CHAPTER 2

REVIEW OF LITERATURE

The review of literature pertaining to the research study titled “Impact of lifestyle interventions on nutritional status, physical activity and sleep pattern of overweight and obese 18-25 year old women during Covid-19” are presented within the following headings:

2.1 Concepts of health and healthy populations

2.1.1 Current scenario of global health

2.1.2 Causes of global mortality

2.2 Current definitions and prevalence of overnutrition

2.2.1 Defining overnutrition, overweight and obesity

2.2.2 Prevalence of overnutrition in the World, Nation and State

2.3 Aetiology of overnutrition

2.3.1 Genetic causes of obesity

2.3.2 Environmental causes of obesity

2.3.3 Gene-Environment Interactions as causes of obesity

2.4 Indicators of overnutrition

2.5 Health complications of overnutrition

2.6 Current methods to assess overnutrition

2.7 Current methods to manage overweight and obesity

2.7.1 Surgery methods

2.7.2 Clinical treatment methods

2.7.3 Lifestyle management methods

2.8 Research gap in existing literature

2.1 Concepts of health and healthy populations

The health of all people is fundamental to achieving peace and security and depends on the full cooperation of individuals (WHO, 2023). As per the Constitution of the World Health Organization, “health” refers to a state of complete physical, mental and social well-being and does not simply mean the absence of disease or infirmity (WHO, 1948). Bircher (2005) attempted to redefine this definition as “a dynamic state of well-being characterised by physical, mental and social potential that meets the demands of life according to age, culture and personal responsibilities.” As time passed by, and the WHO’s definition of health as complete wellbeing no longer fit its purpose due to the rise of chronic diseases, it was also defined as the “ability to adapt and to lead oneself in the presence of social, physical and emotional challenges” (Sartorius, 2006; Huber *et al*., 2011). Oleribe *et al.* (2018) insisted on a new definition of health as “a satisfactory and acceptable state of physical (biological), mental (intellectual), emotional (psychological), economic (financial), and social (societal) wellbeing”. Apart from this one, three ways of defining health seem to be considered and used. First of all, health is the absence of disease or disability. Secondly, health is a state in which an individual can adequately cope with all the demands of daily life (this also means the absence of disease and functional impairment). The third definition states that health is a state of balance, the balance that an individual establishes within himself and between himself and his social and physical environment (Leak *et al.*, 2018; Bircher, 2020; Van Druten, 2022). However, a recent study has argued that the WHO’s 1948 definition still holds true, stating that even though there are two different approaches to understand the definition, namely a perfectionist approach and a holistic approach, they are very much valid and can be used in relevant dimensions (Schramme, 2023).

Population health refers to health outcomes and health determinants in groups at the local, regional, national, and/or global levels. The biological, behavioural, social, environmental, political, and other factors that influence the health status of individuals and populations are referred to as health determinants (Jacobsen, 2022).

In public health, healthy populations are defined as “groups of people within a community or society who have access to the necessary resources and conditions that promote and protect their physical and mental health” (Institute of Medicine, 1988). This definition emphasises the importance of preventive measures, health equity, and the social determinants of health in maintaining the health of a population. From an epidemiological standpoint, healthy populations are those in which the prevalence of diseases and health conditions is at a manageable level, and where factors contributing to disease transmission are under control. In this context, health is often measured by the incidence and prevalence rates of specific diseases and risk factors within a population (Rothman *et al.*, 2008). Healthy populations, in the context of healthcare systems, are groups of patients or individuals who receive appropriate and timely healthcare services to prevent, diagnose, and manage diseases and conditions effectively which highlights the role of healthcare services and medical interventions in maintaining population health (Shi & Singh, 2015). Healthy populations can also be defined from an environmental health perspective as communities or groups of people living in environments that are free from harmful pollutants, toxins, and hazards, thereby reducing the risk of environmentally-induced health problems (Frumkin, 2016). In terms of social determinants of health, which encompass the economic, social, and environmental conditions that shape health outcomes, healthy populations are those where there is a reduction in health inequalities and disparities (Marmot & Wilkinson, 2020).

Thus, a healthy population is a broad and multifaceted concept that can be defined from various perspectives, depending on the context and the goals of public health and healthcare interventions, reflecting the multidimensional nature of health and the various factors that influence it within communities and societies. Effectively understanding these definitions may help in formulating policies aimed at a sustainable, healthy future.

2.1.1 Current scenario of global health

Global health is “a field of academic study, research and applied practice that seeks to improve population health worldwide” (Jacobsen, 2022). In an article that analytically reviewed the definitions of global health over an 11-year period,

the majority of the definitions were based on one of four major themes: an interdisciplinary approach to improving global health that is taught and pursued by research institutions; a humanitarian action which is governed by justice principles; an arrangement of governance that results in national, international, translational and multi-national impact through political decision-making, recognising problems, allocation and exchange of resources transcending borders through multi-faceted approaches (Salm *et al.*, 2021). While some global health projects concentrate on issues that primarily impact individuals in low-income nations, the majority aim to solve complex transnational issues that touch or could potentially affect people everywhere. In order to improve population and environmental health in nations and communities around the world, global health practitioners use tools from public health, medicine, environmental science, the social sciences, engineering, law, and other professions. Similarly, global health researchers examine the many socio-economic, environmental, political, and other factors that contribute to health and well-being from a holistic perspective. Global health initiatives improve health at the population level, starting from the individual because the general state of the community's health also improves along with an individual's health outcome (Jacobsen, 2022).

This is precisely why the Sustainable Development Goals (SDGs) for 2030 were formed way back in 2015, by the United Nations. The SDGs are unique in that they call for action by all countries, poor, rich and middle-income to promote prosperity while protecting the planet. They recognize that ending poverty must go hand-in-hand with strategies that build economic growth and addresses a range of social needs including education, health, social protection, and job opportunities, while tackling climate change and environmental protection (The UN, 2023). To put it simply, they aim to transform the World. They are a call to action to end poverty and inequality, protect the planet, and ensure that all people enjoy health, justice and prosperity, all while ensuring that no individual gets left behind (WHO, 2023). The third SDG is committed to focus on ensuring healthy lives and promoting well-being for all at all ages, and as a result, according to the United Nations, millions of people's health has improved and significant progress has been made in extending life expectancy and decreasing some of the leading causes of infant and maternal death. However, additional effort is required to

entirely eradicate a variety of diseases and deal with a variety of ongoing and emergent health problems (The UN, 2023). In their publication that focused on identifying transformative health systems towards achievement of the SDGs in 67 low-income and middle-income countries, Stenberg *et al.* (2017) proposed that to meet the SDG 3 health goals, all nations will need to increase their spending in health systems and broaden service delivery, although even the most underdeveloped nations may achieve some degree of universality. Due to projected resource limitations, each nation will need to prioritize fairly, plan wisely, and budget sensibly in order to achieve SDG 3 and universal health care.

Another publication that reported the current issues and challenges to global health, noted that increased population, ageing, which is currently more concerned with quantity than quality of life, persistent food problems, and a shortage of safe drinking water puts a combined strain on the resources that humanity must utilize, to a breaking point. With the help of non-governmental organizations, developed countries must assume the initiative in educating underdeveloped countries and entities about implementing sustainable practices that will help control the various challenges to global health with a long-term perspective on removing these obstacles. According to the article, investments must be made in birth control methods, sustainable farming practices, the provision of microloans to access money, and the harvesting of clean water. It further mentions that a combination of individual will and institutional (government or private) funding would be needed to address the expanding issues that affect global health as long as access to resources remains limited and only available to the wealthy, which in turn would only increase the likelihood of a global calamity (Kuriakose, 2020).

For this, it is necessary to think more clearly about what is meant when the term ‘low-resource settings’ are used in global health research and practice. In fact, it is this thought that Van Zyl *et al.* (2021) elaborates in their BMJ Global Health publication. According to them, the transmission of knowledge and understanding between low-resource settings in high-income nations and low-resource settings in low-income and middle-income countries may be constrained by the fact that "low-resource settings" roughly translates to "low-income and

middle-income countries". In other words, instead of umbrella terms and framings such as low-resource setting or high-income, middle-income and low-income countries, research should be specific about why and how a setting is low-resource and along which dimension. They defined the dimensions of being a low-resource setting as including but not limited to financial constraints, inadequate service provisions, fragile physical and intellectual infrastructure, historical and social foundations, geographic and environmental barriers, and human resource limitations. Thus, according to Garcia-Basteiro & Abimbola (2021), a top priority for global health research needs to consist of studies on how to change the structural determinants of health or poverty, get the right interventions in place or understand why they are not in place and strengthen health systems across all socio-economic categories of countries.

However, this proceeds to be a challenge especially, in light of the recent Covid-19 pandemic and other infectious public health concerns that pose a significant threat to the public health and global economy. In a research article that elaborated on the top ten public health challenges to track of in the post-covid era, it was noted that apart from the Covid-19 pandemic, inadequate human resources for health, poor health systems financing, conflict and humanitarian crises, mental health, poverty, climate change, child-health-associated challenges, deteriorating reproductive health issues, and the ‘infodemic’ (too much information including false or misleading information in digital and physical environments during a disease outbreak) were listed as possible contributors of rapidly emerging threats to public health security and a deterioration in global economy. Suggestions made by the authors in this regard included strengthening the degree of international cooperation, solidarity, and support as well as implementing country-compatible and tailored strategies to respond adequately to these public health challenges (Lucero-Prisno *et al.*, 2021). Another publication in The Lancet Global Health argues that while several international initiatives have been developed to strengthen and reform the global architecture for pandemic preparedness and response, including proposals for a pandemic treaty, a pandemic fund, and mechanisms for equitable access to medical countermeasures, there has been insufficient consideration of the vital role of universal health coverage in sustainably mitigating outbreaks, and the importance of robust primary health care

in equitably and efficiently safeguarding communities from future health threats. Hence, in order to ensure fairness in all responses and preparedness initiatives, it was advised that a high-level political pledge to health systems, mediated through successful healthcare diplomacy as well as inclusive worldwide leadership, as crucial (Lal *et al.*, 2022). Faghy *et al.*, (2022) in their publication also proposed that formulating a universal definition, incorporating the lived experience (personal knowledge gained through direct, first-hand involvement in everyday events rather than through constructed representations), the need to increase awareness and sustained support for research, would leave lasting impacts on social and economic activities to be considered in the management of global health crises.

2.1.2 Causes of global mortality

Global mortality, estimated total number of deaths in a population of a given sex and/or age, divided by the total number of this population, expressed per 100,000 population, for a given year, in a given country, territory, or geographic area i.e., the rate at which people die across the world, is a critical indicator of the overall health and well-being of populations. Understanding the causes of global mortality is essential for public health planning, policy development, and intervention strategies (WHO, 2023). In this section, the most prevalent causes of global mortality including infectious and non-communicable diseases, and other factors such as maternal and child mortality rates, injuries and accidents, environmental factors, inaccessibility to quality healthcare, and socio-economic inequalities are briefly discussed.

Infectious diseases have historically been a leading cause of global mortality. Despite significant advances in medicine and vaccinations, infectious diseases such as human immunodeficiency virus infection or acquired immune deficiency syndrome (HIV / AIDS), malaria, tuberculosis, and respiratory infections continue to claim lives worldwide. These diseases often disproportionately affect low-income countries due to limited access to healthcare, sanitation, and education. For instance, in sub-Saharan Africa, HIV/AIDS remains a significant contributor to mortality (UNAIDS, 2020). Non-communicable diseases (NCDs) have emerged as a dominant cause of global mortality in recent decades. NCDs encompass chronic conditions like cardiovascular diseases, cancer, diabetes, and

chronic respiratory diseases. Lifestyle factors, including poor diet, lack of physical activity, and tobacco and alcohol consumption, play a substantial role in the prevalence of NCDs (WHO, 2021). Additionally, these diseases are now affecting individuals at younger ages, posing a significant public health challenge for the future generations. Maternal and child mortality rates remain high in many parts of the world, primarily in low-income countries. Complications during pregnancy and childbirth, inadequate access to prenatal care, and insufficient healthcare infrastructure contribute to maternal mortality (World Bank, 2021). Similarly, child mortality is influenced by factors such as malnutrition, lack of clean water, and limited accessibility to immunizations (UNICEF, 2020). Injuries and accidents, including road traffic accidents, workplace accidents, and interpersonal violence, are another critical contributor to global mortality. These incidents often result from a combination of factors, including inadequate safety regulations, risk-taking behaviours, and limited access to emergency healthcare. The burden of injuries disproportionately affects young adults (WHO, 2018). Environmental factors, such as air pollution and climate change, have increasingly become significant contributors to global mortality. Poor air quality is associated with respiratory diseases and cardiovascular problems, leading to premature deaths (WHO, 2018). Climate change also exacerbates existing health challenges, including heat-related illnesses, the spread of vector-borne diseases, and disruptions to food and water supplies (Watts *et al*., 2019). Limited access to healthcare services is a pervasive issue in many parts of the world. Lack of healthcare infrastructure, trained personnel, and financial barriers prevent millions from receiving essential medical care. This leads to delayed diagnosis and treatment, resulting in increased mortality rates (WHO, 2020). Socio-economic disparities play a crucial role in determining mortality rates. People living in poverty often face a higher risk of mortality due to limited access to education, nutritious food, clean water, and healthcare services. These inequalities are evident both within and between countries (Marmot *et al*., 2020).

Therefore, addressing the multifaceted causes of global mortality requires a comprehensive approach that includes improving healthcare infrastructure, promoting healthy lifestyles, addressing social determinants of health, and addressing the global challenges posed by infectious diseases and environmental

factors. Collaboration among governments, international organizations, and the civil society is essential to reduce global mortality and may improve the well-being of populations worldwide.

2.2 Current definitions and prevalence of overnutrition

2.2.1 Defining overnutrition, overweight and obesity

Obesity is defined as a complex, multi-factorial, preventable and chronic disease process occurring due to frequent abnormal fat accumulation that poses a risk to or impairs health (Hruby & Hu, 2015; Frühbeck *et al.*, 2019; WHO, 2022). Obesity, often results due to positive energy balance occurring repeatedly. The excess energy is then converted into triglycerides, stored in adipose cells that enlarge in size, eventually increasing body fat resulting in weight gain. Evidence suggests that all physiological functions of the body are affected by obesity, cementing the belief that it is a "significant public health threat". Obesity not only elevates the risks for multiple disease conditions but also negatively affects the healthcare costs, work productivity and ultimately the quality of life (Tranæs *et al.*, 2021). Organizations such as the World Obesity Federation, the Medical Associations of America, Canada and others, declared obesity as a distinctly progressive, chronic disease which is now more than just a risk factor by considering the homeostatic mechanisms hindering weight loss and its maintenance as part of the pathophysiology in obese people is the key (Blüher, 2019).

However there have been suggestions to redefine obesity due to its varied areas of effects and multiple causative factors. In 2018, a study recollected that the American Association of Clinical Endocrinologists and American College of Endocrinology reached a conclusion for a "more medically meaningful and actionable definition" for obesity (Upadhyay *et al.*, 2018). In its review of the "International Classification of Diseases ICD-10 and revising the ICD-11 Beta Draft" the European Association for the Study of Obesity (EASO) coined obesity as ABCD as a substantial revision to defining overweight and obesity in agreement to the EASO's proposal for improving the ICD-11 criteria that diagnoses obesity on the extent of excess fat, aetiology and health risks. ABCD

indicates ‘abnormalities’ requiring treatment through the distribution, function and mass of adipose tissues i.e., the treatment of obesity as a chronic disease requires prevention and treatment for it not to get complicated (Garvey, 2022). Table 2.1 displays the number of articles obtained under each keyword as part of the initial literature review which is proof that obesity is already considered as a well-known lifestyle associated disease but currently there is an increasing need for knowledge on treating and managing obesity.

Table 2.1: Absolute Numbers of Initial Keyword Search Queries from Publisher Databases

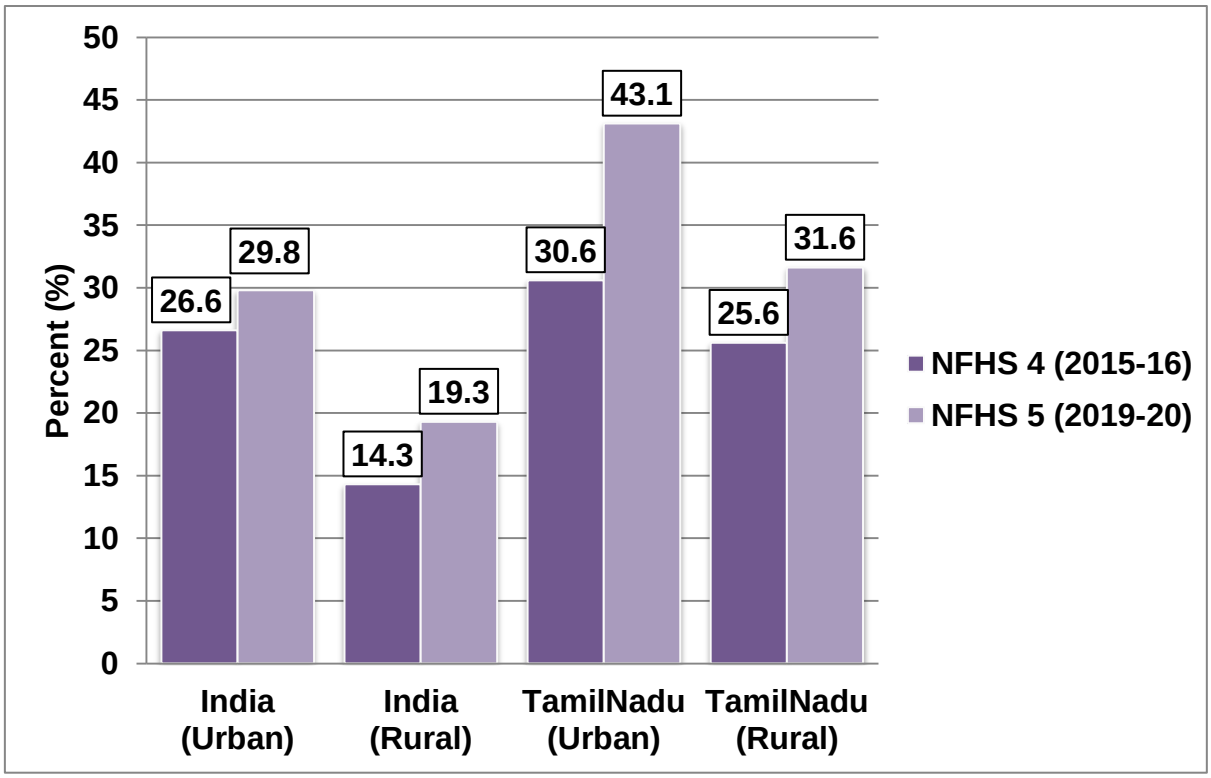
Keywords Used	Elsevier	Pub Med Central	Wiley Library	Sage Publications	Total
Treating obesity	2,89,445	1,88,237	1,99,857	50,621	7,28,160
Obesity interventions	2,13,881	2,03,795	1,11,670	34,849	5,64,195
Obesity prevalence	1,94,296	1,42,640	1,13,369	30,593	4,80,898
Obesity prevention	1,64,793	95,545	1,48,387	42,786	4,51,511
Lifestyle Obesity	1,07,285	38,289	56,571	50,621	2,20,985
Total	**9,69,700**	**6,68,506**	**6,29,854**	**1,77,329**	**24,45,389**

2.2.2 Prevalence of overnutrition in the World, Nation and State

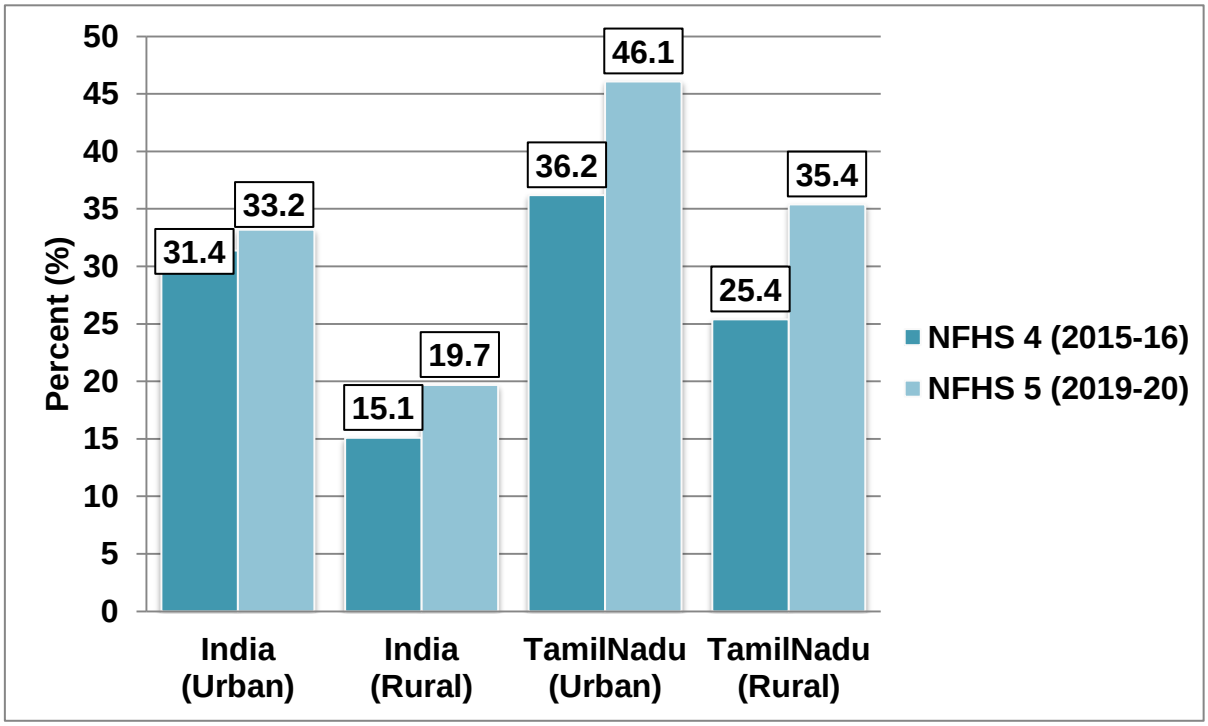
The worldwide overweight and obesity prevalence has risen by 27.5% and 47.1% for adults and children respectively from 1980 to 2013, and is still trending in developing countries thereby becoming a major health issue among adults, children and adolescents across the world (Ng *et al.*, 2014; Engin, 2017). By 2030, this trend is to be even higher with 38% of the adult population becoming overweight and 20% becoming obese (Swain & Chowdhury, 2018). Along with these increasing estimates of the last 35 years (till 2015), the prevalence was observed to be greater among women than men with increasing age and it was reported that even though there was substantial variability between countries and regions, “these trends were relatively uniform worldwide” (Cho *et al.*, 2018). Not much later, the NCD Risk Factor Collaboration investigators reported an accelerated rise in the regional difference in the body mass index (BMI) particularly from south Asia which showed that obesity rates had increased to pandemic levels (Dong *et al.*, 2020). However, when delving into the population

factsheets of developing nations currently facing public health issues of both under and over nutrition, a disparity between the states and sexes is visible. For instance, in 2017 the highest percentage of Indian women with overweight or obesity was 41.4% (a Northern state) while the lowest was 10.3% (a South-Eastern state). Among men, 38.2% (islands in the South) was the highest while 10% (a North-Eastern state) was the lowest. This pattern was repeated in 2021 where 46.2% (a small territory in the South) was the maximum and 11.5% (a North-Eastern state) was the minimum among women while 45.3% (islands in the South) and 13.9% (a North-Eastern state) were the upper and lower limits among men (IIPS-NFHS-4, 2017; IIPS-NFHS-5, 2021). This may also apply to other developing countries. As of 2016, overweight individuals aged 18 and above were 39% while those who were obese were 13% worldwide. Existing projections suggest that at least 16.1% of the world's population by 2025 and 17.5% by 2030 will be obese (GBDOC, 2017; WOF, 2022). Even though these projections exist, it is concerning that policy formation and accurate estimation of health concerns depend heavily on such intra- and inter-national variability. Graphs 2.1 and 2.2 shows the prevalence of Indian men and women who were overweight and obese.

Graph 2.1: Prevalence of overweight and obesity among men (2015-2021)



Graph 2.2: Prevalence of overweight and obesity among women (2015-2021)



On observing the two graphs, it can be seen that the national and state level prevalence of obesity has also risen from 18.9% in 2016 to 22.9 in 2020 and from 20.6% in 2016 to 24.0% in 2020 respectively. A much higher increase was seen in the men and women belonging from Tamil Nadu with almost eight to nine percent increase in both the genders – an 8.8% difference in men and a 9.5% difference in women (IIPS-NFHS-4, 2015-2016 and IIPS-NFHS-5, 2019-2020). As of 2016, overweight individuals aged 18 and above were 39% while those who were obese were 13% worldwide (WHO, 2022). Existing projections suggest that at least 16.1% of the world's population by 2025 and 17.5% by 2030 will be obese (GBDOC, 2017; WHO, 2022 and WOF, 2022). Even though these projections exist, it is concerning that global prevalence studies are lacking as of 2022, especially considering their importance in planning of future health policies.

2.3 Aetiology of overnutrition

In the past, approaches in explaining the high rates of overnutrition have considered a host of potential factors, namely changes in the diet composition, increased intake of calories, lowered physical activity levels as well as gut microbiome alterations.

The basic cause of obesity has been said to be the result of the energy imbalance that occurs due to differences between the consumed calories and the expended calories which creates positive energy balance leading to increased weight gain. This weight gain is also said to be caused due to the interplay between the genes, environment, individual psychosocial behaviours, socio-economic statistics and cultural influences or all of them working in combination (Apovian, 2016). Other reasons explaining the increasing obesity levels are "consumption of a rich and fatty diet, sedentary lifestyles, and urbanization" as seen in developing societies. Though the link between socio-economic status and overnutrition in developing countries is opposite to the developed ones, indications predict that the developing world's poor will eventually experience the burden of overweight or obesity along with the consequential health conditions (Kulkarini *et al.*, 2017). Obesity often carries with it an untrue and stigmatised perception which states that it is caused by the lack of willpower associated inappropriate dietary choices and physical inactivity. In 2008, the Obesity Society expert panel concluded that obesity includes factors that are beyond the control of an individual, and contributes to ill health, functional impairment, reduced quality of life, greater mortality and that successful treatment produces many benefits (Upadhyay, 2018). Studies have also mentioned that obesity is likely to result from the complex interaction between changes in the food environment, environmental and genetic factors, physical activity and socio-economic status thus making it a heterogeneous condition derived from the interactions between genes and lifestyle (Zatterale *et al.*, 2020).

Figure-2 reviews the aetiology of obesity known so far, which is detailed in the subsequent sections below.

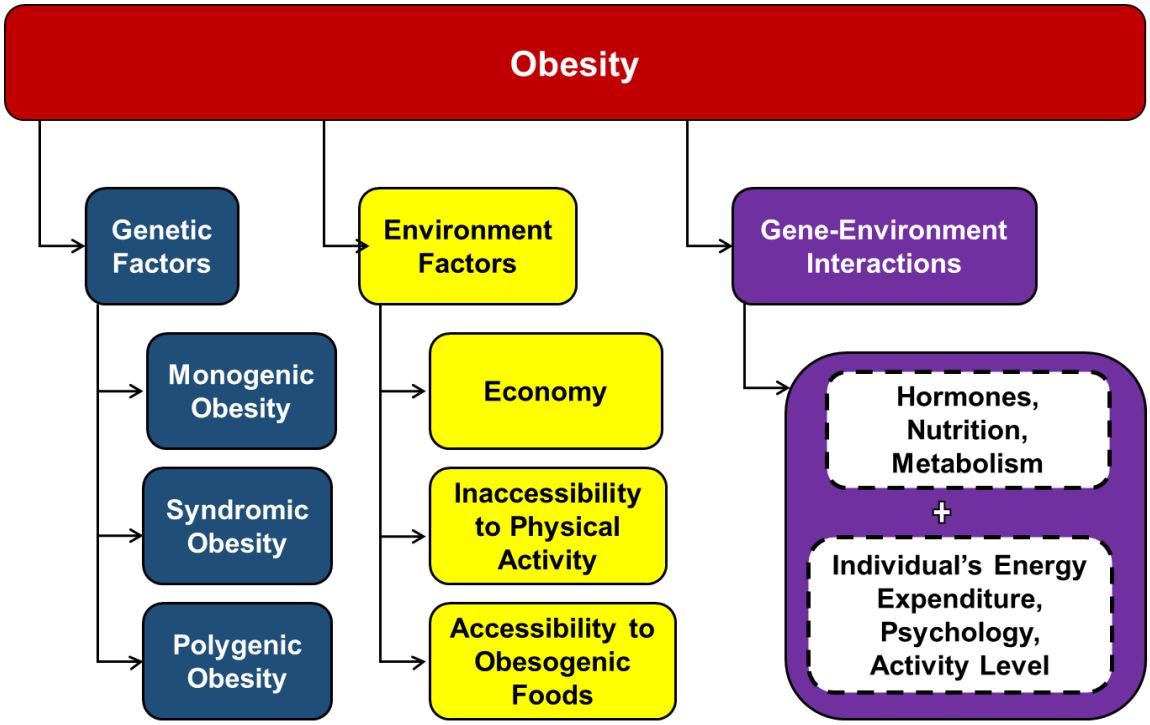


Figure 2.1: Aetiology of Obesity

2.3.1 Genetic causes of obesity

According to Albuquerque *et al.*, (2017) genetic causes of obesity have three types. Monogenic obesity caused by single gene mutations in the leptin-melanocortin pathway that often disturb the systems of appetite and weight regulation, but are not well known and don't explain even 10 percent of obesity cases that are extreme, including mutations in leptin or the leptin receptor and the melanocortin-4 receptor. The second is syndromic obesity where obesity is linked to neuro-developmental, organ or systemic malformations of which Bardet Biedl and Prader Willi are the most frequent forms. Lastly, polygenic obesity is where a large number of genes contribute to a weight-gain-promoting environment such as abundance of food and physical inactivity (Thaker, 2017). However, it has also been proven that regardless of the environment, individuals inheriting larger susceptibility gene subsets tend to be more overweight.

Food intake is regulated by hormonal and neural signals between the CNS and the gut. When understanding obesity, it becomes imperative to examine the CNS circuitry which controls the regulation and dysregulation of appetites. Hormones, including cholecystokinin (CCK), glucagon-like peptide (GLP), leptin,

oxyntomodulin (OXM) and peptide tyrosine-tyrosine (PYY) signal to the appetite control areas in the CNS. It has now been established that increased caloric intake and consequential body mass results from interactions between the CNS and the satiety hormones at the feeding centres paving the way for focussed research to identify pathways and other possible interactions for the role of genes of an individual in appetite dysregulation and associated weight gain. Research also recorded other networks including attention, cognitive control, emotion or memory and reward playing a more involved role in human appetite control. Depressed mood and anxiety are also co-morbidities of obesity and are related to central obesity in particular because emotions are also potent regulators of appetite. Stress is also known to cause appetite changes that may lead to incidence of obesity. In some affected individuals, addictive behaviour may lead to a vicious cycle of stress, body weight stigma and weight gain due to food preferences linked to the psyche and becoming attracted to foods with high calories, fat and sugar. However, due to the social stigmatization of obesity being widespread it continues in contributing to high rates of self-blaming, emotionally driven eating, anxiety, depression, and poor self-esteem. Although the causal factors of obesity include “hormonal, nutritional and metabolic factors” other contributors such as “energy expenditure, psychological factors and sedentary behaviour” should not be ignored (Blüher, 2019; Upadhyay *et al.*, 2018; Garvey, 2022).

2.3.2 Environmental causes of obesity

Physical activity is the biggest contributor to effectively expend energy. A neighbourhood with recreational spaces designated for physical activity has been related to lower incidences of physical inactivity and energy expenditure along with healthy food environments that refers to availability of fresh produce in supermarkets in comparison to convenience stores or fast-food restaurants. In the 2016 study, it was found that for every additional two hours of watching TV, an associated 23 percent increase in obesity occurred, after factors of ageing, smoking, activity levels, and diet were adjusted (Smith & Smith, 2016). World-wide increase in obesity is largely due to some already proven external factors such as dietary habit imbalances, higher consumption of foods rich in carbohydrates and fats, processed outside home, late night working hours, physical inactivity,

increased television watching and an overall sedentary way of life (Paul & Singh, 2017). In developing countries, the rise in the obesity mainly occurs due to “changes in socio-economic status and demographics” along with sedentary lifestyles plus energy and fat rich diets. Economically growing but developing countries are also going through a key change in the composition of their dietary patterns and have begun to experience the epidemic of obesity. For example, the traditional carbohydrate rich diets in India are reportedly giving way to diets high in saturated fat and sugars. Other studies have shown that in developing countries the prevalence of obesity initially increases the individuals of a higher socio-economic status and later shifting to the lower socio-economic status groups according to the nation’s changing economy. In the words of Garvey (2022), the environment can only contribute to a reversal of the prevalent obesity where there is reduced accessibility to processed foods along with measures countering physical inactivity.

2.3.3 Gene-environment interactions as causes of obesity

Interactions between the gene and the environment are jointly called epigenetics. Epigenetic modifications, which impact genetic expression without altering DNA sequence, develop through environmental interactions and are also inherited. Understanding the interplay of these elements is crucial in comprehending the aetiology of obesity and designing effective prevention and intervention strategies. Masood and Moorthy (2023) comprehensively review a host of epigenetic factors that may cause obesity. These include physical inactivity, imbalanced nutrition, the intra-uterine environment, post-natal influences, insufficient sleep, therapeutic drugs, medical conditions, socio-economic status, ethnicity, psychosocial stress, endocrine disrupting chemicals, gut microbiome, and even the approaches of healthcare professionals. Similar research suggests that other another epigenetic factor can be metabolic dysfunction while also highlighting that lifestyle changes such as physical activity and a Mediterranean diet can modify the impact of specific genetic variants such as *FTO* rs9939609 and *MC4R* rs17782313, showing how these variants contribute to the risk of obesity (Flores-Dorantes *et al.*, 2020; Kawai *et al.*, 2021). Research also indicates that stress is an important interactive factor. There are many pathways that

connect stress and obesity, two highly prevalent problems plaguing the modern society. Firstly, stress interferes with cognitive processes such as executive function and self-regulation. Second, stress can affect behaviour by inducing overeating and consumption of foods that are high in calories, fat, or sugar; by decreasing physical activity; and by shortening sleep. Third, stress triggers physiological changes in the hypothalamic-pituitary-adrenal axis, reward processing in the brain, and possibly the gut microbiome. Finally, stress can stimulate production of biochemical hormones and peptides such as leptin, ghrelin, and neuropeptide Y. Obesity itself can be a stressful state due to the high prevalence of weight associated stigma (Tomiyama, 2019; Ghosh *et al.*, 2023). Overall, while genetics predispose individuals to obesity, modifying lifestyle factors can mitigate this risk, highlighting the importance of gene-environment interactions in understanding obesity development.

2.4 Indicators of overnutrition

Obesity is a multifactorial condition influenced by genetic, environmental, and lifestyle factors. A comprehensive approach that takes into account these various indicators is crucial for the early detection and effective management of obesity, ultimately improving individual health and reducing the burden of obesity-related diseases.

a) Body mass index (BMI): BMI is widely used as a screening tool to assess obesity. It provides a simple and cost-effective measure to categorize individuals into different weight categories. However, it does not distinguish between fat and lean body mass, and it may misclassify individuals, especially athletes or older adults with muscle loss. Therefore, BMI should be used in conjunction with other indicators for a more accurate assessment of obesity (WHO, 2020).

b) Waist circumference: Waist circumference is a valuable indicator of central obesity, which is associated with a higher risk of metabolic disorders such as diabetes and cardiovascular diseases. Increased waist circumference is often considered an indicator of abdominal adiposity. The World Health Organization (WHO) recommends waist circumferences of more than 94 cm for men and 80 cm for women as indicators of increased risk (WHO, 2020).

c) Waist-to-Hip Ratio (WHR): WHR is another measure of central obesity that takes into account both waist and hip circumferences. A higher WHR indicates a greater distribution of fat in the abdominal area, which is associated with an increased risk of obesity-related health problems. A WHR above 0.90 for men and 0.85 for women is often considered indicative of central obesity (WHO, 2020).

d) Body fat percentage: Measuring body fat percentage through a body composition analysis directly provides a more accurate assessment of obesity as it considers the proportion of fat in the body. Various methods, including dual-energy X-ray absorptiometry (DEXA), bioelectrical impedance analysis (BIA), and skinfold thickness measurements, can estimate body fat percentage. A body fat percentage above the recommended ranges for age and gender is indicative of obesity (Nuttall, 2015).

e) Comorbidities and health risks: Obesity is often associated with a range of comorbidities and health risks, making them important indicators of the condition. These include type 2 diabetes, hypertension, cardiovascular diseases, sleep apnoea, certain cancers, and musculoskeletal problems. An individual with obesity who presents with one or more of these conditions may require intervention and further evaluation (Blüher, 2019).

f) Physical and functional assessments: Functional assessments, such as mobility and physical fitness tests, can provide valuable insights into the impact of obesity on an individual's daily life. Decreased mobility, impaired physical performance, and difficulties in activities of daily living can all be indicative of obesity-related limitations (Messier, 2017).

g) Family history and genetics: Family history and genetic predisposition have been reported to play a role in obesity. Hence, individuals with a family history of obesity may be at a higher risk. Genetic testing and evaluation of familial obesity patterns can be considered in assessing individual susceptibility to obesity (Loos, 2018).

h) Dietary habits and nutritional assessment: Assessing dietary habits and nutritional intake is essential in understanding the factors contributing to obesity. Poor dietary choices, high-calorie intake, and excessive consumption of

processed foods are indicators of an obesogenic lifestyle. Tools like food recall diaries and dietary assessments can help identify problematic eating patterns (Mozaffarian *et al.*, 2018).

i) Physical activity level: Physical inactivity is a major contributor to obesity. A sedentary lifestyle and low levels of physical activity can lead to weight gain and exacerbate obesity. Monitoring an individual's physical activity habits and exercise routines is crucial when assessing obesity (Bull *et al.*, 2020).

j) Psychological factors: Psychological factors, including depression, anxiety, and stress, can contribute to obesity. Emotional eating and other maladaptive behaviours may be indicators of underlying psychological issues that need to be addressed along with obesity management (Pigsborg *et al*., 2023).

k) Socio-economic and environmental factors: Socio-economic status and environmental factors can influence an individual's risk of obesity. Lower socio-economic status, limited access to healthy food options, and obesogenic environments can all contribute to obesity. Assessing these factors can help identify potential barriers to healthy weight management (Hales *et al*., 2020).

Therefore, obesity is a multi-faceted health condition with numerous indicators beyond just BMI. It is essential to consider a combination of factors, including waist circumference, body fat percentage, comorbidities, genetics, dietary habits, physical activity levels, psychological factors, and socio-economic and environmental influences, when assessing and managing obesity.

2.5 Health complications of overnutrition

The Global Burden of Disease (2013) as reported by Ng *et al.*, (2014) showed consistent risks as BMI rose above 23kg/m^2, especially for diabetes, cardiovascular diseases, cancers, chronic kidney diseases and osteoarthritis. Later research added that overweight or obesity in the middle age groups would shorten the life expectancy by nearly four to seven years by greatly increasing risks of these chronic diseases along with depression, certain cancers and disabilities (Hruby *et al.*, 2016). However, it is now seen that the extreme effect of obesity’s decrease in life expectancy is greater in younger adults than older adults.

Another study showed that an estimated five to twenty years was lost among the obese population based on how severe it was along with the co-morbidities. Other risks of morbidity among patients with excess body weight include diabetes, coronary heart disease, dyslipidaemia, hypertension, respiratory problems, stroke, gallbladder disease, osteoarthritis, sleep apnoea and cancers (Jakicic *et al.*, 2018). In an international study conducted among adults in 2017, the lowest rate of mortality was seen among overweight individuals (BMI ranged from 25 to 27.4kg/m^2) but their obese counterparts (BMI ≥ 30kg/m^2) had a significantly higher overall mortality (Kong *et al.*, 2017). In a similar study conducted a year later, BMI above or greater than 30kg/m^2 was linked to obesity driven mortality (Bhaskaran *et al.*, 2018). Therefore, obesity greatly increases the risks of metabolic diseases including diabetes, fatty liver diseases, hypertension, myocardial infarction, strokes, osteoarthritis, and certain cancers of the breasts, ovaries, prostate gland, liver, kidney or colon and the quality of life being lowered due to unemployment, lower productivity, depression and other social disadvantages. Obesity has been found to be associated with multiple lifestyles or NCDs via different pathways (Garvey, 2022) in the human body (Table 2.2).

a) Obesity and Insulin Resistance

Apart from metabolite flux changes due to adipose tissues, the “active secretion of pro-inflammatory, diabetogenic and atherogenic mediators” play an important role in the inflammation of adipose tissue associated impairment of insulin signalling, and activating pro-inflammatory pathways in the skeletal muscle and liver along with other tissues sensitive to insulin (Blüher, 2016). Metabolism is regulated by adipose tissues by controlling the levels of glycerol, non-esterified fatty acids, pro-inflammatory cytokines, macrophages and lymphocytes of the immune system, the leptin and adiponectin hormones. In obesity, these molecules are increased which affects insulin sensitivity via glycolysis, phosphorylation and gluconeogenesis. The overall outcome of these changes in obesity’s pathophysiology leads to the development of insulin resistance in the liver and muscle through impairing the inhibition of the liver’s glucose output while simultaneously reducing the muscle’s glucose uptake.

Table 2.2: Non-Communicable Disease Risks Linked to Obesity

Measure of Obesity	Affected Body Systems	Possible NCD Risks
Increase in production of adipokines or proinflammatory cytokines	Insulin signalling	Type-2 diabetes, polycystic ovarian syndrome or issues of infertility and cancers
Increase in body weight	Mechanical stress causing:	
	a) Increased compression of renal cells	Systemic and pulmonary hypertension
	b) Increase in soft tissues of the neck	Obstructive sleep apnoea
	c) Higher load on vital joints	Osteoarthritis
	d) Increased abdominal pressure	Gastro-oesophageal reflux disease or oesophageal cancer, coronary artery disease
Increase in lipid, triglyceride and free fatty acid production	a) Lipotoxicity	Non-alcoholic steatohepatitis or Non-alcoholic fatty liver disease leading to strokes
	b) Dyslipidaemia	Congestive heart failure and/or coronary artery disease
Increase in renal blood flow due to volume overload	Increase in sympathetic activities and renin-angiotensin-aldosterone activities	Systemic and pulmonary hypertension leading to vascular disease

Therefore, the chronic adipose cell inflammation is considered a vital risk factor towards the possibility of contracting insulin resistance, and diabetes (type-2) among those who are obese (Albuquerque *et al.*, 2017).

b) Obesity and Type-2 Diabetes

There is evidence where being overweight increases the chances of contracting type-2 diabetes by three times while it is raised to seven when obese (Veit *et al.*, 2022). Risks of diabetes incidence was seen to be 3.6 times or more in

women if their BMI levels were normal, yet elevated (BMI = 23 to 23.9 kg/m^2) in comparison to women with lesser BMI levels (BMI <20 kg/m^2). Impaired insulin sensitivity in the adipose, liver or muscle tissues may result in higher demands of insulin for maintaining normo-glycemia. Single nucleotide polymorphisms or pancreatic β-cell mutations will make them insufficient to neutralize the elevated insulin requirement causing hyperglycaemia due to the higher intake of calories and physical inactivity over time. Thus, obesity has been strongly associated to type-2 diabetes which occurs due to the ability of obesity to enhance insulin resistance (Zatterale *et al.*, 2020).

c) Obesity and Dyslipidaemia

Dyslipidaemia due to the increase of triglycerides and apolipoprotein-B in the blood along with a lowered amount of high-density lipoprotein cholesterol is associated with obesity. The increase in concentration of visceral fat results in a drastic rise in free fatty acid flux in the liver leading to synthesis of triglycerides. Subsequently, very low-density lipoprotein-apolipoprotein-B is increasingly secreted from the liver which induces catabolism of high-density lipoprotein-apolipoprotein-A, leading to dyslipidaemia (Hruby *et al.*, 2016).

d) Obesity and Hypertension

It should be noted that for ages 18 and above, the association between BMI and hypertension is significant. Obesity is caused by changes in the blood system due to volume overload which further results in pressure overload, elevated cardiac output and high peripheral resistance. Additionally, sodium homeostasis is impaired due to a higher salt intake along with increased food consumption, thereby promoting hypertension. Finally, structural dysfunctions may occur due to the higher re-absorption with higher blood flow and glomerular hyperfiltration in the kidneys, all resulting in higher levels of blood pressure (Upadhyay *et al.,* 2018).

e) Obesity and Cardiovascular Disease (CVD)

Elevated bodyweight is also an established risk factor for developing heart diseases and ischemic strokes. More than three times the incidence of heart disease was seen in women with a BMI more than 21kg/m^2 with increments of 2

points per BMI. When adipose tissue inflammation and adipocytokine secretion dysregulation occurs, changes in metabolism and vasculature result along with the progression of cardiometabolic disease. It has now been proven that cardiometabolic disease initiates even as normal weight with excess body fat or as sub-clinical impaired insulin sensitivity that eventually manifests as high blood pressure, prediabetes, dyslipidaemia, hepatic steatosis and metabolic syndrome (Cota *et al.*, 2022).

f) Obesity and Polycystic Ovarian Syndrome (PCOS)

Obesity is confirmed to be involved in the development and progression of PCOS via insulin resistance and hyper-androgenism. Evidence also exists indicating that obesity can be a consequence of PCOS, due to increasing presence of visceral fat. Even though interventions for losing weight effectively regularize menstruation, a strong relationship does exist between hyper-androgenism, hyper-insulinemia and PCOS in relation to obesity (Upadhyay *et al.,* 2018)

g) Obesity and Obstructive Sleep Apnoea (OSA)

Prevalence of OSA is reportedly nearly double in individuals with obesity when compared with lean individuals and double or higher when compared with individuals with normal weight. Chronic OSA can lead to irregular hypoxia, sleepiness during the day or impaired cognition and eventually abnormal glucose metabolism, diabetes, hypertension, strokes, cardiovascular diseases, or sudden-death during sleep. Evidence that suggests obesity as a pre-dispositional factor of OSA owing to the deposition of fat around the upper respiratory airways and walls of the chest along with truncal fat that leads to a decline in the function of residual capacity also exists. Studies suggest that a decline in body weight via lifestyle modifications may alleviate the symptoms linked to OSA especially in young people or patients with obesity (Truby *et al.*, 2022; Lazaro *et al.*, 2023).

h) Obesity and Cancer

Accumulated evidence linking increases in body mass index over time and the development of cancers including cancers of the gall bladder, liver, ovaries

and prostate gland, uterine, cervical, thyroid, breast, oesophagus, colon, rectum, and kidney are present. Causative factors are reported to be an increase in insulin resistance, elevation in insulin-like growth factor (IGF-1) concentrations, obesity linked low-grade chronic inflammation, adipocyte-derived factors being unregulated and/or changes in sex hormones (Hruby & Hu, 2015; Apovian, 2016; Hruby *et al.,* 2016).

2.6 Current methods to assess overnutrition

The BMI continues to be the most widely used criteria for obesity classifications due to its simplicity of use, inexpensiveness and non-invasive method of identifying obesity. The NCD Risk Factor Collaboration (2017) is a notable indicator of obesity pandemic's progress but fails to estimate the actual scale of the problem. The systematic review studies defining obesity using the "body mass index (BMI) in adults and BMI-for-age in children and adolescents" show in a consistent pattern that this use of BMI is "highly specific, but has low to moderate sensitivity" to the extent that nearly 50% of all adults with "excess body fat" are "non-obese". Where there is bias linked with using BMI leads to underestimations of the prevalence of obesity in turn complicating global comparisons (Wadden *et al.*, 2021). Interestingly, metabolically healthy obese (MHO) is now a known sub-category of the obese population who do not have cardio-metabolic complications and other non-communicable diseases. Although studies characterize this sub-category by utilising cut-off ranges for blood pressure, fasting plasma glucose, and glycated haemoglobin, homeostatic model assessment, high density lipoprotein, low density lipoprotein and total cholesterol, triglycerides or triglyceride/HDL ratios, there are no set criteria that separates individuals who are metabolically healthy and the metabolically unhealthy obese (MUO). A similar sub-category is the population that is metabolically unhealthy yet having a normal weight (MUHNW). They are non-obese as per BMI, but have a metabolic profile that is similar to obese patients. On examining all possible interaction and developments among the MHO, MUO, and MUHNW, the study concluded that MHO is a transition state that is paused before naturally progressing into the MUO state (Upadhyay *et al.*, 2018). Assessing obesity by using only BMI makes it a distinctive heterogeneous state with multiple

cardiovascular and metabolic consequences for all individuals differing on their age and gender, the recent guidelines for obesity from the American Association of Clinical Endocrinology as reported by Garvey (2022) calls for the disease management approach to be complication-centric by employing two diagnosis components. Firstly, excess adiposity is confirmed using anthropometric measurements where an increased BMI represents elevated adiposity and secondly, detecting the complications and their severity as the clinical component. Hence, this existing method is ideal due to the accessibility, affordability and reliability of both the procedures to estimate the level of ABCD.

2.7 Current methods to manage overweight and obesity

Effectively managing obesity calls for systematically assessing the factors which potentially affect the intake and expenditure of energy and metabolism (Blüher, 2019). Since an obesogenic environment is increasingly becoming common, the primary prevention of the ABCD should involve the whole population by including public health messages, building a healthy environment and lifestyles, as well as easier access to maternal-foetal health and preventive care. For those who are genetically predisposed, more targeted preventive measures such as maintenance of healthy weight and personalized prescriptions for healthy lifestyles may be required. Preventing further weight gain and emergence of complications should be the secondary prevention efforts, while continuation of lifestyle therapy along with protective medications for cardio and renal systems should be the tertiary prevention (Garvey, 2022). Existing methods to treat obesity focusing on the weight loss approach through medicines, diet and physical activity and surgical options is discussed subsequently.

Weight loss and lifestyle changes are the first-in-line treatment of individuals with obesity since metabolic status and central adiposity have consistently predicted morbidity and mortality (Vlassopoulos *et al.*, 2021). It has been proven that body weight was inversely related to a diet with increase in “fruits, vegetables, whole grains, nuts, and yogurt” (Smith & Smith, 2016). A weight loss of more than seven to ten percent is reported to be initially sufficient to prevent biomechanical and cardiometabolic complications. More than five to fifteen percent of weight loss progressively improves glycated haemoglobin, blood

pressure, and lipids. However, in the case of end-stage complications, more than ten to twenty percent is required to manage the complications. In case of obstructive sleep apnoea patients, a loss of more than or equal to ten percent is required for apnoea or hypopnea index recovery. Towards non-alcoholic fatty liver disease, a five to ten percent weight loss is observed to reduce steatosis, but more than ten percent weight loss is needed with non-alcoholic state-hepatitis and non-alcoholic fatty liver disease for improvements in inflammation and fibrosis. Similarly, a weight loss of more than ten percent may be required for preventing cardiovascular diseases and its associated mortality (Arora *et al.*, 2022). However, Garvey (2022) noted that the multiple dysfunctional responses that were activated due to weight loss, when combined with increased intakes of energy and decreasing energy expenditure, leads to the regaining of the lost weight.

2.7.1 Clinical treatment methods

The concept of utilising ‘medicines to treat obesity’ rather than opting for surgical solutions is emerging. In clinical studies from 2021, 2.4 mg/week of semaglutide achieved more than ten percent of weight loss in a group while the other group achieved more than fifteen percent of weight loss due to lifestyle changes (Wadden *et al.*, 2021). This weight loss mechanism included glucagon like peptide-1 (GLP-1), gastric inhibitory polypeptides, long-acting amylin analogs activin II receptor agonists that lower fat in the body and increase the muscle mass, simultaneously combining satiety hormones including oxyntomodulin, PYY, and amylin (Garvey, 2022). However, this was deemed less efficient since it did not permanently alter “the set point” because the lost body weight is driven back to the initial weight when the medication is terminated (Wadden *et al.*, 2021). Other drugs available are bupropion (90mg), liraglutide (3mg), nateroxone (8mg), orlistat, phentermine, semaglutide and topiramate. However, owing to the side effects that include confusion, dry mouths, nausea, diarrhoea, constipation, elevated heart rates and blood pressure, sleeping difficulties, paraesthesia, steatorrhea and issues of cardiovascular safety (Martinussen *et al.*, 2017; Proietto, 2022), these are not legally used world-wide. Demonstrating lesser side effects than existing synthetic drugs, medicinal herb/plant treatments have shown beneficial effects on obese patients. The potential mechanism of herbal medicines

needing further research may include reducing energy intake as appetite suppressants, enhancing metabolic rates and stimulating thermogenesis, blocking pancreatic lipase activity and lowering the rates of fat absorption while including lipolysis and decreasing lipogenesis (Payab *et al.*, 2020). Thus, there seems to be a new paradigm shift towards managing obesity with medications (Kim *et al.*, 2022). However, there is a need to arrive at safe, accessible, and affordable medicines if obesity is to be decreased without irreversible surgery options, or therapeutic drugs especially for the patients with morbid obesity.

2.7.2 Lifestyle management methods

Evidences from clinical trials and observational cohorts state an almost universal ‘truth’ that in spite of dietary pattern, calorie restriction is related to better long term healthy weight outcomes (Hruby & Hu, 2015). Food choices, including the type and amount of calorie intake of an individual are influenced by the community environments, workplaces, school and of course the home (Apovian, 2016). Another study showed that energy intakes through “animal, saturated and trans fats” or “high intakes of sugar or sweetened beverages or fruit juice” were increasingly associated with weight gain, particularly in already overweight women, which was reversed with a reduction in the consumption of these foods and higher intakes of “vegetables, fruits, whole grains, nuts or yogurt” (Kong *et al.*, 2017). This is still the reason why caloric restriction and avoidance of ultra-processed foods (Harb *et al.*, 2022) is the primordial focus of most approaches to clinically manage weight loss. Non-sustainable behaviour changes aimed at promoting weight loss will fail to offer long-term health benefits due to the physiological and psychological side effects detected of energy restricted diets in susceptible patients including increased food demand, a slow resting metabolic rate, lesser expenditure of energy and bone mineral density with recurring weight regain cycles, lesser self-esteem along with higher chances of developing eating disorders (Dayan *et al.*, 2019). Individual behaviours other than diet such as screen time, stress, sleep and physical activity have also been individually related to body weight changes and maintenance in adults. When integrated with a diet pattern, the aforementioned components have complementary and additive effects on the ability of the individual in obtaining and maintaining a healthy body weight

(Hruby & Hu, 2015). A cutback or total lack of physical activity may be found in neighbourhoods that discourage forms of active transportation including walking or biking, lowered availability of physical education periods in schools and a general environment in the schools and workplaces that enforce the idea that physical activity does not have a priority (Apovian, 2016). It is recommended that at least “150 to 250 minutes per week of moderate intensity activity” is needed to reduce gain or loss of body weight. However, current clinical guidelines (ICMR, 2010; Kong *et al.*, 2017; Hills, 2022) towards the effective management of ABCD suggest a combination outlook including strategies of behaviour change focusing on reduced dietary intake along with a rise in physical activity as early as possible.

2.7.3 Surgery methods

Surgery options to prevent obesity are typically reserved for individuals who are severely obese and have not been successful with other weight loss methods such as diet, exercise, and medication. These surgeries are more accurately described as treatments for existing obesity rather than as a prevention measure. However, they can effectively prevent further weight gain and associated health complications in those who are already severely overweight (Ding *et al.*, 2020). The most common surgery options include the following:

- Gastric bypass surgery: This surgery involves creating a small pouch at the top of the stomach and connecting it directly to the small intestine. This restricts the amount of food the individual can eat and reduces the absorption of nutrients, leading to weight loss.
- Sleeve gastrectomy: In this procedure, a large portion of the stomach is removed, leaving a smaller banana-shaped "sleeve." Similar to gastric bypass surgery, this reduces the food intake of a person and also leads to weight loss.
- Gastric banding: This method involves placing an inflatable band around the upper part of the stomach, creating a small pouch above the band. The band can be adjusted to control the size of the opening between the pouch and the rest of the stomach, limiting the amount of food that can be consumed.

- Biliopancreatic diversion with duodenal switch: This procedure is more complex and involves removing a large portion of the stomach, similar to a sleeve gastrectomy, and rerouting the small intestine to reduce both the amount of food that can be consumed as well as the absorption of nutrients.
- Intragastric Balloon: This option involves placing a deflated balloon into the stomach and then inflating it to reduce the amount of space available for food, promoting a feeling of fullness and reducing the overall food intake.

Although the management of obesity via options of surgery has been established (Dietrich *et al.*, 2018; Syn *et al.*, 2021), there are studies that also mention the drawbacks of using this method (Hamed *et al.*, 2020; Liagre *et al.*, 2021; Aderinto *et al.*, 2023), thereby highlighting the need for reversible, less complicated and economically feasible methods of managing obesity.

2.8 Research gap in existing literature

From the review of the existing literature as detailed above, it seems that unavailability of time, the popular notion that weight loss only happens in gyms or similar institutions dedicated to weight loss and slimming, and the extent of self-motivation and consistent approach required for the same, appear to be the current hindrances to solving obesity through physical activity in college women. Moreover, there are specific diets being tested out instead of encouraging or instilling long term healthy dietary behaviour and even less intervention studies focusing on beneficial lifestyle changes or behaviour change communications especially for women with obesity. Finally, an individual’s motivation is often an underrated, unreported and often disregarded factor due to the overwhelming need for evidence based scientific research.