity must be taken as a disease and given a major importance to reduce it.

5.2 Recommendations

Based on the results of this study following recommendations could be made in order to lower the risk of overweight and obesity in 18-59 years male and female residing in Itahari sub- metropolitan city.

1. The study highlights the alarming prevalence of overweight and obesity among male and female residing in Itahari sub-metropolitan city and the associated factors. This is a serious public health problem and it must be given proper attention through an awareness campaign and knowledge sharing.
2. The study point to a need for behavior change related to improve lifestyle through increased physical activity and improved dietary practices.
3. The study could be replicated in other extended areas of gender, age group and location to explore whether the prevalence problem is widespread and determinants are common.
4. Concerned authorities like sub-metropolitan city official in collaboration with other NGOs and INGOs should work on alerting general mass about obesity associated factors and improving the prevalent share of overweight and obesity.

Part VI

Summary

Obesity is a major health problem, and there is an increasing trend of overweight and obese individuals in developing countries like Nepal. The prevalence of non-communicable diseases is increasing in Nepal. Overweight and obesity are the major risk factors for non-communicable diseases.

The cross-sectional study was conducted to explore the prevalence and risk factors associated with overweight or obesity among 18-59 years male and female residing in Itahari sub- metropolitan city. The anthropometric indicators BMI, WC and WHR were used in the study. Along with the socio-demographic, physical activity, behavioral factors, dietary aspects were also explored via structured questionnaires. The data analysis was performed using Excel 2016 and SPSS version 20. Out of 207 respondents, the study reported that 29.5% of respondents were overweight and 15% were obese as defined by BMI (WHO criteria). While based on WC and WHR, 58.5% and 69.6% males and females were abdominally obese respectively based on the classification given by IDF and WHO.

The study showed that age, physical activity, sleep, consumption of fast foods, carbohydrate intake, protein intake, fat intake and calorie intake were common factors for all of the three dependent variables. In addition, marital status and consumption of paneer/cheese were common factors associated with WC and WHR respectively. While consumption of wheat is only associated with BMI and WC respectively. Factors like consumption of alcoholic drinks and salt intake were only associated with BMI. Consumption of and roots & tuber and other vegetables were only associated with WHR

The reported prevalence of overweight and obesity in Itahari is high and pose a serious health challenge. Thus, timely actions on this issue must be undertaken. Awareness in maintaining healthy body weight, management of associated risk factors and lifestyle intervention programs should be done to combat the prevalent situation.

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Appendices

Appendix A

INFORMED CONSENT LETTER

Namaste!

I am Binod Khanal, a graduate student of BSc. Nutrition and Dietetics in Central Campus of Technology, Dharan and I am here for my dissertation work in Itahari Sub-metropolitan city for the partial fulfillment of my bachelor's degree in Nutrition and Dietetics. The topic for the study is "**RISK FACTOR ASSOCIATED WITH OVERWEIGHT AND OBESITY AMONG 18-59 YEARS MALE AND FEMALE RESIDING IN ITAHARI SUB-METROPOLITAN CITY**".

This study will provide information about the overweight and obesity status and the risk factors associated with it among the study population. During the course of study, it will be required to measure height and weight of the participants followed by the assessment of socio demographic and economic factors, behavioral factors, physical activity, health related factors and dietary factors.

You will be asked some questions and some physical measurements will also be taken with your approve to participate in this study. This study also aims to make you aware about your nutritional status. Your participation in this study will be voluntary. You might have the privilege of not answering the questions if you feel them sensitive. The privacy of your information will be maintained and they will not be misused. I am hopeful that you will be helping me in this study with your participation.

Do you want to get participated in this study?

Yes, I want to be participated in this study and give my consent to take all the required measurements and the answers for this study.

Signature of participants: *Signature of surveyor:*

Date:

Place:

Appendix B

Survey Questionnaires

Participant's Code: Date of Interview (B.S.): ……../….. /…..

A. GENERAL INFORMATION

1. Name of participant:
2. Date of Birth (B.S.): …...../….. /….. Age: ……. Years
3. Address: …… Sub-metropolitan city …… Ward
4. Gender: Male ( ) Female ( )
5. Religion:

   i) Hindu ii) Buddhist iii) Muslim iv) Christian v) Others ……..
6. Caste Ethnicity

   i) Brahmin ii) Chhetri iii) Janajati iv) Chaudhary v) Others ……...
7. Marital Status

   i) Married ii) Unmarried iii) Divorce/ Separated iv) Widowed
8. Education level

   i) Illiterate ii) Primary school iii) SLC level iv)High school v)Bachelar & above
9. Occupation:

   i)Agriculture ii)Service iii)Labour iv)Business v)Foreign employment vi)unemployed vii)Housewife viii)other

10. Yearly income (NRs): a) less than 50k b) (50-150)k c).. (150-250)k d) (250-500)k e) >500k

B. ANTHROPOMETRIC MEASUREMENTS

Indicators	Readings		Mean	Remarks
	A	b		
Weight				BMI =
Height				
Waist circumference				WHR =
Hip circumference				

C. FAMILY INFORMATION

11. Number of Family members: …… a) No. of Females …….. b) No. of Males ……

12. Type of Family: a) Single b) Joint

D. PHYSICAL ACTIVITY QUESTIONNAIRE (IPAQ-SHORT)

13. a) During the last 7 days, on how many days did you do vigorous physical activities (heavy lifting, digging, aerobics, or fast bicycling for more than 10 minutes at a time)?

i. ……. Days per week ii. None

b) How much time did you usually spend doing vigorous physical activities on one of those days? ……Hours …….. Minutes per [day/week]

14. a) During the last 7 days, on how many days did you do moderate physical activities (carrying light loads, bicycling at a regular pace, or double tennis)? Do not include walking.

i. …… Days per week ii. None

b) How much time did you usually spend doing moderate physical activities on one of those days? …….Hours …… Minutes per [day/week]

15. a) During the last 7 days, on how many days did you walk for at least 10 minutes at a time? (This includes walking at work and at home, walking to travel from place to place, and any other walking that is done solely for recreation, sport, exercise or leisure).

i. …….. Days per week ii. None

b) How much time did you usually spend walking on one of those days?

……. Hours …… Minutes per [day/week]

16. During the last 7 days, how much time did you usually spend sitting on a week day? (This includes time spent sitting at a desk, visiting friends, reading, travelling on a bus or sitting or lying down to watch TV).

……Hours …….Minutes per week/day

E. BEHAVIORAL FACTORS

17. How often do you eat in front of TV?

i) Daily ii) Twice a week iii) 3-4 times a week iv) Never

18. Do you smoke or not? i) Yes ii) No

19. Do you drink any type of alcoholic products? i) Yes ii) No

20. How often do you skip breakfast?

i) Daily ii) Once a week iii) Once a week iv) Never

21. How many hours do you sleep at night?
    i) Less than 6 hours ii) 6-8 hours iii) more than 8 hours

22. Do you use contraceptives? i) Yes ii) No

23. If yes, what type of contraceptives do you use?

    i) Depo Provera ii) Pills iii) Injection iv) Others ……

24. Do you have menstrual irregularities/ thyroid problems? i) Yes ii) No

25. Are you on any regular medications? i) Yes ii) No

26. How many times do you eat away from house in a day?

    i) Once ii) 2-3 times iii)rarely

F. DIETARY FACTORS

27. What are you, according to your eating pattern?

    i) vegan ii) lacto-veg iii) lacto-ovo-veg iv) non-veg

28. If non-vegetarian which meat do you usually eat?

    i) white (chicken/duck/fish) ii) red meat (buff/goat)

29. How much oil do you use for cooking monthly while cooking? …….. Liters.

30. How many packets of salt do you use monthly? …….

31. How many meals do you eat in a day? ……..

32. How much water do you drink in a day? …….. Liters/day.

G. FOOD FREQUENCY TABLE

S.N	Type of food	Regular (at least once a day)	Frequent (3/4 times a week)	Rare (once in a week or less)	Never
1	**Cereals**				
	Rice				
	Wheat				
	Maize/Millet/Barley				
2	**Pulses/Legumes**				
	Whole daal				

	Grams/Beans/Peas				
3	**Green Leafy Vegetables**				
4	**Other vegetables**				
5	**Roots and tubers**				
6	**Fruits**				
7	**Dairy products**				
	Milk				
	Curd				
	Ghee/Butter				
	Paneer/Cheese				
8	**Meat**				
	White meat (chicken/fish)				
	Red meat (mutton/beef/pork)				
9	**Fast foods**				

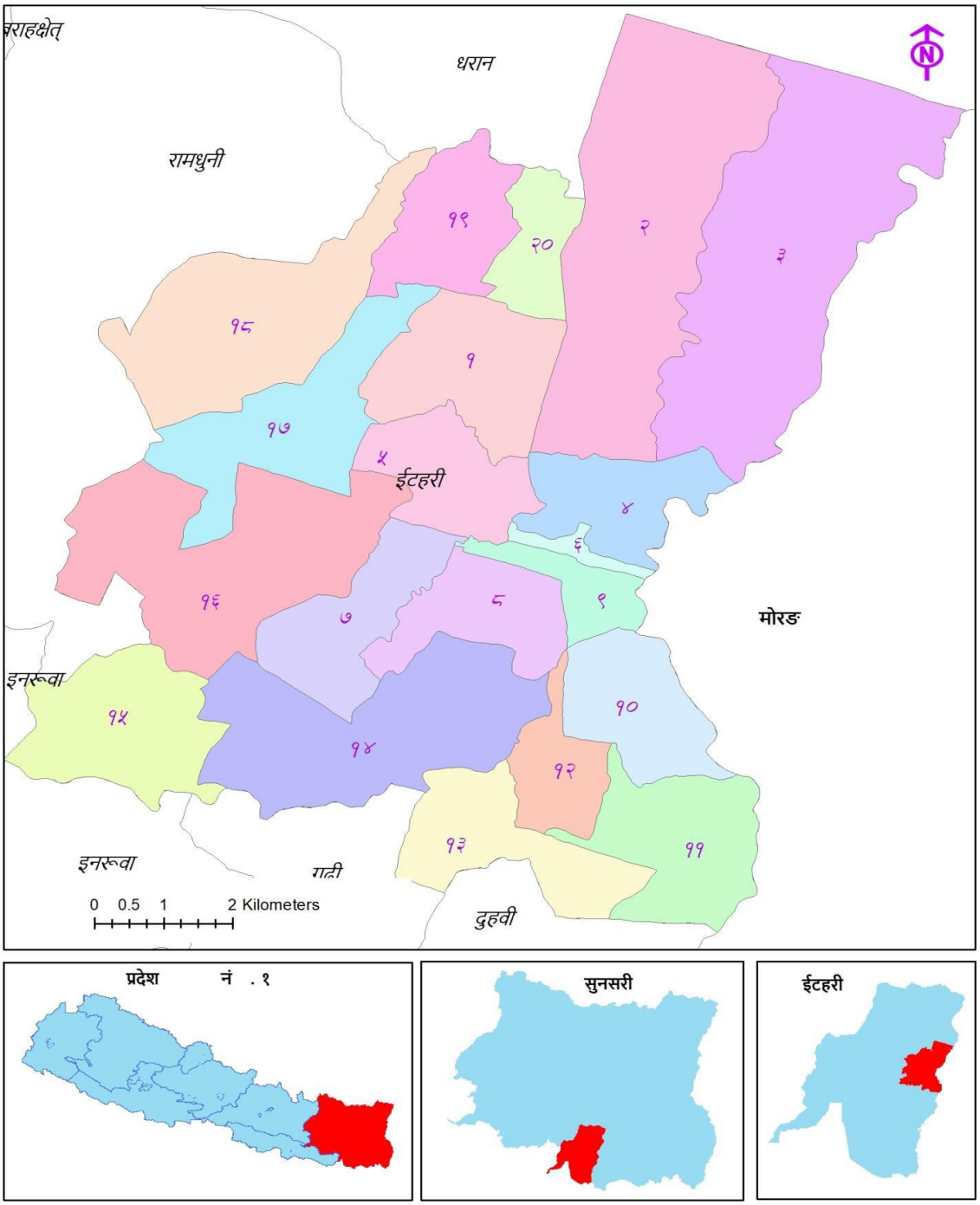
H. 24-HOURS DIETARY RECALL

Timing	Description of food	Serving size	Amounts
Breakfast			
Lunch			
Snacks			
Dinner			

Appendix C

Study site

Itahari Sub-metropolitan City



(Municipality, 2079)

P1:Map of Itahari Sub-metropolitan city

Appendix D

Photo gallery

P2: measurement of height

P3: measurement of weight