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Natural and Synthetic Strategies for Obesity Control

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Abstract: An abnormal or excessive build-up of body fat that compromises health is called obesity, and it is a significant global health concern. It is caused by a chronic imbalance between energy expenditure and calorie intake and is impacted by lifestyle, hormonal, environmental, and hereditary variables. Type 2 diabetes mellitus, cardiovascular illnesses, hypertension, and several types of cancer are among the chronic diseases for which the condition greatly raises the risk. Once thought to as a passive energy store, adipose tissue is now understood to be an active endocrine organ that secretes a variety of bioactive compounds known as adipokines, such as ghrelin, leptin, adiponectin, and peptide YY, which control insulin sensitivity, hunger, and metabolism. Complex mechanisms including insulin resistance, persistent inflammation, hormonal imbalance, and disruption of central appetite control in the hypothalamus are involved in the pathophysiology of obesity. In non-adipose tissues, elevated levels of inflammatory mediators such as TNF-α and IL-6 lead to fat storage and metabolic dysfunction. Genetic predisposition and changes in gut flora also have an impact on the development of obesity. In order to achieve lasting weight loss, traditional management strategies mostly concentrate on lifestyle interventions, such as dietary modification, increased physical activity, and behavioural therapy. For those who do not respond well to lifestyle modifications, pharmacological treatments are advised, and bariatric surgery is taken into consideration in extreme circumstances. Dietary fibre, a balanced diet, and herbal remedies like fenugreek, green tea, turmeric, and ginger—which increase thermogenesis, decrease hunger, and enhance metabolic health—are all part of natural strategies for managing obesity. Anti-obesity drugs like orlistat and GLP-1 receptor agonists, which work by decreasing fat absorption or increasing satiety, are examples of synthetic therapy. For long-term success, managing obesity effectively necessitates an integrated strategy that incorporates pharmacological therapies, natural cures, and lifestyle changes.

Keywords: *Obesity, Leptin Resistance, Insulin Resistance, Chronic Inflammation, Gut Microbiota, Lipase Inhibitors.*

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I. INTRODUCTION

It is often acknowledged that one of the most significant global public health issues is obesity. The mortality rate from overweight and obesity is currently higher worldwide than the mortality rate from under nutrition. Nowadays, a larger percentage of people worldwide are overweight or obese than underweight. Approximately 1.9 billion persons aged 18 and older were overweight in 2016, compared to roughly 650 million adults who were considered obese. (1)

According to the World Health Organization (WHO), obesity is categorised as a chronic non-communicable disease. Chronic conditions such as diabetes, cancer, cardiovascular diseases (CVDs), and certain gastrointestinal tract disorders are the leading causes of death in both developed and developing countries. These diseases not only impose a substantial economic burden due to increased healthcare costs but also significantly reduce life expectancy. (2)

Body weight maintenance requires a careful balance between healthy eating, regular exercise, adequate sleep, and effective stress management (3). The COVID-19 pandemic and the ensuing lockdown protocols presented previously unheard-of challenges for individuals and families, for which society was largely unprepared. These restrictions resulted in significant lifestyle changes, such as poor dietary choices, less exercise, elevated stress levels, and erratic sleep duration and patterns. Measures implemented to limit viral transmission led to a more sedentary lifestyle, increased screen time, and decreased outside activities .(4) Additionally, school closures increased stress levels and reduced sleep since many parents had to

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juggle childcare and working from home at the same time .[4, 5]

One of the most widely used anthropometric metrics for evaluating obesity is body mass index (BMI), which is computed by dividing height in metres squared by body weight in kilograms. Adults are categorised as overweight if their BMI is 25 kg/m² or greater and obese if their BMI is 30 kg/m² or greater. Waist circumference (WC) has become a more significant indication of obesity in addition to BMI. For assessing regional fat distribution and overall obesity status, measurements like hip circumference and waist-to-hip ratio are also useful. [6–8]

Sedentary lifestyles, low levels of physical activity, and genetic vulnerability are often linked to obesity. Adipocyte hypertrophy and hyperplasia cause adipose tissue to expand, which results in macrophage infiltration and persistent inflammation. This process promotes the release of pro-inflammatory cytokines and interferes with the normal secretion of adipocytokines . [9–11] these metabolic disorders play a role in the development of chronic ailments such as type II diabetes, atherosclerosis, hypertension, cardiovascular diseases, and some types of cancer. As a result, obesity is currently considered a serious worldwide public health issue.[12, 13]

The primary approach to limiting adipose tissue accumulation involves the adoption of calorie-restricted diets combined with increased physical activity in individuals with obesity. [14]

The most popular metric for determining the degree of obesity is body mass index (BMI). The American Association of Clinical Endocrinologists (AACE) modified its diagnostic criteria in 2016, combining BMI with the existence of comorbidities associated with obesity (Table 1) [15]. By 2015, about 603.7 million adults and 107.7 million children were considered obese, according to a thorough study that examined data from 68.5 million people between 1980 and 2015.[16]

Table 1 Obesity Classification as Per AACE Guidelines[15]

Diagnosis	Body mass index (BMI)	Clinical component (complication)
Overweight	≥25–29.9	No complications
Obesity stage 0	≥30	No complications
Obesity stage 1	≥25	One or more mild-to-moderate complications
Obesity stage 2	≥25	One or more severe Complications

Managing and treating obesity requires a range of resources, including medications, balanced diets, and the cost of physical activity, due to the high morbidity and death. There are five distinct strategies or tactics for weight loss:

- Reducing food intake by either suppressing orexigenic signals or factors that stimulate food intake or by enhancing the inhibitory effects of anorexigenic signals or factors that depress food intake.
- Preventing the alimentary canal from absorbing nutrients, especially fat.
- Increasing thermogenesis by separating the production of ATP from fuel metabolism, which releases food energy as heat.
- Changing the metabolism or storage of fat or protein via controlling adipose differentiation and apoptosis or fat production and lipolysis. Increased protein or fat turnover may lower body weight by influencing energy expenditure or food intake.
- Modifying the central controller that controls body weight by either changing the internal reference value that the controller seeks or modifying the principal afferent signals about fat reserves that the controller analyses. One possible benefit of this strategy is that it would compel the endogenous controller to control several energy balance pathways and reduce restitution .[17,18]

Adipose tissue plays a dynamic biological role beyond energy storage, acting as an endocrine organ that releases various signalling molecules, collectively referred to as adipokines, such as leptin, adiponectin, and inflammatory mediators. Disruption in adipokine secretion contributes to metabolic disturbances, including insulin resistance, chronic low-grade inflammation, and impaired metabolic homeostasis characteristic of obesity. [19]

Furthermore, because different adipose depots have diverse metabolic and clinical effects, the anatomical distribution of fat accumulation greatly determines the health risks associated with obesity. Therefore, before talking about the classification and health effects of various fat types, a thorough understanding of the mechanisms behind fat formation is necessary.

➢ *There are Two Types of Fat:*

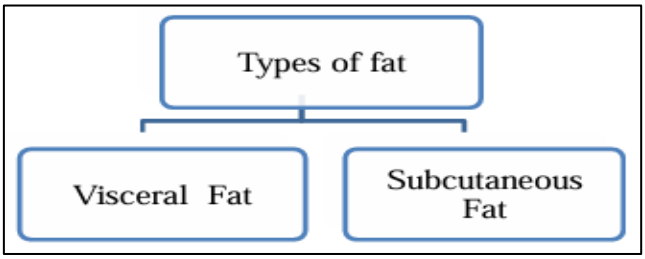

Fig 1 Types of Fat

- Visceral Fat: - Visceral fat is adipose tissue that accumulates around internal organs like the kidneys, liver, intestines, heart, pancreas, and abdominal cavity. It is also referred to as "active fat" because numerous

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studies have shown that it is crucial for hormone control and causes insulin resistance and metabolic syndrome. These hormonal effects affect vital physiological processes like metabolism, appetite regulation, and body fat distribution. [20]

- Subcutaneous Fat: - Subcutaneous fat is found beneath the skin and is usually felt in areas like the underarms, legs, and thighs. Patterns of fat distribution lead to two different body shapes known as apple and pear varieties. Individuals with an android or apple-shaped body type typically develop fat mostly in the upper belly and waist, with additional deposition in the arms, shoulders, and neck. This pattern is mostly caused by visceral fat and is strongly associated with an increased risk of type 2 diabetes and other metabolic disorders .[21]

II. HORMONES RELATED TO OBESITY

An integrated hormonal system that synchronises signals from both central and peripheral tissues is essential for controlling body weight. Increased fat storage, decreased insulin response, and changed appetite regulation are the results of this system's disturbance in obesity. Leptin, ghrelin, insulin, adiponectin, omentin, peptide YY, and acylation-stimulating protein are among the key hormones that are crucial to these processes and contribute significantly to the development of obesity.

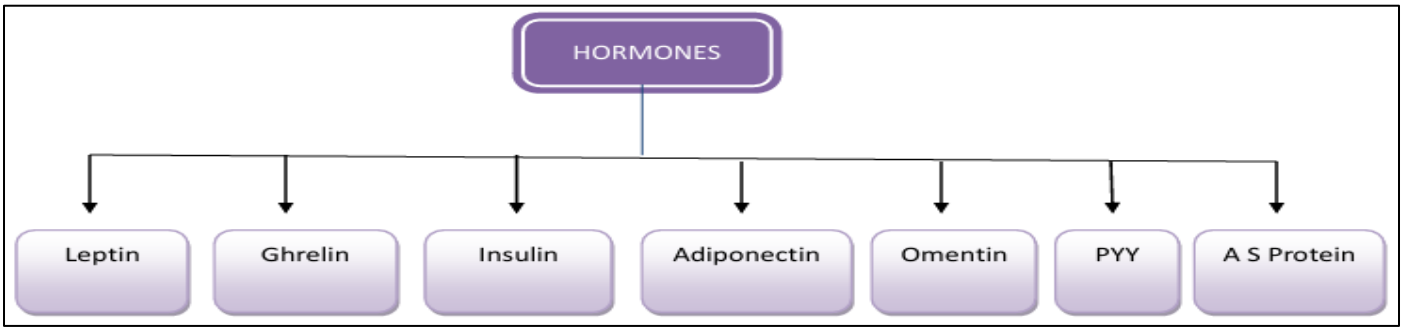

Fig 2 Types of Hormones

➢ *Leptin:*

One important hormone linked to an increase in body weight is leptin. [22] the first adipose hormone that connects peripheral adipose fat mass with central metabolism regulation is leptin, which is produced by the ob (obesity) gene. Leptin reduces appetite in the hypothalamic arcuate nucleus by either increasing the activity of anorexigenic neuropeptides (α-MSH and CART) or lowering the activity of orexigenic neuropeptides (NPY and AgRP). [23, 24]

Obesity causes a decrease in the levels of the soluble leptin receptor (SLR) in the blood. Leptin activity is directly supported by these receptors, which are blood-circulating proteins. The leptin resistance observed in obese individuals may be influenced by the combination of high leptin levels and low SLR. [25] Despite enthusiastic study on the use of leptin in the treatment of obesity, clinical studies have shown that the injection of leptin has little effect on the body weight of obese participants. [23, 24] Extreme obesity may result from a leptin deficit. [26]

➢ *Ghrelin:*

The stomach is the primary site of production for ghrelin, a 28-amino acid peptide hormone. By directly interacting with the GH secretagogue receptor at the pituitary level, ghrelin stimulates the release of growth hormone. [27, 28] Neuroendocrine and metabolic reactions to food consumption appear to be influenced by ghrelin. Its levels in the blood are reduced in obesity and increased in anorexia and cachexia. [29,30,31] Body fat mass, body mass index, plasma leptin, insulin, and glucose levels are all negatively correlated with plasma ghrelin levels . [32] Ghrelin may be essential for regulating hunger and weight, according to several studies. The GH secretagogue receptor (GHS-R1a) in the arcuate nucleus regulates GH secretion, food intake, and obesity. [33, 34]

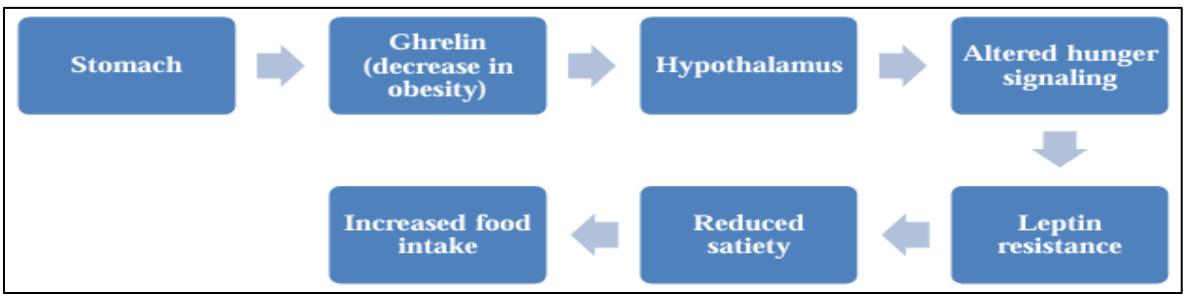

Fig 3 Ghrelin

➢ *Insulin:*

Increased plasma concentrations of free fatty acids, which are constantly produced from adipose tissue, are the primary cause of insulin resistance by excess weight.[35,36] Increased hepatic and muscle fatty acid absorption and oxidation due to increased free fatty acid concentrations

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result in metabolic changes that reduce these tissues ability to absorb and utilise glucose for energy metabolism. [37, 38, 39]Increases in intra-abdominal body fat storage, which releases free fatty acids into circulation more quickly than other adipose tissue compartments. [40]

➢ *Adiponectin:*

Adiponectin is released by mature adipocytes, and individuals with diabetes and obesity have reduced levels of it in their blood. Anti-diabetic and anti-obesity drugs including CB1 antagonists (rimonabant) and PPAR agonists (thiazolidinediones) raise the plasma level of adiponectin. Adiponectin improves insulin sensitivity by activating AMP kinases, which have been connected to the adiponectin receptors R1 and R2 in both human and animal models. ([41, 42]

➢ *Omentin:*

Instead of adipocytes, stromal-vascular cells are the primary source of omentin in visceral fat tissue. [43] Omentin has positive effects on the absorption of glucose and acts as an insulin sensitiser. Omentin is produced in large quantities by adipose tissues, although its plasma levels are reduced in obese people. [44]

➢ *Peptide (PYY):*

Specialised enteroendocrine cells known as L cells, which are primarily located in the distal gastrointestinal tract, manufacture and release Peptide YY (PYY), a 36-amino acid peptide, into the bloodstream. The two main types of PYY that have been identified are PYY1-36 and PYY3-36. Nutrient intake, dietary consistency, calorie load, and nutrient composition all affect circulating PYY levels, which rise in reaction to these factors. PYY levels typically peak 1-2 hours after consumption, after which they remain constant. [45, 46] Low peptide YY concentrations are associated with increased hunger and food intake. Low peptide YY levels are seen in obesity and prior to the onset of type 2 diabetes, and they may play a role in weight gain in these situations. [47]

➢ *Acylation Stimulating Protein:*

Adipocytes produce a 76-amino acid peptide called acylation-stimulating protein, which acts on the C5L2 receptor in adipose tissue to promote the synthesis of triglycerides (TG). [48] Plasma ASP levels are higher in patients with obesity, type 2 diabetes, and cardiovascular disease than in healthy individuals; however, ASP levels are lowered by exercise or weight loss. An ASP-resistant state has also been associated with dyslipidaemia and altered adipose tissue metabolism, which are common in diabetes and cardiovascular disease. It has been suggested that ASP is produced by activating complement C3, an ASP precursor found in adipose tissue. [49] Consequently, ASP may provide a target for controlling the buildup of fat.

III. PATHOPHYSIOLOGY OF OBESITY

Significant advancements in understanding the pathophysiological pathways driving obesity have been made in recent decades. Sedentary behaviour and disturbed neuroendocrine feedback that controls hunger and energy balance are thought to be the main causes of excessive weight gain. Furthermore, aberrant fat storage is promoted by changes in the makeup of the gut microbiota, hormone imbalances, and hereditary predisposition.[50]

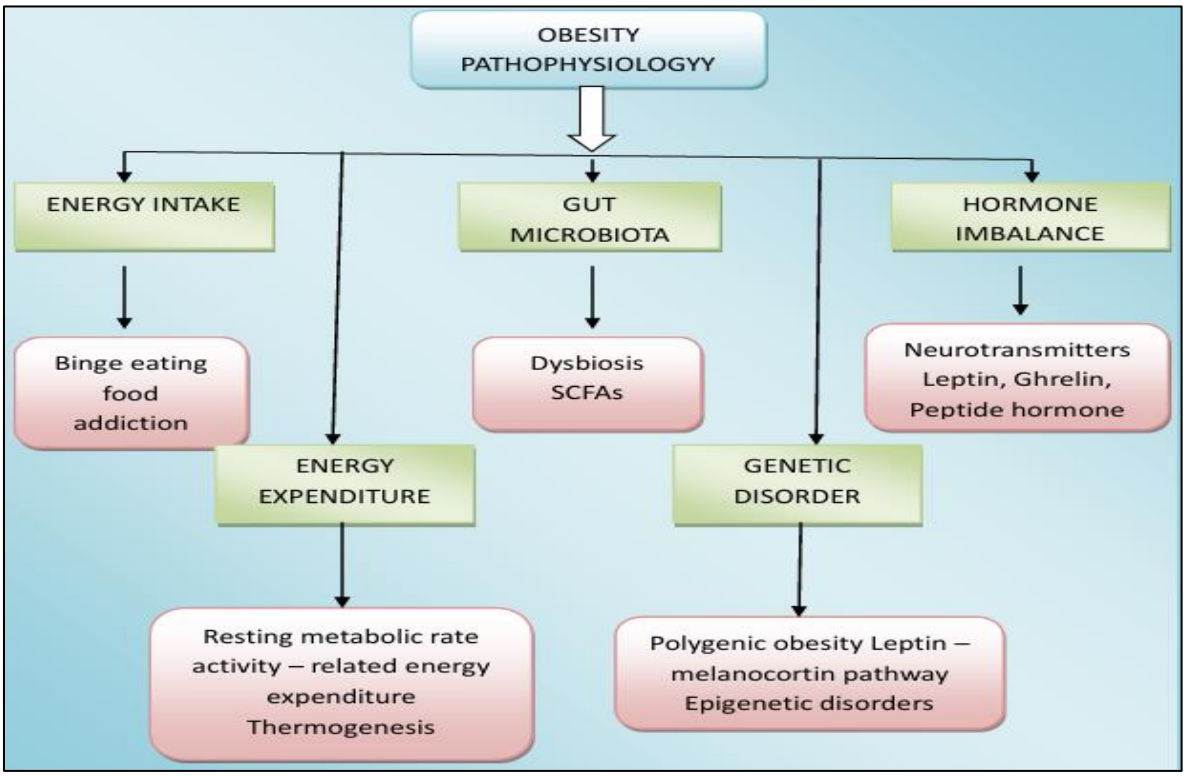

Fig 4 Various Parameters Affecting the Pathology of Obesity.

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➢ *Energy Expenditure and Thermogenesis*

Previously thought of as a passive energy reservoir, adipose tissue is now understood to be an active organ. It releases chemicals that control insulin sensitivity and food intake, such as fatty acids, leptin, and adiponectin. [51] While brown adipose tissue (BAT) uses energy to produce heat, white adipose tissue (WAT) stores it. The conversion of WAT into energy-burning beige adipocytes can be facilitated by external factors such as cold exposure or PPARγ agonists, which may aid in the management of obesity. This process can be facilitated by molecules like as resveratrol, capsaicin, and forskolin. [52, 53]

➢ *Hormonal Imbalance*

The cortico-limbic system, hypothalamus, and hindbrain are among the brain regions that control eating habits. These regions are impacted by hormone levels, fasting, overfeeding, and visual inputs. [54] Food consumption is influenced by neurotransmitters such as dopamine and serotonin; low levels of these neurotransmitters encourage overeating. [55, 56] Gut hormones that control appetite and communicate the availability of energy include ghrelin, PYY, and GLP-1. [57] Adipose tissue produces leptin, which increases satiety; however, obesity-related leptin resistance hinders this signalling. [58]

- *Leptin Resistance*

Leptin regulates immunological response, energy expenditure, and food intake. [59] Leptin resistance, a condition in which elevated leptin levels are unable to adequately communicate with the brain, arises in obesity. This makes leptin therapy ineffective since it interferes with the physiological processes that would typically improve energy expenditure and decrease food cravings. [60] One potential area of research for the treatment of obesity is leptin resistance.

➢ *Gut Microbiota*

The bacteria, viruses, and fungi that make up the gut microbiota have an impact on immunological function and metabolism.[61,62] Short-chain fatty acids (SCFAs) are produced by some gut bacteria and have an impact on metabolism and hunger.[63] Microbial diversity is lower in obese people, and this is associated with inflammation and insulin resistance. [64, 65]A diet heavy in fat can change the composition of the gut microbiome, favouring microorganisms that cause obesity. [66] In addition to increasing energy expenditure, SCFAs and metabolites from gut bacteria can control hormones including GLP-1, which supports insulin signalling and fat metabolism. [67]

➢ *Genetic Predisposition*

Obesity is influenced by both genetic and epigenetic factors, [68] including Prader-Willi syndrome [69] and abnormalities in the leptin-melanocortin pathway. [70, 71] Obesity risk is increased by some genetic alterations that interfere with appetite and weight regulation. These intricate genetic factors differ from person to person.

IV. TRADITIONAL METHODS FOR MANAGING OBESITY

To manage obesity, a comprehensive and multidimensional approach that takes into account various aspects of weight loss, improved metabolic health, and long-term weight maintenance is needed. Dietary modifications, physical activity, medication, lifestyle modifications, and, in severe cases, bariatric surgery are all considered traditional means of controlling obesity. [72]

➢ *Nutritional Measures:*

A key element of managing obesity is nutritional measures. By lowering caloric intake, enhancing diet quality, and encouraging long-lasting dietary adjustments, they aim to achieve energy balance. Through portion management, moderation of high-calorie foods, and the addition of nutrient-dense foods, it entails lowering total energy intake. It is advised to use a balanced strategy that highlights a range of entire foods, such as fruits, vegetables, whole grains, lean meats, and healthy fats. Certain eating habits have been demonstrated to be beneficial for enhancing metabolic health and encouraging weight loss. High consumption of fruits, vegetables, whole grains, legumes, and healthy fats like olive oil characterises the Mediterranean diet, which has been linked to positive results in cardiovascular health and weight control. To encourage long-term adherence and sustained improvements in eating habits, behavioural techniques including portion management, self-monitoring, and mindful eating are frequently incorporated into nutritional treatments.[73]

➢ *Physical Activity:*

Regular physical activity is crucial for controlling obesity. Exercise and physical activity increase energy expenditure, promote weight loss, fortify the heart, and enhance overall health. The American Heart Association and other organisations recommend doing muscle-strengthening exercises two or more days a week in addition to 150 minutes of moderate-intensity aerobic activity or 75 minutes of vigorous-intensity aerobic activity. [73] A combination of strength training (such as bodyweight exercises and weightlifting) and aerobic exercise (such as jogging, cycling, and brisk walking) is recommended to optimise weight loss, preserve muscle mass, and improve metabolic function. Physical activity programs may also include behavioural strategies including goal-setting, self-monitoring, and social support to enhance adherence and long-term maintenance of exercise habits. [74]

➢ *Pharmacotherapy:*

Pharmacotherapy may be an extra therapeutic option for obese people whose weight loss efforts have not been sufficient despite lifestyle modifications. The goals of approved drugs for the treatment of obesity are to reduce food intake, suppress appetite, or stop fat from being absorbed. Prescription medications including as orlistat, liraglutide, and phentermine/topiramate are available for short-term usage under physician supervision. These medications are intended for those who have a BMI of 30 or higher or who have obesity-related comorbidities and have a

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BMI of 27 or higher. They are typically advised in addition to lifestyle modifications. (74)

V. HERBAL TREATMENTS FOR WEIGHT MANAGEMENT

In recent years, there has been increased interest in the potential of herbal remedies as an adjunctive treatment for obesity. Weight control may be impacted physiologically by the bioactive compounds in herbs, which are derived from plants and utilised in traditional medical systems around the world. Herbal remedies can improve conventional approaches and produce better outcomes, but they cannot treat obesity on their own. This section will discuss many herbs that have shown promise in scientific studies for their potential anti-obesity effects. (75)

➢ *Green Tea (Camellia sinensis)*

Camellia sinensis leaves are used to make green tea, which is one of the most popular drinks in the world. Catechins, especially epigallocatechin gallate (EGCG), which have been investigated for their possible involvement in weight management, are among the bioactive substances it contains. (76) It has been discovered that green tea catechins improve fat oxidation and energy expenditure. Additionally, they may promote weight loss by stimulating thermogenesis and inhibiting enzymes involved in fat production. Additionally, green tea possesses anti-inflammatory and antioxidant qualities that could improve metabolic health in general. (75)

Fig 5 Green Tea

- Biological source :- Leaves of Camellia sinensis
- Family :- Theaceae
- Chemical constituents :-Catechins (EGCG – Epigallocatechin gallate), caffeine, flavonoids
- Clinical evidence: - The effects of green tea catechins on body weight and body composition have been the subject of numerous investigations. Green tea drinking has been linked to slight decreases in waist circumference, body weight, and body mass index (BMI), according to several researches. With differences in study designs, doses, and participant characteristics, the total data is still scant and inconsistent. (75)
- Safety Considerations: In general, people believe that drinking green tea is safe. However, because of the possibility of hepatotoxicity and drug interactions, high dosages of green tea extract or supplements containing concentrated catechins should be used carefully. (75)

➢ *Cinnamon (Cinnamomum verum)*

The bark of the Cinnamomum verum or Cinnamomum cassia trees is used to make cinnamon, a spice. For millennia, people have utilised it for its culinary and medicinal qualities. Cinnamaldehyde is one of several bioactive chemicals found in cinnamon that have been investigated for its implications on controlling blood sugar and weight. Mechanisms of Action: It has been discovered that cinnamon increases glucose metabolism and insulin sensitivity. Additionally, it can postpone the emptying of the stomach, which would boost feelings of fullness and decrease hunger. Cinnamon may also contain anti-inflammatory properties that could improve metabolic health. (76)

Fig 6 Cinnamon

- Biological source :- Bark of Cinnamomum verum / Cinnamomum cassia
- Family :- Lauraceae
- Chemical constituents: - Cinnamaldehyde, eugenol, tannins
- Clinical Evidence: A number of small-scale investigations have looked into how supplements containing cinnamon affect metabolic markers and weight loss. Although there is conflicting and limited evidence, several studies have documented improvements in body weight, body fat percentage, and metabolic markers such blood glucose and lipid levels. To prove cinnamon's effectiveness as a treatment for obesity, further carefully planned research is required. (76)
- Safety Considerations: When used as a spice in food, cinnamon is usually harmless. However, long-term usage of cinnamon oil or large dosages of cinnamon supplements may be linked to adverse consequences such allergic responses and liver poisoning. Before consuming cinnamon supplements, people with liver problems or those on medication should use caution and speak with a healthcare provider. (76)

➢ *Turmeric (Curcuma longa)*

The root of Curcuma longa yields turmeric, a spice that is frequently used in Asian cooking and traditional medicine. Curcumin, a bioactive substance found in it, has being researched for possible anti-inflammatory and metabolic benefits. It has been discovered that curcumin modulates a number of molecular targets related to metabolic control and obesity. It might improve insulin sensitivity, prevent fat cell differentiation, and lessen inflammation. Additionally, curcumin may promote fat oxidation and thermogenesis, which could result in weight loss.

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Fig 7 Turmeric

- Biological source :- Rhizomes of Curcuma longa
- Family :- Zingiberaceae
- Chemical constituents :-Curcuminoids (curcumin, demethoxycurcumin), volatile oils (tumerone)
- Clinical Evidence: Preclinical and small-scale human studies examining curcumin's benefits on weight loss and metabolic health have produced encouraging findings. Improvements in body weight, body fat percentage, and metabolic markers like blood glucose and lipid levels have been documented in certain studies. However, more extensive and carefully monitored research is required to validate these results and determine curcumin's effectiveness as an anti-obesity medication. (77)
- Safety Considerations: When included in a diet, turmeric and curcumin are usually regarded as safe. High dosages of curcumin supplements, however, may interfere with some drugs and cause gastrointestinal distress. Before taking curcumin supplements, anyone with gallstone disease, bleeding issues, or anticoagulant drugs should use caution and speak with a healthcare provider.(77)

➢ *Garcinia Gummi – Gutta (Garcinia Cambogia)*

Malabar tamarind, another name for Garcinia Cambogia, is a tropical fruit that is frequently utilised in traditional cooking methods. Hydroxyl citric acid (HCA), the primary component of Garcinia Cambogia, has been investigated for possible effects on fat metabolism and appetite reduction. Citrate lyase, an enzyme involved in the conversion of excess carbs into fat, is thought to be inhibited by HCA. HCA may decrease fat production and increase fat oxidation by blocking this enzyme. Additionally, HCA may raise serotonin levels in the brain, which may lessen cravings for food and hunger. (76)

- Biological source:- Fruit rind of Garcinia gummi-gutta
- Family:- Clusiaceae (Guttiferae)
- Chemical constituents:-Hydroxycitric acid (HCA), flavonoids, xanthones
- Clinical Evidence: Research examining the impacts of the effects of garcinia cambogia on weight loss have been conflicting. While some studies revealed no discernible changes when compared to a placebo, others indicated moderate decreases in body weight and body fat percentage. Larger, well-designed studies are required to ascertain the efficacy of Garcinia Cambogia as an anti-obesity agent because the overall data is inadequate. (76)
- Safety considerations: When used as part of a balanced diet, garcinia cambogia is usually regarded as safe. However, using Garcinia Cambogia supplements or excessive dosages of HCA may result in headaches, gastrointestinal distress, and in rare instances, hepatotoxicity. Before using Garcinia Cambogia products, anyone with liver illness or those on medication should use caution and speak with a healthcare provider. (76)

➢ *Ginger (Zingiber Officinale)*

The rhizome of Zingiber officinale is the source of ginger, a popular spice and herbal treatment. It has been used traditionally for a long time due to its many health advantages, including possible effects on controlling weight. Bioactive substances found in ginger, like gingerol and shogaol, have been investigated for their possible thermogenic and appetite-suppressive properties. Ginger may boost thermogenesis, which raises fat burning and calorie expenditure. Additionally, it may decrease food intake and affect satiety. (76)

Fig 8 Ginger

- Biological source :- Rhizomes of Zingiber officinale
- Family :- Zingiberaceae
- Chemical constituents :-Gingerol, shogaol, zingerone, volatile oils
- Clinical Evidence: The effects of ginger supplementation on body weight and metabolic parameters have been investigated in a number of small-scale investigations. Although a few studies have documented slight decreases in appetite, waist circumference, and body weight, the overall data is conflicting and small. The efficacy of ginger as a treatment for obesity requires more investigation.
- Safety Considerations: When taken as a spice or as part of a diet, ginger is usually regarded as safe. High dosages of ginger pills, however, may result in heartburn, gastrointestinal distress, and drug problems. Before using ginger supplements, anyone with gallstone disease, blood disorders, or anticoagulant drugs should be cautious and speak with a healthcare provider. (76)

➢ *Fenugreek (Trigonella Foenum – Graecum)*

The herb fenugreek is frequently utilised in both traditional medicine and cooking. It includes a number of bioactive substances that have been investigated for their possible effects on weight management, such as soluble

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fibre, galactomannan, and saponins. Weight management may be impacted by fenugreek's potential to promote insulin sensitivity and control blood sugar levels. Additionally, it might make you feel more satisfied and full, which would make you eat less overall. Fenugreek may also encourage fat oxidation and prevent fat buildup.

Fig 9 Fenugreek

- Biological source :- Seeds of Trigonella foenum-graecum
- Family :- Fabaceae
- Chemical constituents :- Saponins (diosgenin), alkaloids (trigonelline), mucilage, fiber
- Clinical Evidence: The effects of fenugreek supplementation on body weight, body composition, and metabolic parameters have been investigated in a number of small-scale investigations. Consuming fenugreek has been linked in several studies to moderate decreases in waist circumference, body weight, and body fat percentage. Nevertheless, the whole data is weak, and more study is required to prove fenugreek's effectiveness as a treatment for obesity.(77)
- Safety considerations: In general, fenugreek is regarded as safe to use as a spice or in food quantities. However, taking fenugreek pills in excess or for an extended period of time may result in gastrointestinal distress, urine that smells like maple syrup, and drug interactions. Because fenugreek supplements may affect uterine contractions, pregnant women should avoid using them .(78)

VI. ANTI – OBESITY DRUGS

For patients who are considered obese and have a body mass index (BMI) of 30 kg/m2 or higher, or a BMI of 27 kg/m2 or higher in the presence of obesity-related conditions like type 2 diabetes mellitus (T2DM), hypertension, dyslipidaemia, or sleep apnoea, the U.S. National Institutes of Health advises using drugs with proven anti-obesity effects . (79) On the other hand, overweight people with a BMI of 25 or 23 kg/m2 or higher who exhibit at least one obesity-related comorbidity should be prescribed anti-obesity medications, according to the Asia-Pacific obesity treatment guidelines. (80)

A. Orlistat

One of the few medications authorised for the treatment of obesity is orlistat. Patients with a body mass index (BMI) of at least 30 kg/m² or BMI of at least 28 kg/m² who also have obesity-related comorbidities such diabetes, hypertension, or dyslipidaemia are prescribed it. To effectively reduce weight, the medication is meant to be used in conjunction with a low-calorie diet and lifestyle changes. (81)

➢ *Mechanism of Action:*

Gastric and pancreatic lipases are specifically and powerfully inhibited by orlistat. By creating a covalent link with the serine residue at the active site of lipase enzymes, it functions in the gastrointestinal tract lumen. Dietary fats cannot be broken down because of this interaction, which inhibits these enzymes' catalytic activity. Triglycerides are typically broken down by lipases into monoglycerides and free fatty acids that the intestine may absorb. Orlistat decreases dietary fat absorption by about 30% by blocking this mechanism, which lowers calorie intake. (82)

➢ *Indications:*

People who are overweight or obese should take orlistat; especially if they have risk factors for obesity such type 2 diabetes, high blood pressure, or abnormal cholesterol. In order to help weight management, it is typically advised as a long-term therapy in conjunction with a diet low in calories and lifestyle modifications.

➢ *Clinical Study and Effectiveness:*

The long-term effects of orlistat were investigated in a clinical research with 3305 participants. Patients lost an average of 2.4% of their body weight after four years of treatment. Additionally, the incidence of type 2 diabetes mellitus was significantly lower in the orlistat group (6.2%) than in the placebo group (9.0%). Orlistat also improved lipid profiles, blood pressure, and insulin sensitivity, primarily because it decreased intestinal fat absorption. (83)

➢ *Adverse Effects:*

Because orlistat leaves undigested fat in the colon, gastrointestinal side effects are frequently linked to its use. Approximately 91% of trial participants experienced at least one gastrointestinal incident, and 8% of patients stopped taking their medication as a result. Oily spots, flatulence with discharge, and other issues relating to defecation are typical symptoms.

➢ *Precautions and OTC Guidelines:*

Additionally, the presence of extra fat in the colon may increase the risk of colorectal cancer. Because orlistat can decrease the absorption of fat-soluble vitamins A, D, E, and K, the over-the-counter (OTC) formulation of the medication suggests taking a daily multivitamin at bedtime. In order to avoid deficiencies, vitamin supplementation is recommended during long-term orlistat therapy. (84)

B. Liraglutide:

The preproglucagon gene is processed post-translationally to create the hormone glucagon-like peptide-1 (GLP-1). It is transformed into GLP-1 amide, the physiologically active molecule that makes up around 80%

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of the body's circulating GLP-1. This hormone is crucial for controlling energy balance and glucose metabolism.

➢ *Physiological Functions:*

GLP-1 helps to maintain blood glucose levels by suppressing glucagon release and controlling glucose-dependent insulin secretion. GLP-1 influences appetite control, satiety, and calorie intake in addition to its function in glucose metabolism. It helps control body weight by increasing feelings of fullness and decreasing hunger. (85)

➢ *Liraglutide in Diabetes and Obesity Management:*

The GLP-1 receptor agonist liraglutide was first authorised to treat type 2 diabetic mellitus (T2DM). To enhance glycaemic control, it is given subcutaneously at doses of 1.2 mg or 1.8 mg per day. A higher daily dosage of 3.0 mg was later authorised for the treatment of obesity. Liraglutide is advised in conjunction with a calorie-restricted diet and frequent exercise for successful weight loss. (86)

➢ *Semaglutide and its Role in Weight Reduction:*

Semaglutide is another GLP-1 receptor agonist that can be used orally or subcutaneously. Although it may not provide the same degree of glycaemic control, it works similarly to liraglutide. Research has demonstrated that administering semaglutide subcutaneously once a week causes more weight loss than administering liraglutide subcutaneously once a day. Semaglutide significantly reduced weight in overweight or obese people without diabetes throughout the course of a 68-week study. (87)

➢ *Combination Therapy with Exercise:*

According to recent research, the efficacy of liraglutide medication is increased when it is combined with regular exercise. In addition to improving weight reduction results, this combination helps lessen some of liraglutide's side effects.

➢ *Adverse effects :-*

Despite its effectiveness in managing obesity, liraglutide may have certain adverse effects. These include elevated heart rate at rest, cholelithiasis (the development of gallstones), and gastrointestinal issues such nausea, vomiting, and diarrhoea. Exercise along with the medication may reduce these side effects and enhance overall therapy results. (88)

C. Lorcaserin:

A medication called lorcaserin is used to help overweight people with weight-related comorbidities and obese people with a BMI of 30 or above lose weight. It is typically recommended as part of an all-encompassing weight-management program along with calorie restriction and physical activity.

➢ *Mechanism of Action:*

Lorcaserin is an agonist of the serotonin 2C receptor. It works by stimulating proopiomelanocortin (POMC) neurones in the hypothalamic arcuate nucleus. This activation increases feelings of fullness or satiety while decreasing hunger and calorie intake, which aids in weight control. (86)

➢ *Selectivity and Advantages:*

Lorcaserin significantly reduces hunger and appetite due to its strong selectivity for serotonin 2C receptors. Due to its selectivity, it does not result in valvular heart defects or pulmonary hypertension, which were frequent adverse effects of previous serotonin-based weight-loss medications. (87)

➢ *Withdrawal from Clinical Use:-*

In 2012, lorcaserin received approval to treat obesity. It was eventually removed from clinical usage, though, after long-term research revealed that individuals taking the medication had a higher risk of developing pancreatic and lung cancer, but not colon cancer. (88)

D. Semaglutide (Ozempic)

One drug that has been approved to treat type 2 diabetic mellitus (T2DM) is semaglutide. It helps control body weight and glucose metabolism by acting as an agonist of the glucagon-like peptide-1 (GLP-1) receptor. The medication can be injected subcutaneously once a week in dosages of 0.25 mg, 0.5 mg, and 1 mg, or taken orally once daily in doses of 3 mg, 7 mg, and 14 mg. Higher weekly subcutaneous doses of 1.7 mg and 2.4 mg were authorised by the US FDA in 2021 for the long-term control of weight in obese or overweight people. (87)

➢ *Clinical Studies and Effectiveness*

The Semaglutide Treatment Effect in People with Obesity (STEP) trials have shown that semaglutide is an effective treatment for obesity. Patients taking 2.4 mg semaglutide lost about 6% of their body weight by week 12 and about 12% by week 28, according to large randomised controlled trials (RCTs). Furthermore, semaglutide is clinically effective as an anti-obesity medication over a period of three to six months in overweight or obese people, according to a recent cohort research.(89)

➢ *Mechanism of Weight Loss*

In addition to improving insulin sensitivity, semaglutide encourages general body weight loss. Rather than altering energy expenditure or resting metabolic rate, its anti-obesity benefit mostly stems from decreased energy intake and appetite suppression. The medication helps people eat fewer calories by lowering cravings for high-fat foods. (90)

➢ *Central and Peripheral Mechanism*

Both central and peripheral processes are thought to be involved in semaglutide's appetite-suppressive activity. Like liraglutide, semaglutide may act centrally on the hypothalamus to suppress appetite. Peripherally, it might decrease stomach motility and trigger gastro-mechanoreceptors, which send signals to the brainstem via the vagus nerve. Reduced hunger and improved feelings of fullness result from this signaling's assistance in suppressing the satiation center. (91)

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➢ *Differences Between Oral and Subcutaneous Formulations*

The adverse effect profiles of injectable and oral semaglutide differ. Although oral tablets do not result in injection-site responses, their increased drug levels in the portal circulation may induce more gastrointestinal problems. Additionally, although there are still few direct pharmacokinetic comparisons, the maximum oral dose results in lower plasma concentrations (approximately 25 nM with oral 20 mg) than the highest subcutaneous dose (about 45 nM with 1 mg injection).[92]

➢ *Common Adverse Effect*

Semaglutide users should be made aware of potential side effects and how to handle them. Gastrointestinal problems include nausea, vomiting, diarrhoea, and constipation are the most often reported side effects. Additionally, there may be a minor, dose-dependent increase in serum lipase and amylase levels, which are often asymptomatic. [93]

➢ *Other Safety Concerns*

According to clinical research, people receiving semaglutide had a marginally greater incidence of malignant neoplasms and gallbladder-related illnesses than those receiving a placebo. Regulatory bodies like the FDA and EMA advise treating pancreatitis as a possible concern until more information is known, even though there is no conclusive evidence linking incretin-based treatments to either acute pancreatitis or pancreatic cancer. [94]

➢ *Psychiatric precautions*

Patients should stop taking semaglutide right away if they have suicidal thoughts, mood swings, sadness, or suicidal behaviour. Semaglutide should therefore not be administered to anyone who have attempted suicide in the past or who are presently contemplating suicide, and close observation is advised throughout treatment.

VII. COMBINATION OF ANTI – OBESITY MEDICATIONS

Combination therapies that include many anti-obesity medications with complementary mechanisms of action are crucial to ensuring maximal efficacy in lowering body weight while preserving safety and acceptability. Through a variety of methods, these combination therapies are intended to target regulating energy systems. As of right now, the only combination drugs with verified data licensed for the treatment of obesity are phentermine/topiramate and naltrexone/bupropion. However, compound-compounded drugs have also been investigated to evaluate their long-term-term effectiveness and side effects. [95]

A. Naltrexone/Bupropion

A combination medication called naltrexone-bupropion is used to treat obesity and overweight people. The combination use of naltrexone and bupropion for the treatment of obesity was approved by the U.S. Food and Drug Administration (FDA) and the European Medicines Agency (EMA) in 2014. However, due to concerns over the combination's safety profile and clinical benefits, the National Institute for Health and Care Excellence (NICE) in the United Kingdom did not endorse it in July 2017. [96]

➢ *Mechanism of Action*

By influencing pro-opiomelanocortin (POMC) neurones in the hypothalamus, which are crucial for controlling appetite, naltrexone has an anti-obesity effect. Bupropion helps regulate appetite and lessen food cravings by increasing dopamine and norepinephrine activity in the brain. These medications work together to promote satiety, decrease appetite, and lessen hunger, which eventually results in lower calorie consumption and weight loss. [97]

➢ *Adverse Effects*

This combo medication has a higher risk of side effects even though it can result in significant weight loss. Typical adverse effects consist of: Headache and vertigo are examples of central nervous system (CNS) consequences. Mental impacts such as anxiety or mood swings vascular consequences include elevated blood pressure GIT issues, such as nausea and vomiting Labyrinth and ear diseases. [98]

B. Phentermine/Topiramate

A combo medication called phentermine-topiramate is used to treat obesity and overweight people. It is recommended in conjunction with a regulated diet and consistent exercise to aid in weight loss. Those with a body mass index (BMI) of more than 30 kg/m² or more than 27 kg/m² with at least one obesity-related disorder, such as diabetes, dyslipidaemia, or hypertension, are advised to use this therapy. The U.S. Food and Drug Administration (FDA) authorised the use of phentermine and topiramate together to treat obesity in 2012. However, due to worries about potential abuse and safety problems, the European Medicines Agency (EMA) has not approved this medication. [99]

➢ *Mechanism of Action*

This combination primarily suppresses appetite and reduces food intake to have an anti-obesity effect. As a noradrenergic agonist with central sympathetic action, phentermine increases the release of neurotransmitters that help reduce hunger, including dopamine, serotonin, and norepinephrine. It is typically used to control obesity in the short term. Conversely, topiramate is a glutamate antagonist, carbonic anhydrase inhibitor, and gamma-aminobutyric acid (GABA) agonist. It was first authorised for the prevention of migraines and the treatment of epilepsy. Significant weight reduction was seen in epileptic patients after its clinical use, which prompted its assessment and application in the treatment of obesity. [100]

➢ *Adverse Effect*

Constipation and dry mouth are frequent side effects of phentermine-topiramate. Patients with a history of heart disease or stroke should exercise caution as it may raise their resting heart rate by up to 20 beats per minute. Regular heart rate monitoring is advised. Phentermine and other hunger suppressants have also been linked to valvular heart disease.[81]Patients should be closely watched for signs of

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elevated anxiety, suicidal thoughts, or mood swings. Alcohol and other central nervous system depressants should be avoided by patients since they can exacerbate adverse effects like lightheadedness and poor coordination. (101)

VIII. CONCLUSION

Hormonal imbalance, metabolic malfunction, and lifestyle factors are all part of the complex and multifaceted illness that is obesity. A comprehensive strategy that incorporates dietary adjustments, exercise, and behavioural modifications is necessary for its management. While synthetic medications have specific therapeutic effects, natural remedies and herbal cures give supportive advantages. However, sustainable lifestyle modifications are necessary for long-term success. To lessen the burden of obesity worldwide and enhance general health outcomes, an integrated approach incorporating prevention, early intervention, and treatment is crucial.

REFERENCES

[1]. Singh, M., Thrimawithana, T., Shukla, R., et al. (2020). Obesity through natural polyphenols: A review. Future Foods, 1(2), 100002.

[2]. World Health Organization. (2002). Diet, nutrition and the prevention of chronic diseases: Report of a joint WHO–FAO expert consultation. Geneva, Switzerland: Author.

[3]. Swift, D. L., McGee, J. E., Earnest, C. P., Carlisle, E., Nygard, M., & Johannsen, N. M. (2018). The effects of exercise and physical activity on weight loss and maintenance. Progress in Cardiovascular Diseases, 61(2), 206–213.

[4]. Vandoni, M., Codella, R., Pippi, R., et al. (2021). Combating sedentary behaviors by delivering remote physical exercise in children and adolescents with obesity in the COVID-19 era: A narrative review. Nutrients, 13(12), 4459.

[5]. Toniolo-Barrios, M., & Pitt, L. (2021). Mindfulness and the challenges of working from home in times of crisis. Business Horizons, 64(2), 189–197.

[6]. Renehan, A. G., Tyson, M., Egger, M., et al. (2008). Body mass index and incidence of cancer: A systematic review and meta-analysis of prospective observational studies. The Lancet, 371(9612), 569–578.

[7]. Seidell, J. C. (2010). Waist circumference and waist–hip ratio in relation to all-cause mortality, cancer, and sleep apnea. European Journal of Clinical Nutrition, 64(1), 35–41.

[8]. Roriz, C., Karla, A., Passos, S., et al. (2016). Anthropometric clinical indicators in the assessment of visceral obesity: An update. Nutrición Clínica y Dietética Hospitalaria, 36(3), 168–177.

[9]. Reyes-Farias, M., Fos-Domenech, J., Serra, D., & Herrero, L. (2021). White adipose tissue dysfunction in obesity and aging. Biochemical Pharmacology, 192, 114723.

[10]. Nicolaidis, S. (2019). Environment and obesity. Metabolism, 100, 153942.

[11]. D'Anneo, A., Bavisotto, C. C., Gammazza, A. M., et al. (2020). Lipid chaperones and associated diseases: A group of chaperonopathies defining a new nosological entity with implications for medical research and practice. Cell Stress and Chaperones, 25(5), 805–820.

[12]. Piché, M. E., Tchernof, A., & Després, J. P. (2020). Obesity phenotypes, diabetes and cardiovascular diseases. Circulation Research, 126(11), 1477–1500.

[13]. Ng, A. C. T., Delgado, V., Borlaug, B. A., et al. (2021). Diabesity: The combined burden of obesity and diabetes on heart disease and the role of imaging. Nature Reviews Cardiology, 18(4), 291–304.

[14]. Saunders, K. H., Umashanker, D., Igel, L. I., et al. (2018). Obesity pharmacotherapy. Medical Clinics of North America, 102(1), 135–148.

[15]. Guidelines Algorithm. (2016). Guidelines algorithm slides [PowerPoint slides].

[16]. The GBD 2015 Obesity Collaborators. (2017). Health effects of overweight and obesity in 195 countries over 25 years. New England Journal of Medicine, 377(1), 13–27.

[17]. National Institutes of Health. (2004). Strategic plan for NIH obesity research (NIH Publication No. 04–5493). U.S. Department of Health and Human Services.

[18]. Bray, G. A., & Tartaglia, L. A. (2000). Medicinal strategies in the treatment of obesity. Nature, 404, 672–677.

[19]. Sidhu, S., Parikh, T., & Burman, K. D. (2017). Endocrine changes in obesity. In K. R. Feingold (Ed.), Endotext. MDText.com, Inc.

[20]. Miranda, J., Vázquez-Polo, M., Pérez-Junkera, G., Fernández-Gil, M. D. P., Bustamante, M. Á., Navarro, V., & Martínez, O. (2020). FODMAP intake in Spanish population: Open approach for risk assessment. International Journal of Environmental Research and Public Health, 17, 5882.

[21]. Pollex, R. L., Hanley, A. J., Zinman, B., Harris, S. B., Khan, H. M., & Hegele, R. A. (2006). Metabolic syndrome in aboriginal Canadians: Prevalence and genetic associations. Atherosclerosis, 184, 121–129.

[22]. Paz-Filho, G., Mastronardi, C. A., & Licinio, J. (2015). Leptin treatment: Facts and expectations. Metabolism, 64, 146–156.

[23]. Heymsfield, S. B., Greenberg, A. S., Fujioka, K., Dixon, R. M., Kushner, R., Hunt, T., et al. (1999). Recombinant leptin for weight loss in obese and lean adults: A randomized controlled dose-escalation trial. JAMA, 282, 1568–1575.

[24]. Fogteloo, A. J., Pijl, H., Frölich, M., McCamish, M., & Meinders, A. E. (2003). Effects of recombinant human leptin treatment on body weight and energy expenditure. Diabetes Nutrition & Metabolism, 16, 109–114.

[25]. Sidhu, S., Parikh, T., & Burman, K. D. (2017). Endocrine changes in obesity. In K. R. Feingold (Ed.), Endotext. MDText.com, Inc.

[26]. Ahima, R. S., & Flier, J. S. (2000). Leptin. Annual Review of Physiology, 62, 413–437.

ISSN No:-2456-2165 https://doi.org/10.38124/ijisrt/26apr1724

[27]. Cordido, F., Penalva, A., Dieguez, C., & Casanueva, F. F. (1993). Growth hormone discharge in obese subjects. Journal of Clinical Endocrinology & Metabolism, 76, 819–823.
[28]. Alvarez-Castro, P., Isidro, M. L., Garcia-Buela, J., Leal-Cerro, A., Broglio, F., & Tassone, F. (2004). GH secretion after ghrelin. Clinical Endocrinology, 61, 250–255.
[29]. Kojima, M., Hosoda, H., Matsuo, H., & Kangawa, K. (2001). Ghrelin discovery. Trends in Endocrinology & Metabolism, 12, 118–122.
[30]. Tschop, M., Weyer, C., Tataranni, P. A., Devanarayan, V., Ravussin, E., & Heiman, M. L. (2001). Circulating ghrelin levels in obesity. Diabetes, 50, 707–709.
[31]. Otto, B., Cuntz, U., Fruehauf, E., Wawarta, R., Folwaczny, C., & Riepl, R. L. (2001). Ghrelin levels in anorexia nervosa. European Journal of Endocrinology, 145, 669–673.
[32]. Ukkola, O. (2003). Ghrelin and insulin metabolism. European Journal of Clinical Investigation, 33, 183–185.
[33]. Shuto, Y., Shibasaki, T., Otagiri, A., Kuriyama, H., Ohata, H., & Tamura, H. (2002). GH secretagogue receptor regulation. Journal of Clinical Investigation, 109, 1429–1436.
[34]. Cummings, D. E., Frayo, R. S., Marmonier, C., Aubert, R., & Chapelot, D. (2004). Ghrelin levels and hunger. American Journal of Physiology, 287, E297–E304.
[35]. Abate, N. (1996). Insulin resistance and obesity. Diabetes Care, 19, 292–294.
[36]. Bjorntorp, P. (1992). Metabolic abnormalities in visceral obesity. Annals of Medicine, 24, 3–5.
[37]. Flier, J. S. (1983). Insulin receptors and resistance. Annual Review of Medicine, 34, 145–160.
[38]. Kahn, C. R. (1980). Insulin receptor role in obesity. Metabolism, 29, 455–466.
[39]. Moller, D. E., & Flier, J. S. (1991). Insulin resistance mechanisms. New England Journal of Medicine, 325, 938–948.
[40]. Kaaks, R., Lukanova, A., & Kurzer, M. S. (2002). Obesity and endometrial cancer. Cancer Epidemiology, Biomarkers & Prevention, 11, 1531–1543.
[41]. Rabe, K., Lehrke, M., Parhofer, K. G., & Broedl, U. C. (2008). Adipokines and insulin resistance. Molecular Medicine, 14, 741–751.
[42]. Guerre-Millo, M. (2008). Adiponectin update. Diabetes & Metabolism, 34, 12–18.
[43]. Yang, R. Z., Lee, M. J., Hu, H., et al. (2006). Omentin as adipokine. American Journal of Physiology, 290, E1253–E1261.
[44]. de Souza Batista, C. M., Yang, R. Z., Lee, M. J., et al. (2007). Omentin levels in obesity. Diabetes, 56, 1655–1661.
[45]. Adrian, T. E., Ferri, G. L., Bacarese-Hamilton, A. J., et al. (1985). Peptide YY hormone. Gastroenterology, 89, 1070–1077.
[46]. Batterham, R. L., Cowley, M. A., Small, C. J., et al. (2002). PYY inhibits food intake. Nature, 418, 650–654.
[47]. Karra, E., & Batterham, R. L. (2010). Gut hormones and weight regulation. Molecular and Cellular Endocrinology, 316, 120–128.
[48]. Paglialunga, S., Schrauwen, P., Roy, C., et al. (2007). Adipose tissue metabolism. Journal of Endocrinology, 194, 293–304.
[49]. Murray, I., Havel, P. J., Sniderman, A. D., & Cianflone, K. (2000). Energy intake in mice. Endocrinology, 141, 1041–1049.
[50]. Oussaada, S. M., van Galen, K. A., Cooiman, M. I., et al. (2019). Pathogenesis of obesity. Metabolism, 92, 26–36.
[51]. Rosen, E. D., & Spiegelman, B. M. (2006). Adipocytes as regulators of energy balance and glucose homeostasis. Nature, 444, 847–853.
[52]. El Hadi, H., Di Vincenzo, A., Vettor, R., & Rossato, M. (2019). Food ingredients involved in white-to-brown adipose tissue conversion and calorie burning. Frontiers in Physiology, 9, 1954.
[53]. Majeed, M., Bani, S., Pandey, A., & Nagabhushanam, K. (2018). Process and compositions for achieving mammalian energy balance. U.S. Patent No. 10,085,963.
[54]. Berthoud, H. R., Münzberg, H., & Morrison, C. D. (2017). Blaming the brain for obesity: Integration of hedonic and homeostatic mechanisms. Gastroenterology, 152, 1728–1738.
[55]. Hesse, S., van de Giessen, E., Zientek, F., et al. (2014). Association of serotonin transporter availability and BMI. European Neuropsychopharmacology, 24, 1240–1247.
[56]. Blum, K., Thanos, P. K., & Gold, M. S. (2014). Dopamine and obesity. Frontiers in Psychology, 5, 919.
[57]. Latorre, R., Sternini, C., De Giorgio, R., & Greenwood-Van Meerveld, B. (2016). Enteroendocrine cells in brain-gut communication. Neurogastroenterology & Motility, 28, 620–630.
[58]. Mok, J. K. W., Makaronidis, J. M., & Batterham, R. L. (2019). Role of gut hormones in obesity. Current Opinion in Endocrine and Metabolic Research, 4, 4–13.
[59]. Dalamaga, M., Chou, S. H., Shields, K., et al. (2013). Leptin in metabolism. Cell Metabolism, 18, 29–42.
[60]. Frederich, R. C., Hamann, A., Anderson, S., et al. (1995). Leptin levels reflect body lipid content. Nature Medicine, 1, 1311–1314.
[61]. Hakansson, A., & Molin, G. (2011). Gut microbiota and inflammation. Nutrients, 3, 637–682.
[62]. Levy, M., Kolodziejczyk, A. A., Thaiss, C. A., & Elinav, E. (2017). Dysbiosis and immune system. Nature Reviews Immunology, 17, 219–232.
[63]. Wong, J. M., de Souza, R., Kendall, C. W., et al. (2006). Colonic health and SCFAs. Journal of Clinical Gastroenterology, 40, 235–243.
[64]. Le Chatelier, E., Nielsen, T., Qin, J., et al. (2013). Gut microbiome richness and metabolic markers. Nature, 500, 541–546.

ISSN No:-2456-2165 https://doi.org/10.38124/ijisrt/26apr1724

[65]. Turnbaugh, P. J., Hamady, M., Yatsunenko, T., et al. (2009). Core gut microbiome in twins. Nature, 457, 480–484.
[66]. Turnbaugh, P. J., Backhed, F., Fulton, L., & Gordon, J. I. (2008). Diet-induced obesity and gut microbiome. Cell Host & Microbe, 3, 213–223.
[67]. Kishino, S., Takeuchi, M., Park, S. B., et al. (2013). Fatty acid metabolism by gut bacteria. Proceedings of the National Academy of Sciences, 110, 17808–17813.
[68]. Loos, R. J. F., & Yeo, G. S. H. (2014). FTO gene and obesity. Nature Reviews Endocrinology, 10, 51–61.
[69]. Thaker, V. V. (2017). Genetic and epigenetic causes of obesity. Adolescent Medicine: State of the Art Reviews, 28, 379–405.
[70]. Mutch, D. M., & Clément, K. (2007). Genetics of human obesity. PLoS Genetics, 2, e188.
[71]. Misra, V. (2005). Bhavaprakasha Nigantu. Chaukamba Sanskrit Sansthan.
[72]. Farooqi, I. S., Bullmore, E., Keogh, J., et al. (2007). Leptin regulates eating behavior. Science, 317, 1355.
[73]. Yun, J. W. (2010). Anti-obesity therapeutics from nature. Phytochemistry, 71, 1625–1641.
[74]. He, R. R., Chen, L., Lin, B. H., et al. (2009). Oolong tea and obesity. Chinese Journal of Integrative Medicine, 15, 34–41.
[75]. Rahman, U., & Zaman, K. (1989). Medicinal plants with hypoglycemic activity. Journal of Ethnopharmacology, 26, 1–55.
[76]. Kim, J. J., Tarnoff, M. E., & Shikora, S. A. (2003). Surgical treatment of extreme obesity. Nutrition in Clinical Practice, 18, 109–123.
[77]. Su, M., Huang, W., & Zhu, B. (2016). Acetylshikonin prevents obesity. PLoS One, 11, e0146884.
[78]. Geller, F., Reichwald, K., Dempfle, A., et al. (2004). MC4R gene and obesity. American Journal of Human Genetics, 74, 572–581.
[79]. Apovian, C. M., Aronne, L. J., Bessesen, D. H., et al. (2015). Pharmacological management of obesity. Journal of Clinical Endocrinology & Metabolism, 100, 342–362.
[80]. Masterson, J. M., Soodana-Prakash, N., Patel, A. S., et al. (2019). BMI and hypogonadism. World Journal of Men's Health, 37, 93–98.
[81]. Kakkar, A. K., & Dahiya, N. (2015). Drug treatment of obesity. European Journal of Internal Medicine, 26, 89–94.
[82]. Apovian, C. M., Garvey, W. T., & Ryan, D. H. (2015). Challenging obesity. Obesity, 23, S1–S26.
[83]. Garcia, S. B., Barros, L. T., Turatti, A., et al. (2006). Orlistat and cancer markers. Cancer Letters, 240, 221–224.
[84]. Shirai, K., Tanaka, M., Fujita, T., et al. (2019). Orlistat long-term study. Advances in Therapy, 36, 217–231.
[85]. Dailey, M. J., & Moran, T. H. (2013). GLP-1 and appetite. Trends in Endocrinology & Metabolism, 24, 85–91.
[86]. O'Neil, P. M., Birkenfeld, A. L., McGowan, B., et al. (2018). Semaglutide vs. liraglutide trial. The Lancet, 392, 637–649.
[87]. Rubino, D. M., Greenway, F. L., Khalid, U., et al. (2022). STEP 8 trials. JAMA, 327, 138.
[88]. Macêdo, A. P. A., Vieira, R. F. L., & Brisque, G. D. (2022). Liraglutide and exercise. Obesities, 2, 285–291.
[89]. Fonseca, V. A., Capehorn, M. S., Garg, S. K., et al. (2019). Insulin resistance and semaglutide. Journal of Clinical Endocrinology & Metabolism, 104, 4078–4086.
[90]. Christou, G. A., Katsiki, N., Blundell, J., et al. (2019). Semaglutide review. Obesity Reviews, 20, 805–815.
[91]. Krieger, J. P., Arnold, M., Pettersen, K. G., et al. (2016). GLP-1 receptors study. Diabetes, 65, 34–43.
[92]. Wharton, S., Calanna, S., Davies, M., et al. (2022). GI tolerability of semaglutide. Diabetes, Obesity and Metabolism, 24, 94–.
[93]. Wilding, J. P. (2017). Combination therapy for obesity. Journal of Psychopharmacology, 31, 1503–1508.
[94]. Bhat, S. P., & Sharma, A. (2017). Drug targets in obesity. Current Drug Targets, 18, 983–993.
[95]. Coulter, A. A., Rebello, C. J., & Greenway, F. L. (2018). Centrally acting agents. Drugs, 78, 1113–1132.
[96]. National Institute for Health and Care Excellence. (2017). Naltrexone–bupropion for managing overweight and obesity.
[97]. Wang, G. J., Tomasi, D., Volkow, N. D., et al. (2014). Naltrexone and brain reactivity. International Journal of Obesity, 38, 682–688.
[98]. Matyjaszek-Matuszek, B., Szafraniec, A., & Porada, D. (2018). Pharmacotherapy of obesity. Endokrynologia Polska, 69.
[99]. Patel, D. K., & Stanford, F. C. (2018). Safety of anti-obesity drugs. Postgraduate Medicine, 130, 173–182.
[100]. Velazquez, A., & Apovian, C. M. (2018). Updates on obesity pharmacotherapy. Annals of the New York Academy of Sciences, 1411, 106–119.
[101]. Incecik, F., Hergüner, M. O., & Altunbaşak, S. (2012). Hypohidrosis during topiramate treatment. Turkish Journal of Pediatrics, 54, 515–518.