ASSESSING DIETARY AND LIFESTYLE FACTORS ASSOCIATED WITH NORMAL WEIGHT OBESITY AMONGST ADULTS RESIDING IN URBAN VADODARA

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CERTIFICATE

This is to certify that the research work embodied in the thesis has been carried out independently by **Ms. Jyotismita Borbora** in pursuit of a degree of Master of Science in Foods and Nutrition (Dietetics) in Faculty of Family and Community Sciences under the guidance of Dr. Vijayata Sengar and represents her original work.

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ABBREVIATIONS

BD- Body Dissatisfaction

BMI-Body Mass Index

CDII- Children Dietary Inflammatory Index

CKD- Chronic Kidney Disease

EAR: Estimated Average Requirement

FFQ- Food Frequency Questionnaire

GPAQ- Global Physical Activity Questionnaire

HDL- High-Density Lipoprotein

HPA- Hypothalamic-Pituitary-Adrenal

LDL- Low Density Lipoprotein

LIPA- Low-intensity physical activity

LM- Lean Mass

MANO- Metabolically Abnormal Individuals With No obesity

MetS- Metabolic Syndrome

MRI- Magnetic Resonance Imaging

MVPA- Moderate To Vigorous Physical Activity

NCD-Non-communicable diseases

NCDs- Non-Communicable Diseases

NWO- Normal Weight Obesity

NWL- Normal Weight Lean

OB- Obese

PSQI- Pittsburgh Sleep Quality index

PSS- Perceived Stress Scale

SES- Socioeconomic Status

T2DM-Type 2 Diabetes Mellitus

TOFI- Thin Outside, Fat Inside

UPF- Ultra-Processed Foods

VAT- Visceral Adipose Tissue

WHO- World Health Organization

WHR- Waist Hip Ratio

WHtR- Waist –Height Ratio

ABSTRACT

The global prevalence of chronic non-communicable diseases (NCDs) such as diabetes and obesity is on the rise, with obesity reaching pandemic proportions worldwide. Obesity manifests in various forms, shaped by genetic, environmental, and lifestyle factors. Central obesity, which is linked to higher metabolic risks, is more common in individuals of South Asian descent. This population often displays a "thin-fat" phenotype, also known as Normal weight Obesity (NWO), characterized by a normal BMI but high body fat percentage, which is prevalent in South Asian populations and poses significant metabolic and cardiovascular risk. From previous studies, despite the increasing recognition of NWO and its health implications, there is a dearth of scientific evidence regarding dietary, physical activity, Chrono-nutrition and lifestyle factors associated with this condition. Thus, the proposed study has been planned to fill the existing gap in knowledge regarding NWO.

OBJECTIVES: To Assess Dietary and Lifestyle Factors Associated with Normal Weight Obesity amongst Adults Residing in Urban Vadodara.

METHODS AND MATERIALS: A cross-sectional study on Normal Weight Obesity has been conducted among the free-living population of urban Vadodara. The Normal weight subjects were enrolled through snowball sampling after obtaining informed consent. Data on Socio-economic status, Family and Medical History, anthropometry and body composition, Biophysical measurement, Physical fitness, Dietary practices, chrono-nutrition profile, Lifestyle factors and stress status had been obtained from the enrolled subjects.

RESULTS: The study findings revealed that about one third of the study participants were found to have normal weight obesity from the baseline with a prevalence of 29.9%. Nearly half of the subjects had normal blood pressure, with males having significantly higher systolic and diastolic blood pressure than females. A significant positive correlation was found between waist circumference, waist hip ratio, and systolic and diastolic blood pressure. Abdominal obesity prevalence increases with age, with younger individuals having a lower prevalence (15.9%), middle-aged individuals (36.1%), and

older individuals (50-59%) having a higher likelihood of obesity. A significant proportion of participants exhibited increased body fat, while 5.9% displayed high visceral fat levels. Skeletal muscle analysis indicated that 68.8% of the participants had low muscle mass, suggesting that individuals with normal weight obesity tend to have higher body fat percentages and lower muscle mass. A significant portion (61.5%) identified as vegetarian, with most participants reporting breakfast 4-6 times per week. Males had a higher total energy intake compared to females, with most participants consuming between 25-50% of the Estimated Average Requirement (EAR). The study concluded that only average fat intake has a significant link between body fat percentage and body fat percentage. A significant negative correlation was observed between body fat % with physical activity.

The current research indicated that body fat percentage is significantly linked to evening eating habits and the time one eats, suggesting that consuming food late at night may lead to increased fat accumulation. A significant negative correlation was observed between stress with physical activity.

CONCLUSION: The study explores the prevalence of Normal Weight Obesity (NWO) and its relationship with socio-economic, medical, anthropometric, dietary, and lifestyle factors. It found that NWO is higher in females and predominantly affects middle-aged individuals. The majority of NWO individuals are lower-middle-income and have medical issues. Despite maintaining a normal BMI, many display elevated body fat levels, diminished muscle mass, and central obesity, increasing their risk for metabolic disorders. The study also identified suboptimal meal timing, late-night consumption, excessive screen time, stress, and inadequate sleep quality as contributing factors. Additionally, the research evicted body age, waist circumference, dietary fat consumption, and physical activity as key factors determining NWO, with physical activity exhibiting the strongest association with body fat percentage.

INTRODUCTION

Non-communicable diseases (NCDs) pose a significant global health challenge as chronic conditions that are not transmitted from person to person. These include cardiovascular diseases, cancers, and chronic respiratory illnesses. Each year, 17 million people die prematurely (before age 70) from NCDs, with 86% of these deaths occurring in low- and middle-income countries. In fact, 77% of all NCD deaths are concentrated in these regions (Kapoor et al., 2019).

South Asian countries, including India, are experiencing a rapid rise in NCDs due to factors such as urbanization, dietary changes, sedentary lifestyles, and population aging. (Kobayashi et al., 2023).This epidemiological shift is creating a dual burden of disease, where NCDs coexist with under-nutrition and infectious diseases. This dual burden may significantly impact the emergence of cardio-metabolic conditions, such as obesity and diabetes (Kapoor et al., 2021)

1.1 Obesity as a Major Public Health Challenge

Obesity has reached pandemic proportions globally, and developing countries are not immune to this trend. Several factors contribute to the increasing prevalence of obesity, including rapid urbanization, dietary shifts towards processed foods and sugary drinks, sedentary lifestyles, and genetic predisposition.

The World Health Organization (WHO) defines overweight and obesity as the excessive accumulation of body fat that poses health risks. By 2030, an estimated 1.5 billion people worldwide are projected to be overweight or obese, making obesity one of the most urgent public health concerns of the 21st century (WHO, 2024).

Obesity is an independent risk factor for several serious health conditions, including cardiovascular diseases, type 2 diabetes mellitus (T2DM), non-alcoholic fatty liver disease, hypertension, stroke, sleep apnea, and cancer. In 2022, around 2.5 billion adults aged 18 and older were classified as overweight, with over 890 million living with obesity. Globally, 43% of adults were overweight, up from 25% in 1990, and 16% were

obese. Regional variations ranged from 31% overweight prevalence in the WHO South-East Asia and African regions to 67% in the Americas (Kapoor et al., 2021).

In India, according to NFHS-5 data**,** 23% of women and 22.1% of men are classified as overweight based on BMI. The highest prevalence was observed in the southern region (46.51%) and the lowest in the eastern region (32.96%). Obesity rates were higher in urban populations compared to rural (44.17% vs. 36.08%), and those over 40 years of age (45.81% vs. 34.58%).

Obesity presents diverse phenotypes, influenced by genetic, molecular, cellular, environmental, social, and economic factors. Based on fat distribution, obesity is categorized into two primary types: gynecoid or "pear-shaped" (fat accumulation in the lower body, such as hips and thighs) and android or "apple-shaped" (fat accumulation in the abdominal region). Central or abdominal obesity, particularly common among Asian Indians, is a more serious form due to its strong association with metabolic disorders and diseases (Mayoral L et al., 2020).

Central obesity plays a critical role in the development of metabolic syndrome (MS), a cluster of risk factors that includes dyslipidemia, hypertension, glucose intolerance, and hyperinsulinemia which is mainly prevalent among South Asian Descendants. Visceral fat accumulation, particularly in the abdominal area, is closely linked to insulin resistance and is a major contributor to type 2 diabetes, cardiovascular disease, and other chronic conditions such as non-alcoholic fatty liver disease and certain cancers. While an increase in body mass index (BMI) is associated with elevated health risks, research indicates that waist circumference, a simple measure of abdominal obesity, is a more reliable predictor of metabolic syndrome and its associated complications than BMI alone (Kapoor et al., 2021, Oliveros et al.,2014).

Prevalence of central obesity among people of South Asian descent ranges from 30.1%-53.3% (Gupta et al., 2023). According to the ICMR - INDIAB 2015 study, the prevalence of central obesity in India is higher than that of generalized obesity (range 16.9%–36.3% vs 11.8%–31.3%), indicating a potential population of individuals with Normal weight

central obesity. The prevalence of abdominal obesity in the country was found to be 40% in women and 12% in men(NFHS-5)**.** Data indicates that 22.1% of men have a BMI above the cut-off range of 25, while 11.9% of men exceed the waist circumference (WC) cut-off range. In comparison, 23% of women have a BMI above 25, and 39.6% of women have a waist circumference exceeding the cut-off range of 80 cm.

In some tropical regions, particularly South Asia, the obesity profile differs from global pattern due to altered body composition. Individuals of South Asian descent often display a "thin-fat" phenotype (also known as normal weight obesity, metabolic obesity, metabolically unhealthy non-obese, skinny fat, and sarcopenic obesity in the past), characterized by increased visceral adiposity and decreased lean mass Despite having a lower BMI, these individuals face higher risks of metabolic disorders, including insulin resistance and cardiovascular disease, due to their unique body composition (Kapoor et al., 2021).

1.1.1 Subtypes of Obesity

Obesity manifests in various subtypes, influenced by genetic background, lifestyle, and environmental factors. Importantly, the classification of these subtypes depends on the obesity indicator used, such as BMI or metabolic status (Table 1.1).

Table 1.1: Subtypes of Obesity

Obese Subtype	Definition	Other Terminology
Metabolically Healthy Obese	Absence of metabolic disorders, including type 2 diabetes mellitus, dyslipidemia, and hypertension	Metabolically normal obese, metabolically benign obese, metabolically healthy overweight/obese
Metabolically Obese Normal Weight	These individuals were characterized by normal body weight and BMI, but presented hyperinsulinemia, insulin resistance, and increased type 2 diabetes, hypertriglyceridemia and cardiovascular diseases predisposition	Metabolically obese healthy ,Metabolically unhealthy normal weight, metabolically abnormal with no obesity, metabolically abnormal individuals with no obesity (MANO), normal weight dyslipidemia, or pre-obesity
Normal Weight Obesity	Individuals who have normal body weight and BMI but high % BF, accompanied by total lean mass deficiency	Metabolically healthy normal weight obese
Metabolic Abnormal Obese	Defined by 2 main factors, BMI and metabolic status, which is classified as having three or more points from the NCEP-ATP III, to define MetS	Metabolically Unhealthy Obesity
Sarcopenic Obese	BMI <25kg/ m^2 low muscle mass and low muscle strength lack physical activity	Sarcopenic overweight

(Oliveros, E., Somers, V. K., Sochor, O., Goel, K., & Lopez-Jimenez,F. (2014).The concept of normal weight obesity. *Progress in cardiovascular diseases*, *56*(4), 426-433.)

1.2 NORMAL WEIGHT OBESITY (NWO)

Normal Weight Obesity (NWO) is defined as having a body mass index (BMI) of 25 kg/m² or lower but with an elevated body fat percentage. The specific cut-off values for body fat percentage vary based on study population, sex, and ethnicity. According to the American Society of Endocrinologists, obesity is defined by a body fat percentage of 35% or higher in women and 25% or higher in men. However, for individuals of Asia-Pacific origin, the cut-off values are lower, at 33.4% for women and 20.6% for men. The concept of normal weight obesity was first introduced in 2006 by De Lorenzo, describing individuals who have a high body fat percentage despite having a normal weight (Kapoor et al.,2020).

1.2.1 PREVALENCE OF NORMAL WEIGHT OBESITY

NWO has been increasingly recognized as a significant health concern, characterized by individuals with normal body weight but high body fat percentages, leading to metabolic risks similar to those seen in obesity. Over the years, the understanding of NWO has evolved, with a growing emphasis on its implications for cardiovascular health and metabolic syndrome, prompting further research into its determinants and the need for refined diagnostic criteria (Kapoor et al., 2019).

The prevalence of NWO varies widely across different populations and demographics, with estimates ranging from 9% to 34% in various studies, highlighting the need for context-specific assessments (Kim MK et al., 2014). In a high diabetes risk Indian population, about one-third were found to have NWO, indicating a notable prevalence that necessitates further investigation into ethnic and lifestyle factors.

Studies have reported that the prevalence of NWO can be as high as 30% in certain populations, with significant differences observed between genders; for instance, 12.3% in men and 25.0% in women. The lack of standardized body fat percentage cut-offs contributes to the variability in reported prevalence rates, complicating the classification and understanding of NWO.

Overall, the growing body of research emphasizes the importance of recognizing NWO as a distinct health risk, particularly in populations that may not be classified as overweight or obese.

1.2.2 PATHOPHYSIOLOGY OF NWO

The prevalence of normal weight obesity (NWO), commonly referred to as the TOFI (Thin Outside, Fat Inside) phenotype, is influenced by multiple factors. In the South Asian population, several key contributors have been identified in the pathogenesis of this thin-fat phenotype (Figure 1.2).

1.2.2.1 Environmental Factors

Although overt obesity has been on the rise in South Asian countries, largely due to increased urbanization and reduced physical activity, there remains a paradox. The increased intake of high-fat, high-sugar diets, combined with easy access to energy-dense foods and limited physical activity, has accelerated the development of this phenotype. Rapid economic transitions in many tropical regions have led to greater availability of processed foods, reduced physical activity due to mechanized lifestyles, and environmental factors such as pollution, all of which have contributed to the rising rates of obesity in these countries **(**Kapoor et al., 2020).

Figure 1.1: Spectrum of Obesity in any community

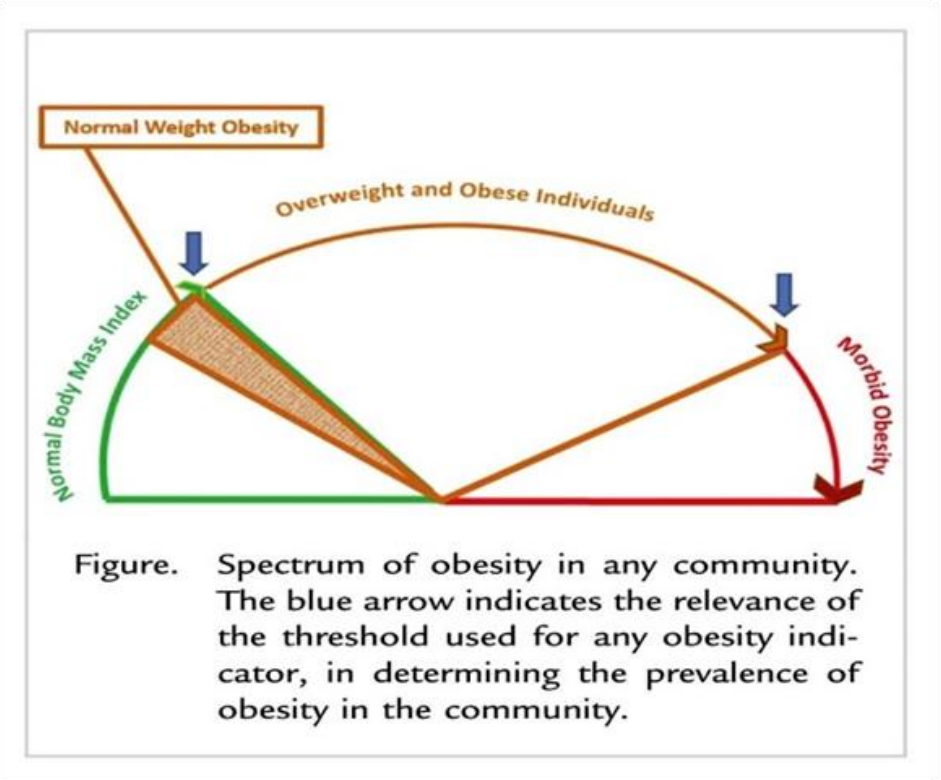


Figure. Spectrum of obesity in any community. The blue arrow indicates the relevance of the threshold used for any obesity indicator, in determining the prevalence of obesity in the community.

Source: Kapoor N et al., 2020

Figure 1.2: Pathogenesis of NWO

Source: Kapoor N et.al.,2021

1.2.2.2 Low Birth Weight and Developmental Origins

Low birth weight has been strongly implicated in the development of the "thin-fat" phenotype, particularly in the Indian population. In 2003, Yajnik et al**.** provided evidence that this phenotype is present even at birth. It is hypothesized that maternal malnutrition leads to intrauterine growth retardation through maternal stress and elevated glucocorticoid levels, which in turn affect the fetal hypothalamic-pituitary-adrenal (HPA) axis (Miazgowski et al , 2004). This dysregulation promotes ectopic fat deposition, including in organs like the pancreas. Studies have further demonstrated that individuals with low birth weight tend to develop unhealthy fat distribution, reduced lean body mass, impaired glucose tolerance, and elevated diastolic blood pressure as early as their second decade of life (Thomas et al., 2012).

Recent research has shown that postnatal diet also plays a critical role in the development of NWO. Maejima et al. (2020) demonstrated that both birth weight and early-life nutrition influence fat distribution and metabolic outcomes later in life, further contributing to the pathophysiology of the thin-fat phenotype.

1.2.2.3 Fat Overflow Hypothesis

The classical thin-fat phenotype seen in South Asians can be explained by the fat overflow hypothesis. South Asians possess a lower capacity for subcutaneous fat storage. When exposed to excess caloric intake, the limited capacity of subcutaneous adipose tissue becomes overwhelmed, leading to the spillover of excess fat into ectopic sites. These ectopic sites include visceral adipose tissue (VAT) in the omentum, as well as fat deposits in the kidneys, heart, liver, and intestines. As a result, South Asians often exhibit higher amounts of VAT despite having similar overall body fat percentages when compared to populations of European descent, increasing their risk of developing NWO and related metabolic complications (Anand SS et al., 2011).

1.2.2.4 Genetic Factors

Variants in genes such as FTO and MC4R have been associated with this phenotype, although further studies are required to fully understand their roles. Additionally, due to the higher prevalence of consanguinity in South Asian populations, monogenic forms of obesity are more commonly observed, further complicating the pathophysiology of NWO in this region **(Vasan Anand Sk et al., 2012).**

1.2.3 RISK FACTORS FOR NWO

Genetic predispositions and with a history of low birth weight is also linked to normal weight obesity (NWO) and may serve as a significant predictor for the future emergence of thin fat phenotype and its associated complications(Thomaset et al., 2012).

Psychogenic stress is increasingly recognized as a significant risk factor for NWO. Chronic stress activates the HPA axis, increasing deposition of visceral fat, which contributes to thin fat phenotype development (Miazgowski et al., 2004).

Low levels of physical activity are also strongly associated with NWO. Interventional studies have demonstrated that regular aerobic exercise can reduce visceral fat accumulation and improve insulin sensitivity in peripheral tissues, underscoring the importance of physical activity in preventing NWO (Kapoor et al., 2021).

In addition, low physical activity combined with a diet high in simple carbohydrates promotes fat accumulation in muscles and the liver, which leads to insulin resistance. Specific dietary patterns also play a role in NWO, with higher intake of saturated fats and lower fiber consumption being particularly linked to NWO in women. Recent research has also shown that increased meat consumption is a risk factor for NWO development in men. (Ryan et. al., 2006, Hashimepour S 2016, Hairston et al., 2012).

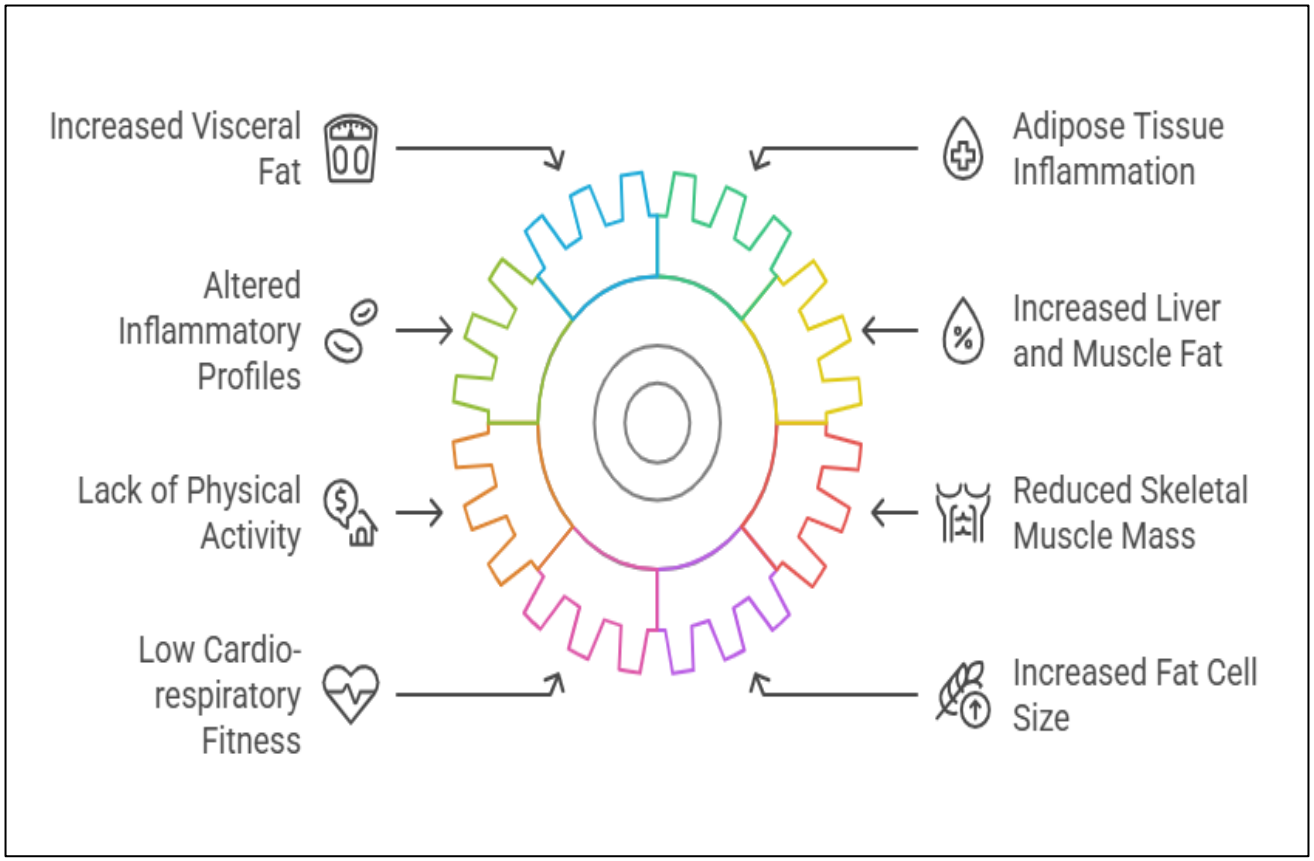
1.2.4 CAUSES AND CONSEQUENCES OF NWO

The NWO phenotype, particularly prevalent in the South Asian population, has significant clinical implications due to its association with increased cardiometabolic risk. A recent study conducted in South India found that individuals with normal weight obesity exhibited a significantly higher prevalence of type 2 diabetes, hypertension, and dyslipidemia, as defined by NCEP-ATP III guidelines, compared to individuals without obesity. Importantly, the prevalence of these cardiometabolic risk factors was similar to that observed in individuals with overt obesity (Thomas et al., 2018)

Normal weight obesity has been identified as an independent risk factor for the presence of soft atherosclerotic plaques in blood vessels. Fat accumulation in the liver, or hepatic steatosis, is a key example, with studies showing that 25–50% of patients with steatosis develop diabetes, indicating a potential causal role in diabetes onset. Additionally, hepatic steatosis is associated with an increased risk of CVD and progression to steatohepatitis, cirrhosis, and hepatocellular carcinoma. Additionally, the thin-fat phenotype has clinical relevance in tropical countries, particularly in the intersection of non-communicable diseases with chronic infectious conditions (Anand SS et al.,2011).

Excess visceral fat also significantly heightens the risk of chronic kidney disease (CKD), with diabetes being the leading cause of CKD. These findings highlight the clinical relevance of "thin outside, fat inside" (TOFI) phenotypes, where individuals with normal BMI may still harbor substantial visceral fat, increasing their susceptibility to metabolic and cardiovascular diseases (Kapoor et al., 2021).

Figure 1.3: Causes and Consequences of NWO



Ref: Ding, C., Chan, Z., &Magkos, F. (2016)

1.3 RATIONALE OF THE STUDY

The global rise of non-communicable diseases (NCDs), such as obesity and type 2 diabetes, underscores the urgent need to address varying obesity phenotypes, particularly Normal Weight Obesity (NWO). NWO, characterized by a normal BMI but high body fat percentage, is prevalent in South Asian populations and poses significant metabolic and cardiovascular Risk. The South Asian phenotype, influenced by genetic, environmental, and developmental factors, demonstrates that individuals with a normal BMI can still suffer from significant metabolic and cardiovascular risks due to excess visceral fat**.** (Kapoor et al., 2020). There is a paucity of information regarding the determinants of NWO in the general population. While several studies have explored the associations between chrono-nutrition and abdominal and visceral fat obesity, there is a significant gap in research focusing on the relationship between chrono-nutrition profile and normal weight obesity. NWO is particularly frequent in young and middle-aged adults, and low physical activity is considered a primary contributing factor. Given that metabolic imbalances can begin early in life, identifying NWO in young adults provides an opportunity for early intervention (Rodriguez M et al 2020).

Despite the increasing recognition of NWO and its health implications, there is a dearth of scientific evidence regarding dietary, physical activity, chrono-nutrition and lifestyle activity factors associated with this condition. Thus, taking into consideration all the above-mentioned factors,the current study was undertaken with the **broad objective** of assessing dietary and lifestyle factors associated with normal weight obesity amongst adults residing in urban Vadodara.

1.4 SPECIFIC OBJECTIVES

- To assess the prevalence of normal weight obesity amongst adults residing in urban Vadodara.
- To evaluate the dietary practices of the enrolled subjects.
- To assess the physical activity profile, lifestyle status, chrono nutrition profile etc. of the enrolled subjects.
- To identify the determinants of normal weight obesity amongst adults

REVIEW OF LITERATURE

Non-communicable diseases (NCDs) represent a significant global health challenge, particularly in South Asian countries where their prevalence is rapidly increasing. Factors such as urbanization, dietary changes, and sedentary lifestyles contribute to this alarming trend, leading to a dual burden of disease that includes both NCDs and under-nutrition. This epidemiological shift is particularly concerning as it fosters the emergence of cardio-metabolic conditions, including obesity and diabetes, which are exacerbated by genetic predispositions and environmental influences. The rising rates of obesity, especially central or abdominal obesity, are linked to serious health risks, including metabolic syndrome, type 2 diabetes, and cardiovascular diseases, making it imperative to address these issues effectively in the affected populations (Kim MK et al., 2014).

NORMAL WEIGHT OBESITY

Normal Weight Obesity (NWO) is characterized by individuals who have a normal Body Mass Index (BMI) but elevated body fat percentage, leading to increased cardiometabolic risks. This condition has been increasingly recognized in various populations, particularly among South Asians, where it poses significant health challenges (Kapoor et al., 2019).

The prevalence of NWO varies widely across different ethnicities and populations, with estimates ranging from 9% to 34%. This variability is influenced by diverse methodologies for body fat assessment and differing cut-off points used to define obesity (Franco et.al., 2016).

The condition is particularly burdensome in populations at high risk for metabolic disorders, such as the Indian demographic, where a significant proportion of individuals with normal BMI also present with high body fat percentages. Table 2.2 shows the prevalence of NWO with respect to body fat percentage in different countries.

From the above table 2.2, among the Tropical Countries, the highest prevalence was observed in China, with 36% among men and 29% among women. India followed with a prevalence rate of 32%. In contrast, significantly lower prevalence was observed among Caucasians, with 3.2% in men and 10.1% in women.

Table 2.1: Global studies on Normal weight obesity among different countries

Title	Year of Published, Number of Subjects	Key Findings
The paradox of obesity with normal weight; a cross-sectional study	Lahal et al., 2023(Israel) N= 3,001	• Among the 967 participants classified as normal weight, 26% of men and 38% of women were identified as having excess adiposity. • Normal-weight obese individuals exhibited higher triglyceride levels (men: 101.2 ± 50.3 mg/dL; women: 101.4 ± 91.1 mg/dL) compared to their normal-weight lean counterparts, with significant differences in low-density lipoprotein (LDL) and total cholesterol levels observed in men. • Notably, 60% of women with normal weight obesity had an abdominal circumference ≥88 cm, while only 4% of men had an abdominal circumference ≥102 cm.
Normal-weight obesity syndrome: diagnosis, prevalence, and clinical implications	Franco et al., 2016 (Korea) N =12,217	The study revealed that the prevalence of NWO was significant, with rates of 36% in men and 29% in women who had a normal body mass index (BMI) defined as 18.5-22.9 kg/m² for Asians.

		The findings indicated that individuals with NWO were at an increased risk for various health issues, including cardiovascular diseases, insulin resistance, and other chronic conditions. The study underscores the importance of recognizing NWO as a distinct clinical entity that requires attention for early intervention and preventive measures.
The Concept of Normal Weight Obesity	Oliveros E et al., 2014	Findings indicate that individuals with normal BMI but central obesity face a significantly higher risk of mortality compared to those with normal BMI and no central obesity. The study concludes that WC and WHR are more effective measures for stratifying risk and developing therapeutic guidelines for fat loss in CHD patients.
Prevalence of normal weight obesity in Switzerland: effect of various definitions	Marques Vidal et al., 2012 (Switzerland) N=6,189	The findings revealed that the prevalence of NWO in men was consistently below 1%, while in women, it varied significantly from 1.4% to 27.8%, depending on the cut-off used. The use of age- and gender-specific cut points yielded more consistent results compared to a single cut-off, which tended to overestimate NWO prevalence in older adults and underestimate it in younger individuals.

Table 2.2: Prevalence of NWO with different criteria of body fat percentage

Author/s	Title	Body fat % - criteria	Prevalence	Country
Kapoor et al.,2020	Normal Weight Obesity: An Under recognized Problem in Individuals of South Asian Descent	≥ 20.6% in men; ≥ 33.4% in women	32% [95% confidence interval (CI) 29.1-34.5].	India
Kim et al 2014	Normal weight obesity in Korean adults	≥ 20.6% in men; ≥ 33.4% in women	36% in men; 29% in women	Korea
Madeira et al. 2013	Normal Weight Obesity Is Associated with Metabolic Syndrome and Insulin Resistance in Young Adults from a Middle-Income Country	TSF + þSSF ≥ P90 ~ 23.1% in men; 33.3% in women	9.2% in men; 9.0% in women	Brazil
Marques-Vidal et al.2010	Normal weight obesity: Relationship with lipids, glycaemic status, liver enzymes and inflammation	≥ 30% overall	3.2% in men; 10.1% in women	Caucasians
Romero-Corral et al.2010	Normal weight obesity: a risk factor for cardio-metabolic dysregulation and cardiovascular mortality	≥ 20.6% in men; ≥ 33.4% in women	Among normal-BMI subjects: 33.4%	North Americans

Ramsaran C et al 2017	Normal weight obesity among young adults in Trinidad and Tobago: prevalence and associated factors	≥23.1% males, ≥33.3% females	19.9% [95% confidence interval (CI) 15.1-25.7].	Trinidad and Tobago
Ji T et al 2020	Prevalence of Normal-Weight Obesity in Community-Dwelling Chinese Older Adults	male ≥25% and female ≥35%)	10.7%	China

Table: 2.3 Global studies of relationship Between Normal weight obesity and body composition

Title	Year of Published, Number of Subjects	Key Findings
Assessing the Risk of Normal Weight Obesity in Korean Women across Generations: A Study on Body Composition and Physical Fitness	Cho Y et al., 2024 (Korea) N=11,835	● In Korean women, the prevalence of NWO was 18.3%. They also had higher waist circumference and blood pressure compared to the normal BMI group. ● Additionally, the NWO group demonstrated lower levels of strength, endurance, power, balance, and coordination, with reduced muscle mass and physical fitness, similar to the obese group, but significantly lower than the normal BMI group.
Association between Normal Weight Obesity and Skeletal Muscle Mass Index in Female University Students with Past Exercise Habituation	Oshita K et at., 2022 N=120 females	● Notably, 60% of the normal weight-obese (NW-O) group had a low skeletal muscle index (Low-SMI), indicating a significant link between NW-O and reduced muscle mass. ● The results showed that NW-O individuals had lower lower limb muscle mass compared to their normal weight peers, despite having a normal body mass index (BMI). ● This suggests that NW-O is associated with higher body fat and lower muscle mass, raising concerns about potential future health issues.
Characteristics of Body	Maitiniyazi G et al., 2021 (China) N=279	● Among the participants, 26 males (25.5%) and 71 females (40.1%) were identified as NWO. ● Compared to NWNO students, those with NWO had

Composition and Lifestyle in Chinese University Students with Normal-Weight Obesity: A Cross-Sectional Study		significantly higher body weight, BMI, body fat mass, visceral fat area, waist circumference, and hip circumference in both males and females.
Dieting practices, weight perceptions, and body composition: A comparison of normal weight, overweight, and obese college females	Brenda M Malinauskas et al., 2020 N=185 female	● Findings revealed that 83% of participants engaged in dieting for weight loss, perceiving that their body weight would increase by 2–6% in the absence of dietary control. ● The perceived attractive weight was lower than their current weight across all BMI categories, with normal-weight participants considering 94% of their current weight as ideal, overweight participants perceiving 85%, and obese individuals perceiving 74% as their ideal weight. ● While 80% of participants reported engaging in physical activity for weight control, only 19% exercised at an intensity sufficient for effective weight loss. ● These findings highlight the need for targeted health education interventions to promote evidence-based dietary practices and sustainable weight management strategies among college-aged females.
Anthropometric, body composition, and somatotype characteristics	Yasuda et al., 2019(Japan) N=124	● The prevalence of presarcopenia (36.3%) was higher than that of normal-weight obesity (16.9%) and obesity (4.8%). ● Anthropometric and sarcopenia-related measures were significantly higher in the normal-weight obesity and

of Japanese young women: Implications for normal-weight obesity syndrome and sarcopenia diagnosis criteria		standard groups compared to the pre-sarcopenia group.
Body composition and lung function in cystic fibrosis: association with adiposity and normal weight obesity	Patterson et al., 2016, (USA) N= 32	Within the CF cohort, FEV1% predicted demonstrated a positive correlation with fat-free mass index ($\beta = 6.31 \pm 2.93$, $P = 0.04$) and an inverse association with body fat percentage.
Association of body composition and eating behavior in the normal weight obese syndrome	Di Renzo,L., et al 2016 N=79	● Significant differences ($p < 0.001$) in EDI-2 subscale scores were observed among the groups, indicating a progressive increase in psychopathological traits with higher body fat composition. ● The NWO group was distinguished from the PreOB/OB group based solely on body composition parameters rather than BMI. ● Women classified as NWO demonstrated intermediate EDI-2 scores between NWL and PreOB/OB individuals, particularly in aspects of drive for thinness and body dissatisfaction. ● The NWO syndrome not only presents a heightened risk for cardiovascular and metabolic diseases but also exhibits significant psychological overlap with eating disorders.

2.1 Normal Weight Obesity and Body Composition

Body composition, particularly the accumulation of visceral fat, is a significant factor in the development of NWO, as individuals with normal weight but high visceral fat are at increased risk for metabolic disorders (Maitiniyazi G et al., 2021).

The condition is particularly burdensome in populations at high risk for metabolic disorders, such as the Indian demographic, where a significant proportion of individuals with normal BMI also present with high body fat percentages.

2.2 Normal Weight Obesity and Physical Activity

Regular physical activity is crucial for maintaining healthy body composition; studies indicate that replacing sedentary time with moderate-to-vigorous physical activity can lead to reductions in visceral fat, thereby mitigating the risks associated with NWO. The relationship between physical activity and body composition is complex; while exercise is beneficial, the type and intensity of physical activity, along with dietary habits, play critical roles in determining body fat distribution and overall health. (Wiayatunga et al., 2022).

Table 2.4: Global studies on association of Physical Activity and Normal weight obesity

Title	Year of Published, Number of Subjects	Key Findings
Habitual physical Activity and Dietary profiles in Older Japanese Males with Normal – Weight Obesity	Yusei T et al .,2023 (Japan) N=143	● The normal-weight obese group exhibited significantly lower levels of high-density lipoprotein (HDL) cholesterol and higher levels of triglycerides and alanine transaminase compared to the non-obese group, with all differences being statistically significant. ● No significant differences in physical activity and dietary habits were found between the non-obese and normal-weight obese groups.
Objectively Measured Physical Activity Is Lower in Individuals with Normal Weight Obesity in the United States	Wijayatunga et al., 2022(US) N=	● Individuals with NWO engaged in significantly less moderate to vigorous physical activity (MVPA) compared to NWL, with a difference of about 8 minutes per day. ● Low-intensity physical activity (LIPA) was also lower in the NWO group by approximately 17 minutes per day compared to NWL.

Research indicates that visceral fat mass, rather than BMI alone, plays a crucial role in metabolic disorders, with NWO individuals showing higher dyslipidemia and impaired glucose tolerance. Notably, reducing visceral fat over time significantly decreases metabolic risks, emphasizing the need to assess and manage visceral fat accumulation for better metabolic health (Yusei T et al .,2023).

Sedentary behavior is positively correlated with waist circumference and clustering metabolic risk scores, and it is associated with obesity and an increased risk of cardiovascular morbidity and mortality.

Because only "healthy" adults were chosen for the study, the differences between the Normal Weight Obesity (NWO) and Obese (OB) groups and Normal Weight Lean (NWL) persons were not statistically significant, despite the fact that both groups had higher levels of inactive time (Wijayatunga et al., 2022).

The results indicate that in order to improve their general health and reduce the dangers associated with sedentary behavior, individuals with NWO should increase their participation in all types of physical activity, including both MVPA and light-intensity physical activity (LIPA)(Wijayatunga et al., 2022).

2.3 Normal Weight Obesity and Physical Fitness

Higher physical fitness, indicated by grip strength and activity levels, correlates with improved body composition, suggesting its role in mitigating NWO’s adverse effects.

Table 2.5: Studies on association between Normal Weight Obesity and physical fitness

Title	Year of Published, Number of Subjects	Key Findings
Insufficient Physical Fitness and Deficits in Basic Eating Habits in Normal-Weight Obese Children Are Apparent from Pre-School Age or Sooner	Musalak M et al., 2021 N=188	● Normal-weight obese children exhibited significantly lower performance in muscular fitness, cardio-respiratory fitness, and running agility compared to their normal-weight non-obese peers, with p-values ranging from 0.03 to less than 0.001 and effect sizes from low to medium. ● In comparison to overweight and obese peers, normal-weight obese children did not show significant differences in most physical fitness tests. ● The study found that NWO boys had a significantly higher preference for sweet foods and drinks compared to NWNO boys. In contrast, NWO girls exhibited a more negative attitude towards food consumption compared to their NWNO counterparts.
Relationships between plasma apelin and adiponectin with normal weight obesity, body composition, and cardiorespiratory fitness in	Bellissimo,M.P., et al, 2021 N=177	● The results indicated that 14.7% of participants were categorized as lean, 23.7% as having NW, and 61.6% as overweight and obese. ● Plasma adiponectin levels were significantly higher in the overweight –obese group compared to both thre lean and NOW groups ($p< 0.05$), while no significant

working adults		differences were found between the lean and NOW group($p>0.05$). ● This study highlights the complex relationship between composition between body adipokines, and exercise tolerance, suggestion that while adiponectin levels vary with body fat distribution, aapelin levels do not distinguish between different body composition categories.
Normal-Weight Obesity Is Associated with Poorer Cardiometabolic Profile and Lower Physical Fitness Levels in Children and Adolescents	Garcia Hermosa et al., 2020 N=79	● The findings revealed that 48.10% of the participants were classified as normal weight obese (NWO), while 22.79% were normal weight lean (NWL), and 29.11% were pre-obese or obese (Pre OB/OB) based on their BMI and body composition. ● Significant differences were observed among the groups in terms of the Eating Disorder Inventory-2 (EDI-2) subscales, indicating a progressive increase in psychopathology associated with body composition. ● The strongest correlations were identified between BMI and various psychological scores, such as drive for thinness (DT), body dissatisfaction (BD). ● The analysis showed that %TBF at (total body fat percentage) correlated exclusively with body composition variables, while the NWO group was distinguished from the Pre OB/OB.

		● This study highlights the complex interplay between body composition and psychological factors in women with NWO syndrome, suggesting that these individuals may be at a heightened risk for both metabolic and psychological issues.
Physical Fitness but Not Diet Quality Distinguishes Lean and Normal Weight Obese Adults	Bellissimo, M.L., eta al, 1963-1973	● VO_2 max was significantly lower in individuals with NWO than in lean individuals (36.2 ± 0.8 vs. 40.2 ± 1.0 mL/min/kg, $p<0.05$). ● Diet quality scores were similar between NWO and lean groups but higher in both compared to overweight-obese individuals ($p<0.05$). ● Diet quality and VO_2 max were inversely related to body fat percentage and visceral adipose tissue ($p<0.05$), irrespective of weight status. ● NWO individuals had elevated fasting insulin, insulin resistance, LDL cholesterol, and triglycerides, along with reduced HDL cholesterol, compared to lean individuals ($p<0.05$).

Sedentary time did not differ significantly between the NWO and NWL groups, indicating that while NWO individuals are less active, they do not spend more time sedentary. NWO was highly prevalent among those with a normal BMI, affecting a substantial proportion of both men and women, revealing hidden health risks. Lower leisure-time physical activity, higher smoking rates, and increased alcohol consumption were more common in NWO individuals, particularly men. These findings highlight the need for increased physical activity to mitigate risks associated with higher body fat percentages, emphasizing targeted interventions for healthier body composition .The studies emphasizes the importance of identifying markers for NWO early in life to prevent the development of obesity-related health issues as children grow (Musalak et al., 2021; Bellissimo et al, 2021).

2.4 Normal Weight Obesity, Diet and Lifestyle Factors

NWO (Normal Weight Obesity) is increasingly associated with poor dietary habits, particularly high consumption of ultra-processed foods (UPFs), which can lead to excess body fat accumulation (Kobayashi et al., 2023).

Dietary factors play a crucial role in the prevalence of NWO, with studies indicating that diets high in protein, fiber, and nutrient-dense foods like fish and vegetables can protect against obesity, while high sugar intake, especially from confectionery, is linked to increased NWO risk. Lifestyle factors, including physical inactivity, inadequate sleep, and higher alcohol consumption, significantly contribute to the development of NWO, suggesting that sedentary behaviors can exacerbate unhealthy eating patterns a body fat accumulation (Hadaye et al.,2020).

A holistic approach that integrates healthy dietary choices, active lifestyles, and consideration of chrononutrition is essential for effectively addressing NWO and improving overall health outcomes, as these factors are interlinked in promoting metabolic health.

Table 2.6: Global and National Studies on association between Normal Weight Obesity,Diet and Lifestyle factors

Title	Year of Published, Number of Subjects	Key Findings
Higher consumption o ultra-processed foods and a pro-inflammatory diet are associated with the normal -weight obesity phenotype in Brazilian children	Kota.B.C et al., 2024 (Brazil) N=365 childrens	• The study utilized the Children's Dietary Inflammatory Index (C-DII) to assess dietary patterns among children, revealing that higher C-DII scores indicate a more pro-inflammatory diet associated with increased consumption of ultra-processed foods (UPFs). • A significant positive association was found between UPF consumption and C-DII scores, while unprocessed or minimally processed food intake was negatively correlated with C-DII scores, suggesting dietary quality impacts inflammatory markers. • The research highlighted that NWO prevalence among children is influenced by dietary habits, with higher UPF consumption linked to increased serum inflammatory markers, reinforcing the need for dietary interventions.
Association of Nightly Fasting, Meal Frequency, and Skipping Meals with Metabolic Syndrome among Kuwaiti Adults	Alkhulaifi F et al., 2024(Kuwait) N= 757	• The research indicates that a higher frequency of meals is associated with a lower prevalence of metabolic syndrome among Kuwaiti adults. • The study also highlights that increased meal frequency is linked to a lower prevalence of elevated triglycerides,

		particularly in men.This finding emphasizes the potential benefits of frequent eating patterns in managing triglyceride levels. • While no significant association was found between nightly fasting duration and metabolic syndrome, a longer fasting duration was associated with a lower prevalence of elevated triglycerides. • This suggests that longer periods of fasting may contribute positively to triglyceride management.
Association of normal weight obesity with lifestyle and dietary habits in young Thai women: A cross-sectional study	Kobayashi et al., 2023(Thailand). N=250 female	• The study found that 46.8% of the participants, who were classified as having a normal body type, were identified as having NWO. • The NWO group exhibited significantly higher weight, BMI, and body fat ratio (BFR) compared to the non-normal weight obesity (NO-NWO) group, with all differences being statistically significant. However, muscle mass was lower in the NWO group. • The NWO group exhibited significantly higher consumption of UPFand sweetened beverages compared to the NO-NWO group highlighting the need for awareness and lifestyle modifications to mitigate health risks.
Association of Normal Weight Obesity with	Arshad et al., 2022 (Pakistan) N=125	• The study found that the prevalence of NOW among the participants was 28.8%.

Dietary Habits Among Young Adults in Pakistan		• The results highlighted a positive association between unhealthy dietary habits, such as excessive consumption of white rice/bread, starchy vegetables, flavored milk, junk food, and confectionary, and higher body fat percentages among individuals classified as having NWO. • The study concluded that there is a significant link between dietary habits and body fat status, emphasizing the need for awareness regarding healthy eating patterns to mitigate the risk of NWO in young adults .
Dietary and Biochemical Characteristics Associated with Normal-Weight Obesity	Amani et al.,2017 Iran N=90	NWO individuals had significantly lower dietary intake of fruits (frequency factor [FF] legumes,nuts and,beta-cryptoxanthin, lycopene and serum TAC levels compared to the NW group. Additionally, a significant negative correlation was observed between serum TAC levels and body fat.
Dietary and lifestyle characteristics associated with normal-weight obesity: the National FINRISK 2007 Study	Manisto et al., 2014 (Finland) N=4786	• Among participants with a normal BMI, 34% of men and 45% of women were classified as having NWO, indicating a significant prevalence of this condition. • NWO men had the highest intake of beef compared to other weight categories, while NWO women reported the highest sugar intake, particularly from confectionery, and the lowest intake of root vegetables. • The study found that NWO participants had similar

		intakes of cereals and milk compared to overweight individuals, but their overall dietary patterns included lower intakes of healthy foods like root vegetables and fish, and higher intakes of unhealthy options like confectionery. ● The findings suggest that despite having a normal weight, NWO individuals exhibit unhealthy dietary habits that may contribute to their excessive body fat percentage.
Sociodemographic and Lifestyle Factors in relation to Overweight Defined by BMI and "Normal-Weight Obesity"	Kapoor et al., 2021 (India) N=292	● The results indicated a statistically significant improvement in systolic blood pressure and serum HDL levels in the intervention group after two years indicating some positive effects of lifestyle changes. ● Despite improvements in certain cardiovascular risk factors, no significant changes were observed in other lipid and glucose-related parameters, suggesting that the lifestyle intervention may require a longer duration to yield more substantial benefits. ● The study highlighted that individuals with NWO may be inherently more resistant to lifestyle changes, raising questions about the effectiveness of short-term interventions for this specific phenotype. ● However, no significant differences were observed in other lipid and glycemic parameters, suggesting that

		while the intervention had some positive effects, these changes may not be clinically meaningful.
Obesity Prevalence and Determinants among Young Adults, with Special Focus on Normal-Weight Obesity; A Cross-Sectional Study in Mumbai	Hadaye et al.,2020 (Mumbai) N=269	● The study found that 42.01% of participants were obese, and 16.1% had NWO. ● Significant associations with obesity included sex, high protein diet, frequency of restaurant visits, lower intake of homemade meals, heavy physical activity, and alcohol consumption. ● Factors significantly linked to NWO were fish intake, physical activity, protein diet, and daytime sleep.

2.5 Normal Weight Obesity and Chrono nutrition

The concept of chrono nutrition emphasizes the timing of food intake and its impact on metabolic health. Irregular eating patterns can disrupt circadian rhythms, leading to metabolic dysregulation and weight gain, which is particularly relevant for individuals with NWO.

Chrononutrition emphasizes the synchronization of food intake with the body's circadian rhythms, suggesting that meal timing can significantly influence metabolic health and body composition. Research indicates that late eating patterns are associated with adverse nutritional and metabolic outcomes, including obesity and metabolic syndrome (Azahari N et al., 2023).

Studies have shown that variations in meal timing, such as early versus late eating, can impact body mass index (BMI) and overall body composition, regardless of total caloric intake. The interaction between biological rhythms and nutrition highlights the importance of meal frequency, duration, and regularity in maintaining metabolic health and reducing chronic disease risk (Cunha et al., 2023).

Observational data suggest that longer eating durations and later meal timings correlate with increased abdominal obesity and elevated fasting glucose levels, indicating a need for lifestyle modifications to improve health outcomes. Overall, the integration of chrononutrition principles into daily lifestyle choices can enhance diet quality and support better metabolic health(Cunha et al., 2023).

Table 2.7: Studies on Chrono nutrition and its association with diet, lifestyle factors and adiposity.

Title	Year of Published, Number of Subjects	Key Findings
Late meal intake is associated with abdominal obesity and metabolic disorders related to metabolic syndrome: A chrono nutrition approach using data from NHANES 2015-2018	Cunha et al., 2023 (U.S) N=7,379	● Adults with an eating duration exceeding 12 hours had a 15% higher prevalence of abdominal obesity compared to those with a shorter eating duration (≤12 hours). ● Individuals with timing of their last meal (average time 22:03) showed a 12% increased prevalence of abdominal obesity. ● Later eating midpoints were associated with elevated fasting glucose levels ● Among elderly participants, those with longer eating durations (>12 hours) had a significantly higher prevalence of elevated triglycerides compared to those with shorter durations.
Association Between chrono nutrition Profile and Diet Quality Among Iium Kuantan Students	Azahari et al., 2023 (Malaysia) N=129	● The study found no statistically significant association between various chrono nutrition profiles (such as night eating, breakfast skipping, and evening eating) and diet quality among the students. ● A notable observation was that a significant portion of students (67.4%) reported eating after 11:00 p.m. However, this behavior did not correlate with improved diet quality, which aligns with findings from other studies

		indicating that late-night eating can lead to poorer dietary choices. ● The study highlighted that many students frequently skip breakfast, which is associated with a less diverse dietary intake. Regular breakfast consumption is generally linked to better diet quality, but this was not reflected in the findings of this study. ● The research noted that many students exhibited late chronotype behaviors due to their busy schedules. This late chronotype was associated with poorer dietary adherence, yet the study did not find a significant impact on overall diet quality.
Smoking, Screen-Based Sedentary Behavior, and Diet Associated with Habitual Sleep Duration and Chronotype: Data from the UK Biobank	Patterson et al., 2016 (UK) N= 439,933	● Findings indicated that short sleepers (those getting less than 7 hours of sleep) were 45% more likely to smoke tobacco compared to those with adequate sleep (7-8 hours) (9.8% vs. 6.9%) ● Late chronotypes (individuals who prefer staying up late) were more than twice as likely to smoke compared to intermediate chronotypes (14.9% vs. 7.4%). ● Long sleepers reported an average of 0.61 more hours of television viewing per day than adequate sleepers, while early chronotypes had 0.20 fewer hours of computer use than intermediate chronotypes.

2.6 Normal Weight Obesity and Non –Communicable Diseases

Normal weight obesity (NWO) is linked to higher prevalence of metabolic risk factors and an increased risk of metabolic syndrome (MetS). People with NWO have a distinct feature of higher FMR, reflecting high total body fat (FM) and/or low total body lean mass (LM), which plays an important role in determining its relationship with MetS. NWO is an important risk factor in determining MetS susceptibility, though the underlying pathology is not fully understood (Kim J et al., 2023).

Growing evidence supports NWO as a potential biomarker for cardiometabolic complications. The association between NWO and MetS may stem from excessive fat accumulation, contributing to dyslipidemia, insulin resistance, reduced serum vitamin D, elevated inflammatory cytokines, and oxidative stress (Kim J et al., 2023).

Additionally, low skeletal muscle mass or sarcopenia in NWO can further exacerbate inflammation, impair glucose metabolism, decrease basal metabolic rate, and reduce functional capacity and physical fitness (Kim M.et.,al 2013).

These studies underscore the importance of assessing both central and general obesity and highlights the need for lifestyle interventions focusing on diet quality, physical activity, and stress management for individuals with normal weight but increased metabolic risk.

Table: Different global and national studies on Normal Weight Obesity and Normal Weight Central Obesity with NCDs

Title	Year of Published, Number of Subjects	Key Findings
Normal Weight Obesity Associated with Enhanced Echo Intensity, Insulin Resistance, and Decreased Muscle Strength in Young Adults	Gunaseelan et al., 2024 N=80	● The NWNO group demonstrated higher handgrip strength, while the NWO group had greater subcutaneous fat thickness and echo intensity. ● Additionally, glucose, insulin levels, and insulin resistance were significantly elevated in the NWO group
Normal-Weight Obesity and Metabolic Syndrome in Korean Adults: A Population-Based Cross-Sectional Study	Kim et al., 2023 (Korea) N=5962 male,6558 female.	● NWO males and females were 2.7 times and 1.9 times more likely to develop MetS compared to normal-weight, non-obese individuals. ● These findings suggest that NWO is a useful biomarker for identifying the risk of MetS and should be considered for early intervention.
Normal Weight Obesity Is Associated with Metabolic Syndrome and Insulin Resistance in Young Adults from a Middle-Income Country	Madeira et. al., 2013 (Brazil) N=1222	● NWO was strongly associated with metabolic syndrome and insulin resistance, indicating that individuals with NWO face significant clinical risks, despite having a normal BMI.
Normal weight obesity in Korean adults	Kim et.,al 2013 (Korea)	● There were significant and graded associations between higher BF percentages and the prevalence of CVD risk

	N= 5313 men and 6904	factors. The first cut-off values, indicating being overweight, were 20.6% BF for men and 33.4% BF for women. ● These individuals exhibited lower appendicular skeletal muscle mass, a more atherogenic lipid profile, and increased insulin resistance.
Normal weight obesity: Relationship with lipids, glycaemic status, liver enzymes and inflammation	Marques-Vidal et ,al 2008 Switzerland) N=3,213	● The prevalence of NWO was 5.4% in women and less than 3% in men, leading the analysis to focus primarily on women. ● Women with NWO had higher body fat percentages than those classified as overweight. ● After adjusting for age, smoking status, education, physical activity, and alcohol consumption, NWO women showed higher blood pressure, elevated lipid levels, and a greater incidence of dyslipidemia and fasting hyperglycemia compared to lean women.
Normal Weight Obese (NWO) Women: An Evaluation of a Candidate New Syndrome"	Lorenzo et al., 2006 (Italy) N=74	● The results revealed significant differences in HDL-cholesterol levels between NWO women and both control and pre-obese/obese groups. ● Additionally, significant correlations were found between NWO status and a cardiovascular risk index, suggesting that NWO women are at higher risk of cardiovascular complications.

The double burden of normal weight obesity and Normal weight central obesity (NWCO)on Hypertension Risk : A cross-sectional study	M Makwana et al., 2024 (Gujarat) N=1000	● The prevalence of NWO was found to be 38%, affecting 228 out of 600 normal-weight individuals, while NWCO prevalence was 32%, impacting 192 of the same group. ● Additionally, the odds for pre-hypertension were also elevated for those with NWO (OR 1.7, 95% CI 1.1-2.6) and NWCO (OR 2.0, 95% CI 1.3-3.2). ● Individuals with NWO and NWCO exhibited significantly higher odds of hypertension, with odds ratios (OR) of 3.2 (95% CI 2.1-4.7) and 3.5 (95% CI 2.3-5.2), respectively, compared to metabolically healthy normal-weight individuals ● The findings suggest that a significant portion of normal-weight adults in this population are at an elevated cardiovascular risk due to excess body fat and abdominal adiposity, indicating the need for better assessment methods beyond BMI.
Hypertension in Individuals with Normal-Weight Obesity and Normal-Weight Central Obesity: A Study on Sunni Muslims of Uttar Pradesh, North India	Shimrah el al., 2023 (Uttar Pradesh) N=100 males and 114 females	● The prevalence of NWO in the total population was 21.9%. On the other hand, the prevalence of NWCO was 3.3%, 21.5%, and 12.1% as per WC, WHR, and WHtR respectively. ● The mean value of SBP and DBP was higher in individuals with NWO and NWCO.

Prevalence of Normal weight obesity and its cardiometabolic implication among government doctors in Gujarat, India: a cross-sectional study	M Makwana et al., 2023 (Gujarat) N=490	● The study found that: overall obesity prevalence was 20% (101 doctors). ● NWO was present in 48.7% (239 doctors).NWCO was observed in 42.8% (210 doctors) ● There were significant increases in mean BMI, blood pressure, glucose, and LDL levels from normal weight to NWO/NWCO groups ($p < 0.05$). ● NWO and NWCO were associated with higher odds of hypertension, dyslipidemia, and elevated fasting blood sugar compared to non-obese individuals, even after adjusting for confounders.

The rising prevalence of non-communicable diseases (NCDs) in South Asian countries, driven by urbanization, dietary changes, and sedentary lifestyles, underscores the urgent need for research to address these health challenges.

The phenomenon of Normal Weight Obesity (NWO) is increasingly recognized as a significant health risk, particularly among young and middle-aged adults, necessitating further investigation into its dietary and lifestyle factors.

Late meal intake has been linked to abdominal obesity and metabolic disorders, indicating that understanding-eating patterns is crucial for developing effective interventions.

The review of literature highlighted the importance of examining physical activity and dietary profiles in populations with NWO, as these factors are essential for identifying at-risk individuals and implementing targeted health strategies.

Overall, the present study aims to fill critical gaps in the existing literature, providing a foundation for public health policies that can effectively combat the dual burden of NCDs and obesity-related conditions.

METHODS AND MATERIALS

Normal Weight Obesity (NWO) is characterized by a normal BMI but high visceral fat, and is linked to factors such as genetic predisposition, psychogenic stress, low physical activity, and diet. NWO significantly raises the risk of type 2 diabetes, hypertension, dyslipidemia, and soft atherosclerotic plaques. Poor diet, lack of physical activity, and other lifestyle factors lead to adverse body composition, increasing the likelihood of metabolic diseases. Addressing this issue requires tailored interventions and a deeper understanding of the underlying genetic and environmental factors contributing to NWO.

The global rise of non-communicable diseases (NCDs), such as obesity and type 2 diabetes, underscores the urgent need to address varying obesity phenotypes, particularly Normal Weight Obesity (NWO). NWO, characterized by a normal BMI but high body fat percentage, is prevalent in South Asian populations and poses significant metabolic and cardiovascular risk. The South Asian phenotype, influenced by genetic, environmental, and developmental factors, demonstrates that individuals with a normal BMI can still suffer from significant metabolic and cardiovascular risks due to excess visceral fat (Kapoor N et.al., 2020). There is a paucity of information regarding the determinants of NWO in the Indian population. While several studies have explored the associations between Chrono nutrition and abdominal and visceral fat obesity, there is a significant gap in research focusing on the relationship between Chrono-nutrition and normal weight obesity. NWO is particularly frequent in young and middle-aged adults, and low physical activity is considered a primary contributing factor. Given that metabolic imbalances can begin early in life, identifying NWO in young adults provides an opportunity for early intervention. Despite the increasing recognition of NWO and its health implications, there is a dearth of scientific evidence regarding dietary, physical activity, Chrononutrition and lifestyle factors associated with this condition. Thus, the proposed study has been planned to fill the existing gap in knowledge regarding NWO.

3.1 BROAD OBJECTIVE

Assessing dietary and lifestyle factors associated with normal weight obesity amongst adults residing in urban Vadodara

3.2 SPECIFIC OBJECTIVES

- To assess the prevalence of normal weight obesity amongst adults residing in urban Vadodara.
- To evaluate the dietary practices of the enrolled subjects.
- To assess the physical activity profile, lifestyle status, Chrono nutrition profile etc. of the enrolled subjects.
- To identify the determinants of normal weight obesity amongst adults

3.3 ETHICAL APPROVAL

The Maharaja Sayajirao University of Baroda's Faculty of Family and Community Sciences' institutional review board granted the study's design and protocol ethical approval with the ethical approval number as IECHR/FCSc/M.Sc/10/2024/48.

3.4 STUDY AREA: Urban Vadodara

3.5 STUDY DESIGN:

3.5.1 Enrolment of subjects: The free-living population of age group(20-59yrs) had been selected through snowball sampling from the urban Vadodara.

3.5.2 Sample size calculation:

Sample was calculated taking Prevalence rate of 32% of normal weight obesity (Kapoor N. et al., 2020). Formula used for the sample size calculation: $N= (Z)^2 p (1-p) /d^2$ 6

- Z is the Z- score corresponding to the desired confidence level
- P is the estimated prevalence of the condition in the population
- E is the margin of error, indicating the acceptable difference between the sample estimate and the true population value.

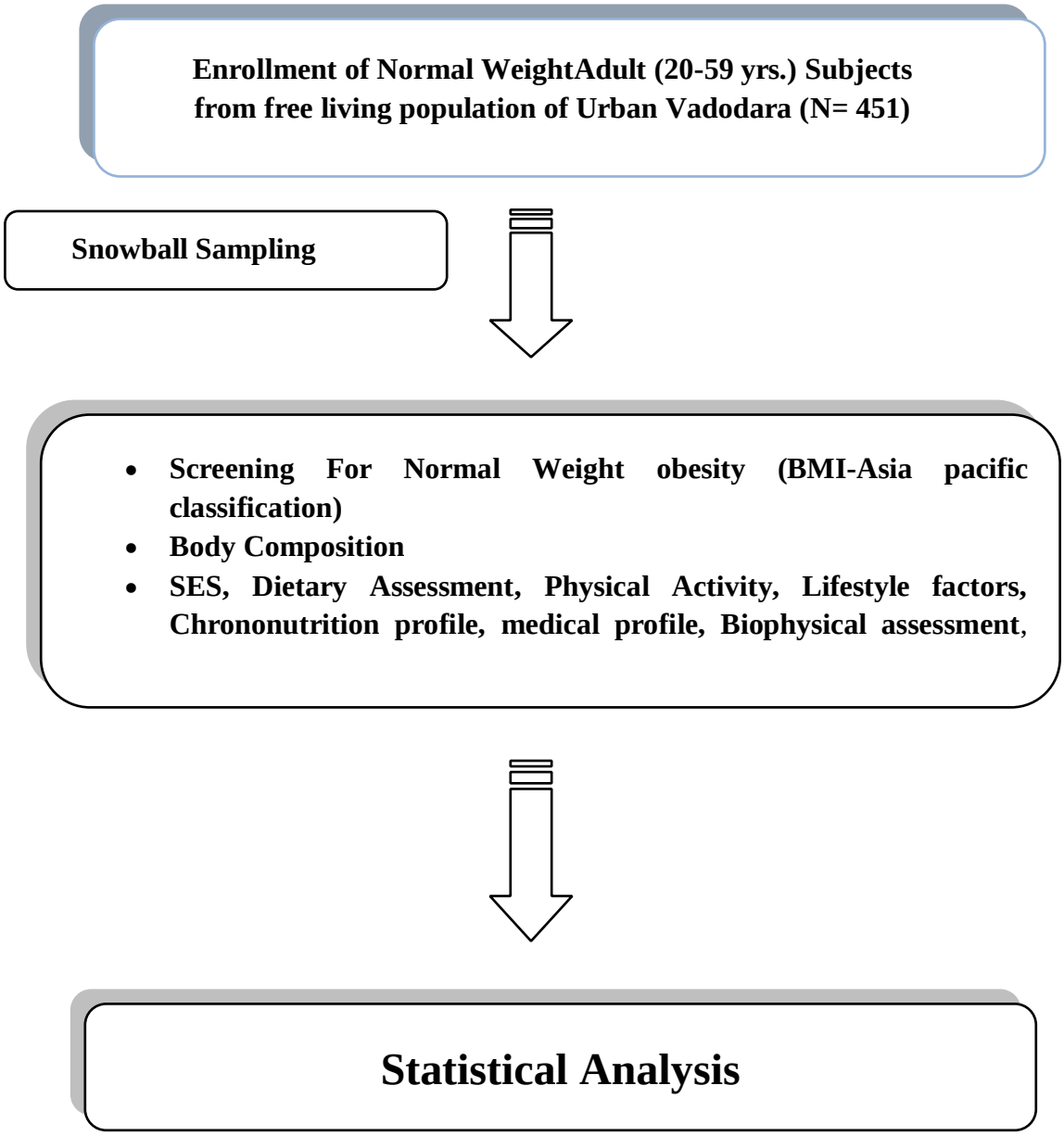
$N= (Z)^2 p (1-p) /d^2 = (1.96)^2 \times (0.32) (0.68)/ (0.05)^2 = 391$

A sample size of 391 is obtained. Using a confidence level of 95% (which corresponds to =1.96 (Z= 1.96) and assuming 5 % margin of error and considering 10% attrition The final sample size is rounded off to 450.

3.5.3 Study design:

A cross-sectional study on Normal Weight Obesity has been conducted among the free-living population of urban Vadodara. The Normal weight subjects were enrolled through snowball sampling after obtaining informed consent. Data on Socio-economic status, Family and Medical History, anthropometry and body composition, Biophysical measurement, Physical fitness, Dietary practices, chrono-nutrition profile, Lifestyle factors and stress status had been obtained from the enrolled subjects.

Figure 3.1: Study Design



3.6 TOOLS AND TECHNIQUES

The following information was collected through the structured questionnaire:

3.6.1 BACKGROUND INFORMATION: The background information including age, gender, marital status, Type of family and number of family members were collected from the participants

3.6.2 SOCIO-ECONOMIC STATUS: Socioeconomic status (SES) serves as a pivotal determinant influencing the health outcomes of individuals and families. The socio-economic status based on Kuppuswamy's Socio economic scale (2024 modified) including educational qualification of head of the family, occupation and family monthly income.

3.6.3 MEDICAL AND FAMILY HISTORY:

Medical and family history of the subjects was collected in order to know the presence of any associated comorbidities or complications like diabetes, hypertension, chronic heart disease, cancer or any other condition.

3.6.4 ANTHROPOMETRIC DATA

3.6.4.1 WEIGHT

Weight was measured to the nearest 0.5 kg with the help of a bathroom weighing scale and it was calibrated prior to each measurement.

3.6.4.2 HEIGHT

Height was measured using a stadiometer and it was calibrated prior to each measurement. Then corresponding height was noted from the standardized stadiometer, in centimeters to the nearest 0.1 cm.

Table3.1: Educational qualification of head of the family

Professional and honors	7
Graduate or post graduate	6
Intermediates or diploma	5
High school certificate	4
Middle school certificate	3
Primary school certificate	2
Illiterate	1

(Source: Kuppuswamy's Socio economic scale 2024 modified)

Table 3.2: Occupation categories

Legislators, senior officials and managers	10
Professionals	9
Technical and associate professionals	8
Clerks	7
Skilled worked and shop and market sales workers	6
Skilled agricultural and fishery workers	5
Crafts and related trade workers	4
Plant and machine operator and assemblers	3
Elementary occupations	2
Unemployed	1

(Source: Kuppuswamy's Socio economic scale 2024 modified)

Table 3.3: Family Income per month

2,13,814and above	12
1,06,850-2,13,813	10
80,110-1,06,849	6
53,361-80,109	4
31,978-53,360	3
10,703-31,977	2
≤10,702	1

(Source: Kuppuswamy's Socio economic scale 2024 modified)

Table 3.4: Socio economic status

Upper (I)	26-29
Upper middle (II)	16-25
Lowermiddle (III)	11-15
Upperlower(IV)	5-10
Lower (V)	<5

(Source: Kuppuswamy's Socio economic scale 2024 modified)

3.6.4.3 BODY MASS INDEX

According to the NHLBI, BMI was calculated as weight in kilograms divided by the square of the height in meters (kgs/m^2) and has been categorized into four groups according to Asia – Pacific classification.

BMI was calculated using the following formula below:

BMI = Weight (kg)/Height x Height (m^2)

3.6.4.4 WAIST CIRCUMFERENCE

The WHO protocol for measuring waist circumference instructs that the measurement be made at the approximate midpoint between the lower margin of the last palpable rib and the top of the iliac crest. The subject was asked to breathe normally and was asked to breathe out gently at the time of making measurements to prevent them from contracting their muscles or from holding their breath. A non-stretchable fiberglass tape was used to perform this measurement. The normal cut-off of waist circumference of Asian men is ≤90cm and for Asian women is ≤80cm (According to Indian Dietetics Association,2006).

3.6.4.5 HIP CIRCUMFERENCE

The hip circumference measurement was taken around the widest portion of the buttocks using a non-stretchable fiberglass tape.

3.6.4.6 WAIST HIP RATIO (WHR)

The waist hip Ratio is calculated by dividing the waist measurement by hip measurement. The Formula is: WHR= Waist circumference / hips circumference. A waist hip ratio of ≥ 0.90 in males and ≥0.80 in females was considered to diagnose the presence of abdominal Obesity (According to Indian Dietetics Association,2006)

3.6.4.7 WAIST –HEIGHT RATIO (WHtR)

The Waist –Height ratio is calculated by dividing the waist in cm measurement by height in cm. 0.5 is the cut-off for Waist-Height Ratio that is accepted universally to measure central obesity in children above 6 years and adults.

3.6.5 BIOPHYSICAL MEASUREMENT

According to the American Heart Association, blood pressure is a Pressure that pushes blood through arteries, veins and capillaries. The blood pressure is the result of two forces: 1) Systolic pressure occurs as blood pumps out of the heart and into the arteries that are part of the circulatory system. 2) Diastolic pressure is created as the heart rests between heart beats.

Table: 3.5 Classification of BMI was done according to Asia Pacific criteria, 2024

Category	Asia pacific BMI cut-offs
Underweight	<18.5
Normal	18.5-22.9
Over-weight	23-24.9
Obese	>=25

Table 3.6 Blood Pressure was measured using a sphygmomanometer by standard technique.

Blood Pressure Category	Systolic pressure (mmHg)	Diastolic Pressure (mmHg)
Normal	<120	<80
Elevated	120-129	<80
High BP (Stage 1)	130-139	80-89
High BP (Stage 2)	>140	>0
Hypertensive Crisis	>180	>120

(Source:Hypertension guidelines Resources: American Heart Association ;2017)

3.6.6 BODY COMPOSITION

The Body fat, Visceral fat and Skeletal muscle were measured using the Omron Full Body Sensor Body Composition Monitor and Scale (Model HBF-375) that estimates the body fat percentage by the Bioelectrical Impedance Method having weak electrical current of 50 kHz and less than 500 μA. Body tissues having high water content include muscles, blood, bones that conduct electricity easily. While body fat does not store much water, therefore has little electric conductivity and higher resistance which slows the rate of travel of current and therefore helps to estimate the fat, visceral fat and muscle content of the body.

3.6.6.1 BODY FAT

Body fat serves a vital role in storing energy and protecting internal organs. We carry two types of fat in our bodies: 1) essential fat which is stored in small amounts to protect the body and 2) stored fat which is stocked for energy during physical activity. While too much body fat may be unhealthy, having too little fat can be just as unhealthy. Body fat was classified according to the cutoffs provided by the omron healthcare.

3.6.6.2 VISCERAL FAT

Visceral fat is found in the abdomen and surrounding vital organs. It is different from the subcutaneous fat. Too much visceral fat is thought to be closely linked to increased levels of fat in the bloodstream, which may lead to conditions such as high cholesterol, heart disease and type 2 diabetes.

3.6.6.3 SKELETAL MUSCLE

Skeletal muscles are attached to the skeleton and come in pairs – one muscle to move the bone in one direction and another to move it back the other way. Increasing skeletal muscle will increase your body's energy requirements. Building skeletal muscle can help prevent “rebound” weight gain. The maintenance and increase of skeletal muscle is closely linked to resting metabolism rate.

Table 3.7: Body Fat Percentage Classification

Classification	Male	Female
Low (-)	5.0-9.9%	5.0-19.9%
Normal (0)	10.0-19.9%	20.0-29.9%
High (+)	20.0-24.9%	30.0-34.9%
Very High (++)	≥25.0%	≥35.0%

(Source: Omron health care)

Table 3.8 Classification of Visceral fat

Category	Cut-off
Normal	≤9
High	10-14
Very high	≥15

(Source: Omron health care)

Table 3.9: Classification of Skeletal muscle

Gender	Age	Low (-) (%)	Normal (0) (%)	High (+) (%)	Very High (++) (%)
Female	**18-39**	**<24.3**	**24.3-30.3**	**30.4-35.3**	**≥35.4**
	40-59	<24.1	24.1-30.1	30.2-35.1	≥35.2
	60-80	<23.9	23.9-29.9	30.0-34.9	≥35.0
Male	**18-39**	<33.3	33.3-39.3	39.4-44.0	≥44.1
	40-59	<33.1	33.1-39.1	39.2-43.8	≥43.9
	60-80	<32.9	32.9-38.9	39.0-43.6	≥43.7

(Source: Omron health care)

3.6.7 DIETARY PRACTICES

This information was collected from subjects using the following tools.

3.6.7.1 FOOD HABIT

The information regarding eating habits, skipping of meals, frequency of eating outside food, cravings etc. was assessed.

3.6.7.2 24-HOURS DIET RECALL

Information on dietary intake of past 24hrs was taken by dietary recall of previous three consecutive days (2 working days and 1 free day) with details regarding the ingredients and amount of food by using standard cups and spoons. Average calorie intake and nutrient intake was calculated by using IFCT 2017 for the subjects.

3.6.7.3 FOOD FREQUENCY QUESTIONNAIRE (FFQ)

This method was used to know the frequency of consumption of cereals and millets, Legumes and pulses, fruits, vegetables, milk and milk products consumption, nuts and oilseeds consumption, sugar and salt consumption meat, fish and eggs, along with processed and ultra processed food.

3.6.8 LIFESTYLE FACTORS

3.6.8.1 PHYSICAL ACTIVITY

Information regarding physical activity was obtained with the help of Global Physical Activity Questionnaire (GPAQ,2002). It collects information on physical activity in three settings domains including the sedentary behavior and it comprises 16 questions.

The domains are:

- Activity at work
- Travel to and from places
- Recreational activities

600 MET minutes were classified as normal physical activity and less than 600 MET minutes were classified as having low physical activity.

3.6.8.2 STRESS

Stress among the participants was assessed using the perceived stress scale by Sheldon Cohen. The Perceived Stress Scale (PSS,1983) is the most widely used psychological instrument for measuring the perception of stress. It is a measure of the degree to which situations in one's life are appraised as stressful. Scoring of the PSS ranges from 0 to 40. Higher the scores, higher the perceived stress. Scores ranging from 0-13 are considered low stress, scores ranging from 14-26, moderate stress and scores ranging from 27-40 are considered as high perceived stress.

3.6.8.3 SLEEP

The Pittsburgh Sleep Quality index (PSQI,1989) was used to assess the sleep quality among participants. The PSQI contains 19 self-rated questions and 5 questions rated by the bed partner or roommate. The scoring is divided into 7 components which have a range of 0-3 points with "0" scoring indicating no difficulty, while scoring of "3" indicating severe difficulty. The scores of the 7 components are then added and one "global" score is obtained that ranges from 0-21 where "0" indicates no difficulty and "21" indicates severe difficulties in all areas. A global score of 5 or more indicates poor sleep quality.

3.6.8.4 SCREEN TIME

Screen time was assessed by using SCREEN-Q, a comprehensive tool.

3.6.8.4 ADDICTION PATTERN

Information regarding their present and past addiction including tobacco, snuff, tea, coffee, alcohol, cigarette/bidi were studied and this information was elicited through interview method.

3.6.9 CHRONONUTRITION PROFILE

Chrono nutrition profile was assessed using the Chrono nutrition profile scoring method developed by Allison Christine Engwall. Six chrono nutritionbehaviour cut-off scores are categorized into one of three. Chrono nutrition behaviour cutoffs for each chrono nutrition behaviour(0-good, 1=fair, and 2-poor). These scores are then totaled to obtain Chrono nutrition Profile score which represents one's chrono nutrition profile. Scoring ranges from 0 to 12 with 0 indicating good chrono nutrition status and 12 indicating poor chrono nutrition status. (Engwall A.C .2018).

3.6.10 PHYSICAL FITNESS

3.6.10.1 FLEXIBILITY TEST

Sit and Reach test was used for the flexibility of the hamstrings and lower back. Procedure: Sit with legs and 5 inches apart. Slowly stretching towards the ties and then measure the distance stretched by using a centimeter scale from the tip of the fingers till the toes.

3.6.10.2 CARDIO-RESPIRATORY

Cardio respiratory was assessed by Harvard step test. The test consists of stepping up and down on a 20 inch (50.8cm) high bench or stepper and continuing for 5 mins. When finished the heart rate was taken for 30 seconds. Three readings were taken at 1 min, 2mins and 3mins.

Table 3.10:CHRONO-NUTRITION PROFILE (Engwall, A.C. 2018)

Chrono nutrition Profile		**Scoring (cut-off)**
Eating Window	Duration between first eating event and last eating event	>14:00 hrs. 12:00 to 14:00 hrs. ≤12:00 hrs.
Breakfast skipping	Frequency of breakfast skipping	≥4days/ week 2-3days /week 1day/week or less
Evening latency	Duration between last eating event and sleep onset	≤2:00 hrs. 2:01 to 6:00 hrs. >6:00 hrs.
Evening eating	Risk of eating late in the waking day	≥23:00 hrs. 20:00 to 22:59 hrs. <20:00hrs.
Night eating	Frequency of night eating	≥4days/ week 2-3days /week 1day/week or less
Largest meal	Meals in which largest amount is eaten	Dinner / supper Lunch Breakfast

Table 3.11: Cut-off of flexibility test

Scores	**Classification**
>14	Poor
10-14	Fair
5-9	Good
0-4	Very good
<0	Excellent

(Source: Donatella. D, 1990)

Table 3.12: Cut-off value for Cardio-respiratory Endurance

	Excellent	**Above average**	**Average**	**Below average**	**Poor**
Male	>90	80-90	65-79	55-64	<55
Female	>86	76-86	61-75	50-60	<50

(Source:Brouha et al.,1943)

3.6.10.3 MUSCULAR STRENGTH

Muscular Strength was assessed by using a handgrip dynamometer test, which is a mechanical device to measure the force generated in a specific muscle group. It is measured in kilograms.

3.6.10.4 MUSCULAR ENDURANCE

For Muscular endurance, sit –up test was used to measure the strength of abdominal muscles the person should lie on his back, with knee flat to 90^0, feet flat on the floor. A variation of this movement was possible where the hands are placed at the back of the head and the nose would touch the thigh to complete the sit-up position. The aim is to achieve the highest score in 1mins.

Table 3.13: Cut-off value for Muscular Strength

AGE	Male			Female		
	Weak	**Normal**	**Strong**	**weak**	**Normal**	**Strong**
20-24	<36.8	36.8-56.6	>56.6	<21.5	21.5-35.3	>35.3
25-29	<37.7	37.7-57.5	>57.5	<25.6	25.6-41.4	>41.4
30-34	<36.0	36.0-55.8	>55.8	<21.5	21.5-35.3	>35.3
35-39	<35.8	35.8-55.6	>55.6	<20.3	20.3-34.1	>34.1
40-44	<35.5	35.5-55.3	>55.3	<18.9	18.9-32.7	>32.7
45-49	<34.7	34.7-54.5	>54.5	<18.6	18.6-32.4	>32.4
50-54	<32.9	32.9-50.7	>50.7	<18.1	18.1-32.9	>31.9
55-59	<30.9	30.9-48.5	>48.5	<17.7	17.7-31.5	>31.5

(Source: Lampiran handgrip Dynamometer)

Table 3.14: Cut-off for Muscular Strength

Age category	Gender	Good	Average	Fair
18-25	Male	45-48	36-38	32-34
	Female	37-42	29-32	25-28
26-35	Male	45-41	32-34	2-30
	Female	33-37	25-28	21-24
36-45	Male	36-40	28-29	24-26
	Female	27-30	20-22	16-18
46-55	Male	29-33	22-24	18-21
	Female	22-25	14-17	10-13

(source: Methodologies for Fitness Assessment; Ray Sen K et al)

Table3.15: Tools and Parameters used for conducting the present study.

SL NO	PARAMETERS	TOOLS
1	Background information	Semi structured questionnaire*
2	Socio–economic status	Semi structured questionnaire*based on Kuppuswamy's Socioeconomic scale (2024modified)
3	Medical and family History	Semi structured questionnaire*
	Nutritional status	
4	Anthropometric Measurements weight (kg) height (cm) waist circumference (cm) hip circumference (cm)	 Bathroom scale Stadio-meter Fibre glass tape Fibre glass tape
5	Body Composition	Bioelectrical impedance (Karada scan)
6	Biophysical Measurement	Sphygmomanometer by standard technique
7	Dietary Practices/intakes	Semi structured questionnaire* (dietarypractices, 3 consecutivedays24hourdietary call,Foodfrequency questionnaire)
	Lifestyle pattern	
8	Addiction, sleep, screen-time, stress (pattern)	Semi structured questionnaire *for Perceived stress scale (CohenS,1983),sleep (Pittsburgh Sleep Quality Index, PSQIbyBuysseD,1989)
9	Chrono-nutrition profile	Chrono nutrition profile scoring method (Engwall, A. C. 2018)
10	Physical activity pattern	Global physical activity questionnaire (GPAQ) (WHO, 2002)
	Physical Fitness	
11	Cardio-respiratory Flexibility Muscular Endurance Muscular strength	Harvardsteptest (Brouhaetal.,194) Sit and reach test (DonatellaD,1990) Sit –up test (Diener M,1995) Handgrip Dynamometer (Luna-HerediaE, 2005)

*Collection of data will be done using Epicollect5 software

3.7 INCLUSION AND EXCLUSION CRITERIA

Inclusion criteria

- Adults (20-59yrs)
- Participants who give consent

Exclusion criteria

- Pregnant and lactating women
- People who are critically ill and People who have undergone any major surgery in the past 6 Months
- Subjects with pacemaker or any other electronic device implantation/metallic device implantation

3.8 DATA MONITORING, MANAGEMENT AND ANALYSIS

The data was entered and then was analysed using Microsoft excel (2016 or above), and SPSS version 20 or above.

- Frequency distribution and percentage was calculated for all parameters that were expressed in a rank order fashion.
- Means and standard errors were calculated for all parameters that were expressed numerically.
- Independent‘t’ test was used to compare differences between the means in different groups.
- Chi-square test was used to assess the differences between the frequency distribution of the groups.
- Correlation Coefficient was computed between indicators of nutritional status and other parameter of interest.
- Multiple regression analysis was carried out to identify the determinants of NWO.

RESULTS AND DISCUSSION

The increasing prevalence of non-communicable diseases (NCDs) in South Asia, driven by urbanization, genetic Predisposition and lifestyle changes, necessitates urgent research to address these health challenges, particularly obesity and metabolic disorders. The dual disease burden in these regions includes NCDs and under-nutrition, highlighting the complexity of health issues faced by populations (Kapoor et al., 2021).

Normal Weight Obesity (NWO) is identified as a significant health risk, characterized by a normal BMI but high visceral fat, which is linked to various metabolic diseases, including type II diabetes and hypertension.

The literature review highlighted the critical role of dietary habits, such as late meal intake and ultra-processed food consumption are associated with a higher prevalence of abdominal obesity and metabolic disorders, emphasizing the importance of meal timing in dietary habits. Studies on normal-weight obesity (NWO) reveal that individuals with this condition exhibit higher blood pressure, low skeletal muscle mass, poor physical activity and physical fitness, indicating a need for further investigation into dietary and physical activity and fitness profiles.

There is a paucity of information regarding the determinants of NWO in the general population. While several studies have explored the associations between chrono-nutrition and abdominal and visceral fat obesity, there is a significant gap in research focusing on the relationship between these factors amongst normal weight obese. The present study focuses on examining the physical activity and dietary profiles of individuals with NWO, aiming to identify at-risk populations and inform targeted health interventions.

The present study was undertaken for "**Assessing dietary and lifestyle factors associated with normal weight obesity amongst adults residing in urban Vadodara."**

The study employed a cross-sectional study design targeting the free-living population aged 20-59 years in urban Vadodara, selected through snowball sampling to ensure diverse representation.

Data collection involved a semi-structured questionnaire to gather data on background information, socio-economic status, medical and family history, body composition, dietary practices, lifestyle factors, physical activity, chrono-nutrition and physical fitness to understand their impact on NWO and related health outcomes.

The findings from the study are expected to fill existing gaps in the literature, providing a robust foundation for public health policies aimed at combating the dual burden of NCDs and obesity-related conditions in South Asia.

Baseline data information has been discussed under the following sections:

1. Personal Background
2. Socio-economic Background
3. Medical and family history
4. Anthropometric profile
5. Biophysical Measurement
6. Body Composition analysis

The results of **Normal Weight Obesity Data** are discussed under the following sections:

1. Personal Background
2. Socio-economic Background
3. Anthropometric profile
4. Biophysical Measurement
5. Body Composition analysis
6. Chrono-nutrition profile
7. Dietary intake
8. Physical Activity
9. Physical fitness
10. Lifestyle Factors (Sleep, Stress, Screen Time, Addiction)

SITUATIONAL ANALYSIS

4.1 Background Information of the subjects at Baseline

The data presented in Table 4.1.1 provides background information that includes age, marital status and type of family of the baseline subjects of the study. The age distributions of the respondents were almost similar in the different age groups. The largest groups were 20-29 years (25.7%) and 40-49 years (25.7%), followed by 50-59 years (24.6%) and 30-39 years (23.9%). This suggests that the study included participants from a wide range of age groups, ensuring a diverse representation.

The majority of the participants were married (74.1%), followed by 24.6% who were unmarried 24.6 % and 1.3% were widowed. This data highlighted that most participants were in stable family settings, which may have influenced their social and economic dynamics.

The nuclear family (60.3%) was the most common family structure among the respondents, followed by Joint families (20.8%) and extended families (18.8%) also formed a significant proportion.

4. 2. SOCIO-ECONOMIC STATUS OF THE SUBJECTS AT BASELINE

The data from table 4.1.2 shows that the majority of respondents had a formal education, with the highest percentage having a graduate or postgraduate degree (37.9%), High school certificate holders (27.3%) and those with an intermediate diploma (22.2%) formed a significant proportion of the sample, suggesting that most individuals had at least secondary-level education. A small percentage of the respondents were illiterate (1.1%) or had only primary (4.0%) or middle school education (7.1%), indicating limited access to higher education for some. Professional and honors degree holders (0.4%) were extremely few, which might suggest limited opportunities for specialized professional education in the study population.

The largest proportion of respondents was skilled workers and shop/market sales workers (30.8%), indicating that many individuals were engaged in occupations requiring specialized skills or business-related activities. A considerable number were employed as technical and associate professionals (22.8), (17.7%) from Unemployed individuals, craft and related trade workers (10.9%), plant and machine operators (3.3%), elementary occupations (4.4%), and skilled agricultural and fishery workers (4.9%) have lower representation. Professionals (3.3%) and legislators/senior officials (0.0%).

The data shows that a majority of families (32.4%) earned between 10,703 and 31,977 monthly, with a significant portion (25.5%) also falling within the 31,978 -53,360 range. The smallest portion, 4.4%, earns above 2,13,814, indicating income inequality. The majority of families fall within the mid-range income range, while only a small percentage earn significantly higher amounts. This suggests that a larger portion of families earns mid-range incomes.

The data shows the distribution of individuals based on their socio-economic status, with each category representing a different class. The lower middle class is the largest, with 38.8% of the population in this class, followed by 288.1% upper lower class. The lowest class was the smallest, with 0.2% in the category. Overall, the upper middle and lower middle classes represent about 70% of the population.

Table 4.1.2: Socio-Economic Status of subjects at baseline (N=451)

Variables	Frequency (n)	Percentage(%)
Educational Qualification		
Illiterate	5	1.1
Primary School Certificate	18	4.0
Middle School Certificate	32	7.1
High School Certificate	123	27.3
Intermediates Or Diploma	100	22.2
Graduate Or Post Graduate	171	37.9
Professional And Honors	2	0.4
Occupational Status		
Unemployed	80	17.7
Elementary Occupations	20	4.4
Plant And Machine Operator and Assemblers	15	3.3
Crafts And Related Trade Workers	49	10.9
Skilled Agricultural and Fishery Workers	22	4.9
Skilled Worked and Shop and Market Sales Workers	139	30.8
Clerks	8	1.8
Technical And Associate Professionals	103	22.8
Professionals	15	3.3
Legislators, Senior Officials and Managers	0	0.0
Family Income Per Month (INR)		
≤10,702	22	4.9
10,703-31,977	146	32.4
31,978-53,360	115	25.5
53,361-80,109	82	18.2
80,110-1,06,849	36	8.0
1,06,850-2,13,813	30	6.7
2,13,814and Above	20	4.4
Socio-Economic Status		
Upper(I)	8	1.7
Upper Middle (II)	140	31.2
Lower middle (III)	175	38.1
Upper lower (IV)	127	28.1
Lower (V)	1	0.2

4.3. MEDICAL HISTORY: Low birth weight has been strongly implicated in the development of the "thin-fat" phenotype, particularly in the Indian population (Kapoor et.al., 2021).

Table 4.1.3.1 presents the frequency distribution of birth weight among baseline subjects (N=451), categorized into low birth weight (LBW), normal birth weight (NBW), and high birth weight (HBW). The majority of participants (63.8%) were classified as having normal birth weight (NBW), indicating a typical birth weight distribution within the subjects. Low birth weight (LBW) was observed in 7.76% of the participants. A significant proportion (28.3%) had (>3.0kgs), which may have implications for metabolic health in later life.

The medical history analysis of subject at baseline (N=451) revealed that 56.3% had at least one medical condition**,** while 43.7% reported no health issues**.** Asthma (39.7%) was the most prevalent condition, followed by hypertension (8.64%) and hypo/hyperthyroidism (5.3%)**.** Diabetes mellitus (5.5%) was observed in a smaller proportion, often coexisting with hypertension (0.7%) or dyslipidemia (0.2%). Other conditions, including dyslipidemia (1.9%), metabolic dysfunction-associated steatotic liver disease (0.2%), and PCOS/PCOD (0.2%)**,** were less frequent.

4.4. FAMILY HISTORY PROFILE: The family medical history of subjects at baseline (N=451) that shown in table 4.1.4.1 indicates that the most prevalent conditions among immediate family members were hypertension (HT) (8.9% in mothers, 6.4% in fathers), diabetes mellitus (DM) (5.7% in mothers, 6.4% in fathers), and hypothyroidism/hyperthyroidism (4.2% in mothers, 0.4% in fathers, 0.4% in siblings)**.** Other conditions, including hyperlipidemia (1.3% in mothers, 0.2% in fathers), coronary heart disease (CHD) (0.9% in mothers, 1.8% in fathers), stroke (0.4% in fathers), and cancer (0.4% in fathers, 0.2% in grandparents)**,** were less frequent. A significant majority (82.7% for DM, 97.3% for hyperlipidemia, and over 99% for stroke, asthma, and cancer) reported no family history of these conditions**.** The presence ofHT and DM in both parents suggests a genetic predisposition tometabolic and cardiovascular disorders, emphasizing the need for preventive measures in at-risk individuals.

Table 4 .1.3.1 Birth-weight categorization of subjects at baseline (N=451)

Birthweight categorization	Frequency(n)	Percentage (%)
Low Birth Weight (<2.5 kgs)	35	7.76
Normal Birth Weight (2.5-3.0kgs)	288	63.8
(>3.0kgs)	128	28.3

Table 4.1.3.2: Medical history of subjects at baseline (N=451)

Medical history	Frequency(n)	Percentage (%)
Diabetes mellitus (type I and II)	25	5.5
Dyslipidaemia	9	1.9
Hypertension	39	8.64
Hypo/ Hyperthyroidism	24	5.3
Asthma	178	39.4
Metabolic Dysfunction associated steatotic liver disease	1	0.2
None	197	43.7
PCOS/PCOD	1	0.2

Table 4.1.4.1: Family history of subject at baseline (N=451)

	HTN	**Hypothy/Hyperthy**	**Hyperdislipedemia**	**DM**	**Stroke**	**Asthma**	**CHD**	**Cancer**
Mother (M)	40(8.9)	19(4.2)	6(1.3)	26(5.7)	0(0)	1(0.2)	4(0.9)	0(0)
Father (F)	30	40(.4)	1(0.2)	29(6.4)	2(0.4)	1(0.2)	8(1.8)	2(0.4)
Siblings (S)	0(0)	0(0)	0(0)	0(0)	0(0)	0(0)	0(0)	0(0)
Grandparents (G)	5(1.1)	1(0.2)	5(1.0)	8(1.8)	0(0)	1(0.2)	2(0.4)	1(0.2)
M+F	13(2.8)	2(0.4)	0(0)	7(1.6)	0(0)	0(0)	0(0)	0(0)
M+S	0(0)	0(0)	0(0)	1(0.2)	0(0)	0(0)	0(0)	0(0)
M+G	0(0)	0(0)	0(0)	1(0.2)	0(0)	0(0)	0(0)	0(0)
F+S	0(0)	3(0.6)	0(0)	0 (0)	0(0)	0(0)	0(0)	0(0)
F+G	0(0)	0(0)	0(0)	1(0.2)	0(0)	1(0.2)	0(0)	0(0)
S+G	0(0)	0(0)	0(0)	0	0(0)	0(0)	0(0)	0(0)
M+F+S	0(0)	0(0)	0(0)	0	0(0)	0(0)	0(0)	0(0)
M+F+G	1(0.2)	0(0)	0(0)	1(0.2)	0(0)	0(0)	1(0.2)	0(0)
M+S+G	0(0)	0(0)	0(0)	0	0(0)	0(0)	0(0)	0(0)
F+S+G	0(0)	0(0)	0(0)	0	0(0)	0(0)	0(0)	0(0)
M+F+S+G	0(0)	0(0)	0(0)	0	0(0)	0(0)	0(0)	0(0)
Total	0(0)	0(0)	0(0)	0	0(0)	0(0)	0(0)	0(0)
No History	360	422(93.6)	439(97.3)	373(82.7)	449(99.6)	447(99.1)	436(96.7)	448(99.3)

(Value in parentheses indicates percentage)

(HTN=hypertension, DM =Diabetes, CHD=Coronary Health Disease

4.5: BIOPHYSICAL MEASUREMENT

The Blood Pressure of the subject was assessed by using sphygmomanometer by standard technique and was classified according to AHA, 2017). More than half of the population (55%) has some form of abnormal blood pressure (elevated BP or hypertension), although only 8.3 % of the subject had reported hypertension (table 4.1.3) 41.2% of the individuals (HTN Stage I, Stage II, and Crisis) have hypertension, which is a significant concern as it increases the risk of Metabolic Syndrome .Only 45% of the individuals had normal BP, suggesting that the majority of the population may require medical or lifestyle interventions. The high prevalence of Stage II hypertension (30.1%) was alarming, as it indicates severe hypertension requiring medical treatment. The presence of 2% in the hypertension crisis category highlighted the need for immediate medical intervention for some individuals.

From the table 4.1.5.2it illustrates that Systolic blood pressure was significantly ($p<0.001$) higher in men (130 mmHg) than in women (117 mmHg), suggesting that hyper tension wasmore common in men.

Males were at higher cardiovascular risk than females, as evidenced by their higher diasto lic blood pressure (86.4 mmHg compared to 80.5 mmHg) wich is significant ($p<0.001$).

Agerelated increases in hypertension are suggested by the significantly ($p<0.001$)higher s ystolic blood pressure (130 mmHg) in older adults (40-
59 years)comparedtoyoungeradults (117 mmHg).

In addition, older adults diastolic blood pressure was also significantly ($p<0.001$) higher (86 mm Hg) than younger adults (80.9 mm Hg), suggesting that arteries become stiffer and more resistant to pressure as people age.

4.6. ANTHROPOMETRIC PROFILE

Anthropometric profile (Weight, height, BMI) Gender-wise and Age-wise measures among subjects at baseline. (N=451) is shown in Table 4.1.6.1

From the table 4.1.6.1, it can be observed that mean height of male was 168.0±7.4cm which was significantly ($p<0.001$) different from mean height of female (153.0±5.7cm), whereas the mean weight of male (69.2±12.4kgs) was also observed to be significantly ($p<0.001$) higher than female (58.5±12.7kgs). There was no significant difference between the BMI of both Males (24.39±4.07kgs/ m^2) and females (24.90±4.9kgs/ m^2).

Age-wise anthropometric profile of subjects reveals there were significant ($p<0.001$) different between the mean height of 20-39years (161.3±10.1cm) and 40-59years adults (159.6±9.8cm), while older adults (40-59years) had mean weight (66.63±12.49kg) significantly $p<0.001$higher than younger adults (20-39years) at mean weight (61.01±14.32 kg). There was significant ($p<0.001$) difference between the mean BMI of younger adults (23.2±4.1 kg/m^2) and older adults (26.1±4.5kg/m^2), which was higher than normal cut-off.

Table 4.1.6.2 presents the frequency distribution of Body Mass Index (BMI) categorization among the baseline subjects (N=451), highlighting the prevalence of obesity and weight-related variations in the study population.

Table 4.1.5.2: Gender wise mean blood pressure of Baseline data (N=451)

Blood pressure	Systolic (mmHg)	Diastolic (mmHg)	t-value
	Mean ±SD	Mean ±SD	
Gender			
Female (n=228)	117±20.5	80.5±12.2	7.031***
Male (n=223)	130±17.7	86.4±11.1	5.321***
Age			
20-39years (n=224)	117±18.7	80.9±12.6	7.357***
40-59years (n=227)	130±19.4	86.0±10.9	4.554***
***p<0.001 is considered to be significant**			

Table 4.1.6.1: Anthropometric profile -Gender-wise and Age-wise (N=451)

Anthropometric profile	Mean ±SD		t-value
Gender-wise			
	Female (n=228)	**Male (n=223)**	
Height(cm)	153.0±5.7	168.0±7.4	24.198***
Weight(kgs)	58.5±12.7	69.2±12.4	8.958***
BMI(kgs/m$^{2)}$	24.90±4.9	24.39±4.07	1.200
Age-wise			
Anthropometric profile	**20-39years (n=224)**	**40-59years (n=227)**	
Height(cm)	161.3±10.1	159.6±9.8	1.871***
Weight(kg)	61.01±14.32	66.63±12.49	4.443***
BMI(kgs/m$^{2)}$	23.2±4.1	26.1±4.5	7.126***
***p<0.001 is considered to be significant.			

Table 4.1.6.2: Prevalence of obesity of subjects at baseline (N=451)

BMI categorization (kgs/m$^{2)}$	Frequency (n)	Percentage (%)
Underweight (<18.5 kgs/m^2)	31	6.9
Normal(18.5-22.9 kgs/m^2)	166	36.8
Overweight (23-24.9 kgs/m^2)	50	11.1
Obese(≥25 kgs/m^2)	204	45.2

The data indicates that 45.2% of the participants were classified as obese**,** making it the most prevalent BMI category. Additionally, 11.1% of subjects were over-weight, indicating that a total of 56.3% of the population (overweight + obese) had excess body weight, which further reinforces concerns about the rising prevalence of obesity-related health risks, while 6.9% of participants were underweight**.**

The prevalence of obesity based on Age and gender has been shown in the table 4.1.6.3 The prevalence of obesity was almost equal for both genders, though slightly higher in males. More females (19.5%) fall in the normal weight range than males (17.5%), A slightly higher percentage of males (22.8%) are classified as obese compared to females (22.4%).A small proportion of both females (3.1%) and males (3.5%) are underweight. The proportion of overweight individuals was identical for both genders at 5.5%. The younger age group (20-39 years) has a higher proportion (5.5%) of underweight compared to the older group (1.1%). The prevalence of overweight and underweight individuals was slightly higher in younger adults (6.0%) and (5.5%) compared to the older age group (5.1%) and (1.1%). The prevalence of obesity was significantly higher in the 40-59 years age group (30.1%) compared to the 20-39 years group (15.0%), indicating a need to intervene during early adulthood.

Table 4.1.6.4 provides insights into the distribution of waist circumference (WC), waist-to-hip ratio (WHR), and waist-to-height ratio (WHtR) among the study participants.

A waist circumference above 80 cm (females) and 90 cm (males) is considered high risk for metabolic disorders, indicating a significant number of individuals may be at risk (Source: Indian dietetics federation,2006)

From the table 4.1.6.4 showed that (43.90%) had a, indicating as low risk of obesity-related complications. The results indicate a high prevalence central obesity among the study population, as evidenced by the 56.09% of participants with an elevated Waist circumference. Among the participants, 304 (67.4%) had a normal WHR, indicating a lower risk of obesity-related complications. Almost one-third of the subject had elevated WHR indicating a high prevalence of abdominal obesity

Table 4.1.6.3: Prevalence of obesity based on Age and Gender at baseline (N=451)

Variables	Female(n-228)	Male(n-223)
Underweight	14(3.1%)	16(3.5%)
Normal	88(19.5%)	79(17.5%)
Overweight	25(5.5%)	25(5.5%)
Obese	101(22.4%)	103(22.8%)
	20-39years (n=224)	**40-59years (n=227)**
Underweight	25(5.5%)	5(1.1%)
Normal	104(23.0%)	63(13.9%)
Overweight	27(6.0)	23(5.1%)
Obese	68(15.0%)	136(30.1)

(Value in parentheses indicates percentage)

Table 4.1.6.4: Anthropometric Status of subjects at baseline (N=451)

Variables	Frequency(n)	Percentage (%)
Waist Circumference		
Normal (cm) **Female <80cm, male <90cm**	198	43.90
High (cm) **Female >80cm, male >90cm**	253	56.09%
Waist Hip Ratio		
Normal (cm) **Male <0.9,Female<0.8**	304.0	67.4
Abdominal Obesity (cm) **Male >0.9, female >0.8**	147	32.6
Waist Height Ratio		
Non risk (<0.5)	119	26.4
Risk(>0.5)	329	72.9

Nearly one fourth of the subjects (26.4%) were classified as "Non-risk," suggesting likelihood of obesity-related complications. A majority, (72.9%), were categorized as "At risk," indicating a higher prevalence of short height phenotype along with central obesity and its associated health risks. WHtR is a more reliable indicator of central adiposity than BMI and is often used as a predictor for cardiovascular disease and metabolic syndrome.

From the table 4.1.6.5 it has been found that males had a higher average waist circumference **(**91.3±11.3cm**)** than females (84.1±12.2cm). Mean waist circumference (87.7±12.3cm) suggested a tendency towards central obesity, particularly in males. The hip circumference was significantly higher ($p<0.01$) in females (98.0±13.0cm) than males **(**97.0±9.43cm**)** with total mean hip circumference (98±11.4cm) . Males (0.9±0.09) have higher Waist –hip Ratio than female (0.8±0.4±0.5), but found to be not significantly different .The waist-height ratio (WHtR) was significantly($p<0.05$) higher among female **(**0.599±0.55**)** than males **(**0.54±0.07**)**.

From the table 4.1.6.6 , it can been observed that waist circumference were significantly ($p<0.001$) higher in the 40-59 age group (92.5±13.1cm) compared to the younger group (82.3±11.1cm) ,also Older individuals have a higher mean hip circumference (99.0±13.1cm) than younger adults (95.5±8.74cm) which was significant at $p<0.001$, while the waist-hip ratio increased significantly($p<0.05$) with age from 0.9±0.2in younger adults to 0.9±0.4in older adults).This indicates that abdominal obesity increases with age. Also, waist-height ratio is significantly higher ($p<0.05$) in the older adults 40-59years (0.609±0.9) than younger adults 20-39 years (0.508±0.06).

Table 4.1.6.5: Anthropometric Status-Gender-wise (N=451)

Anthropometric Profile	Female (n=228)	Male(n= 223)	Total (N=451)	t- test
	Mean ± SD			
Waist Circumference(Cm)	84.1±12.2	91.3±11.3	87.7±12.3	6.530***
Hip Circumference (Cm)	98.0±13.0	97.0±9.43	98±11.4	1.361**
Waist-Hip Ratio	0.8±0.4±0.5	0.9±0.09	0.85±0.77	1.964^{ns}
Waist-Height Ratio	0.599±0.55	0.54±0.07	1.505*	1.505*
*p <0.05,***p<0.001 is considered to be significant and ns is considered non-significant				

Table 4.1.6.6 Anthropometric Status – Age-wise at baseline (N=451)

Anthropometric Profile	20-39 years (n=224)	40-59years (n= 227)	Total (N=451)	t- value
	Mean±SD			
Waist Circumference(cm)	82.3±11.1	92.5±13.1	87.7±12.3	8.119***
Hip Circumference (cm)	95.5±8.74	99.0±13.1	98±11.4	4.697***
Waist –Hip Ratio	0.9±0.2	0.9±0.4	0.90±0.3	2.399*
Waist-Height Ratio	0.508±0.06	0.609±0.9	0.54±0.36	2.295*

P value is considered for independent t-test for continuous variables, *p <0.05,***p<0.001 is considered to be significant.

4.7. BODY COMPOSITION PROFILE

The frequency distribution of body composition measures among subjects at baseline. (N=451) is shown in Table 4.1.7.1, Skeletal muscle distribution, visceral fat, and body fat percentage are all included in the analysis.

Percentage of Body Fat: Body fat % was categorized into low, normal, high and very high category according to the classification given by the Omron health care as mentioned in table 3.7.

High body fat was present in 28% of subjects, while extremely high body fat was present in the majority (61.2%) of the subject**.** A small fraction of participants (0.4%) had low body fat levels, whereas only 10.4% had a normal body fat percentage.

Visceral Fat: Visceral fat was categorized into normal, high and very high according to the classification given by the Omron health care as mentioned in table 3.8. 67.4% of subjects were classified within the normal range, while 32.6% had high visceral fat. Notably, no participants were categorized as having very high visceral fat levels. The presence of high visceral fat in nearly one-third of the population indicates a potential risk for metabolic syndrome and associated complications, despite the majority falling within the normal range.

Skeletal Muscle Mass: It was categorized into low, normal, high and very high according to the classification given by the Omron health care as mentioned in table 3.9. Skeletal muscle analysis revealed that 75.3% of the participants had low skeletal muscle mass, while 24.1% had normal levels. Only 0.4% exhibited high skeletal muscle mass, and no individuals were classified as having very high skeletal muscle levels

Table 4.1.7.1: Body composition profile of baseline subjects (N=451)

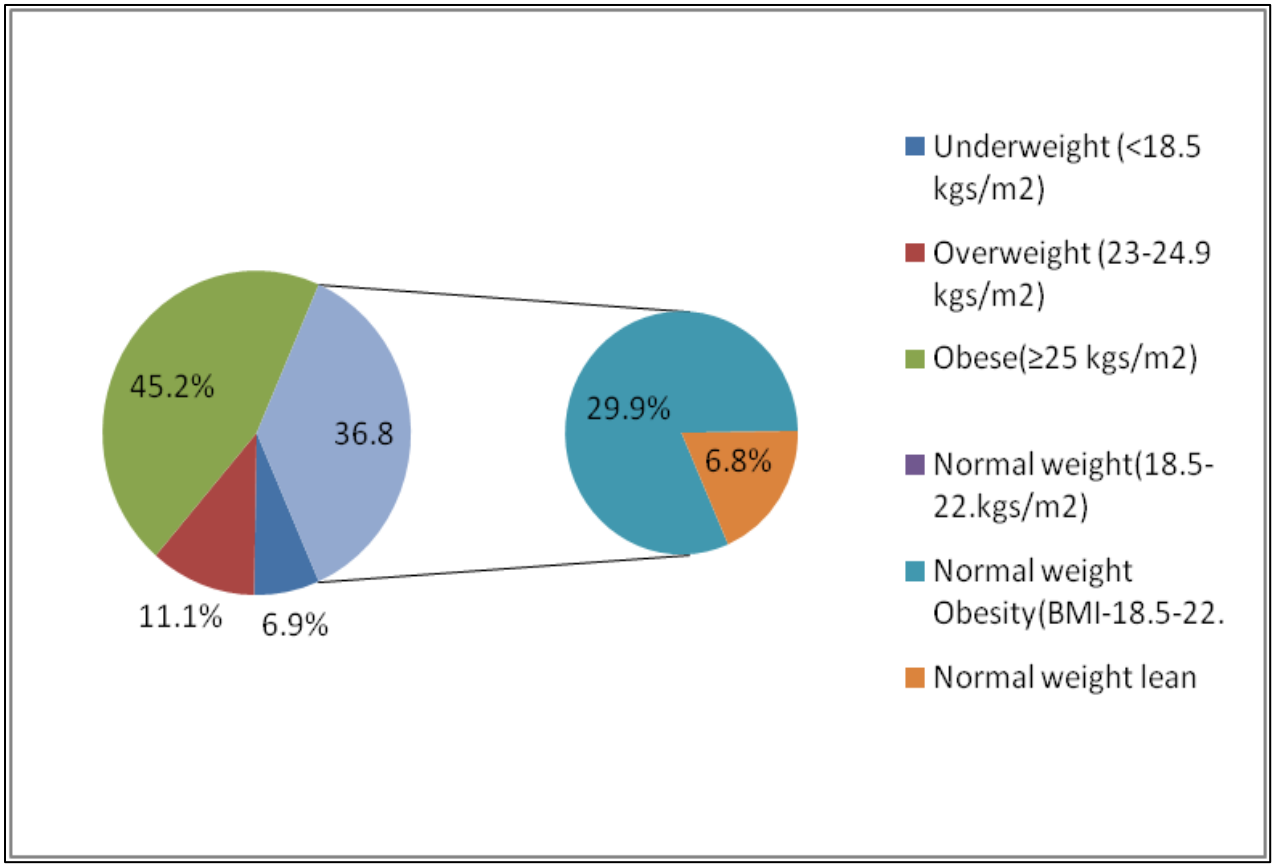
Body composition table	Frequency(n)	Percentage (%)
Body Fat Percentage		
Low (Male – 5.0-9.9%) (Female 5.0-19.9%)	2	0.4
Normal (Male 10.0-19.9%) Female -10.0-29.9%)	47	10.4
High (Male -20.0-24.9%) (Female -30.0-34.9%)	126	28
Very high (male - ≥25.0%)Female -≥35.0%	276	61.2
Visceral Fat		
Normal (≤9)	304.0	67.4
High(10-14)	147	32.6
Very High(≥15)	0	0
Skeletal Muscle		
Low(Male< 33.3%) Female -<24.3%)	340	75.3
Normal (Male -33.3-39.1%) (Female -24.3-30.1%)	109	24.1
high (male – 39.4-43.88) (Female -30.4-34.9%)	2	0.4
Very High (male ≥43.9%) Female ≥ 35.2%)	0	0

.

From above Findings, it has been found that though notable subjects belongs to Normal BMI category, but prevalence of high body fat percentage is also high .From the graph illustrated in figure 4.1.1, the prevalence of obesity based on BMI and total Body fat percentage had observed that 36.8% of participants had a normal BMI, a notable proportion within this group had normal weight obesity (NWO) (29.9%), a condition characterized by normal BMI but excessive body fat. Similarly, 6.8% of participants were classified as normal weight lean (NWL), indicating individuals with normal BMI and low body fat percentage.

From the table 4.1.7.2, Age group between 40-59 years have mean body fat percentage 34.3±7.3% have significantly ($p<0.001$) higher body fat percentage than younger age group (20-39years) (28.5±7.3 %), where both the age group have higher mean body fat percentage from the cut-off according to Omron healthcare. The mean body age of younger adults (34.8±11.4years) were significantly ($p<0.001$) higher than older adults (56.3±11.5years). Males (1409.0±233.1 kcal) have significantly ($p<0.05$) higher resting metabolism than females (1359.1±251.0 kcal). The mean subcutaneous fat of older adults (27.6±9.5%) is significantly ($p<0.001$) higher than younger adults (22.4±8.6%), while males have significantly higher skeletal muscle mass (28.2±4.9%) than females (24.7±4.1%) with $p<0.001$.

Fig 4.1.1: Distribution of respondent according to body fat% and BMI



Source: BMI classification (Asia-pacific, ,2024) and Body fat percentage (Omron Health care)

Table 4.1.7.2: Body composition profile Age-wise among subject at baseline (N=451)

Body composition profile	20-39 years (n=224)	40-59 years (n= 227)	t- value
Total body fat %	28.5±7.3	34.3±7.3	8.853***
Body age(years)	34.8±11.4	56.3±11.5	19.979***
Resting metabolism (kcal)	1359.1±251.0	1409.0±233.1	2.188*
Subcutaneous fat(%)	22.4±8.6	27.6±9.5	6.110***
Skeletal muscle (%)	28.2±4.9	24.7±4.1	10.623***
*p <0.05,***p<0.001 is considered to be significant.			

Table 4.1.7.3: Body composition profile gender-wise among subject at baseline (N=451)

Body composition profile	Female (n=228)	Male (n= 223)	t- value
Total body fat %	35.98±5.38	26.72±6.59	16.351**
Body age(years)	47.48±16.03	43.72±15.25	2.545*
Resting metabolism(kcal)	1217.33±155.92	1554.76±192.82	20.456***
Subcutaneous fat%	30.17±5.8	19.67±9.33	14.348***
Skeletal muscle %	22.78±2.51	30.13±3.72	24.634***
*p <0.05***p<0.001 is considered to besignificant.			

4.8: PERCEPTION OF BODY TYPE

Table 4.1.8.1: Body type perceptions of the subject at Frequency (N=451)

Variables	Frequency(n)	Percent(%)
Ectomorph	36	8.0
Endomorph	191	42.4
Mesomorph	224	49.7

From table 4.1.7.3, females with mean body fat percentage (35.98±5.38%) have significantly ($p<0.01$) higher body fat percentage than males **(**26.72±6.59%), where both the gender have higher mean body fat percentage from the cut-off according to Omron health care. The mean body age of female (47.48±16.03years) were significantly ($p<0.05$) higher than male (43.72±15.25years). Males (1554.76±192.82 kcal) have significantly ($p<0.001$) higher resting metabolism than females (1217.33±155.92kcal). The mean subcutaneous fat of female **(**30.17±5.8%) was significantly ($p<0.001$) higher than males **(**19.67±9.33), while males have significantly higher skeletal muscle mass (30.13±3.72) than females (22.78±2.51%) with $p<0.001$.

Table 4.1.8.1 shows the frequency distribution of somatotypes (body types) among the baseline subjects (N=451), categorized as ectomorph, endomorph, and mesomorph**.** It shows that 8.0% of the subject perceived themselves as ectomorph, Mesomorphs (49.7%) constituted the largest proportion of participants perceiving it and Endomorphs (42.4%) formed a significant proportion, characterized by higher fat accumulation and a rounder body structure**.**

ASSESSING DETERMINANTS OF NORMAL WEIGHT OBESITY

A total of 451 individuals were screened according to body fat percentage (Omron healthcare criteria) and BMI according to Asia pacific cut-off of which 135(29.9%) individuals who had been found to be in this Normal weight obesity phenotype.

The results of these Normal weight obese (NWO) individuals are discussed under the following sections:

1. Personal Background
2. Socio-economic Background
3. Anthropometric
4. Biophysical Measurement
5. Body Composition
6. Chrononutrition
7. Dietary information
8. Physical activity
9. Physical Fitness
10. Lifestyle Factors(Sleep, stress, screen time, addiction)

BACKGROUND INFORMATION

The data presented in Table 4.2.1.1 provides background information that includes age, marital status and type of family of the NWO subjects of the study (N=135). Table 4.2.1.1 shows that the prevalence of NWO among males were 45.93% and females were 54.07%. NWO subjects were classified into four age groups 20-29,30-39,40-49,50-59. The highest percentage of respondents (32.6%) belong to the 20-29 age group, 26.7% from40-49 age group,24.4% from 30-39 age and 50-59 age group has the lowest representation at 16.3%.

The majority of respondents (68.1%) were married, while 31.9% are unmarried, and 1.3%were widowed. The nuclear family type was the most common, with 52.6% of respondents belonging to this type,26.7%from joint family and 20.7% from extended family (Table 4.2.1).

The gender –wise mean age of Normal weight obesity that has been showed in table 4.2.1.2 reveals that the mean age of NWO male is 37.5 ±12.50 years, where for NWO female, the mean age is 35.9 ±11.5 years, having mean age of total NWO subject 36.64±11.97 years

Table 4.2.1.1:Background information of NWO subjects (N=135)

Variables	Frequency (n)	Percentage (%)
Gender		
Male	62	45.93
Female	73	54.07
Age Group		
20-29	44	32.6
30-39	33	24.4
40-49	36	26.7
50-59	22	16.3
Marital Status		
Married	92	68.1
Unmarried	43	31.9
widow /widower	6	1.3
Type Of Family		
Extended	28	20.7
Joint	36	26.7
Nuclear	71	52.6

Table 4.2.1.2: Gender-wise Mean Age of NWO subject

Gender	Female (n=73)	Male (n=62)	Total (N-135)
	35.9years ±11.5	37.5years ±12.50	36.64±11.97

4.2 2. SOCIO-ECONOMIC BACKGROUND

From the table 4.2.2.1 it can be observed that the highest percentage of respondents (34.1%) had a graduate or postgraduate.29.6% from high school, 23.0% hold an intermediate or diploma, A small portion (8.1%) had only a middle school certificate, and 3.7% had a primary school certificate. Only a smaller portion belonged to both illiterate and professional and honors degrees (0.7%).

The largest group (34.1%) consisted of skilled workers, shopkeepers, and market sales workers, indicating that trade and commerce are the most common occupations. Almost one fifth (19.3%) of the subjects were unemployed,18.5% were in technical and associate professions, 8.9% work in crafts and related trades, 5.2% each were engaged in elementary occupations and agriculture/fishery, 3.7% work as plant and machine operators and assemblers, and 3.0% were professionals, and no respondents were belonged to legislators, senior officials, or managers.

The largest proportion of respondents (34.1%) was within the monthly income range of ₹10,703 - ₹31,977, indicating that most individuals can be classified under lower middle-income group, followed by (25.2%) ₹31,978 -₹53,360.Approximately, 15.6% of respondents had a monthly family income ranging from₹ 53,361 - ₹80,109. Nearly 8.1% of participants earned between 80,110 -1,06,849, and 6.7% were in both the₹ ≤10,702 and ₹1,06,850 - ₹2,13,813 income brackets. The highest income category (2,13,814 and above) is the least represented at 3.7%, suggesting that only a small percentage of individuals fall into the upper-income group.

As can be observed from the table 4.2.2.1, the socio-economic status of the respondents revealed that the largest portion of subjects (42.2%) belonged to lower-middle (III) class, indicating that most respondents belonged to the middle-income segment. More than two-fourths (28.9%) belonged to the upper-lower (IV) class26.7% were in the upper-middle (II) class, only 1.5% belonged to the upper (I) class, 0.7% belong to the lowest socio-economic class (V), showing minimal representation of Socio-economic status.

Table 4.2.2.1: Socio-Economic Status of NWO subjects (N=135)

Variables	Frequency (n)	Percentage (%)
Educational Qualification		
Illiterate	1	.7
Primary School Certificate	5	3.7
Middle School Certificate	11	8.1
High School Certificate	40	29.6
Intermediates Or Diploma	31	23.0
Graduate Or Post Graduate	46	34.1
Professional And Honors	1	.7
Occupational Status		
Unemployed	26	19.3
Elementary Occupations	7	5.2
Plant And Machine Operator and Assemblers	5	3.7
Crafts And Related Trade Workers	12	8.9
Skilled Agricultural and Fishery Workers	7	5.2
Skilled Worked and Shop And Market Sales Workers	46	34.1
Clerks	3	2.2
Technical And Associate Professionals	25	18.5
Professionals	4	3.0
Legislators, Senior Officials and Managers	0	0.0
Family Income Per Month		
≤10,702	9	6.7
10,703-31,977	46	34.1
31,978-53,360	34	25.2
53,361-80,109	21	15.6
80,110-1,06,849	11	8.1
1,06,850-2,13,813	9	6.7
2,13,814and Above	5	3.7
Socio-economic Status		
Upper(I)	2	1.5
Upper middle(II)	36	26.7
Lower middle(III)	57	42.2
Upper lower(IV)	39	28.9
Lower (V)	1	.7

Table 4.2.2.2shows the frequency distribution of birth weight among NWO subjects (N=135), categorized into low birth weight (LBW), normal birth weight (NBW), and high birth weight (HBW).The majority of participants (66%) were classified as having normal birth weight (NBW), indicating a typical birth weight distribution within the subjects. Low birth weight **(**LBW) was observed in 8.9% and 24.4% belonged to (>3.0 kgs) category.

The medical history analysis of subject a(N=135) in table 4.2.2.3 revealed that 78.7%had at least one medical condition, while 40.7% reported no health issues**.** Asthma (39.7%) was the most prevalent condition, followed by hypertension (6.6%) and Diabetes mellitus (5.1%)**,** hypo/hyperthyroidism (4.4%)was observed in a smaller proportion, often coexisting with hypertension (0.7%) or dyslipidemia (0.2%). Other conditions, including dyslipidemia (1.4%),were less frequent.

4.2.3: ANTHROPOMETRIC PROFILE

Table4.2.3.1 provides insights into the distribution of waist circumference (WC), waist-to-hip ratio (WHR), and waist-to-height ratio (WHtR) among the study participants.

A waist circumference above80 cm (females) and 90 cm (males**)**is considered high risk for metabolic disorders, indicating a significant number of individuals may be at risk. From the table 4.2.3.1, it has been showed that 71.9% had a, indicating as low risk of obesity-related complications. The results indicate a high prevalence central obesity among the study population, as evidenced by the 28.1% of participants with an elevated Waist circumference. This indicates that 28.1% belongs to Normal weight central obesity, NWCO (Central obesity characterized by increased waist circumference (waist circumference ≥ 90 cm in men and ≥ 80 cm in women) which is a subset of NOW despite a normal BMI, termed normal-weight central obesity (NWCO), may constitute a high-risk factor).

Among the participants, 34.8%had a normal WHR, indicating a lower risk of obesity-related complications. The results indicate a high prevalence of abdominal obesity among the NWO subject, as evidenced by the 65.2% of participants with an elevated WHR.

Table 4.2.2.2: Birth-weigth of the NWO subject (N=135)

Birthweight	Frequency(n)	Percent (%)
Normal birth weight (2.5-3.0kgs)	90	66.7
Low birth weight (<2.5 kgs)	12	8.9
(>3.0 kgs)	33	24.4

Table 4.2.2.3: Medical history of NWO subjects (N=135)

Medical history	Frequency(n)	Percentage (%)
Asthma	55	40.7
Diabetes mellitus (type I and II)	7	5.1
Dyslipidemia	2	1.4
Hypertension	9	6.6
Hypo/ Hyperthyroidism	6	4.4
None	66	32.3
Total	451	100.0

Table 4.2.3.1: Anthropometric Profile of NWO Participants(N=135)

Variables	Frequency(n)	Percentage (%)
Waist Circumference(cm)		
Normal (≤80cm for female, ≤90cm for males)	97	71.9%
High (>80cm for female,>90cm for males)	38	28.1%
Waist Hip Ratio		
Normal (Female ≤0.8, male ≤0.9)	47	34.8
AO(>0.8 for female, 0.9cm for males)	88	65.2
Waist Height Ratio		
Non risk(<0.5)	58	42.9
Risk(>0.5)	77	57.0

(Source: IDA, 2006)

Among 135 NWO individuals, 42.9%wereclassified as "non-risk," suggesting likelihood of obesity-related complications. A majority,57%,were categorized as "At risk," indicating a higher prevalence of short height phenotype along with central obesity and its associated health risks

The table 4.2.3.2reveals, gender-wise mean anthropometric profile of the participants where the mean weight of males (62.05±4.5 kgs.) was significantly ($p<0.001$) higher than females (51.1±4.5 kgs).The mean height of males (168.79±6.8cms) were significantly ($p<0.001$) higher than female(153.69±5.5cms. Whereas mean Waist circumference among males (85.839±6.8cms) were significantly higher than females(77.479±7.12cms) at $p<0.001$and (85.839±6.8cms) with total mean of Waist Circumference (81.35±8.12cm).For hip circumference,the mean value among males (94.03±5.27cm) is slightly higher than females (93.027±4.8cm) but no significant difference were observed, with total mean93.48±5.03cm. The mean Waist –hip ratio was slightly higher ($p<0.001$) among females (0.82±0.07)from the normal cut-off (<0.8) than males (0.90±0.58), which was under normal ranges with a total (0.864±0.75). Both the gender had normal waist-height ratio, male (0.503±.46) and female (0.49±0.04).

From the table 4.2.3.3, it illustrates although the abdominal obesity was more prevalent among females (31.5%) than males (24.2%) but it was significantly different. whereas majority belong to normal category. Thus, gender does not have a statistically significant impact on whether a participant has abdominal obesity as it has different cut-off.

The prevalence of abdominal obesity rose with age, as shown in table 4.2.3.4: low among younger persons (15.9% in those aged 20 to 39) moderate among individuals in their middle years (36.1% among those aged 40–49) highest among those aged 50–59 (63.6%). As people age, the proportion of those with normal WC drops significantly, from 84.1% in the youngest group to just 36.4% in the oldest. Age-related differences in the prevalence of abdominal obesity are strongly significant. This indicates that waist circumference was highly influenced by age, with older people having a higher likelihood of abdominal obesity. Abdominal obesity, a known risk factor for metabolic diseases

Table 4.2.3.2:Anthropometric Profile Gender-wise of NWO Participants

Anthropometric	Female (n=73)	Male (n=62)	Total (N-135)	t-value
Weight (kgs)	51.1±4.5	62.05±4.5	56.14±7.8	11.136***
Height (cm)	153.69±5.5	168.79±6.8	168.7±9.7	14.164***
Waist Circumference (cm)	77.479±7.12	85.839±6.8	81.35±8.12	6.924***
Hip circumference (cm)	93.027±4.8	94.03±5.27	93.48±5.03	1.156^{ns}
Waist –hip ratio	0.82±0.07	0.90±0.58	0.864±0.75	7.051***
Waist Height Ratio	0.49±0.04	0.503±.46	0.501±0.48	$.421^{ns}$
P value is based for independent t-test for continuous variables,***p<0.001,**p<0.01are s considered to be significant and ns is considered as non-significant				

Table 4.2.3.3: Association of Gender with Abdominal Obesity

Variables	Female(n=73)	Male (n=62)	Total (N=451)	Chi square value
Abdominal obesity (AO)(cm)	23(31.5%)	15(24.2%)	38(28.1%)	$.887^{ns}$
Normal (cm)	50(68.5%)	47(75.8 %)	97(71.9%)	
P value is based for chi-square for categorical variables, non-significant				
(value in parentheses indicates percentage)				

Table 4.2.3.4: Association of age with waist circumference

Variables	**20-29(n=44)**	**30-39(n=33)**	**40-49(n=36)**	**50-59(n=22)**	Total	Chi square value
Abdominal obesity (cm)	7(15.9%)	4(15.9%)	13(36.1%)	14(63.6%)	38(28.1%)	22.278**
Normal (cm)	37(84.1%)	29(87.9%)	23(63.9%)	8(36.4%)	97(71.9%)	
P value is based for chi-square for categorical variables, where **p<0.01 which is considered significant.						

(value in parentheses indicates percentage)

Table 4.2.3.5: Correlation between Anthropometric profile with central obesity (N=135)

Variables	**Waist circumference (cm)**	**WHR**	**WHtR**
Waist circumference(cm)	1	.836**	.762**
WHR	.836**	1	.706**
WHtR	.762**	.706**	1
P value is based on Pearson correlation for continuous variable			

such diabetes, hypertension, and cardiovascular diseases, is much more common in older people (40–59 years old).

As is evident from table 4.2.3.5 a significant positive correlation was observed between waist circumference with Waist hip ratio and Waist-height and also with Waist hip ratio with waist, ratio at p <0.001 (Pearson correlation)

4.1.4. BIOPHYSICAL MEASUREMENT PROFILE

From the table 4.2.4.1, it was observed that nearly half (47.4%) of the NWO subjects had normal blood pressure, 52.6% of the individuals had some form of elevated blood pressure, with 40.8% falling into hypertensive stages (Stage 1, Stage 2, or crisis).A significant 23.0% are in HTN Stage 2, 17.8% were in HTN stage 1 and 3.7% were in HTN crisis category

The gender –wise mean Systolic and diastolic (mmHg) of Normal weight obese as shown in table 4.2.4.2 reveals that males had significantly (p<0.001)elevated systolic(126.6±10.8mmHg) and diastolic (84.9±10.8nnHg) blood pressure (according to AHA, 2017 cut-off) than females (Systolic 112.02±15.2mm of Hg and diastolic - 77.8±9.3mmHg) with total mean systolic (118.7±17.09mmHg) and diastolic (81.10±10.6mmHg).Similarly Older adults (40-59years) had significantly(p<0.001) elevated Systolic(125.40±16.96mmHg) and diastolic (84.34±10.86mmHg) blood pressure than 20-39years (Systolic 113.73±15.50mmHg; diastolic 78.66±9.87mmHg).

As is evident from table 4.2.4.5 a significant positive correlation was observed between waist circumference, Waist hip ratio and Waist-height Waist hip ratio with both systolic and diastolic blood pressure at p <0.001 (Pearson correlation).

Table 4.2.4.1: Blood Pressure categorization among the subject (N=135)

Blood pressure Categorization (mmHg)	Frequency (n)	Percentage (%)
Elevated (120—129/80mmHg)	11	8.1
HTN Crisis(>180/120mmHg)	5	3.7
HTN stage 1(130-139/80-89mmHg)	24	17.8
HTN stage 2 (>140/90mmHg)	31	23.0
Normal(>120/80mmHg)	64	47.4

Table 4.2.4.4:Blood pressure measurement with age and gender among NWO subject(N=135)

Variables	Female (n=73)	Male (n=62)	Total (N-135)	t-value
Systolic (mmHg)	112.02±15.2	126.6±10.8	118.7±17.09	5.458***
Diastolic (mmHg)	77.8±9.3	84.9±10.8	81.10±10.6	4.110***
	20-39years (n=77)	**40-59years (n=53)**	**Total (N-135)**	**t-value**
Systolic (mmHg)	113.73±15.50	125.40±16.96	118.7±17.09	.159***
Diastolic (mmHg)	78.66±9.87	84.34±10.86	81.10±10.6	3.172***
P value is based for t –test for continuous variables, where **p<0.001 which is considered significant				

Table 4.2.4.5: Correlation between central obesity and blood pressure (N=135)

Variables	Systolic blood pressure (mmHg	Diastolic blood pressure (mmHg)
Waist circumference(cm)	.544**	.440**
WHR	.509**	.367**
WHtR	.310**	.214*
P value is based on Pearson correlation for continuous variable		

4.2.5 BODYCOMPOSITION

The tables 4.2.5.1 shows the body composition profile of NWO individuals(N=135) based on Body Fat Percentage, Visceral Fat, and Skeletal Muscle**.,** representing majority of individuals (62.2%) had elevated body fat, which may increase the risk of obesity-related diseases Whereas (37.7%)individuals belong to very high fat category.

Majority (94.1%) of subjects were classified within the normal range, while 5.9% had high visceral fat. Notably, no participants were categorized as having very high visceral fat levels. The skeletal muscle analysis showed that majority **(**68.8%) of participants had low muscle mass**,** while30.3% had normal levels**.** Only 0.7% had high skeletal muscle mass**,** and

Table4.2.5.2 reveals the Gender-wise mean body composition of participants, the mean total body fat% of female (33.878±2.9%) were significantly ($p<0.001$) higher than male(24.363±4.032%). The mean Visceral fat (%) of males (1128±80.89%) were significantly ($p<0.001$)higher than female (4.36±1.55%).Whereas, mean Resting metabolism (kcal)among both females and males were (1128±80.89kcal) and (1461±111.6kcal) which were significantly different ($p<0.001$) with total mean of resting metabolism (1281±191kcal). For Subcutaneous fat(%) the mean value among females (26.58±2.27%) was significantly ($p<0.001$) higher than males (17.787±9.15%) due to physiology fat accumulation of women is different from men, with total mean 22.54±7.7%. The mean Skeletal muscle mass(%) were significantly higher ($p<0.001$) among males (31.316±2.5%)and female (23.79±2.25%)from the normal ranges (Omron healthcare) with total (27.24±4.4%).None was categorized as having very high muscle levels.

The table4.2.5.3 reveals Age -wise mean body composition of participants, the mean total body fat percentage of 40-59years (30.83±6.17%) were significantly ($p<0.05$) higher than 20-39years(28.46±5.53%) with total mean of total body fat % (29.58±5.8%). Mean Visceral fat (%) of older adults (6.33±2.07%) were significantly ($p<0.001$) higher than younger group (4.56±1.74%) with total mean visceral fat (5.3±2.07%) in the normal range.

Whereas mean Resting metabolism among both older and younger were not significantly with total mean of resting metabolism (1281±191kcal). For Subcutaneous fat (%) the mean value among older adults (24.24±9.69%) was significantly ($p<0.05$) higher than younger adults (21.27±5.67%) with age, fat accumulation increases, with total mean 22.54±7.7%. The mean Skeletal muscle mass % were significantly higher ($p<0.05$) among younger (28.09±4.59%) and older (26.14±4.02%)from the normal ranges (omron healthcare) with total (27.24±4.4%).

The table 4.2.5.4 presents the association between total body fat and different variables, such as age, gender, anthropometric measures, body composition; the total body fat was categorized into HF (Higher Fat)and VHF (Very High Fat)groups.

The majority of individuals in both HF and VHF categories belong to the 20-29 age group, with 25.7% in HF and 25.2% in VHF. The proportion of individuals decreases with age, except for the 50-59 age group, where a relatively higher percentage was in the VHF category (18%) compared to HF (3**%).** Females (32.6%) have a slightly higher prevalence of HF than males (29.6%).However, the association between gender and total body fat was not statistically significant**.** A significant proportion (33.3%) of individuals with HF has a non-risk waist-height ratio, while only 9.7% of VHF individuals have a non-risk ratio. This shows that individuals with a higher waist-height ratio are more likely to have very high fat levels. For waist –hip ratio, 26.7% of people with VHF and 38.5% of people with HF have abdominal obesity but not statically significant.Although the waist circumference and total body fat also shown significant association. The HF (25.9%) and VHF (3.0%) categories are more likely to include those with low skeletal muscle mass. Very little skeletal muscle mass (less than 0.7% in HF and none in VHF) was present. This suggests a strong association between elevated levels of total body fat and poor skeletal muscle mass.

As is evident from table 4.2.5.5, a significant positive correlation was observed between waist circumference with visceral fat percentage and body age. Positive correlation was also found between waist-hip circumference and waist-height ratio with body age and visceral fat percentage. Thus, it concludes that with increase abdominal obesity, visceral fat percentage also increase that lead increase in body age with May causes inflammation.

Table 4.2.5.1: Body Composition Profile of Participants (N=135)

Variables	Frequency(n)	Percentage (%)
Total Body Fat Percentage		
Low (Male – 5.0-9.9%) (Female 5.0-19.9%)	0	0
Normal (Male 10.0-19.9%) Female -10.0-29.9%)	0	0
High (Male -20.0-24.9%)(Female -30.0-34.9%)	84	62.2
Very high (Male -≥25.0%) (Female -≥35.0%)	51	37.7
Visceral Fat		
Normal (≤9)	127	94.1
High(10-14)	8	5.9
Very High(≥15)	0	0
Skeletal Muscle		
Low (Male< 33.3%) Female -<24.3%)	93	68.8
Normal (Male -33.3-39.1%) (Female -24.3-30.1%)	41	30.3
high (male – 39.4-43.88) (Female -30.4-34.9%)	1	.7
Very High (male ≥43.9%) Female ≥ 35.2%)	0	0

Table 4.2.5.2: Body composition profile gender-wise among the NWO subject

Variables	Female (n=73)	Male (n=62)	Total (N-135)	t- value
Total Body fat (%)	33.878±2.9	24.363±4.032	29.58±5.8	15.556***
Visceral fat (%)	4.36±1.5	6.4±2.09	5.3±2.07	6.730***
Resting metabolism (kcal)	1128±80.89	1461±111.6	1281±191	20.0268***
Subcutaneous fat (%)	26.58±2.27	17.787±9.15	22.54±7.7	7.933***
Skeletal muscle mass (%)	23.79±2.25	31.316±2.5	27.24±4.4	18.293***
**p<0.001 which is considered significant				

Table 4.2.5.3: Body composition profile gender-wise among the NWO subject

Variables	20-39years(n=77)	40-5years (n=53)	Total (N-135)	t- value
Total Body fat (%)	28.46±5.53	30.83±6.17	29.58±5.8	2.353*
Visceral fat (%)	4.56±1.74	6.33±2.07	5.3±2.07	5.401***
Resting metabolism (kcal)	1283.66±194.14	1278.9±190.39	1281±191	.142ns
Subcutaneous fat (%)	21.27±5.67	24.24±9.69	22.54±7.7	2.237*
Skeletal muscle mass (%)	28.09±4.59	26.14±4.02	27.24±4.4	2.571*
P value is based for t –test for continuous variables, where *p<0.05, ***p<0.001 which is considered significant				

Table 4.2.5.4: Association of total body fat of subject with anthropometric, body composition

Variables	High Fat %	Very High Fat %	Chi square
Age			
20-29	35(25.7)	9(25.2)	26.215***
30-39	23(17.0)	10(17.0)	
40-49	22(16.3)	14(16.3)	
50-59	4(3.0)	18(3.0)	
Total	84(62.2%)	51(37.8%)	
Gender			
Female	44(32.6)	29(21.5)	1.375ns
Male	40(29.6)	22(16.3)	
Total	84(62.2%)	51(37.8%)	
Waist-Height Ratio			
Non risk(≤0.5)	45(33.3)	13(9.7)	13.717**
Risk (>0.5)	39(28.9)	38(28.1)	
Total	84(62.2%)	51(37.8%)	
Waist –hip Ratio			
Abdominal Obesity	52(38.5)	36(26.7)	2.763ns
Normal	32(23.7)	15(11.1)	
Total	84(62.2%)	51(37.8%)	
Waist Circumference			
Abdominal Obesity	52(38.5)	36(26.7)	2.763ns
Normal	32(23.0)	15(11.1)	
Total	84(62.2%)	51(37.8%)	
Skeletal Muscle Mass			
High	1(0.7)	0(0.0)	20.784**
Normal	48(35.5)	47(34.8)	
Low	35(25.9)	4(3.0)	
Total	84(62.2%)	51(37.8%)	
*p <0.05, **p<0.01, ***p<0.001 is considered to be significant and "ns" as not significant			

(Value in parentheses indicates percentage)

Table4.2.5.5: Correlation Between body composition and anthropometric among NWO subject (N=135)

Variables	Visceral fat %	Body age
Waist circumference	.613**	.354**
WHR	.450**	.261**
WHtR	.394**	.455**
Body fat %	.134	.492**
Visceral%	1	.620**
P value is based on Pearson correlation for continuous variable		

4.2.6. DIETARY INFORMATION

Dietary habits

Information regarding dietary habits was collected using semi-structured questionnaire. Figure 4.2.6.1 interprets the food choices among the NWO subjects, it can be seen that majority of the participants were vegetarian (61.5%) while 34.8% were non-vegetarian and 3.7%were Ovo-vegetarian. These finding underscores the prevalence of vegetarianism among the NWO participants.

Figure4.2.6.2shows that majority (77.8%) of the NWO individuals consumed meal 2-3 times in a day, while (20.0%) consumed meal >3 times/day and smaller portion(2.2%) of participants consumed meal <two times /day.

Figure4.2.6.3 shows that (42.2 %) of the NWO individuals consumed breakfast4-6 times in a week, a significant portion, 51 subjects (37.8%)**,** consumed breakfast only 2-3 daysaweek,Only22 subjects (16.3%) have breakfast every day, A small fraction, 5 subjects (3.7%)**,** never eat breakfast.

Figure4.2.6.4 shows that majority (52.6 %) of the NWO individuals sometimes skipped meals in a week, a significant portion (25.9%) skipped meals often, 17.0% skipped meals rarely and small portion (4.4%) skipped meals daily.

Figure 4.2.6.5, shows the reasons for skipping meals. It was observed that almost majority (73.3%) of the NWO individual skipped meals due to lack of time or too busy, while 17.0%skipped meals for fasting,7.4% skipped meals for lack of appetite and smaller portion (2.2%) for inability to cook.

Figure 4.2.6.6, shows the preference of participants for most important meal of the day based on quantity. It was observed that almost majority of the NWO individual consider lunch(53.3%) the main meal of the day, while 28.9% consider breakfast as their main meal and 17.8% had dinner as their main meal.

The figure 4.2.6.7illustrate the frequency distribution data for the consumption of outside or restaurant food It was observed that majority of participants (63.0%) participants consumes outside food occasionally, while (20.0%) frequently have food outside, a

smaller group (15.6%) experiences outside food rarely, a very small proportion (1.5) of participants experience outside food daily.

The figure4.2.6.8 shows that the majority of participants (60.0%) experience food cravings occasionally, while about one-fifth of the participants (28.9%) frequently experience food cravings, a smaller group (14%) experiences food cravings rarely, a very small proportion (10.4) of participants experience food cravings daily.

The figure4.2.6.9 shows that the majority of participants (57.0 %) craved for savory food while 28.1 % participants craved for spicy food, a smaller group (14.1%) craved for sweet food, a very small proportion (0.7) of participants craved for others.

The figure4.2.6.10 shows that the majority of participants (58.5 %) had cravings at evening, while 32.6 % participants had cravings at mid-morning,5.2 %had at morning and 3.7% at night.

The figure4.2.6.11shows that the majority of participants (57.8 %) perceived chikki as healthy while 39.1% perceived sev mumra as healthy; a smaller group (10.4%) perceived bhajiya as healthy.

The Table 4.2.6.1 presents the association between total body fat and food habits. Snacking also had a significant association with High fat percentage. It has been seen that individuals who snack often (17.7%HF and 11.1%VHF) and sometimes (41.5%HF and 18.5%VHF) have higher fat percentages.

Compared to VHF, HF had a higher incidence of non-vegetarians (22.2%) and ovo-vegetarians (3.0%). There were a notable percentage of vegetarians in both HF (37.0%) and VHF (24.4%).This implies that a larger accumulation of body fat is linked to non-vegetarian meals.

Fig 4.2.6.1: Food habit among NWO subjects (N=135)

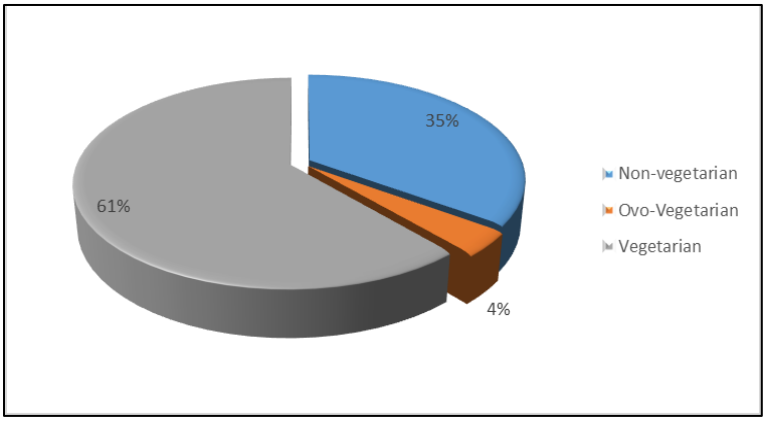


Fig 4.2.6.2: Consumption of meal in a day among NWO subject (N=135)

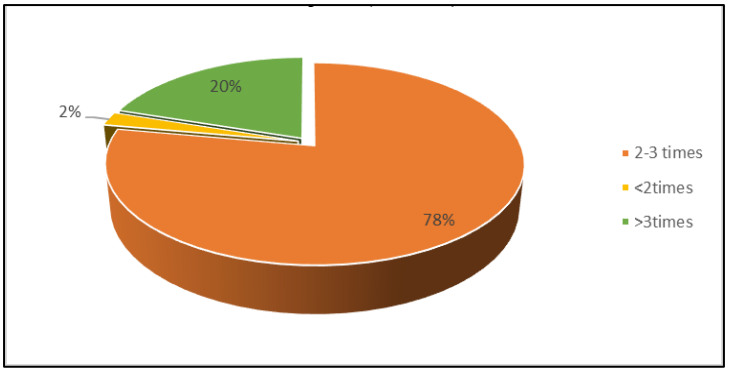


Fig 4.2.6.3: Consumption of breakfast in a day among NWO subject (N=135)

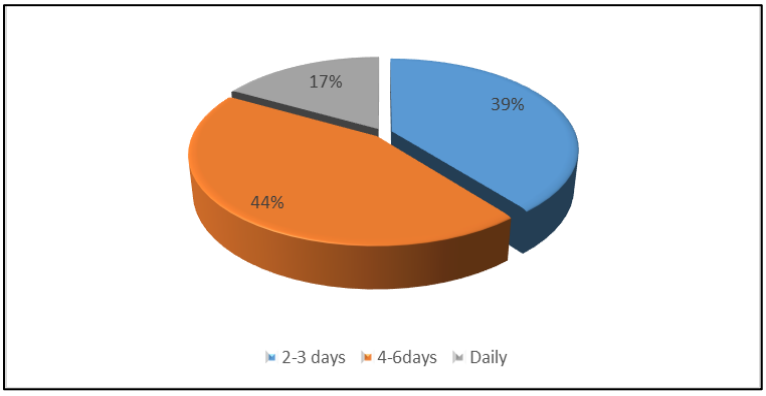


Fig 4.2.6.4: Skipping of meals among NWO subject (N=135)

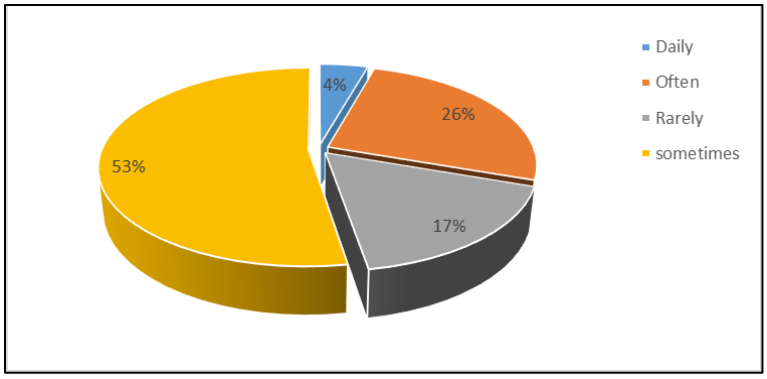


Fig 4.2.6.5: Reasons for skipping meals among NWO subject (N=135)

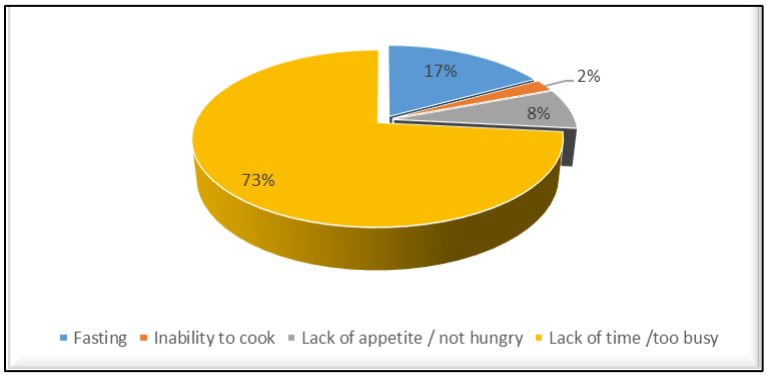


Fig 4.2.6.6: Main meal of the dayamong NWO subject (N=135)

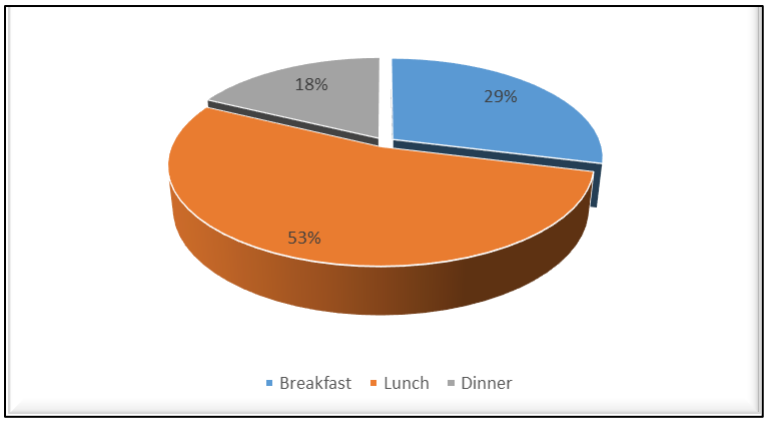


Fig 4.2.6.7: Consumption of outside / restaurant food among NWO (N=135)

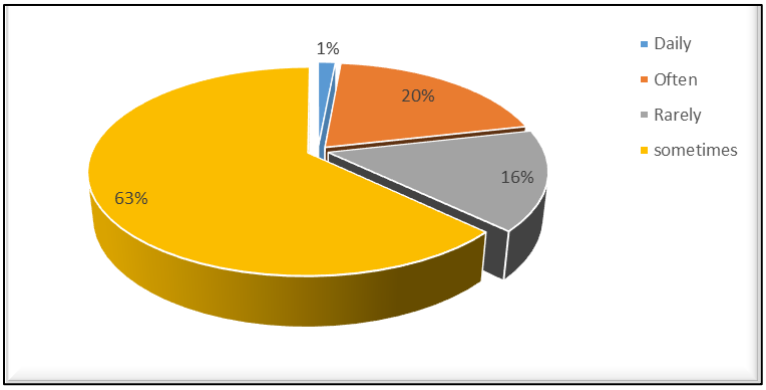


Fig 4.2.6.8: Cravings for food among NWO (N=135)

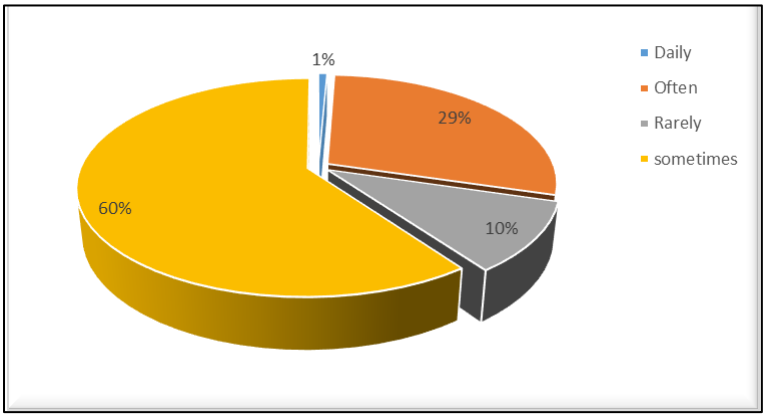


Fig 4.2.6.9: Time of the day participants generally have cravings for food among NWO (N=135)

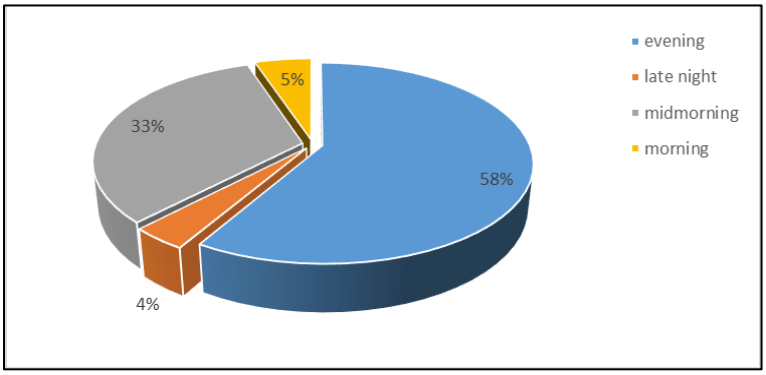


Fig 4.2.6.10: Type of food subject craved among NWO (N=135)

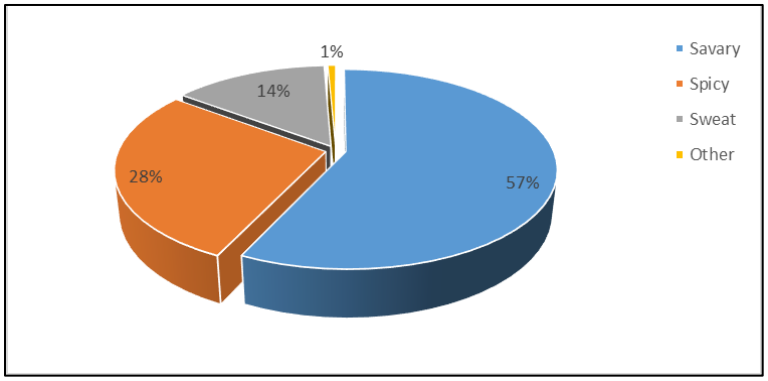
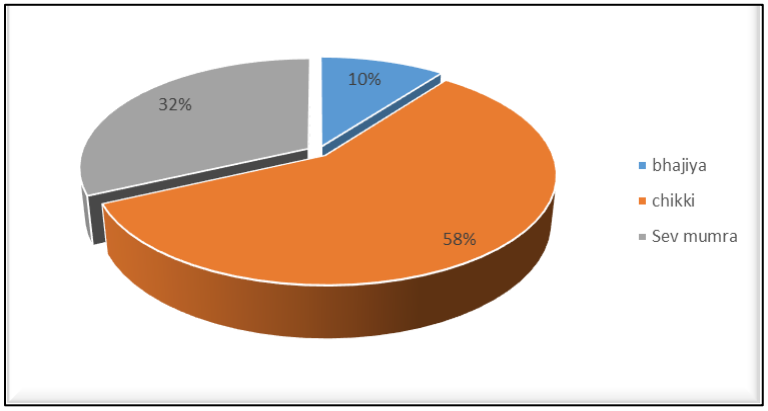


Fig 4.2.6.11: Perception Of healthy food among NWO (N=135)



FREQUENCY OF CONSUMPTION FOR VARIOUS FOODS

Frequency of consumption for various foods was assessed using a semi structured food frequency questionnaire. Fig 4.2.6.12 indicates that rice (91.9%) and whole-wheat flour (94.1%) are the most frequently consumed grains on a daily basis. In contrast, refined wheat (maida) was consumed much less frequently each day (2.2%), though 44.4% of individuals do eat it once a week. White bread was mainly consumed once a week (42.2%), while brown wheat was primarily eaten two times a week (40.0%).It was also noted that millets (Brown Bajra, Jowar, and Ragi) are consumed on an occasional basis. Parboiled rice had a very low daily consumption rate (1.5%), and a significant percentage of people (71.1%) never eat it, indicating it was not a popular choice. Semolina (Suji) was moderately integrated into people's diets: it was often consumed once a week (29.6%) or twice in a week (25.2%), suggesting it was typically reserved for specific dishes like upma or halwa rather than regular meals.

One of the most popular pulses, pigeon peas were consumed four times a week (31.9%) and may be a staple food. Green grams were frequently added to meals, although not every day. With 46.7% consumed every day and another 46.7% once a week, pea consumption was moderate. With 31.9% consuming it twice a week and 23.0% once every two weeks, lentil consumption was moderate. In contrast, soy and rajma were generally consumed infrequently.

The frequency distribution of pulses and legumes among respondents was displayed in Fig 4.2.6.13. The most popular pulse was the Bengal gram, which was consumed twice a week by 60.7% of people. Although not daily, black grams are also frequently consumed.

Table 4.2.6.1: Association of total body fat with food habits of the subjects (N=135)

Variables	High Fat %	Very High Fat %	Chi square value
Snacking			
Daily	1(0.7)	0(0.0)	14.742*
Often	24(17.7)	15(11.1)	
Rarely	3(2.2)	11(8.1)	
Sometimes	56(41.5)	25(18.5)	
Total	84(62.2%)	51(37.8%)	
Food Habit			
Non vegetarian	30(22.2)	17(12.6)	26.601***
Ovo-vegetarian	4(3.0)	1(0.7)	
Vegetarian	50(37.0)	33(24.4)	
Total	84(62.2%)	51(37.8%)	

*p <0.05, **p<0.01, ***p<0.001 is considered to besignificant(Value in parentheses indicates percentage)

Fig 4.2.6.12: Consumption of cereal among NWO subjects(N=135)

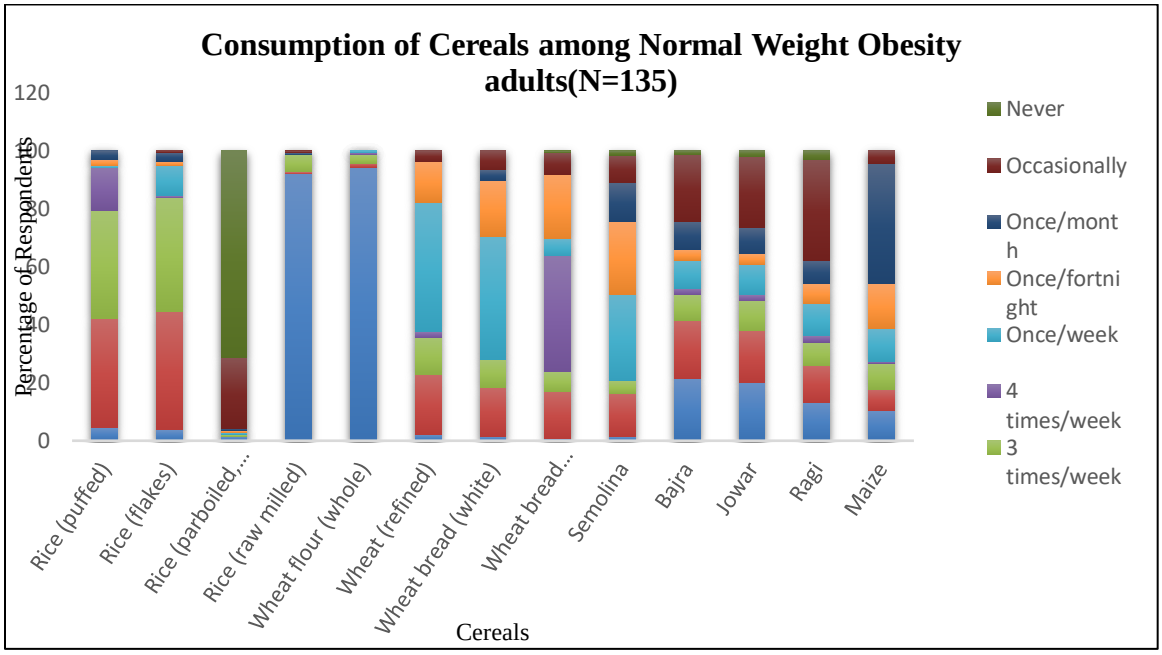
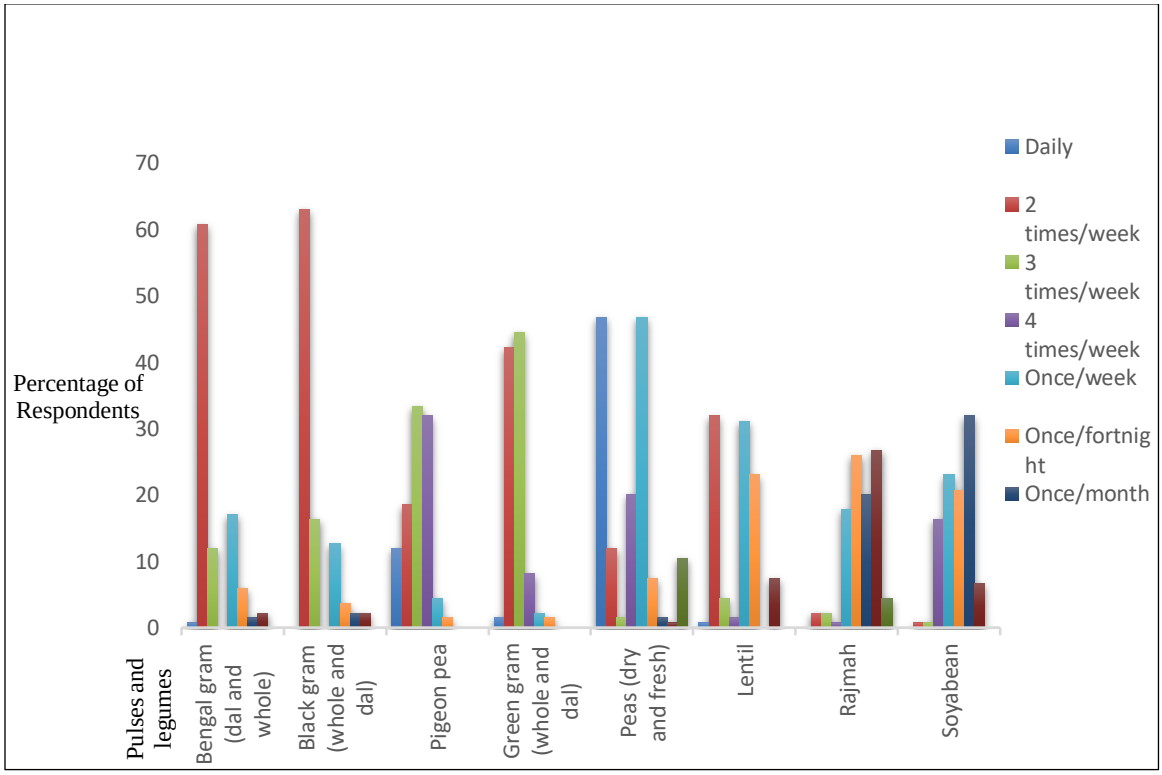


Fig 4.2.6.13: Consumption of pulses among NWO subjects (N=135))



The data illustrate in fig 4.2.6.14 that spinach (43.0%), fenugreek leaves (34.5), and cabbage(47.7%) were the most commonly consumed green leafy vegetables, with the majority consuming them 2 times in a week. Mint (25.5%), colocasia leaves (34.88%), and mustard leaves(34.8) were consumed at a moderate amount, having twice in a week andonce in a week. Amaranth was consumed the least, with most participants reported to consume occasionally (25.9%) and only least number of participants have never consumed Green leafy vegetable

The Fig 4.2.6.15 showed that the most commonly eaten vegetables are Ladies Finger (Okra), Cauliflower, Brinjal (Eggplant), Bottle Gourd, Bitter Gourd, and French Beans. 80 % people, Cauliflower by 71%, Brinjal by 48.9%, Bottle Gourd by 73 %, Bitter Gourd by 7.4%, and French Beans by 1.5%, consumed Ladies Finger daily. These vegetables are part of meals and consumed by varying percentages.

Fig 4.2.6.16: examined the consumption frequency distribution of roots and tubers among 135 participants. Potatoes ranked as the most commonly eaten, with 96.3% of participants consuming them daily. Carrots were eaten by 47.4% of the participants, with 15.6% having them twice, 13.3% three times, and 4.4% four times a week. Onions were consumed daily by 94.8% of participants, making them nearly as prevalent as potatoes. Radish consumption was lower and showed significant variability, with most individuals eating them infrequently. The consumption of beetroot was comparable to that of radish, with a tendency for lower-frequency intake. To summarize, potatoes and onions were the most regularly consumed roots and tubers, with a notable number of individuals eating them 2-3 times per week.

The Fig 4.2.6.17 presents data on fruit consumption among NWO subjects, revealing that Apple and Banana are the most frequently consumed fruits. Oranges and papayas are moderately consumed, but a significant portion of subjects does not consume them regularly. Grapes and mango are rarely consumed, with 88.9% never eating them and 87.4% never eating grapes. Berries are the least preferred fruits, with 84.4% never consuming them. This pattern could indicate accessibility, affordability, seasonal availability, or taste preferences among the subjects. Further statistical analysis or graphical representations are requested.

Fig 4.2.6.14: Consumption of Green leafy vegetables among NWO subjects (N=135)

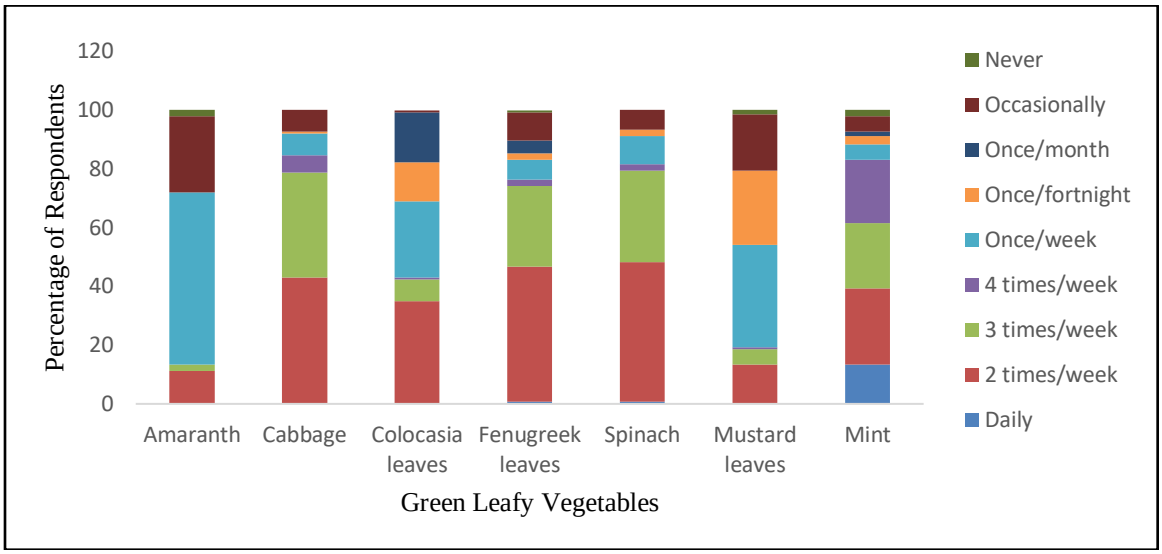


Fig 4.2.6.15: Consumption of other vegetables among NWO subjects (N=135)

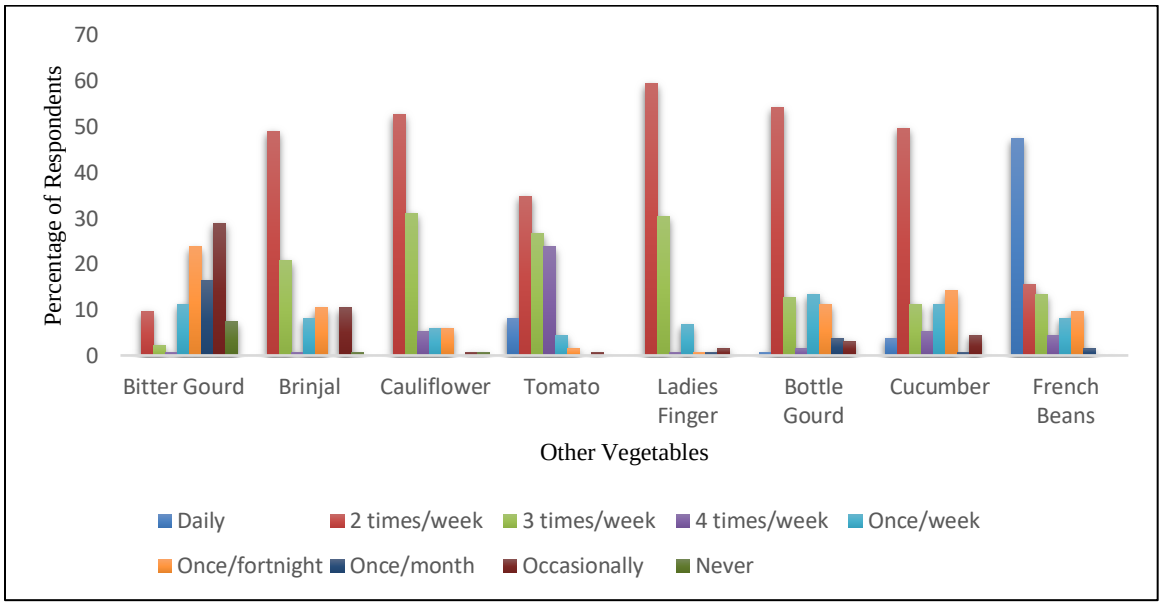


Fig 4.2.6.16: Consumption of root and tubers among NWO subjects (N=135)

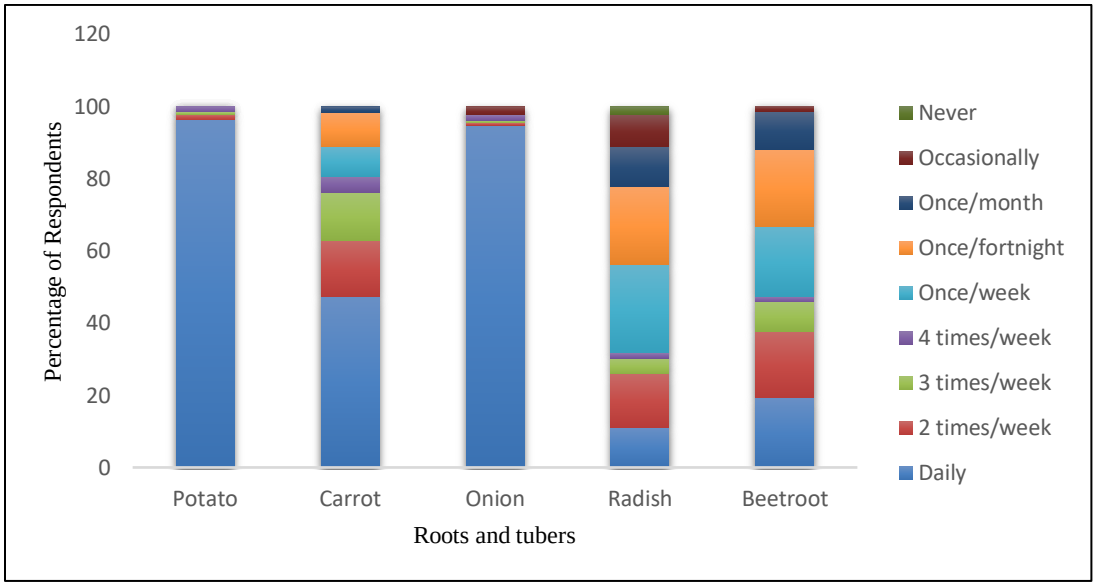
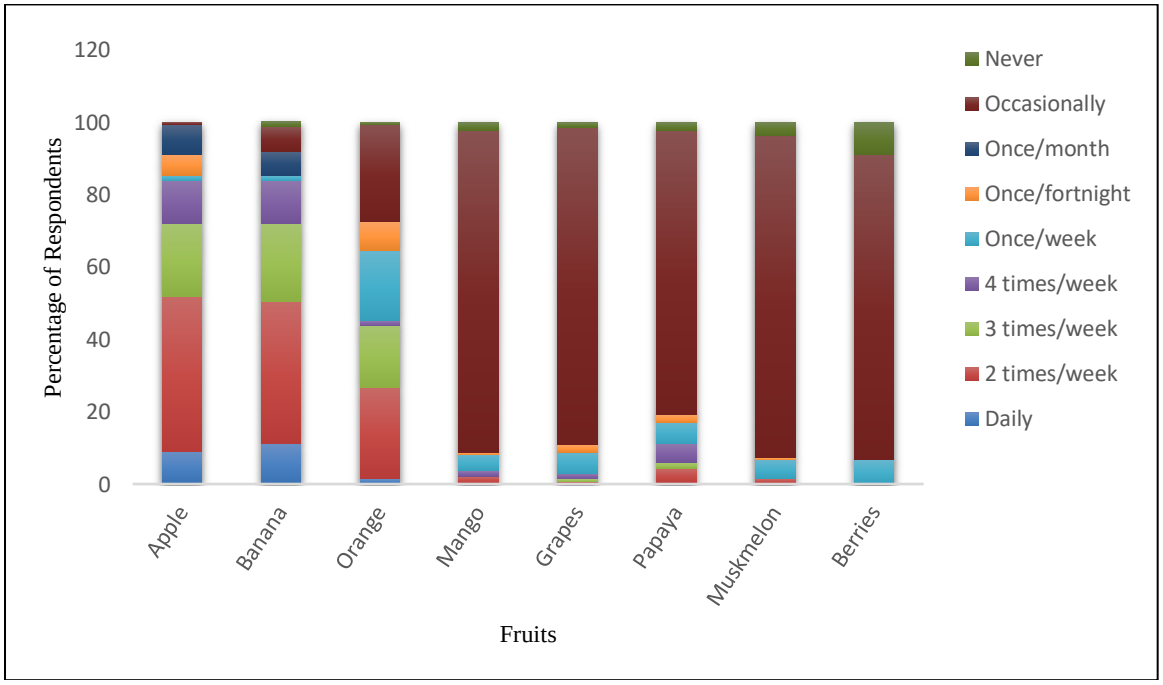


Fig 4.2.6.17: Consumption of fruits among NWO subjects (N=135)



The fig 4.2.6.18 shows that the majority of respondents do not regularly consume meat, fish, or eggs, with high non-consumption rates for all categories. Eggs and chicken were more popular than beef and prawns, but their consumption was still low. This suggests dietary patterns influenced by vegetarianism, cultural norms, or economic factors.Majority of the participants do not consumed eggs on a daily basis, while 1.5% consumed chicken 2-3 times a week and 20.7% have it once a week. Fish, beef, and prawns are also consumed occasionally, which suggests a lack of preference or possible dietary restrictions. Only 3.0% of the respondents eat eggs every day, with 7.4% and 5.9% having them 2-3 times a week. Although 11.1% consume fish three times a week and 9.6% once a week, the majority (72.6%) never eat fish.

The Fig4.2.6.19 illustrated the frequency distribution of milk and dairy products among participants. Milk was the most frequently consumed dairy product, with 70.4% of individuals consuming it daily. Curd had a moderate level of consumption, as 45.9% of respondents consume it daily, while 20% consumed it three times a week. Khoa was consumed sometimes, with 48.1% of subjects having it once a week and 29.3% once every two weeks. Paneer was also infrequently consumed, with 47.4% of individuals eating it once a week and 42.2% consuming it once a fortnight.

The data in Table 4.2.6.20 presents the frequency distribution of consumption of nuts, oilseeds, and fats (oils, ghee, and butter) among respondents.

Refined oil was a staple cooking medium for 97.8% of respondents, while cold-pressed oil was also widely used. Ghee was moderately consumed, likely due to individual preferences or dietary habits. Butter was less commonly consumed daily (0.7%), with 40.7% consumed twice a week. Groundnuts and sesame seeds were commonly consumed nut/oilseeds, while almonds are considered a luxury or health food. Cashews were a popular but non-essential nut, while raisins are seen as optional or supplementary food. Walnuts are included for their health benefits.

Fig 4.2.6.18:Consumption of meat / fish /eggs among NWO subjects (N=135)

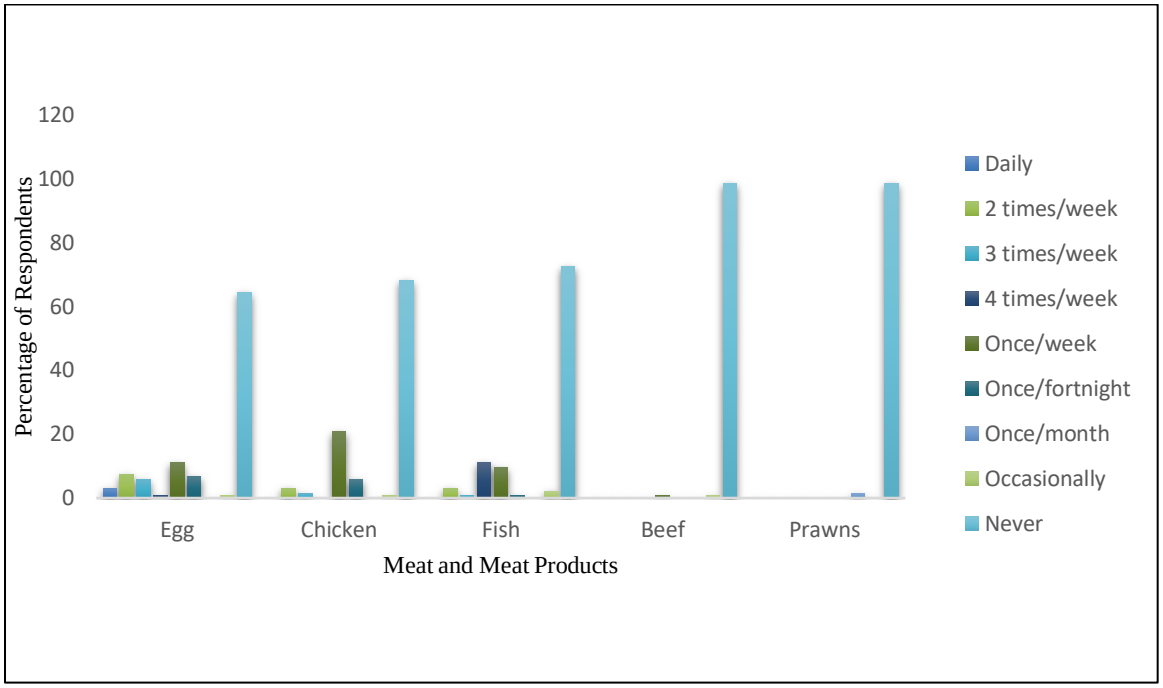
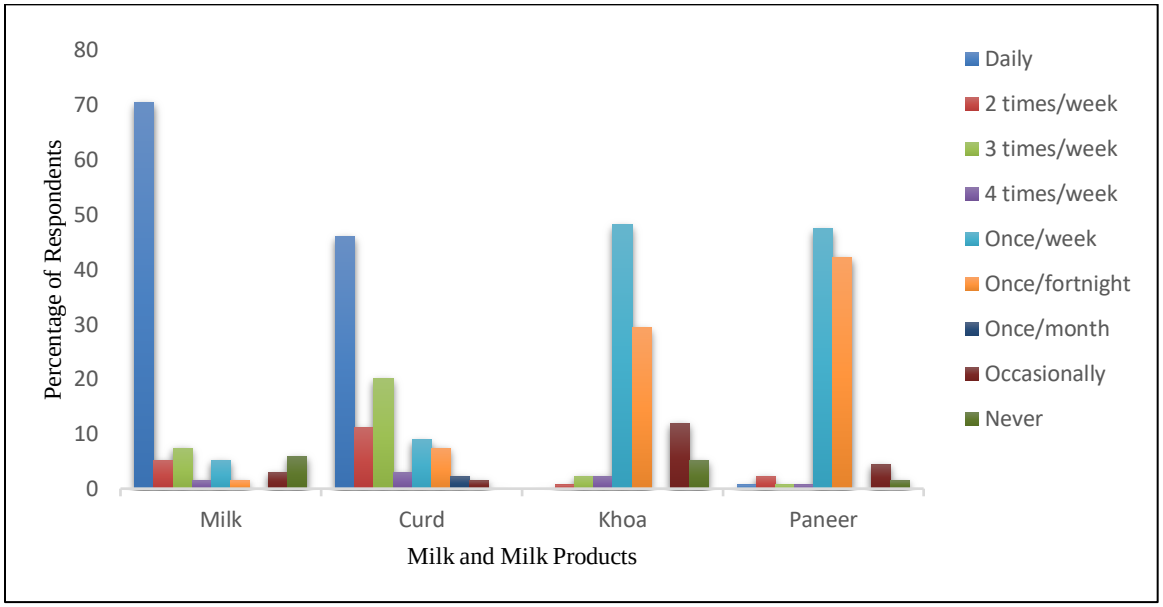


Fig 4.2.6.19: Consumption of milk and milk product among NWO subjects (N=135)



According to the data in Table 4.2.6.21, 97.8% of respondents consumed sugar on a daily basis, with moderate intakes of jaggery and honey. Most people's diets consist primarily of sugar, with jaggery being ingested in moderation. Although honey can be used as a substitute sweetener, most people do not need it on a regular basis. Salt been consumed daily reveals that 100% respondent consumed every day. The most popular sweetener was still sugar, which was followed by honey and jaggery.

According to the data, 92.6% of people drink tea or coffee every day, while a lesser percentage only do so twice a week. The most popular snack was biscuits, which are consumed twice a week by 43.7% of people. A common snack, 42.2% of people consumed namkeen three times a week. Snack like Gathiya, chivda, papdi and sevmumra were consumed majorly thrice in a week. 48.9% of people consumed sweets once a week, making them a moderately consumed processed food. Many people indulge in ice cream at least once a week, and it was moderately enjoyed. The intake of fruit juices was moderate, with 26.7% drinking them every two weeks and 25.9% drinking them every week.

Samosas and kachoris were among the processed foods that are occasionally consumed; 28.9% of people eat them once every two weeks. The fact that the majority of respondents do not regularly consume protein supplements like whey protein and whey isolate suggested that they are not a regular part of their diet. Puff consumption was lower, with 15.6% consuming them twice a week and 25.9% consuming them once a week. Furthermore, alcohol was an uncommon beverage because a significant portion of the population never drinks it. Conversely, processed and ultra-processed foods, as well as snacks like cookies, namkeen, and sweets, are the most frequently ingested.

Fig 4.2.6.20: Consumption of sugar and salt among NWO subjects (N=135)

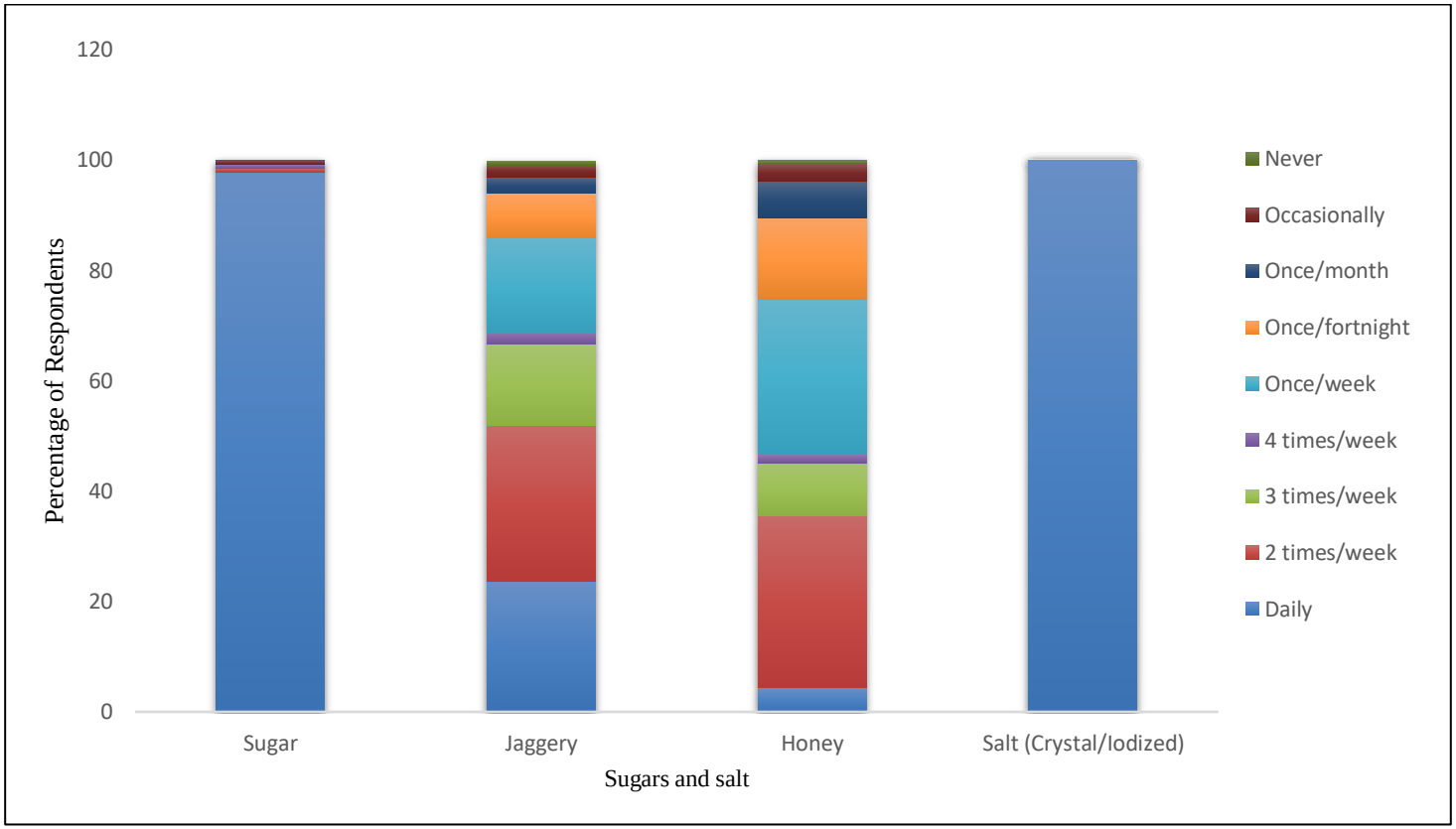


Fig 4.2.6.21: Consumption of Nuts and oilseeds among NWO subjects (N=135)

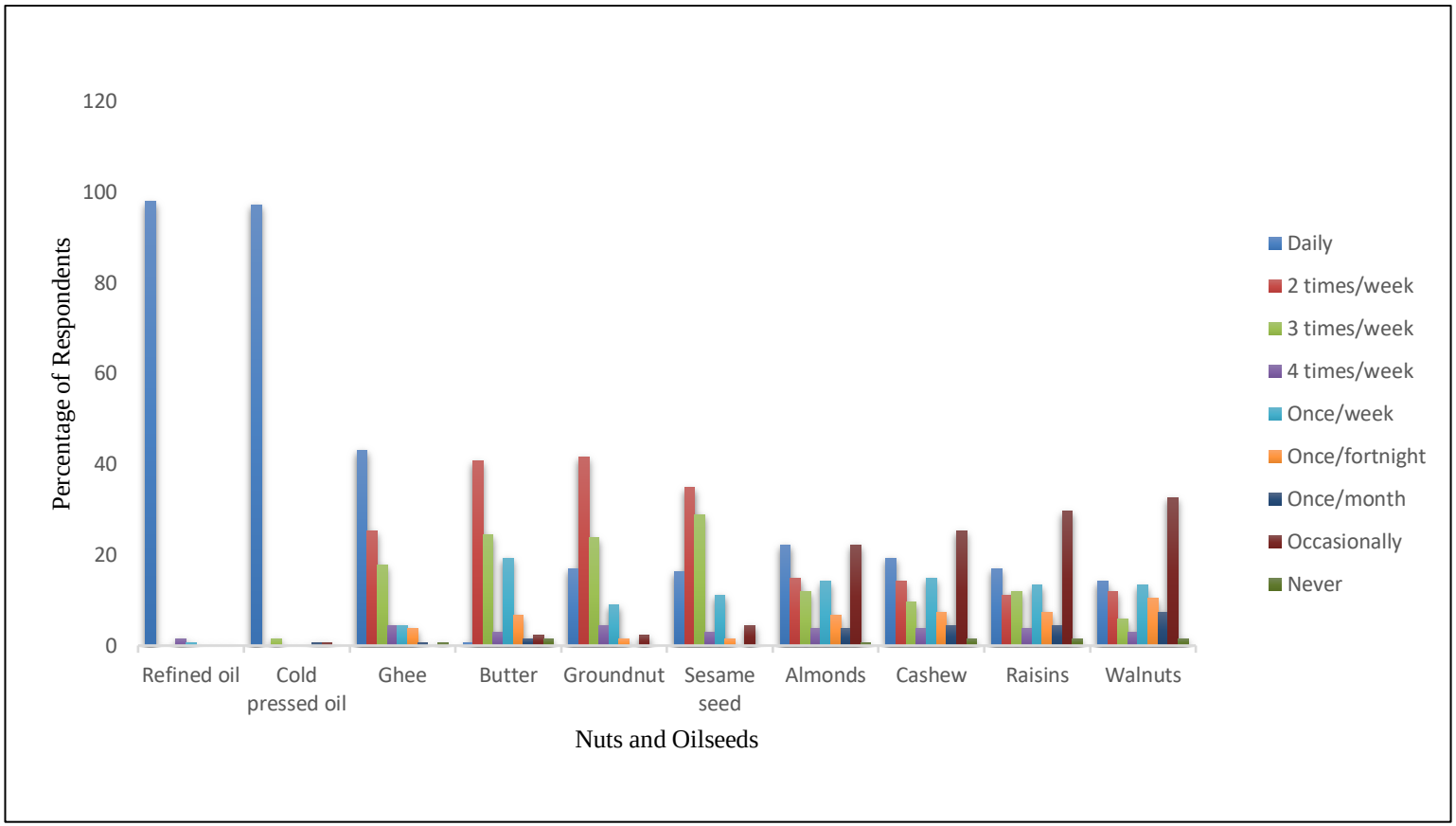
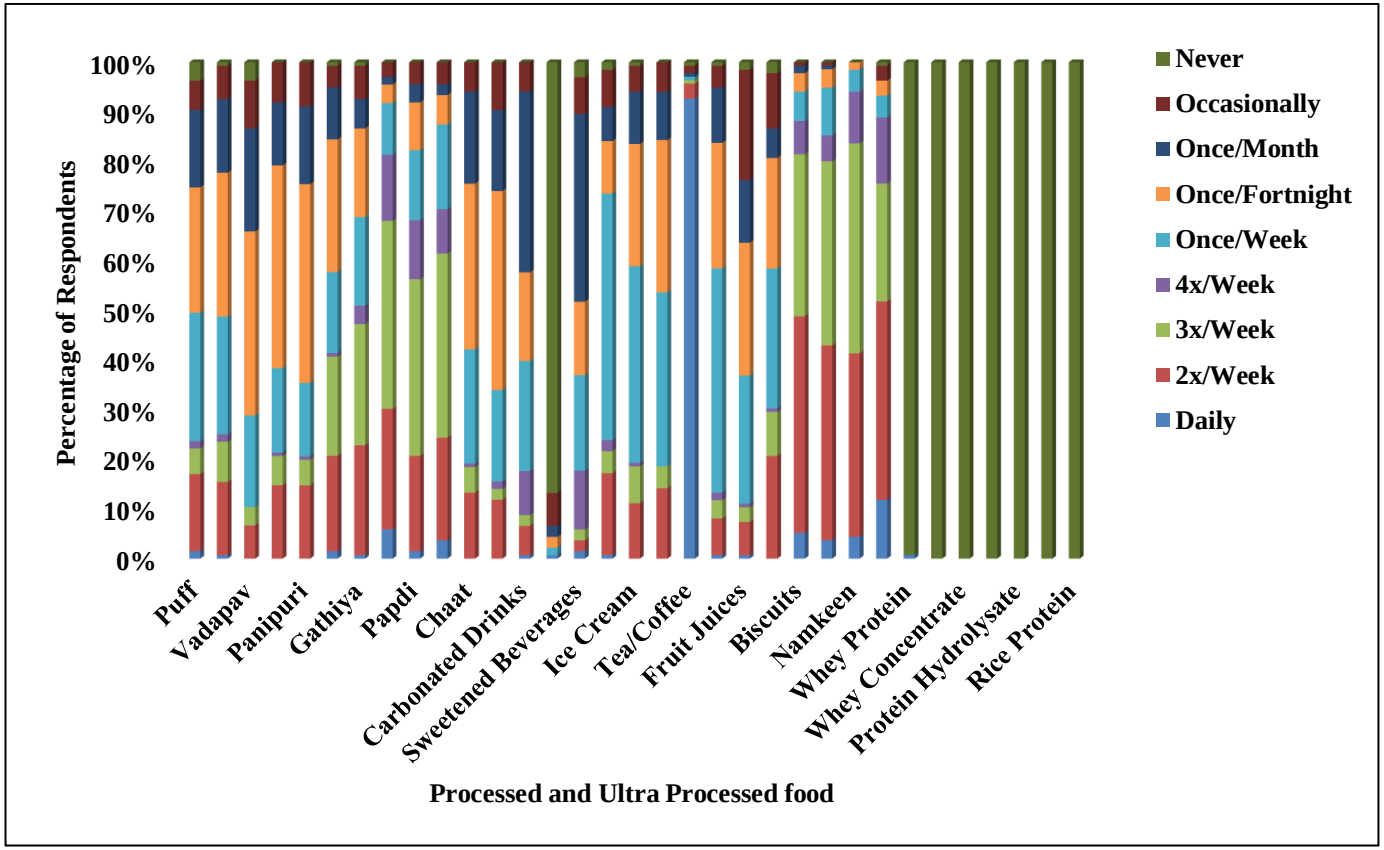


Fig 4.2.6.22: Consumption of processed and ultra-Processed food among NWO subjects (N=135)



24-HR DIETARY RECALL

Nutrient intake among NWO subject by 24-hr Recall Method

Table 4.2.6.2 illustrated the day-wise mean nutritional consumption of NWO subject. The dietary consumption of the study participants was meticulously recorded over a span o three consecutive 24 hr dietary recall methods. Two working day and one free day were included for the recall (Appendix) Nutrients intake from recall was calculated using IFCT 2017. From the table it has been found that mean nutrient intake of day 3 was higher among the participants than Day 2 and Day 1.

Table4.2.6.3 illustrates the gender –wise mean nutrient intake of NWO participants. From the table it clearly showed that the mean total energy consumption of energy, total Carbohydrate, total fat among males was significantly higher than females. There was significant differences of total energy ($p<0.05$), total carbohydrate ($p<0.01$) and total fat ($p<0.01$).There is no significant difference in protein intake between males and females. P-value: 0.045 indicating a statistically significant difference in fat intake between the groups. P-value: 0.020 showing a statistically significant difference in protein intake between groups.

The findings shown in Table4.2.6.4 suggest that a significant proportion of the subjects in the subjects exhibited varying levels of energy consumption in relation to the Estimated Average Requirement (EAR).The energy intake level, carbohydrate intake and protein in the tables was observed that majority of the subjects falls under 25-50% of EAR (46.6%) and 50-75% of the EAR (41.4%), 25-50% of EAR (49.6), 50-75% of EAR (48.2%) respectively. Furthermore, the data also revealed that total fat intake level falls under exceeding 100% (36.3%) of EAR and75-100% (34.0%).

Table4.2.6.5 illustrates the gender –wise mean nutrient percentage of NWO participants. From the table it clearly showed that the mean total energy consumption of energy, total Carbohydrate, total fat among female was higher than male. There is significant differences of total carbohydrate ($p<0.05$) between the age group.There isno significant difference in total energy intake, protein intake and fat intake the age group.

Table Mean 4.2.6.2: Day Wise Nutrient intake of the subject (N=135)

Nutrients	**Day 1**	**Day2**	**Day3**
Energy (kcal)	1098±371	1102±395	1171±354
Carbohydrate (g)	158±72	156±73	162±69
Protein (g)	32±33	31±34	35±34
Fat (g)	42±13	42±14	44±16

Table4.2.6.3: Gender Wise Mean Nutrient Intake of the subject (N=135)

Nutrient	**Gender**	**Mean ± SD**	**t-value**
Energy (kcal)	**Female (n=73)**	1061.60±204.67	2.942*
	Male (n=62)	1210.72±372.03	
Carbohydrate (g)	**Female (n=73)**	147.17±34.18	2.780**
	Male (n=62)	172.45±68.31	
Protein (g)	**Female (n=73)**	32.43±26.2	.377^{ns}
	Male (n=62)	33.85±15.07	
Fat (g)	**Female (n=73)**	41.00±7.18	2.847**
	Male (n=62)	45.97±12.72	
*p <0.05, **p<0.01, ***p<0.001 is considered to be significant, ns is not considered significant.			

Table4.2.6.4:Percent EAR of Nutrient intake of NWO subject (N=135)

Nutrients	**<25%**	**25-50%**	**50-75%**	**75-100%**	**>100%**
Energy (%)	1(0.7)	63(46.6)	56(41.4)	14(10.3)	0(0)
Carbohydrate (%)	1(0.7)	67(49.6)	49(36.2)	15(11.1)	2(1.5)
Protein (%)	0(0)	18(13.3)	65(48.2)	23(17.0)	29(21.5)
Fat (%)	0(0)	0(0)	40(29.7)	46(34.0)	49(36.3)

Table4.2.6.6 illustrates the gender –wise mean nutrient percentage of NWO participants. From the table it clearly showed that the mean total energy consumption of energy, total Carbohydrate, total fat among female was significantly higher than male. There is significant differences of total energy ($p<0.01$), total carbohydrate ($p<0.05$) and total fat ($p<0.001$).There was no significant difference in protein intake between males and females.

The table 4.2.6.7 showed the association of Body fat % with Mean Nutrient intake of subject which reveals Individuals in the HF group consume slightly more calories (1145 kcal) than the VHF group (1104 kcal), but the difference is not statistically significant**.** It was observed that The HF group consumes slightly more carbohydrates (164.8g) than the VHF group (148.8g). The HF group had a higher average protein intake (35.7g) compared to the VHF group (28.8g). Both groups have similar fat intake (43.5g in HF vs. 43.0g in VHF), with no significant difference.

The findings in Table 4.2.6.8 illustrates the average nutrient consumption of participants divided into three dietary groups: Vegetarian, Non-vegetarian, and Ovo-vegetarian. For energy intake, Ovo-vegetarians exhibited the highest average energy consumption (1399.0 ± 498.1 kcal). Non-vegetarians had a moderate energy intake (1167.9 ± 313.9 kcal). Vegetarians reported the lowest energy intake (1092.5 ± 273.5 kcal). The combined average energy intake for all groups was 1130.1 ± 301.8 kcal. This implied that Ovo-vegetarians tended to consume more energy, potentially due to their inclusion of eggs, which are energy-dense. Non-vegetarians also demonstrate higher intakes, while vegetarians show the least intake. In terms of carbohydrate, Ovo-vegetarians ingest the most carbohydrates (179.8 ± 62.2 g). Vegetarians (158.9 ± 56.0 g) and non-vegetarians (156.4 ± 49.9 g) had comparable intake levels. The overall average carbohydrate consumption stood at 158.8 ± 54.0 g. This suggested that ovo-vegetarians tend to depend more on carbohydrate-rich foods, likely due to a diet abundant in grains, fruits, and vegetables.

Table4.2.6.5:Age Wise Mean Nutrient Percent (%EAR) Intake of the subject (N=135)

Nutrient	Gender	Mean ± SD	t value
%Energy	**20-39years (n=77)**	54.13±14.02	1.861^{ns}
	40-59years (n=58)	49.45±14.79	
	Total (n=135)	52.12±14.5	
%Carbohydrate	**20-39years (n=77)**	56.75±18.59	1.986*
	40-59years (n=58)	50.59±16.78	
	Total (n=135)	54.11±18.04	
%Protein	**20-39years (n=77)**	88.21±60.45	$.762^{ns}$
	40-59years (n=58)	80.4±56.75	
	Total (n=135)	84.87±58.80	
%Fat	**Female (n=73)**	95.98±25.92	1.131^{ns}
	Male (n=62)	90.987±27.41	
	Total (n=135)	93.7±26.6	
*p <0.05, **p<0.01, ***p<0.001 is considered to be significant, ns is considered not significant.			

Table4.2.6.6: Gender Wise Mean Nutrient Percentage Intake of the subject (N=135)

Nutrient	Gender	Mean ± SD	t value
%Energy	**Female (n=73)**	55.19±14.3	2.713**
	Male (n=62)	48.512±14.18	
	Total (n=135)	52.12±14.5	
%Carbohydrate	**Female (n=73)**	57.77±15.98	2.613*
	Male (n=62)	49.80±19.45	
	Total (n=135)	54.11±18.04	
%Protein	**Female (n=73)**	90.08±73.03	1.119
	Male (n=62)	78.73±35.05	
	Total (n=135)	84.87±58.80	
%Fat	**Female (n=73)**	101.0±26.6	3.586***
	Male (n=62)	85.2±34.1	
	Total (n=135)	93.7±26.6	
*p <0.05, **p<0.01, ***p<0.001 is considered to be significant, ns is considered not significant			

Table4.2.6.7: Body fat% with Mean Nutrient intakes (N=135)

Nutrient intake	High fat %(HF)(n-84)	Very high fat %(VHF)(n-51)	t-value
Average Energy(kcal)	1145.±280	1104.1±335.9	.779ns
Average Carbohydrate (g)	164.8±56.1	148.8.±49.2	1.680ns
Average Protein (g)	35.7.±25.6	28.8.±12.6	1.814ns
Average Fat (g)	43.5.±8.9	43.0.±12.5	.237ns
P value is based on independent t test for continuous variables, ns is considered not significant.			

Table 4.2.6.8: Food Habit –wise Mean nutrient intakes of the subject (N=135)

Nutrient intake	Vegetarian (83)	Non- vegetarian (47)	Ovo-vegetarian (5)	Total
Average Energy(kcal)	1092.5.± 273.5	1167.9.±313.9	1399.0 ±498.1	1130.1±301.8
Average Carbohydrate (g)	158.9±56.0	156.4±49.9	179.8±62.2	158.8±54.0
Average Protein (g)	35.0±2.0	40.9±21.8	31.5±19.3	33.1±21.8
Average Fat (g)	42.3±10.6	44.8±10.2	33.1± 21.8	43.3± 10.4

In case of protein intake, it has been found that non-vegetarians report the highest protein consumption (40.9 ± 21.8 g), which was anticipated based on their intake of meat and fish. Vegetarians show a moderate protein intake (35.0 ± 2.0 g). Ovo-vegetarians have the lowest protein consumption (31.5 ± 19.3 g), possibly due to reduce intake of legumes or other plant protein sources. The overall average protein intake was 33.1 ± 21.8 g. This trend correlates with the expectation that non-vegetarians have a greater protein intake due to their use of animal-derived proteins. Non-vegetarians have the highest fat consumption (44.8 ± 10.2 g), closely followed by vegetarians (42.3 ± 10.6 g). - Ovo-vegetarians demonstrate the lowest fat intake (33.1 ± 21.8 g). - The overall average fat intake was 43.3 ± 10.4 g.

As is evident from table 4.2.6.9, a significant positive correlation was observed between waist circumference and average energy (kcal), Average carbohydrate However; significant correlation was not found between average protein (g) and fat (g). Negative correlation was found between body fat % with all the nutrients, which may be due affected by other factors like physical activity and physical fitness at at *p <0.05 and **p<0.01 (Pearson correlation)

Table 4.2.6.9: Correlation between Nutrient intake with anthropometric, body composition among NWO subject (N=135)

Variables	Avg Energy(kcal)	Avg Carbohydrate(g)	Avg Protein(g)	Avg fat(g)
Waist cirmcumference(cm)	.180*	.188*	.035	.143
Body fat %	-.253**	-.281**	-.076	-.260**
P value is based onPearsoncorrelation for continuous variable				

4.2.7 CHRONONUTRITION PROFILE

Chrononutrition Profile was assessed using the chrononutrition profile scoring method (A C Enwall).The graph illustrates the assessment of the 6 indicators of Chrononutrition profile that includes:

- **Eating windows –** Duration Between first eating event and last eating event (HH:MM)
- **Breakfast skipping** includes frequency of breakfast skipping (days / week)
- **Evening Latency** includes duration between last eating event and sleep onset (HH:MM)
- **Evening Eating** includes risk of eating late in the waking day (HH:MM)
- **Night Eating** includes frequency of night eating (Days/Week)
- **Largest Meal** includes meal in which largest amount of food is eaten.

The chrononutrition profile among NWO participants has been shown in table 4.2.7.1

It shows that 83.7% NWO participants had fair chrononutrition profile followed by 12.5% good chrononutrition profile and 3.7% poor chrononutrition profile. This indicates that majority of the subjects had a fair chrononutrition profile which may be contributed by various factors like duration between the meals, skipping of meal, night eating, evening eating, main meal of the day and duration of last eating and sleep onset.

The fig 4.2.7.1 illustrates that majority of the participants (71.1%) had fair duration between first eating events, last eating event, followed by 26.7 had good duration, and 2.25 had poor duration. In terms of Breakfast skipping, majority (64.4) NWO participants skipped 2-3days /week, while 17 % skipped ≥4days/ week and 18.5% skipped 1day/week or less.

Majority (88.9%) of the NWO participants had fair duration between last eating events, sleep onset, followed by 8.1 % had poor duration, and 35 had good duration. The graph also shows that 83.7% had fair risk of eating late in the waking day, while 8.1 % had good and poor risk of eating late in the waking day.62.2 % participants had good

frequency of night eating, 33.3 5 had fair frequency of night eating and 3.7% had poor frequency of night eating. Majority of the participants 56.7 % had lunch as the largest meal, 23% had breakfast and 20.7% had dinner.

Table 4.2.7.2 provides an overview of the mean chrononutrition profiles based on gender and age. Males (5.22 ± 1.7) exhibit slightly higher chrononutrition scores than females (5.192 ± 1.2), which is statistically significant ($p < 0.05$), indicating a noteworthy difference in scores between the sexes. On the other hand, the younger age group (20-39 years) demonstrates a higher mean score (5.403 ± 1.43) compared to the older group (40-59 years) (4.94 ± 1.44), but this difference is not statistically significant, implying that the variation in chrononutrition scores between these two age categories is not substantial enough to be considered meaningful.

The findings from the table 4.2.7.3 showed that significant association between skipping of breakfast ($p<0.05$), Evening eating ($p<0.05$) and large meal of the day ($p<0.05$) with age category of subject. Younger individuals were more likely to skip breakfast, eat more in the evening, and had poorer meal timing. Eating window, evening latency, and night eating were not significantly associated with age, suggesting that these behaviors are more evenly distributed across different age groups.

Table 4.2.7.1: Chrononutrition Profile among NWO participants

Chrononutrition profile	n (%)
Good	17(12.5)
Fair	113(83.7)
Poor	5(3.7)

(Value in parentheses indicated percentage)

Table 4.2.7.2:Chrononutrition scorewith age and gender of subject (N=135)

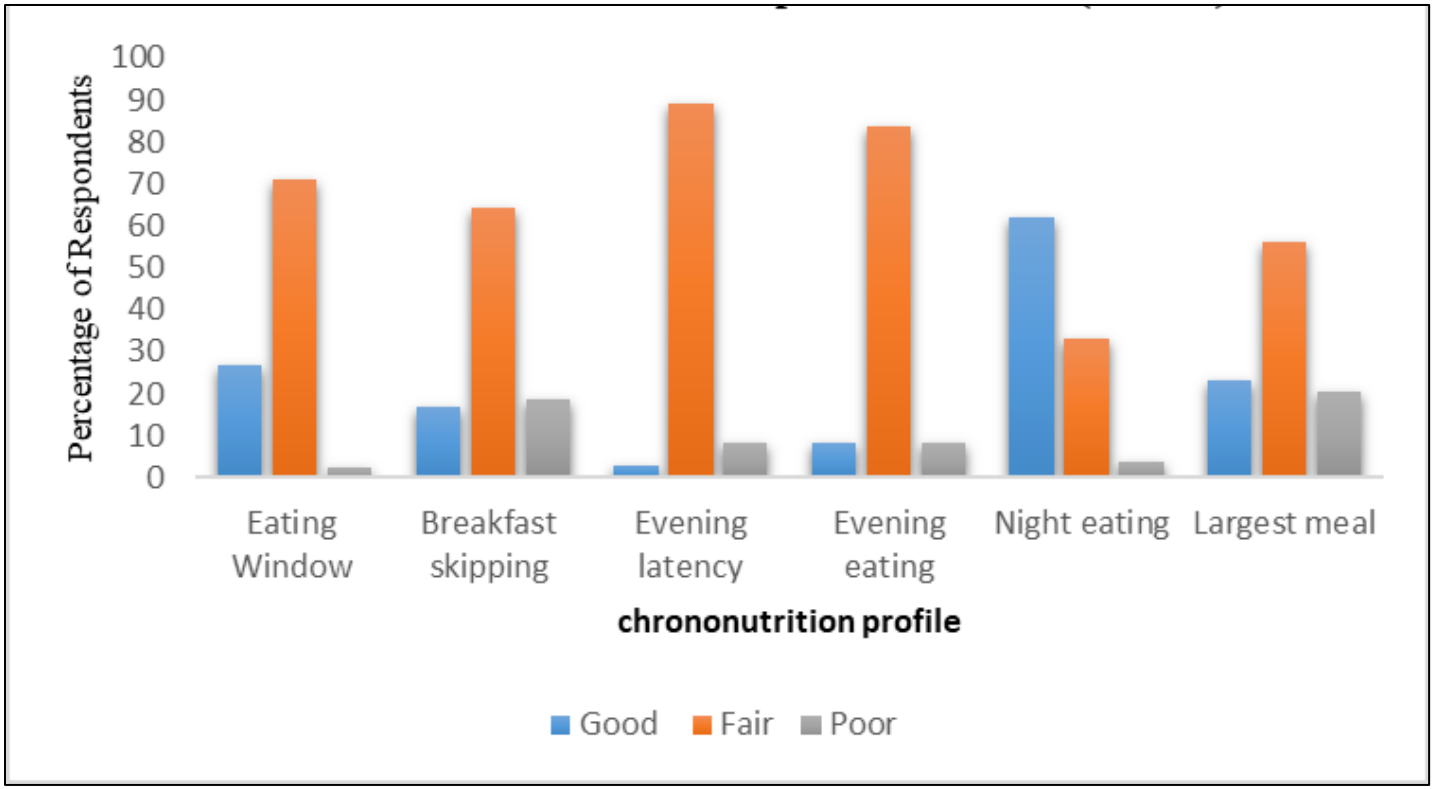
Variables	Mean ±SD		t-test
Gender	**Female (n=73)**	**male (n=62)**	
	5.192±1.2	5.22±1.7	.135*
Age	**20-39years (n=77)**	**40-59years (n=58)**	
	5.403±1.43	4.94±1.44	1.816
*p <0.05, **p<0.01,***p<0.001 is considered to be significant			

Table 4.2.7.3: Association of Age of subject with the indicator of chrononutrition profile(N=135)

Chrononutrition profile	20-29 (n=44)	30-39(n=33)	40-49(n=36)	50-59(n=22)	Chi square value
Eating window					
Good	13(9.6)	6(4.4)	9(6.7)	8(5.9)	5.060^{ns}
Fair	29(21.5)	27(20.0)	26(19.3)	14(10.4)	
Poor	2(1.5)	0(0.0)	1(0.7)	0(0.0)	
Total	44(32.6)	33(24.4)	36(26.7)	22(16.3)	
Skipping breakfast					14.433^{*}
Good	7(5.2)	2(1.5)	9(6.7)	5(3.7)	
Fair	23(17.0)	28(20.7)	21(15.6)	15(11.1)	
Poor	14(10.4)	14(2.2)	6(4.4)	2(1.5)	
Total	44(32.6)	24(24.4)	36(26.7)	22(16.3)	
Evening latency					9.104^{ns}
Good	2(1.5)	1(0.7)	1(0.7)	0(0.0)	
Fair	40(29.6)	32(23.7)	30(22.2)	18(13.3)	
Poor	2(1.5)	0(0.0)	5(3.7)	4(3.0)	
Total	44(32.6)	33(24.4)	36(26.7)	22(16.3)	
Evening eating					21.370^{*}
Good	1(0.7)	0(0.0)	5(3.7)	5(3.7)	
Fair	36(26.7)	33(24.4)	27(20.0)	17(12.6)	
Poor	7(5.2)	0(0.0)	4(3.0)	0(0.0)	
Total	44(32.6)	33(24.4)	36(26.7)	22(16.3)	
Night eating					11.292^{ns}
Good	21(15.7)	26(19.4)	20(14.9)	17(12.7)	
Fair	20(14.9)	6(4.5)	14(10.4)	5(3.7)	
Poor	3(2.2)	1(0.7)	1(0.7)	0(0.0)	
Total	44(32.8)	33(24.6)	35(26.1)	22(16.4)	
Largest meal					13.137^{*}
Good	13(9.6)	4(6.7)	9(6.7)	5(3.7)	
Fair	17(12.6)	25(14.1)	19(14.1)	15(11.1)	
Poor	14(10.4)	4(5.9)	8(5.9)	2(1.5)	
Total	44(32.6)	33(24.4)	36(26.7)	22(16.3)	

*p <0.05, **p<0.01, ***p<0.001 is considered to besignificant.(value in parentheses indicates percentage)

Fig 4.2.7.1: Indicators of chrononutrition profilefor NOW subjects (N=135)



The findings from the table 4.2.7.4illustrate that body fat percentage had significant association with Evening Latency ($p<0.01$) and withEvening eating ($p<0.01$). Individuals with very high body fat (VHF) tend to had poorer evening latency and evening eating habits, suggesting that late-night eating behaviors may contribute to higher fat accumulation. Eating window, skipping breakfast, night eating, and largest meal timing were not significantly associated with body fat percentage, indicating that these factors may not be primary contributors to fat accumulation.

4.2.8PHYSICAL ACTIVITY

The physical activity of NWO participants was assessed by GPAQ developed by WHO, 20. It collects information on three domains.

These domains are:

- Activity at work
- Travel to and from places
- Recreational activities

The data in table 4.2.8.1 categorizes individuals based on their weekly Metabolic Equivalent Task (MET) minutes, which was a measure of physical activity:< 600 MET mins per week (51.1%): A majority (51.1%) belongs < 600 MET mins per week indicatinglow physical activity.This suggests a sedentary lifestyle, increasing the risk of obesity, cardiovascular diseases, and metabolic disorders. While substantial proportion (48.9%) belongs > 600 MET mins per week indicating moderate to high physical activity levels that contribute to better health and fitness. Activity of the NWO participants.

The sitting time was classified into four categories: low Risk (<4 hours/day), Medium Risk (4-8hours / day), High Risk (8-11 hours/day), and Very High Risk (>11 hours/day) using the threshold in the study Sitting time and all-cause mortality in 2012. The findings from the table 4.2.8.2 revealed that 57% of the NWO participants belonged to low risk factors, while 39.5 % were in medium risk, 1.5% were in high-risk category and no participants were in the high-risk category.The table 4.2.8.3 shows the gender-wise mean physical activity and sitting time that revealed Males exhibited considerably higher levels of physical activity (2167.1 MET mins/week) when compared to females (702.47 MET mins/week) which was highly significant ($p < 0.001$).

Table 4.2.7.4: Association of total body fat of subject with the indicator of chrononutrition profile (N=135)

Chrononutrition	High fat %(HF)(n-84)	Very high fat %(VHF)(n-51)	Chi square value
Eating window			3.519^{ns}
Good	19(14.1)	17(12.6)	
Fair	63(46.7)	32(23.7)	
Poor	1(0.7)	2(1.5)	
Total	84(62.2%)	51(37.8%)	
Skipping breakfast			4.785^{ns}
Good	13(9.6)	10(7.4)	
Fair	55(40.7)	32(23.7)	
Poor	16(11.7)	9(6.7)	
Total	84(62.2%)	51(37.8%)	
Evening latency			14.391^{**}
Good	4(3.0)	0(0.0)	
Fair	74(54.8)	46(34.1)	
Poor	6(4.4)	5(3.7)	
Total	84(62.2%)	51(37.8%)	
Evening eating			14.789^{**}
Good	4(3.0)	7(5.2)	
Fair	73(54.1)	40(29.6)	
Poor	7(5.1)	7(3.0)	
Total	84(62.2%)	51(37.8%)	
Night eating			2.833^{ns}
Good	52(38.8)	32(23.9)	
Fair	27(20.1)	18(13.4)	
Poor	4(3.0)	1(0.7)	
Total	84(62.2%)	51(37.8%)	
Largest meal			5.309^{ns}
Good	17(12.6)	14(10.4)	
Fair	47(34.8)	29(21.5)	
zPoor	20(14.8)	8(5.9)	
Total	84(62.2%)	51(37.8%)	

, *p <0.05, **p<0.01, ***p<0.001 is considered to be significant. (value in parentheses indicates percentage)

Table 4.2.8.1: Physical Activity of the NWO participants (N=135)

Physical Activity categorization	Frequency (n)	Percentage (%)
< 600MET minutes per week	69.0	51.1
> 600MET minutes per week	66.0	48.9

Table4.2.8.2: Sitting Hours Among NWO participants (N=135)

Categorization Risk factor	Frequency(n)	Percentage(%)
Low Risk	77	57
Medium Risk	54	39.5
High Risk	2	1.5
Very high risk	0	0

Table 4.2.8.3: physical activity and sitting time gender-wise NWO participants(N=135)

Variables	Female (n=73)	Male (n=62)	Total (N-135)	t-test
Total physical activity (MET mins/ week)	702.466±1031.6	2167.097±2545	1375±2014.6	4.502***
Sittingtime(mins) / day	216.164±91	202.58±98.9	209.9±95.0	.827^{ns}
***p<0.001 is considered to be significant and ns as non- significant				

This indicated that the disparity in physical activity levels between males and females is statistically significant. This implies that men tend to be much more active than women in this sample. The overall average physical activity (1375 MET mins/week) signifies low to moderate levels of physical activity within the total sample, alongside considerable variation (±2014.6 MET mins) among individuals.

As is evident from table 4.2.8.4, a significant negative correlation was observed between body fat % with physical activity at **p<0.01 (pearson correlation). That shows that with increased physical activity body fat % decreases.

4.2.9 PHYSICAL FITNESS

The Physical Fitness has been divided into four category: Flexibility, Cardio-respiratory Endurance, Muscular strength and Muscular Endurance.

The table shows that majority (80.6%) of NWO participants had excellent flexibility, 95.5% had excellent Cardio Respiratory Endurance, 81.5 % has weak muscular strength and 77.0 %had fair muscular endurance. Table 4.2.9.2 illustrate that reduced body fat is associated to increased flexibility. Of those with HF, 65.1% have "Excellent" flexibility, whereas 34.9% have VHF. Only the VHF group has poor flexibility (33.3%).This emphasizes the association of decrease flexibility with high fat %(p<0.005).

4.2.10LIFESTYLE FACTORS

SLEEP

The Pittsburgh Sleep Quality index (PSQI) was used to assess the sleep quality of the subjects. A global score of 5 or more indicates poor sleep and less than 5 is considered as good sleep.

The tables 4.2.10.1. showed that more than half of the NWO participants had poor quality of sleep and 39.3 % participants had good quality of sleep. This indicated that majority of NWO subjects had poor quality of sleep among the subject that may be contributed by various indicators like duration of sleep, sleep disturbances, sleep latency, day dysfunction, efficiency of sleep, overall sleep quality, and any medication to sleep.

Table 4.2.8.4: Correlation between Physical activity with body fat %among NWO subject (N=135)

Variables	Total physical activity	Sitting time
Body fat %	-.317**	-.044
P value is based onpearsoncorrelation for continuous variable		

Table 4.2.9.1: Physical fitness among NWO subject (N=135)

Physical Fitness	Frequency (n)	Percentage (%)
Flexibility		
Excellent	109	80.6
Very good	3	2.2
Good	14	10.3
Fair	8	5.9
Poor	1	0.7
Cardio-Respiratory Endurance		
Excellent	129	95.5
Above average	5	3.70
Average	1	0.7
Below	-	-
Poor	-	-
Muscular Strength		
Strong	1	0.7
Normal	24	17.8
Weak	110	81.5
Muscular Endurance		
Good	2	1.5
Average	9	6.6
Fair	104	77.0
NA	20	14.8

Table 4.2.9.2: Association of flexibility and body fat % among NWO subject N=135)

Flexibility	Excellent	Fair	good	Poor	Very good	Total	Chi square value
High fat % (HF %)	71(65.1 %)	4(50.0 %)	7(50.0%)	0(0%)	1(33.3 %)	83(61.5 %)	20.072*
Very High fat % (VHF %)	38(34.9 %)	3(37.5 %)	7(50.0%)	1(33.3 %)	2(66.7 %)	51(37.8 %)	
P value is based on chi square for categorical variables, *p <0.05, is considered to be significant.							

(Value in parentheses indicates percentage)

Table 4.2.10.1: Sleep Quality among NWO subject (N=135)

Sleep quality	Frequency (n)	Percentage (%)
Good sleep	53	39.3
poor sleep	82	60.7

The study analyzed sleep quality indicators among NOW subjects, categorizing them as Better, Good, Bad, and Worse. From graph 4.2.10a.1 The majority of participants had either better or good sleep duration, with a small percentage suffering from inadequate sleep. 12.1% of participants reported experiencing sleep disruptions, which had an effect on the quality of their sleep. 3.32% of individuals reported having sleep delay, with 8.85% reporting poor sleep latency and 16.6% reporting acceptable sleep latency.

Daytime drowsiness or exhaustion from sleep was indicated by a moderate percentage of subjects who reported having poor or severe sleep disorder. A total of 24.1% of individuals reported having good sleep efficiency, 3.54% having good sleep efficiency, and 1.71% having low sleep efficiency. A total of 24.1% of individuals reported having good sleep efficiency, 3.54% having good sleep efficiency, and 1.71% having low sleep efficiency. 1.71% of respondents said their overall sleep quality was good, with 24.8% reporting good sleep quality and 3.3% reporting bad sleep quality. Only 0.8% of people needed frequent usage of sleep aids, and 17.7% of people did not need them. Thus, majority of participants (more than 70%) report having good or better sleep based on all indicator.. Less than 10% of respondents said they had poor or worse sleep in a number of areas, most notably dysfunction, latency, and sleep disturbances. Screen use in the middle of the night may be a factor in sleep disruptions and delayed sleep latency.

This fig 4.2.10.1determines association of sleep quality (measured by PSQI)) between individuals with high body fat percentage and very high body fat percentage**.** Participants with very high body fat % have a slightly higher mean sleep score (6.569) than those with high body fat % (6.190), but this difference was not statistically significant. The mean sleep score for both groups was around 6, suggesting moderate sleep quality. Since the score does not significantly differ between the groups, factors other than body fat percentage (e.g., lifestyle, stress, physical activity) may have a greater impact on sleep quality.

STRESS

Perceived stress scale by Sheldon Cohen was used to assess the stress among the respondent. From the tables 4.2.10b.1 it was observed that 48.8% of the NWO individuals had moderate stress, while 39.2% had perceived stress and a small portion had low stress.

This table 4.2.10.3 analyzes the link between perceived stress levels and various age categories among Normal-Weight Obese (NWO) participants, with the highest percentage of high stress (50.0%) found in the 20-29 age range, followed by 45.5% in the 30-39 category. The age groups 40-49 (27.8%) and 50-59 (27.3%) exhibit lower rates of high perceived stress. Moreover, the proportion of individuals reporting low stress increases with age, rising from 4.5% in the 20-29 age group to 31.8% in the 50-59 group. The most commonly reported level of stress overall was moderate (48.9%). The 40-49 age group represents the highest percentage (58.3%) in this category. Age has a significant impact on perceived stress levels ($p < 0.05$). Younger individuals (20-39 years) tend to experience higher levels of stress compared to older individuals. Conversely, older participants (50-59 years) demonstrate greater levels of low stress, indicating potentially better stress management or stability in life. Across all ages, moderate stress was the most prevalent category, peaking in the 40-49 age group.

As is evident from table 4.2.10.4, a significant negative correlation was observed between stress with physical activity at**$p<0.01$ (pearson correlation). That shows that with increased physical activity stress decreases.

Fig 4.2.10.1: Indicator of Sleep quality of NWO subject (N=135)

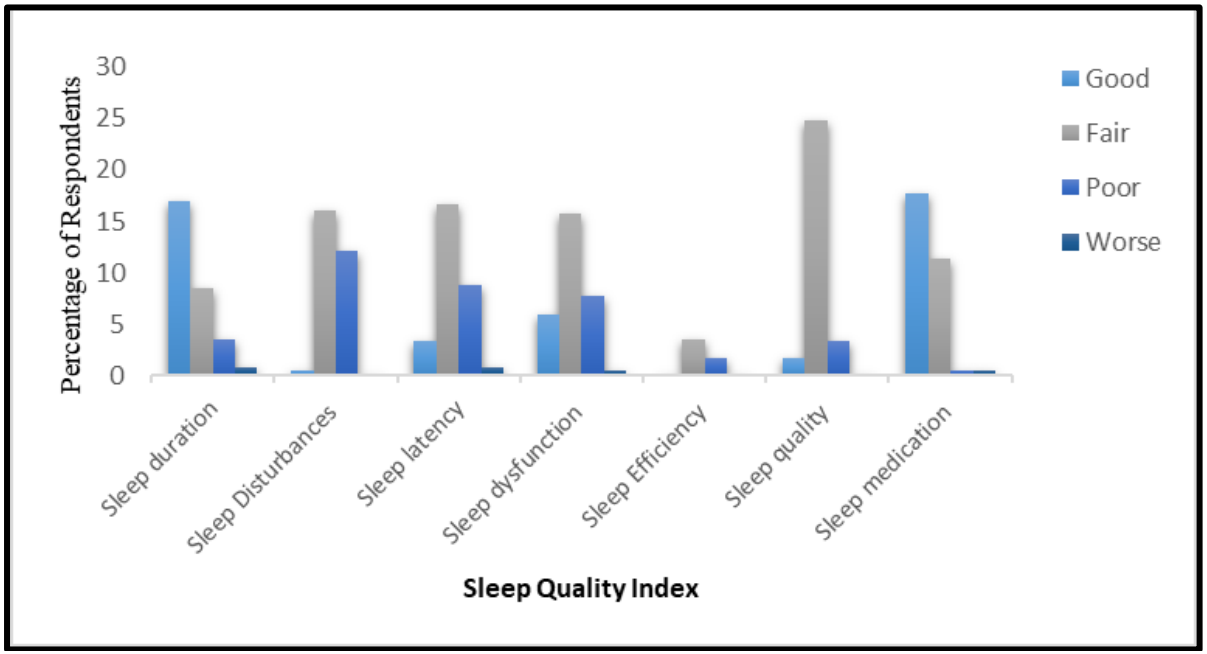


Table 4.2.10.2: Association of body fat percentage with Sleep quality(N=135)

Variables	Mean ±SD		t-test value
Sleep index score	**High Body fat %(n=84)**	**Very High Body fat % (n=51)**	
	6.190±2.69	6.569±2.50	**.813^{ns}**
P value is based onindependent t-test for continuous variables, ns –not significant			

Table 4.2.10.3: Perceived stress among the NWO subjects(N=135)

Perceived stress scale	Frequency(n)	Percentage(%)
Low Stress	16	11.9
Moderate Stress	66	48.8
Perceived Stress	53	39.2

Table 4.2.10.4 Association of perceived stress with Age (N=135)

Perceived stress score	**20-29 (n=44)**	**30-39(n=33)**	**40-49(n=36)**	**50-59(n=22)**	**Chi square value**	**20-29 (n=44)**
Perceived stress score						15.122*
High	22(50.0%)	15(45.5%)	10(27.8%)	6(27.3)	53(39.3%)	
Low	2(4.5%)	2(6.1%)	5(13.9%)	7(31.8%)	16(11.9%)	
Moderate	20(45.5%)	16(48.5%)	21(58.3%)	9(40.9%)	66(48.9%)	
P value is basedfor chi squarefor categorical variables, *p <0.05, is considered to besignificant(value in parentheses indicates percentage)						

Table 4.2.10.5: Correlation between stress with physical activity (N=135)

Variables	Stress
Total Physical activity	-.317**
P value is based onpearsoncorrelation for continuos variable	

SCREEN TIMING

Screen time was assessed by using SCREEN-Q. Table 4.2.10.6 showed the screen timing and duration of screen time among study population it can be seen that majority 97% of the participants have screen time of more than 2hours post dinner and 3% have screen time less than 2 hours /day .This indicated a possible danger for adverse health consequences, including ineffective sleep, eyestrain from screens, and a decrease in physical activity. The low percentage of individuals with minimal screen time (≤2 hours) highlighted a behavioral trend toward prolonged screen use in this population. Hours of 9:00 PM to 10:00 PM and 10:00 PM to 11:00 PM saw the most screen usage. A significant portion of participants (66.5%) continued using screens beyond midnight, potentially affecting sleep patterns and overall health.

Table4.2.10.7 illustrates the association of screen time with body fat percentage among NWO participants. From the table it clearly showed that the screen time >2hours have higher body fat percentage than subject that had < 2hours /day screen time ($p<0.01$).Thus, there was a significant association between screen time with body fat percentage protein intake between males and females.

ADDICTION

The frequency distribution of addiction among the NWO participants is shown in the table 4.2.10.9, which was divided into three categories: Present (now addicted), Past (previously addicted), and none(never addicted). With 91.9% of subjects presently drinking tea, tea consumption was the most common addiction. Coffee consumption was also considerable, with 48.1% of subjects regularly drinking coffee.

Less than 10% of participants use alcohol, cigarettes, or tobacco, indicating a comparatively low prevalence of addiction. More than 90% of the participants had never used snuff, alcohol, cigarettes, tobacco, or pan masala. Only coffee (2.2%) and cigarettes (1.5%) have past addictions mentioned, suggesting little prior substance usage.

Table 4.2.10.6: Duration of screen time (N=135)

Screen time	**n**	**(%)**
Duration of screen time post dinner		
< ½ hours/day	1	0.7
½ -1hours/ day	1	0.7
1-2 hours/day	2	1.5
>2 hours/ day	131	97.0
Duration of screen time post dinner		
<20:00pm	5	3.7
21:00pm	51	37.7
22:00pm	39	28.8
23:00pm	24	17.7
>00:00am	16	11.8

Table 4.2.10.7: Association of screen time with body fat % (N=135)

Screen Time	**High fat % (n-84)**	**Very high fat % (n-51)**	**Total (N=135)**	**Chi square value**
<2 hours/ day	0(0%)	4(7.8%)	4(3.0%)	6.789**
>2 hours/ day	84(100.0%)	47(92.2%)	131(97.0%)	
**p <0.01, is considered to besignificant.(value in parentheses indicates percentage)				

Table 4.2.10.8: Addiction among the NWO subjects

Addiction	**Present (Frequency)**		**Past Frequency**		**None**	
	n	%	n	%	n	%
Alcohol	12	8.9	0	0	123	91.1
Cigarette	9	6.7	2	1.5	124	91.9
tobacco	13	9.6	0	0	122	90.4
Pan masala	10	7.4	0	0	125	92.6
snuff	8	5.9	0	0	127	94.1
tea	124	91.9	2	1.5	9	6.7
coffee	65	48.1	3	2.2	67	49.6

From the table 4.2.10.9 it highlighted that Males had significantly higher consumption alcohol ($p<0.01$), tobacco ($p<0.001$), pan masala ($p<0.001$), coffee ($p<0.01$) than females. There was no association of tea consumption with gender as both groups had higher tae consumption.

4.2.11 Determinants of Normal Weight Obesity amongst Adults

A total of three factors entered the equation of multiple regression when body fat % was taken as the dependent variable as shown in table 4.2.11.1.Body age was the first factor to be entered in the multiple regression and explained for 23.6% variation seen in body fat% among adults. Waist circumference entered at the second step and accounted for 21.3% of the variation. Age entered at the third step and explained 14% variation. Gender entered in fourth step accounting for 21.5% variation. The four factors together explained 80.4% of variation in body fat percentage.

Table 4.2.11.2 shows that the factor dietary fat was entered for regression accounting for 68% variation in body fat percentage at $p<0.001$ which was strongly associated with body fat percentage.

Table 4.2.11.3 shows the factor physical activity was entered for multiple regression analysis accounting for 94% variation in body fat percentage at $p<0.001$ which was strongly associated with body fat percentage.

From the previous analyses different variables were found to be associated with body fat percentage, of which anthropometric parameter (age, gender, waist circumference, body age), dietary fat and physical activity were found to be strongly associated.

Table 4.2.10.9: Addiction among NWO subjects- Gender wise (N=135)

Alcohol	Female (n=73)	Male (n=62)	Total	Chi square value
Present	1(1.4%)	2(3.2%)	3(4.2)	14.787**
Past	0	9(6.7%)	9(6.7%)	
None	72(98.6%)	51(82.3%)	123(91.1%)	
Tobacco				
Present	1(1.7%)	12(19.4%)	13(9.6%)	12.461***
Past	0(0%)	0(0%)	0(0%)	
None	72(98.6%)	50(80.6%)	122(90.4%)	
Pan masala				
Present	0(0%)	10(16.1%)	10(16.1%)	12.716***
Past	0(0%)	0(0%)	0(0%)	
None	73(100.0%)	52(93.9%)	125(92.6)	
Tea				
Present	65(89.0%)	59(95.2%)	124(91.9%)	2.186a ns
Past	1(1.4%)	1(1.4%)	2(1.5%)	
None	7(9.6%)	2(1.5%)	9(6.7%)	
Coffee				
Present	24(32.9%)	41(66.1%)	65(48.1)	14.862**
Past	2(2.7%)	1(1.6%)	3(2.2%)	
None	47(64.4%)	20(32.3%)	67(49.6%)	

***p<0.001, **p<0.01,*p<0.001, is considered to be significant and ns as non- significant

(value in parentheses indicates percentage)

4.2.11.1: Table: Anthropometric factors significantly associated with body fat%

Variables	Adjusted R^2	SE	Variation Explained	'F' Value
Body age	.236	5.1547	23.6	42.496***
Waist circumference	.449	4.3791	21.3	52.287***
Age	.589	3.7841	14	45.769***
Gender	.804	2.6103	21.5	145.308***
***P<0.001 is considered significant.				

4.2.11.2 Table: Nutrient intakes significantly associated with body fat%

Variables	Adjusted R^2	SE	Variation Explained	'F' Value
Dietary fat	.061	5.7171	68%	9.666**
***P<0.001 is considered significant.				

4.2.11.3 Table: Physical activity factors significantly associated with body fat%

Variables	Adjusted R^2	SE	Variation Explained	'F' Value
Physical activity	.094	5.6158	94%	14.861***
***P<0.001 is considered significant.				

The research indicates that Normal Weight Obesity (NWO) is mainly influenced by factors related to socio-economic status, medical conditions, body measurements, dietary habits, and lifestyle choices. It discovered that NWO is more commonly found in women, particularly affecting those in middle age. Most individuals with NWO fall into the lower-middle-income category and typically have at least one health issue. Although they maintain a normal Body Mass Index (BMI), many exhibit high body fat percentages, reduced muscle mass, and central obesity, which heightens their likelihood of developing metabolic disorders. The investigation also identified that poor meal timing, late-night eating, excessive screen time, moderate stress levels, and insufficient sleep quality lead to fat accumulation and metabolic health issues. Recommendations for the future include improving dietary quality, increasing physical activity levels, and effectively managing stress.

DISCUSSION

The present cross-sectional study was aimed to assess dietary and lifestyle factors associated with normal weight obesity amongst 451 adults residing in urban Vadodara. The study was conducted targeting the free-living population aged 20-59 years in urban Vadodara, selected through snowball sampling to ensure diverse representation. Screening and enrolments were done according to Asian pacific BMI classification and body fat % (Omron healthcare) on subject at baseline. The findings from the study conducted amongst adults at urban Vadodara at baselines includes background information, Socio-economic status, medical and family history, Biophysical assessment, anthropometric profile, body perception and Body composition profile

The study analysed that less than one third of the study participants were found to have normal weight obesity from the baseline with a prevalence of 29.9% indicating a rate that is relatively significant when compared to the global prevalence rates, which range from 9% to 34%. This outcome was consistent with the findings of Kapoor et al.(2020), who noted a higher prevalence of NWO in Asians, which can be attributed to their generally smaller body size compared to other ethnic groups. NWO prevalence was higher than 20.7% among Kerala adults (Kapoor et al., 2020)) and lower than 48.7% among government doctors in Gujarat (M, Makwana, et al. (2024)The prevalence of obesity in the current study among the subjects at baseline was found to be higher, contributing the majority (45.2%), which is similar to the overall obesity prevalence (44.17%) in urban populations in India(NFHS-5) and higher than the urban population of Gujarat (8.94%). The prevalence of obesity was slightly higher in males (22.8%) than in females (22.4%), while is similar to prevalence of obesity among men (22.1%) and 23% among women (NFHS-5) and higher than the prevalence of obesity among doctors in Gujarat as studied by M Makwana et al.,(2024) (10%).

The findings reveal a high prevalence of central obesity (56.09%), which may contribute to metabolic disorders, cardiovascular diseases, and other obesity-related health risks. Waist circumference, hip circumference, WHR, and WHtR were all significantly higher in older adults, indicating an increased risk of abdominal obesity with aging which found

significantly higher than 50% of abdominal obesity in India (NFHS-5) and 30.1%-53.3% from previous study on adults of South Asian descent (Gupta et al., 2023).The study also highlighted a significant prevalence of excessive body fat (62%) alongside low skeletal muscle mass (75.3%) among many participants in the urban demographic at baseline. Over half of the population (55%) exhibited some type of abnormal blood pressure (either elevated BP or hypertension), which was significantly greater than the 40.6% observed among Indians (NFHS-5). Medical history indicated that merely 8.64% reported having hypertension, suggesting that most participants were unaware of their hypertension status, which implies that a considerable portion of the population may need medical or lifestyle changes.

The present study showed that prevalence of NWO among males were 45.93% and females 54.07% which is higher compared to study conducted in Korea by Franco et al., (2016) (36% in men and 29% in women). Another study found that 28% of men and 42% of the women were NWO (Manissto et al., 2007), which concluded that there is higher prevalence of Normal weight obesity among females and males in the present study due wide distribution of age, socio-economic background. Among the age group, highest prevalence (32.6%) was found to be amongst 20-29years which could due to urbanization, sedentary lifestyle, dietary habits, eating late meal.

Anthropometric Profile: The key findings of the present study show that there was a higher prevalence of Central obesity among NWO subject. 28.1 % more than one fourth of the subject has NWCO, 65.1% had elevated waist-hip ratio and 57.1% at risk indication short height phenotype that increases with age (older adults having significantly higher central obesity than young adults) These findings indicate a significantly higher prevalence of central obesity compared to Shimrah et al.,2023 study, where NWCO prevalence from total population(Non-obese, Obese was much lower (3.3% (WC), 21.5% (WHR), and 12.1% (WHtR). Ahirwar et al., (2019), estimated that 16.9%–36.3% of Indians may have abdominal obesity, while recent studies report rates ranging from 19% to 71.2%. Data from the LASI 2017-19 survey showed regional variations in NWCO prevalence where among men, Haryana had the highest rate (26.4%) and among women, Kerala had the highest prevalence (39.1%) whereas abdominal

obesity was more prevalent among females (31.5%) than males (24.2%) in this study. Thus, early screening using WC, WHR, and WHtR could help identify at-risk populations earlier.

Biophysical Measurement: The research indicated that 47.4% of subjects categorized as NWO exhibited normal blood pressure, whereas 52.6% display elevated blood pressure, with 40.8% classified under various hypertensive stages. This is comparatively greater than the hypertension rates among NWO found in the Kapoor N et al., (2020) study, while the research conducted in Gujarat revealed that 27% of NWO individuals were hypertensive (M Makwana et al, 2024). The average systolic blood pressure (118.7±17.09mmHg) and diastolic blood pressure (81.10±10.6mmHg) values from supported from p with the mean systolic (129.1mmHg) and diastolic (77.5mmHg) blood pressure values reported by Kapoor N et al., (2020), males exhibited significantly higher systolic and diastolic blood pressure levels than females, and older adults demonstrated higher values than their younger counterparts. Furthermore, hypertension was found to be more common in men (47.6%) compared to women (43.8%) according to the LASI 2017-19 survey. Interestingly, only 6.6% of the individuals with a medical history reported being hypertensive, indicating that a significant portion of the adult population in urban Vadodara is either unaware of early screening or less likely to undergo blood investigations. Asthma was identified as the most prevalent condition (40.7%) among adults with NWO, while only a small proportion reported other conditions such as diabetes, dyslipidemia, or thyroid disorders.

Body Composition profile: A significant proportion of participants (62.2%) exhibited increased body fat, which could elevate the risk of diseases associated with obesity, while 5.9% displayed high visceral fat levels. The skeletal muscle analysis indicated that 68.8% of the participants had low muscle mass, with roughly one-third showing normal levels, suggesting that individuals with normal weight obesity (NWO) tend to have higher body fat percentages and lower muscle mass. These findings align with the research by Oshita K et al.,2022 which reported that 60% of the normal weight-obese (NW-O) group presented a low skeletal muscle index (Low-SMI).

Additionally, the study revealed that the average total body fat percentage for females (33.878±2.9%) was notably greater than that of males (24.363±4.032%). Conversely, the average visceral fat percentage for males (128±80.89%) was significantly higher than for females (4.36±1.55%). Skeletal muscle mass was considerably greater in both males and females (31.316±2.5%) compared to the normal ranges (27.24±4.4%), while the average total body fat percentage for females (18.2 ± 2.6%) was significantly higher than that for males (16.5 ± 3.4%). This supports findings from a global study by Maitiniyazi et al., (2021), which also indicated that skeletal muscle mass was significantly higher in both males and females (29.2 ± 2.9%) compared to normal ranges (20.0 ± 1.96%).

The current study determined that body fat percentage is significantly linked to age and skeletal muscle mass, supporting the results of the study conducted by Maitiniyazi et al., (2021).

Dietary intake and habit: The present study examined the eating patterns of individuals with normal weight obesity (NWO). A significant portion (61.5%) identified as vegetarian, with a notable representation of vegetarians in both high fat (HF) (37.0%) and very high fat (VHF) (24.4%) categories, which contradicts the findings of a study by M Makwana et al.,(2020) which reported that 95% were non-vegetarian. Most participants (42.2%) reported having breakfast 4-6 times per week, and lunch was considered the primary meal by 53.3% of those with NWO. A majority (52.6%) admitted to occasionally skipping meals due to factors such as time constraints, busy schedules, fasting, lack of appetite, and cooking difficulties. Additionally, 63.0% reported consuming food from restaurants occasionally. The prior research found that more frequent visits to restaurants and higher junk food consumption were key contributors to NWO, as noted by Hadaye R et al (2020). Almost 60.0% experienced food cravings, with savory items being the most desired, followed by spicy and sweet foods. Snacking was also notably linked to higher fat percentages; the study conducted byArshad et al., 2022 et al., (2022). indicated a significant association between dietary habits and body fat levels, highlighting the necessity for raising awareness about healthy eating practices to reduce the risk of NWO among young adults.

The present study evaluated the average nutritional intake of NWO participants using three consecutive day 24-hour recall methods. The findings revealed that the average nutrient consumption on day 3 exceeded that of days 1 and 2. When analyzed by gender, males demonstrated a considerably higher total energy intake compared to females.

The study revealed that rice and whole wheat flour were the most frequently consumed grains on a daily basis, followed by refined wheat (maida) and white bread. Pulses and legumes were also prevalent, with the Bengal gram being the most popular pulse. The most popular snack was biscuits, with 43.7% eating them twice a week. Namkeen was consumed three times a week, and snacks like Gathiya, chivda, papdi, and sevmumra are consumed three times a week. Fruit juices were moderately consumed, with 26.7% drinking them every two weeks and 25.9% every week. The current research reinforces the findings of prior studies indicating that diets low in protein and high in fiber cereals were more prevalent among individuals with NWO (Arshad et al., 2022). The dietary habits observed in this study, characterized by high energy, high fat, high carbohydrate, high sugar, and high salt consumption among adults with NWO, align with the findings that Thai adults following a Westernized carbohydrate-based diet face an increased risk of metabolic syndrome (Hgoc et al., 2020). The NWO group demonstrated significantly greater consumption of ultra-processed foods and sweetened drinks when compared to the NO-NWO group (Kobayashi et al.,2023). Previous research has shown a positive correlation between unhealthy eating patterns—including excessive intake of white rice/bread, starchy vegetables, flavored milk, junk food, and sweets—and elevated body fat percentages among individuals identified with NWO (Arshad et al., 2022). Significant association were found between obesity and factors such as a high-protein diet, frequency of dining out at restaurants, and reduced consumption of home-cooked meals. Factors notably associated with NWO included fish intake. (Hadaye et al., 2020)

Chrononutrition Profile: The present study indicated that the majority of individuals with NWO exhibited a fair chrononutrition profile, potentially affected by factors such as the duration of meals, meal skipping, late-night eating, main daily meals, and the interval between the last meal and sleep onset. Most participants reported skipping breakfast 2-3 times weekly, which contradicts their assertion that they occasionally skip meals, and

88.9% maintained a reasonable gap between their last meal and sleep onset. Additionally, the study revealed that 83.7% faced a moderate risk of eating late during their waking hours. Male participants had slightly higher mean chrononutrition profiles compared to females, possibly attributable to men's work schedules, late-night awakeness, and night shift work. The study also reported a significant association between skipping breakfast, evening eating habits, and the size of the main meal in relation to age, indicating that younger individuals were more likely to skip breakfast and exhibit poor meal timing. This suggests that the younger generation tends to stay awake late at night due to educational demands or busy work schedules, leading to unhealthy eating practices and a sedentary lifestyle. Research indicates that body fat percentage is significantly linked to evening eating habits and the time one eats, suggesting that consuming food late at night may lead to increased fat accumulation. This aligns with the findings of Cunha et al., (2023), which emphasized that a longer eating duration among adults corresponds to a higher prevalence of abdominal obesity, as well as hypertriglyceridemia in older adults. Additionally, later meal timings were connected to higher fasting glucose levels, while a global study revealed no significant relationship between various chrononutrition patterns—such as night eating, skipping breakfast, and evening eating—and diet quality among students (Azahari et al., 2023).

Physical Activity: The current studyclassified individuals according to their weekly Metabolic Equivalent Task (MET) minutes, revealing that 51.1% possessed low levels of physical activity, which heightens the risk of obesity and cardiovascular issues. A significant portion (48.9%) maintained moderate to high levels of physical activity, which fosters improved health and fitness. The majority of the participants fell into the low-risk category for sitting time (57.1%). No association was found between sitting time and gender, although males exhibited considerably higher levels of physical activity than females, highlighting a notable disparity in activity levels or greater skeletal muscle mass in males compared to females. There was also no association established between physical activity and body fat percentage. Overall, the average level of physical activity is categorized as low to moderate. A previous cross-sectional study indicated that decreased regular physical activity was linked to an increase in visceral fat accumulation (Ozaki K et al.). Individuals categorized as having Normal Weight Obesity (NWO)

participated in significantly less moderate to vigorous physical activity (MVPA) than those with Normal Weight Lean (NWL), with an approximate daily difference of 8 minutes. Low-intensity physical activity (LIPA) was also about 17 minutes per day less in the NWO group compared to the NWL group (Wijayatunga et al., 2022), while research by (Olafsdottir et al., 2016) demonstrated that self-reported physical activity and leisure-time physical activity durations were lower in both adults and adolescents with NWO when compared to NWL.

Physical Fitness: The research identified four distinct categories of physical fitness: flexibility, cardio-respiratory endurance, muscular strength, and muscular endurance. The majority of participants demonstrated excellent flexibility, strong cardio-respiratory endurance, but weak muscular strength and diminished muscular endurance. Nearly 14.8% of individuals chose not to participate in the muscular endurance test for personal reasons. Among those classified with HF, 52.6% displayed "Excellent" flexibility, while 28.1% fell into the VHF category. The VHF group is the only one that exhibited poor flexibility (0.7%). This highlights the importance of maintaining fitness and flexibility to prevent overall body fat accumulation. No correlation was found between body fat percentage and muscular strength, muscular endurance, or cardio-respiratory endurance, likely due to a substantial number of participants being concentrated in one test category. This is alignedwith the findings reported by Musalaket al.,(2021), which indicated that normal-weight obese children showed significantly lower performance in muscular strength and cardio-respiratory endurance.

Lifestylefactors:

Sleep: The research indicated that more than half of the participants currently have insufficient sleep quality, with only 39.3% reporting good sleep. This is attributable to a number of factors, including sleep duration, disturbances during sleep, latency in falling asleep, daytime dysfunction, overall efficiency, and the use of sleep medications. Most participants achieved good or better sleep duration, though a minority reported inadequate sleep. About 12.1% reported experiencing interruptions during sleep, while 3.32% faced delays in falling asleep. The majority exhibited good sleep efficiency, with 24.1% rated as having good efficiency and 3.54% achieving good efficiency as well. The

use of screens during the night could contribute to sleep disruptions and increased sleep latency. There is no significant statistical difference in sleep quality between those with high body fat percentages and those with very high body fat percentages. Additionally, no correlation was found between sleep quality and body fat percentage. A study by Cha et al.,(2018) suggests that consistently getting at least six hours of sleep influences BMI. Irregular sleep patterns or insufficient sleep heighten the risk of being overweight or obese, as inadequate sleep can lead to altered metabolic responses in the body, potentially resulting in increased fat accumulation. The majority of normal-weight participants who did not obtain enough sleep, and more than half of those who slept during the day, were classified as normal weight and overweight (Hadaye et al.2020).

Addiction: Evidence of addiction was identified, with tea being the most commonly consumed item, followed by coffee. Prior research indicates a link between alcohol consumption and obesity, but not specifically with NWO (Cha et al., 2018) Higher rates of smoking and increased alcohol intake were more prevalent among NWO individuals, particularly men (Hadaye et al., 2020). However, in the current study, self-reported addiction among NWO participants revealed a lower incidence of consuming alcohol, smoking,suff, pan masala and bidi. In contrast, a study conducted in Gujarat by M Makwana et al.,(2022) found that only 20.2% of NWO subjects were alcohol consumers, and 14% were smokers.

This showcases the impact of environmental elements such as socioeconomic status, stress levels, sleep patterns, genetic predispositions changes in nutrition, various lifestyles choices, and may influence normal weight obesity individuals. Long work hours, irregular schedules, and increased stress can disrupt the ability to maintain healthy dietary habits and lifestyle choices.

These results highlighted the critical need for health promotion strategies such as enhancing diet quality, boosting physical activity, and managing stress among NWO adults. Regular evaluations of body composition, alongside BMI, are necessary during health assessments. As this approach will help them address rising obesity rates and related health issues within the group.

SUMMARY AND CONCLUSIONS

The global rise of non-communicable diseases (NCDs), such as obesity and type 2 diabetes, underscores the urgent need to address varying obesity phenotypes, particularly Normal Weight Obesity (NWO). NWO, characterized by a normal BMI but high body fat percentage, is prevalent in South Asian populations and poses significant metabolic and cardiovascular risk.

The present study was undertaken to assess dietary and lifestyle factors associated with normal weight obesity amongst 451 adults residing in urban Vadodara. The study was conducted on the free-living population aged 20-59 years in urban Vadodara, selected through snowball sampling to ensure diverse representation. Screening and enrolment was done according to Asian pacific BMI classification and body fat % (Omron healthcare) on subject at baseline. Information on Socio-economic status, Family and Medical History, anthropometry and body composition, Biophysical measurement, Physical fitness, Dietary practices, chrono-nutrition profile, Lifestyle factors and stress status was obtained from the enrolled subjects.

Despite the increasing recognition of NWO and its health implications from previous global and national studies, there is a dearth of scientific evidence regarding dietary, physical activity, Chrono-nutrition and lifestyle factors associated with this condition. Thus, the proposed study was undertaken to fill the existing gap in knowledge.

BROAD OBJECTIVE

Assessing dietary and lifestyle factors associated with normal weight obesity amongst adults residing in urban Vadodara

SPECIFIC OBJECTIVES

- To assess the prevalence of normal weight obesity amongst adults residing in urban Vadodara.
- To evaluate the dietary practices of the enrolled subjects.

- To assess the physical activity profile, lifestyle status, Chrono nutrition profile etc. of the enrolled subjects.
- To identify the determinants of normal weight obesity amongst adults

Background information, Socio-economic status of the subjects at baseline

- The majority were married (74.1%), with a small percentage being widowed (1.3%). The nuclear family (60.3%) was the most common, followed by joint families (20.8%) and extended families (18.8%). This suggests a diverse representation of age groups and family structures.
- The majority of respondents had formal education, with a high percentage of graduates or postgraduates. Most individuals had at least secondary-level education, with a small percentage being illiterate or having only primary or middle school education.
- Skilled workers and shop/market sales workers were the largest occupations.
- The majority of families earned between 10,703 and 31,977 monthly, with a significant portion falling within the 31,978-53,360 range. Income inequality was observed, with a smaller portion earning above 2,13,814.
- The data also showed a distribution of individuals based on socio-economic status, with the lower middle class being the largest.

Biophysical, medical and family history of the subjects at baseline

- The study found that 63.8% of participants had normal birth weight, with a significant proportion having high birth weight.
- More than half of the respondents had at least one medical condition, with asthma being the most prevalent. Hypertension (HTN), diabetes mellitus (DM), and hypothyroidism/hyperthyroidism were the most common family medical conditions.
- The presence of HTN and DM in both parents suggests a genetic predisposition to metabolic and cardiovascular disorders, emphasizing the need for preventive

measures in at-risk individuals. The majority of participants reported no family history of these conditions.

Anthropometric profile of the subjects at baseline

- The study found significant differences in height and weight between male and female participants, with males having a significantly higher mean height and weight. The mean BMI of older adults was also higher than younger adults.
- The prevalence of obesity was almost equal for both genders, with a slightly higher percentage of males being obese. The younger age group had a higher proportion of underweight individuals, while the older age group had a slightly higher prevalence of overweight and underweight individuals.
- The study found that 43.90% of participants had a low risk of obesity-related complications, while 56.09% had elevated waist circumference. 67.4% had a normal waist-height ratio (WHR), while 24.6% were "Non-risk" and 72.9% were "At risk".
- Males had higher average waist circumference and hip circumference, suggesting a tendency towards central obesity.
- The waist-hip ratio was higher among females, and older adults had higher hip circumference and waist-hip ratio. Abdominal obesity increases with age, and the waist-height ratio is higher in older adults.

Body composition profile of the subjects at baseline

- The study analyzed body fat percentages and visceral fat levels in a population. High body fat was found in 28% of subjects, with extremely high fat in the majority (61.2%).

- Visceral fat was classified into normal, high, and very high, with 67.4% within the normal range and 32.6% having high levels. Skeletal muscle mass was categorized into low, normal, high, and very high.
- The prevalence of obesity was found to be high, with 36.8% of participants having normal BMI and 29.9% having normal weight obesity.
- The age group between 40-59 years had significantly higher body fat percentages, with younger adults having higher body age and higher resting metabolism.
- Females had significantly higher body fat percentages than males, with higher body age and higher resting metabolism.

Highlights from the information collectedof the subjects at baseline

The present study found a high prevalence of overall obesity and overweight among adults in Urban Vadodara. Biophysical and medical evaluations revealed a significant occurrence of health conditions, especially asthma, hypertension, and diabetes mellitus, alongside a genetic inclination towards metabolic disorders. The anthropometric assessments showed gender variations in height, weight, and body composition, where males exhibited higher average height and weight, and females had higher waist-hip ratios. There was a notable incidence of obesity, with a considerable percentage having elevated levels of body fat and visceral fat, particularly among the middle-aged population.

NORMAL WEIGHT OBESITY

Background Information and socio-economic status of NWO subjects

- The prevalence of normal weight obesity (NWO) among males was 45.93%, while females were 54.07%. . The mean age of NWO was 37.5 ±12.50 years for males and 35.9 ±11.5 years for females
- The age group was classified into four age groups: 20-29years, 30-39years, 40-49years, 50-59years.

- The majority of respondents were married, with nuclear families being the most common. The majority of respondents had a graduate or postgraduate degree, with skilled workers, shopkeepers, and market sales workers being the most common occupations.
- Most respondents were classified as lower-middle-income, with the highest income category being the lowest at 3.7%. The largest portion of respondents belonged to the lower-middle class, with 28.9% belonging to the upper-lower class and 26.7% in the upper-middle class.

Medical and family history and Biophysical Measurements of NWO subjects

- The majority of participants (66%) had normal birth weight, while 8.9% and 24.4% had LBW and 24.4% had HBW.
- The study analyzed the medical history where around 78.7% who reported at least one medical condition. Asthma was the most prevalent condition, followed by hypertension, diabetes mellitus, hypo/hyperthyroidism, and dyslipidemia.
- Nearly half of the subjects had normal blood pressure, while 52.6% had elevated blood pressure when checked. Males had significantly higher systolic and diastolic blood pressure than females, and older adults had higher systolic and diastolic blood pressure.
- A significant positive correlation was found between waist circumference, waist hip ratio, and systolic and diastolic blood pressure.

Anthropometric profile of NWO subjects

- More than two-thirds of the NWO subjects had a low risk of obesity-related complications, while 28.1% had normal-weight central obesity. Nearly one-third

of the subjects had a normal waist height ratio, while 65.2% had an elevated waist circumference. 42.9% were non-risk, while 57% were at risk.

- The gender-wise mean anthropometric profile revealed that males had significantly higher weight and height, waist circumference, hip circumference, and waist-hip ratios.
- Abdominal obesity prevalence increases with age, with younger individuals having a lower prevalence (15.9%), middle-aged individuals (36.1%), and older individuals (50-59%) having a higher likelihood of obesity.
- A significant positive correlation was found between waist circumference, waist hip ratio, waist-height, and waist hip ratio.

Body composition of NWO subjects

- A significant proportion of participants (62.2%) exhibited increased body fat, which could elevate the risk of diseases associated with obesity, while 5.9% displayed high visceral fat levels.
- The skeletal muscle analysis indicated that 68.8% of the participants had low muscle mass, with roughly one-third showing normal levels, suggesting that individuals with normal weight obesity (NWO) tend to have higher body fat percentages and lower muscle mass.
- The majority of individuals with high body fat (HF) and low body fat (VHF) are in the 20-29 age group, with 25.7% in HF and 25.2% in VHF. The proportion decreases with age, except for the 50-59 age group, where 18% is in VHF.
- Females have a slightly higher prevalence of HF than males, but the association between gender and total body fat is not statistically significant.
- High waist-height ratios are more likely to have very high fat levels. A significant positive correlation was observed between waist circumference, visceral fat percentage, and body age.

Dietary intake and habits of NWO subjects

- A significant portion (61.5%) identified as vegetarian. Most participants (42.2%) reported having breakfast 4-6 times per week, and lunch was considered the primary meal by 53.3% of those with NWO. A majority (52.6%) admitted to occasionally skipping meals due to factors such as: time constraints, busy schedules, fasting, lack of appetite, and cooking difficulties. Additionally, 63.0% reported consuming food from restaurants occasionally.
- The study analyzed the average nutritional intake of NWO participants using three 24-hour recall methods. Results showed that the average nutrient consumption on day 3 exceeded that of days 1 and 2.
- Males had a higher total energy intake compared to females. Most participants consumed between 25-50% of the Estimated Average Requirement (EAR) for all the nutrients, with total fat intake exceeding 100%. The study concluded that average fat intake as a percent EAR had a significant association with body fat percentage.
- The most frequently consumed grains were rice and whole wheat flour, followed by refined wheat and white bread. The most common fruits are apples, bananas, eggs, chicken, milk, and khoa. Refined oil is the most common cooking medium, and the most common sweetener is sugar. Snacks include biscuits, namkeen, and fruit juices. Protein supplements are not regularly consumed, and alcohol is an uncommon beverage.

Physical Activity Profile of NWO subjects

- A significant portion (48.9%) maintain moderate to high levels of physical activity, which fosters improved health and fitness. The majority of participants fell into the low-risk category for sitting time (57.1%).
- No association was found between sitting time and gender, although males exhibited considerably higher levels of physical activity than females,

highlighting a notable disparity in activity levels or greater skeletal muscle mass in males compared to females.

- A significant negative correlation was observed between body fat % with physical activity.

Physical Fitness of NWO subjects

- The majority of participants demonstrated excellent flexibility, strong cardio-respiratory endurance, but weak muscular strength and diminished muscular endurance. Nearly 14.8% of individuals chose not to participate in the muscular endurance test for personal reasons.
- Among those classified with HF, 52.6% displayed "Excellent" flexibility, while 28.1% fell into the VHF category. The VHF group is the only one that exhibited poor flexibility (0.7%).
- No correlation was found between body fat percentage and muscular strength, muscular endurance, or cardio-respiratory endurance.

Chrono nutrition profile of NWO subjects

- The majority (83.7%) of NWO participants had a fair chrono nutrition profile
- Male participants had slightly higher mean chrono nutrition profiles compared to females. Younger individuals were more likely to skip breakfast and exhibit poor meal timing.
- Most participants reported skipping breakfast 2-3 times weekly, which contradicted their assertion that they occasionally skipped meals, and 88.9% maintained a reasonable gap between their last meal and sleep onset.
- The current researchindicates that body fat percentage was significantly linked to evening eating habits and the time one eats, suggesting that consuming food late at night may lead to increased fat accumulation.

Lifestyle of NWO subjects

- The research indicates that more than half of the participants currently had insufficient sleep quality, with only 39.3% reporting good sleep.
- There was no significant statistical difference in sleep quality between those with high body fat percentages and those with very high body fat percentages. Additionally, no correlation was found between sleep quality and body fat percentage
- Moderate stress was the most frequently reported level (48.9%), with the 40-49 age group showing the highest rate (58.3%). Age plays a significant role in influencing perceived stress levels, as younger individuals tend to report higher stress compared to their older counterparts. A significant negative correlation was observed between stress and physical activity.
- The study also looked into screen timing and duration; notably, 97% of participants had screen time exceeding 2 hours after dinner, which may adversely affect sleep quality and pose potential health risks.
- Evidence of addiction was identified, with tea being the most commonly consumed item, followed by coffee, but self-reported addiction among NWO participants is lower.

Determinants of Normal weight obesity

- The study analyzed factors influencing normal weight obesity among adults, including body age, waist circumference, age, and gender. Multiple regression analysis showed that body age, waist circumference, age and gender together contributed to 80.4% of the variation in body fat percentage.
- Dietary fat, and physical activity were found to be strongly related to body fat percentage.
- Physical activity, in particular, accounted for 94% of the variation in body fat percentage, indicating a strong correlation with body fat percentage.

CONCLUSIONS

The study provided valuable insights into the prevalence of Normal Weight Obesity (NWO) and assessed the dietary and lifestyle factors associated with NWO individuals

This research emphasized the primary factors contributing to Normal Weight Obesity (NWO) and its relationship with various socio-economic, medical, anthropometric, dietary, and lifestyle variables. The occurrence of NWO was found to be somewhat higher in females compared to males, with middle-aged individuals being predominantly affected. Economic analysis indicated that the majority of individuals with NWO were situated in the lower-middle-income bracket, and a noteworthy percentage had at least one medical issue, with asthma, hypertension, and diabetes being the most prevalent.

Body composition and anthropometric evaluations revealed that while individuals maintained a normal BMI, a considerable number displayed elevated body fat levels, diminished muscle mass, and central obesity, which heightens their risk for metabolic disorders. Analysis of dietary practices indicated imbalanced macronutrient consumption, characterized by high fat intake, irregular eating patterns, and frequent meal skipping. Almost half of the participants reported engaging in moderate to high levels of physical activity, which illustrated a negative relationship between body fat percentage and physical activity, underscoring the significance of an active lifestyle in preventing NWO. Chrono nutrition and lifestyle assessments identifiedsuboptimal meal timing, late-night consumption, excessive screen time, moderate stress, and inadequate sleep quality as factors that contributed to fat accumulation and metabolic health complications. Additionally, the research revealed thatbody age, waist circumference, dietary fat consumption, and physical activity were key factors determining NWO, with physical activity exhibiting the strongest association with body fat percentage.

FUTURE RECOMMENDATIONS

- These results highlight the urgent necessity for health promotion efforts, such as enhancing diet quality, boosting physical activity, and managing stress among individuals.
- Regular evaluations of body composition alongside BMI are essential during health screenings.

- Similar research with larger sample sizes nationwide can provide a clearer picture of the actual prevalence of normal weight obesity in the country.
- Longer duration studies with dietary, physical activity and lifestyle interventions can be conducted.
- Future studies should aim for longitudinal designs with biochemical evaluations to gain a clear understanding of NWO and its long-term health consequences.

LIMITATIONS

- Due to budget constraints, no biochemical estimations were conducted to assess chrono nutrition and metabolic syndrome indicators**,** limiting the ability to establish direct physiological or metabolic links with NWO. Even secondary data for most of these subjects was unavailable as they never got these tests done owing to their normal weight status.
- In particular, due to budget constraints, employing bioelectrical impedance for body composition analysis may have drawbacks in precisely determining body fat percentage when compared to more sophisticated methods such as dual-energy X-ray absorptiometry (DEXA) scans.

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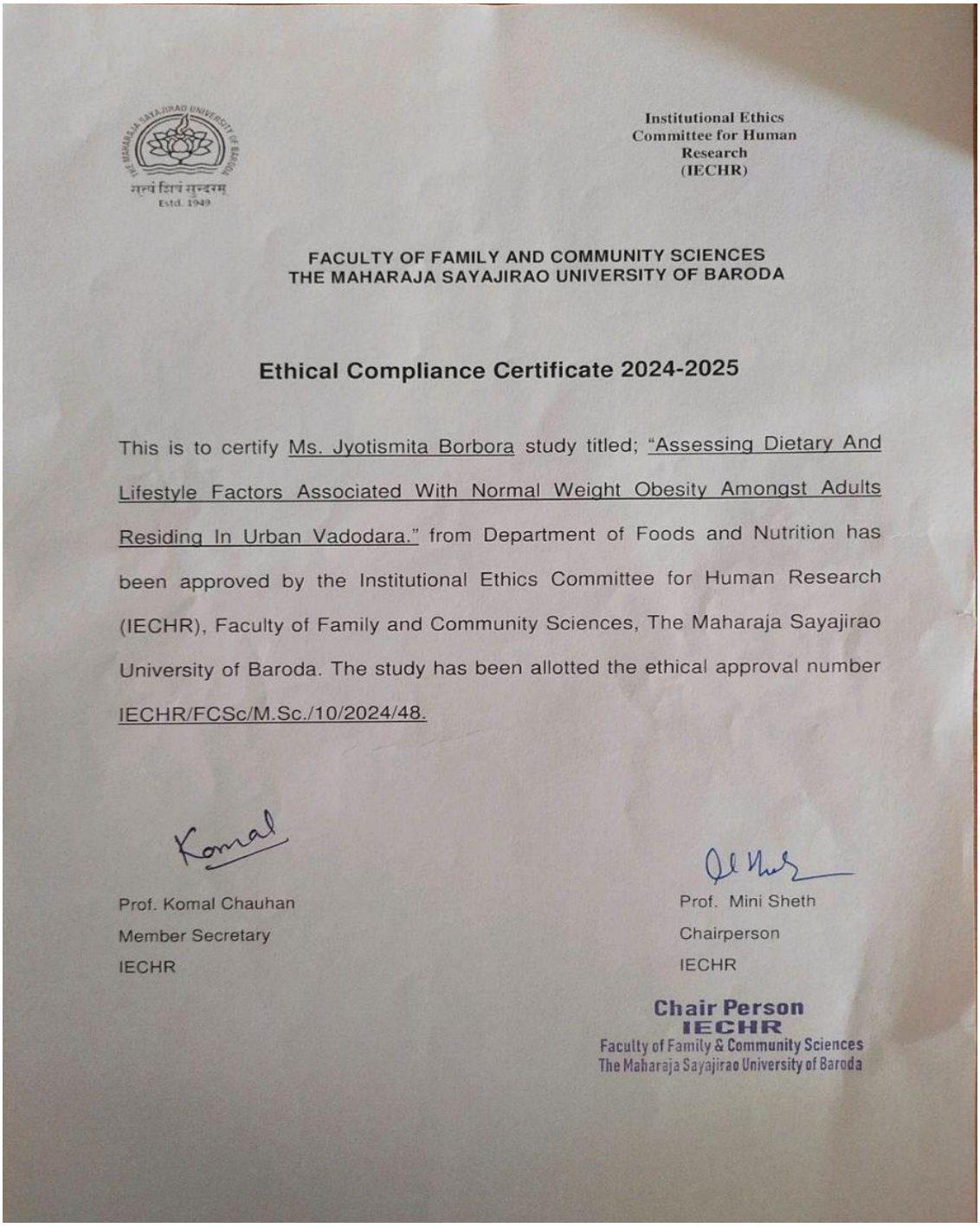
ANNEXURES

ANNEXURE I
Ethical Approval certificate



Institutional Ethics Committee for Human Research (IECHR)

FACULTY OF FAMILY AND COMMUNITY SCIENCES
THE MAHARAJA SAYAJIRAO UNIVERSITY OF BARODA

Ethical Compliance Certificate 2024-2025

This is to certify Ms. Jyotismita Borbora study titled; "Assessing Dietary And Lifestyle Factors Associated With Normal Weight Obesity Amongst Adults Residing In Urban Vadodara." from Department of Foods and Nutrition has been approved by the Institutional Ethics Committee for Human Research (IECHR), Faculty of Family and Community Sciences, The Maharaja Sayajirao University of Baroda. The study has been allotted the ethical approval number IECHR/FCSc/M.Sc./10/2024/48.

Komal

Prof. Komal Chauhan
Member Secretary
IECHR

Prof. Mini Sheth
Chairperson
IECHR

Chair Person
IECHR
Faculty of Family & Community Sciences
The Maharaja Sayajirao University of Baroda

ANNEXURE III

The Maharaja Sayajirao University of Baroda
Faculty of Family and Community Sciences
Department of Foods and Nutrition

INFORMED CONSENT FORM

To Assess Dietary and Lifestyle Factor Associated with Normal Weight Obesity Amongst Adults Residing in Urban Vadodara

I ----------have been fully informed about the purpose of study titled "**ASSESSING DIETARY AND LIFESTYLE FACTOR ASSOCIATED WITH NORMAL WEIGHT OBESITY AMONGST ADULTS RESIDING IN URBAN VADODARA"**

Dr. Vijayata Sengar
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Globally, the prevalence of chronic non-communicable diseases (NCDs) such **as** diabetes and obesity is rising at an alarming pace that underscores the urgent need to address varying obesity phenotypes, particularly Normal Weight Obesity (NWO).NWO, characterized by a normal BMI but high body fat percentage, is prevalent in South Asian populations and poses significant metabolic and cardiovascular risk factor .Despite the increasing recognition of NWO and its health implications, there is dearth scientific evidence on the dietary, lifestyle, and physical activity factors associated with this condition. Thus, this study has been planned to assess the dietary and lifestyle factors associated with normal weight obesity (NWO) among adults residing in urban Vadodara.

PROTOCOL FOR THE STUDY

If you decide to join this study, information regarding medical and family history of lifestyle diseases, details of the diet, physical fitness and lifestyle factor, will be assessed

with the help of a questionnaire. Your anthropometric measurements will be taken, body composition will be analyse and Biophysical parameters will be done by Sphygmomanometer.

COSTS

This study requires only your time and co-operation. All the costs incurred on the assessment of body composition will be borne by the researchers and there is no financial compensation for your participation in this research.

POSSIBLE BENEFITS AND RISKS

The study will help to increase scientific knowledge and we will be able to assess the dietary and lifestyle factor of adults (20-59yrs), residing at urban Vadodara. As a participant of the study, you will be given a brief report on your status.

CONFIDENTIALITY

In the study, your identity will be kept confidential. The results of the study, including anthropometric , dietary and lifestyle factor or any other data, may be published for scientific purposes but will not reveal your name or include any identifiable references to you.

RIGHT TO WITHDRAW

Your decision to join this study is voluntary. You may quit at any time, for any reason, without notice. We hope you will take part for the entire study period because we need all the information to draw correct conclusions.

VOLUNTARY CONSENT

Your co-operation is important to the success of this study. Unless many volunteers like you agree to join; this study will not be possible. In order for this study to be valid, you should not join other health studies where you would be assigned to receive a medication, special test, or special treatment.

AVAILABILITY OF RESULTS AND CONSULTATION

A copy of the record card will be provided to you for future use. If you have any questions about any part of the study or your rights as a volunteer, you can contact the investigators mentioned above.

INVESTIGATOR'S STATEMENT

I have explained the research program, the purpose of the study and the possible benefits and risks to the participant. The participant was given an opportunity to discuss these procedures and to ask any additional questions.

Signature of Investigator with date

PARTICIPANT STATEMENT

I certify that I have read, or had read to me, and that I understand the description of the study .By signing this form I am attesting that I have read and understood the information above. I give my consent to be included as a subject in the study being carried out by Dr Vijayata Sengar, and her student in The Maharaja Sayajirao University of Baroda.

I have had a chance to ask questions about the study. I understand that I may ask further questions at any time. I have been explained to my satisfaction the purpose of this clinical trial and I am also aware of my right to opt out of the study any time.

Participant name _____
Signature_____
Place: _____
Date: _____
Contact No: _____

ANNEXURE II

Questionnaire for collecting data on Socio Economic status, anthropometry, dietary intakes, physical activity and fitness, Chrono - nutrition profile etc.

SECTION 1 : BACKGROUND INFORMATION

- Name : ----------
- Age : ☐☐ Years)
- Gender 1. Male ☐ Female ☐
- Date of Birth : ----------
- Address : ----------

- Contact No: 1. ---------- 2----------
- Marital status : Unmarried ☐ married ☐
  Divorcee ☐ Widow/ widower ☐
- Type of family : Nuclear ☐ Joint ☐ Extended ☐
- Number of members in a family : ☐☐

SECTION 2: SOCIO ECONOMIC STATUS:

- What is your highest level of qualification

Professional and honors	
Graduate or post graduate	
Intermediates or diploma	
High school certificate	
Middle school certificate	
Primary school certificate	
Illiterate	

- Occupation Status :

Legislators , senior officials and managers	
Professionals	
Technical and associate professionals	
Clerks	
Skilled worked and shop and market sales workers	
Skilled agricultural and fishery workers	
Crafts and related trade workers	
Plant and machine operator and assemblers	
Elementary occupations	
Unemployed	

- Family Income per month :

2,13,814 and above	
1,06,850-2,13,813	
80,110-1,06,849	
53,361-80,109	
31,978-53,360	
10,703-31,977	
≤10,702	

- Socio economic status :

Upper (I)	
Upper middle(II)	
Lower middle (III)	
Upper lower (IV)	
Lower (V)	

SECTION 3: MEDICAL AND FAMILY HISTORY

- Do you suffer from any one of the following **(Please tick)**

Hypertension	
Hypo/ Hyperthyroidism	
Dyslipidaemia	
Diabetes mellitus (type I and II)	
PCOS/PCOD	
Metabolic Dysfunction associated steatotic liver disease	
Any other (specify)	

Family history (Please tick)

Type	Mother (1)	Father (2)	Sibling (3)	Grandparents (4)
Hypertension				
Hypo/ Hyperthyroidism				
Hyperlipidaemia				
Diabetes mellitus (type I and II)				
Stroke				
Asthma				
CHD				
Cancer				
Others (specify)				

- Birth-weight ≤2.5kgs ☐ 2.5-3.0kgs ☐ ≥3.0kgs ☐
- History of any kind of allergy:
  yes ☐ No ☐

  Specify the allergy ----------
- Are you on medication presently : yes ☐ No ☐

  Specify the medication ----------
- Any kind of dietary supplementation yes ☐ No ☐

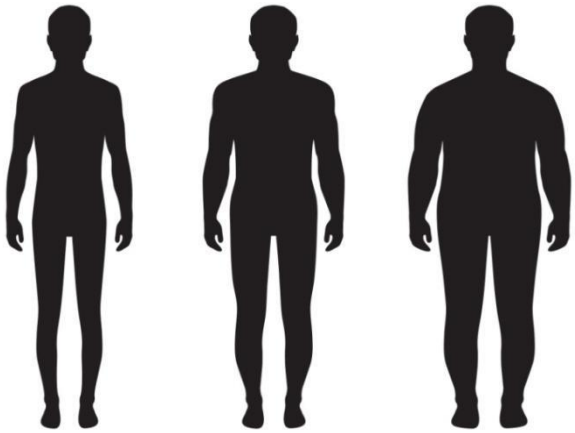
  Specify the dietary supplement ----------

SECTION 4: ANTHROPOMETRY:

Parameters	Values
Weight (kgs)	
Height (cm)	
BMI(kgs/m^2)	
Waist circumference (cm)	
Hip circumference(cm)	
Waist / Hip ratio	
Waist / height ratio	
Body fat %	
Skeletal muscle %	
Visceral Fat %	
Subcutaneous fat %	
Sub WB%_____, T_____, A_____, L_____ Skel WB %_____, T_____, A_____, L_____	
Resting metabolism	

- **SELF- PERCEPTION:**

Choose from the following any one body type that you feel suits your body image:



☐ ☐ ☐

SECTION 5: PHYSICAL FITNESS

	Fitness test	**Details/ Score**
Cardio-respiratory	**Harvard step test (**(Brouha et al.,1943)	
Flexibility	**Sit and reach test** (Donatella D, 1990)	
Muscular Endurance	**Sit –up test (**Diener M,1995)	
Muscular strength	**Handgrip Dynamometer** (Luna-Heredia E, 2005)	

SECTION 6: BIOPHYSICAL MEASUREMENT:

- Blood pressure
- Systolic BP(mmHg)---------- Diastolic BP (mmHg)----------

SECTION 7: DIETARY PRACTICES

- Dietary Habit

  Vegetarian ☐ Non-vegetarian ☐ Ovo-Vegetarian ☐
- How Many times a day do you eat?

  <2times ☐ 2-3 times ☐ > 3times ☐
- How many days a week you consume breakfast?

  Daily ☐ 4-6days ☐ < 3days ☐ Never ☐
- How often you skip meal?

  Daily ☐ often ☐ sometimes ☐ rarely ☐ never ☐
- Reasons for skipping meal

1. Lack of time /too busy
2. Lack of appetite / not hungry
3. Inability to cook
4. Fasting

- What meal do you consider the main meal of the day?
  Breakfast ☐ lunch ☐ dinner ☐
- Where you consume meal mostly?
  Homemade ☐ canteen / cafeteria ☐ restaurant ☐ street ☐ food
- How often you eat outside/restaurant food?
  Daily ☐ often ☐ ometimes ☐ rarely ☐ never ☐
- How many litres of water do you consume per day?
  < 1 litre ☐ 2-3litre ☐ >3 litre ☐
- How often you have cravings for food?
  Daily ☐ often ☐ sometimes ☐ rarely ☐ never ☐
- What type of food do you crave food?
  Sweet ☐ Savory ☐ spicy ☐ other ☐
- At what time of the day do you generally have cravings
  Morning ☐ Midmorning ☐ Evening ☐ late night ☐
- What according to you is healthy?
  Bhajiya ☐ chikki ☐ SevMumra ☐
- How would you rate your diet?
  Excellent ☐ good ☐ fair ☐ poor ☐

24 HOUR DIETARY RECALL (2WORKDAY + 1FREE DAY)

Meal time	Name of the food stuff	Ingredients	Raw amt. used for Family (gm) [A]	Cooked vol. for Family (ml)[B]	Vol. consumed by subject (ml)[C]	Raw amt. consumed by subject [D] D=A×C/B
Morning						
Mid Morning						
Lunch						
Evening Tea						
Dinner						

FOOD FREQUENCY QUESTIONNAIRE

Food items	Daily	2 times /week	3 times / week	4 times /week	Once / week	Once/ fortnight	Once / month	Occasionally	Never
Cereal and millet									
Rice (puffed)									
Rice (flakes)									
Rice (parboiled , milled)									
Rice , raw milled									
Wheat flour (whole)									
Wheat (refined)									
Wheat Bread (white)									
Wheat bread (brown)									
Semolina									
Bajra									
Jowar									
Ragi									
Maize									
Legumes									
Bengal gram (dal and whole)									
Black gram (whole and dal)									
Pigeon pea									

Green gram (whole and dal)									
Peas (dry and fresh)									
Lentil									
Rajmah									
Soyabean									
Green leafy Vegetable									
Amaranth									
Cabbage									
Colocasia leaves									
Fenugreek leaves									
Spinach									
Mustard leaves									
Mint									
Other vegetables									
Bitter Gourd									
Brinjal									
Cauliflower									
Ladies finger									
Bottle gourd									
Cucumber									
French beans									
capsicum									

Roots and Tubers									
Potato									
Carrot									
Onion									
Radish									
Beetroot									
Fruits									
Apple									
Banana									
Orange									
Mango									
Papaya									
Grapes									
Muskmelon									
Berries									
Milk and milk products									
Milk									
Curd									
Khoa									
Paneer									
Flesh foods and egg									
Egg									

Chicken									
Fish									
Beef									
Prawns									
Nuts and oilseed									
Refined oil									
Cold pressed oil									
Ghee									
Butter									
Groundnut									
Sesame seed									
Almonds									
Cashew									
Raisins									
Walnuts									
Sugar and salt									
Sugar									
Jaggery									
Honey									
Salt (crystal or iodized salt									
Ultra-processed food /Processed Food									
Puff									

Samosa /kachori									
Vadapav									
Frankie									
Panipuri									
Khakra									
Gathiya									
Sev mumra									
Papdi									
Chivda									
Chaat									
Dabeli									
Carbonated drinks									
Sweetened beverage									
Sweets									
Ice-cream									
Chocolate									
Tea/ Coffee									
Cakes / pastries									
Fruit juices									
Ketchups									
Alcoholic beverages									
Biscuits									

Bakery items									
Namkeen									
Pickles									
Whey protein									
Whey isolate									
Whey concentrate									
Casein protein									
Protein hydrosylate									
Soy protein									
Rice protein									

SECTION 8: CHRONO-NUTRITION PROFILE (Engwall, A. C. 2018)

		Scoring (cut-off)	**POINTS**
Eating Window	Duration between first eating event and last eating event	>14:00 hrs. 12:00 to 14:00 hrs. ≤12:00 hrs.	
Breakfast skipping	Frequency of breakfast skipping	≥4days/ week 2-3days /week 1day/week or less	
Evening latency	Duration between last eating event and sleep onset	≤2:00 hrs. 2:01 to 6:00 hrs. >6:00 hrs.	
Evening eating	Risk of eating late in the waking day	≥23:00 hrs. 20:00 to 22:59 hrs. <20:00hrs.	
Night eating	Frequency of night eating	≥4days/ week 2-3days /week 1day/week or less	
Largest meal	Meals in which largest amount is eaten	Dinner / supper Lunch Breakfast	

- **SECTION 9: PHYSICAL ACTIVITY :Global Physical Activity Questionnaire (WHO, 2002)**

Physical Activity		
Please answer these questions even if you do not consider yourself to be a physically active person.		
Question	Response	Code
Activities at Work		
Does your work involve vigorous-intensity activity that causes large increases in breathing or heart rate like [carrying or lifting heavy loads, digging or construction work] for at least 10 minutes continuously?	Yes 1 No 2 If No, go to P 4	P1
In a typical week, on how many days do you do vigorous- intensity activities as part of your work?	Number of days ⌊__⌋	P2
How much time do you spend doing vigorous-intensity activities at work on a typical day?	Hours : minutes ⌊__⌋⌊__⌋ : ⌊__⌋⌊__⌋ hrs mins	P3 (a-b)

Does your work involve moderate-intensity activity, that causes small increases in breathing or heart rate such as brisk walking [or carrying light loads] for at least 10 minutes continuously?	Yes 1 No 2 If No, go to P 7	P4
In a typical week, on how many days do you do moderate- intensity activities as part of your work?	Number of days ⌊__⌋	P5
How much time do you spend doing moderate-intensity activities at work on a typical day?	Hours : minutes ⌊__⌋⌊__⌋ : ⌊__⌋⌊__⌋ hrs mins	P6 (a-b)
Travel to and from places		
The next questions exclude the physical activities at work that you have already mentioned. Now I would like to ask you about the usual way you travel to and from places. For example to work, for shopping, to market, to place of worship. [Insert other examples if needed]		
Do you walk or use a bicycle (pedal cycle) for at least 10 minutes continuously to get to and from places?	Yes 1 No 2 If No, go to P 10	P7
In a typical week, on how many days do you walk or bicycle for at least 10 minutes continuously to get to and from places?	Number of days ⌊__⌋	P8
How much time do you spend walking or bicycling for travel on a typical day?	Hours : minutes ⌊__⌋⌊__⌋ : ⌊__⌋⌊__⌋ hrs mins	P9 (a-b)
Physical Activity, Continued		
Question	Response	Code
Recreational activities		
The next questions exclude the work and transport activities that you have already mentioned. Now I would like to ask you about sports, fitness and recreational activities (leisure).		
Do you do any vigorous-intensity sports, fitness or recreational (leisure) activities that cause large increases in breathing or heart rate like [running or football] for at least 10 minutes continuously?	Yes 1 No 2 If No, go to P 13	P10

In a typical week, on how many days do you do vigorous- intensity sports, fitness or recreational (leisure) activities?	Number of days ⌊__⌋	P11
How much time do you spend doing vigorous-intensity sports, fitness or recreational activities on a typical day?	Hours : minutes ⌊__⌋⌊__⌋ : ⌊__⌋⌊__⌋ hrs mins	P12 (a-b)
Do you do any moderate-intensity sports, fitness or recreational (leisure) activities that cause a small increase in breathing or heart rate such as brisk walking, [cycling, swimming, volleyball] for at least 10 minutes continuously?	Yes 1 No 2 If No, go to P16	P13
In a typical week, on how many days do you do moderate- intensity sports, fitness or recreational (leisure) activities?	Number of days ⌊__⌋	P14
How much time do you spend doing moderate-intensity sports, fitness or recreational (leisure) activities on a typical day?	Hours : minutes ⌊__⌋⌊__⌋ : ⌊__⌋⌊__⌋ hrs mins	P15 (a-b)
Sedentary behaviour		
The following question is about sitting or reclining at work, at home, getting to and from places, or with friends including time spent sitting at a desk, sitting with friends, traveling in car, bus, train, reading, playing cards or watching television, but do not include time spent sleeping.		
How much time do you usually spend sitting or reclining on a typical day?	Hours : minutes ⌊__⌋⌊__⌋ : ⌊__⌋⌊__⌋ hrs mins	P16 (a-b)

SECTION 10: LIFESTYLE PRACTICES:

- **ADDICTION PATTERN :**

Product	**Frequency (present)**	**Frequency (past)**	**Reason for quitting**
Alcohol			
Cigarette/bidi			
Tobacco/gutka			
Pan masala			
snuff			
Tea			

Coffee			
Other (specify)			

- **STRESSPATTERN: (**Cohen S ,1983)

Please tick the option that is applicable to you:

0 - never 1 - almost never 2 - sometimes 3 - fairly often 4 - very often

1	In the last month, how often have you been upset because of something that happened unexpectedly?	**0**	**1**	**2**	**3**	**4**
2	In the last month, how often have you felt that you were unable to control the important things in your life?	**0**	**1**	**2**	**3**	**4**
3	. In the last month, how often have you felt nervous and stressed?	**0**	**1**	**2**	**3**	**4**
4	In the last month, how often have you felt confident about your ability to handle your personal problems?	**0**	**1**	**2**	**3**	**4**
5	In the last month, how often have you felt that things were going your way?	**0**	**1**	**2**	**3**	**4**
6	In the last month, how often have you found that you could not cope with all the things that you had to do?	**0**	**1**	**2**	**3**	**4**
7	In the last month, how often have you been able to control irritations in your life?	**0**	**1**	**2**	**3**	**4**
8	In the last month, how often have you felt that you were on top of things?	**0**	**1**	**2**	**3**	**4**
9	In the last month, how often have you been angered because of things that happened that were outside of your control?	**0**	**1**	**2**	**3**	**4**
10	In the last month, how often have you felt difficulties were piling up so high that you could not overcome them?	**0**	**1**	**2**	**3**	**4**

- **SLEEP PATTERN (**Pittsburgh Sleep Quality Index (PSQI), Buysse D , 1989)

The following questions relate to your usual sleep habits during the past month only. Your answers should indicate the most accurate reply for the majority of days and nights in the past month. Please answer all questions.

1. **During the past month, when have you usually gone to bed at night?**
   Usual bedtime ----------
2. **During the past month, how long (in minutes) has it usually takes you to fall asleep each night?**
   Number of minutes----------
3. **During the past month, when have you usually gotten up in the morning?**
   Usual getting up time----------
4. **During the past month, how many hours of actual sleep did you get at night? (This may be different from the number of hours you spend in bed.)**

Hours or sleep per night ----------

5. During the past month, how often have you had Not during Less than Once or Three or more trouble sleeping because you...	Not during the past month	Less than once a week	Once or twice a week	Three or more times a week
a) Cannot get to sleep within 30 minutes				
b) Wake up in the middle of the night or early morning				
c) Have to get up to use the bathroom				
d) Cannot breathe comfortably				
e) Cough or snore loudly				
f) Feel too cold				
g) Feel too hot				
h) Have bad dreams				
i) Have pain				
Other reason(s), please describe:				
6. During the past month, how often have you taken medicine to help you sleep (prescribed or "over the counter")?				
7. During the past month, how often have you had trouble staying awake while driving, eating meals, or engaging in social activity				

	No Problem at all	Only a very slight problem	Somewhat of a problem	A very big problem
8. During the past month, how much of a problem has it been for you to keep up enough enthusiasm to get things done?				
	Very good	Fairly good	Fairly bad	Very bad
9. During the past month, how would you rate your sleep quality overall?				
	No bed partner or roommate	Partner or roommate in other room	Partner in same room but not same bed	Partner in same bed
10. Do you have a bed partner or roommate?				
	Not during the past month	Less than once a week	Once or twice a week	Three or more times a week
If you have a roommate or bed partner, ask him/her how often in the past month you have had:				
a. Loud snoring				
b. Long pauses between breaths while asleep				
. Legs twitching or jerking while you sleep				
d. Episodes of disorientation or confusion during sleep				

e. Other restlessness while you sleep, please describe				

- **SCREEN TIME**

a. Screen time (TV/laptop/ social media) post dinner ----------pm

b. Duration of screen time :

1.< ½ hours / day	
2. ½ -1 hour/day	
3. 1-2 hours/day	
4. >2 hours/day	