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Oxidative Stress and Non-Communicable Disease: A Comprehensive Review of Lifestyle Interventions

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Abstract:

Diabetic complications, cancer, neurodegenerative dementia, heart disease, and other age-related chronic illnesses are exacerbated by the Western lifestyle. A person's susceptibility to more NCDs and continual degenerative changes is increased when they engage in unhealthy lifestyle choices, which may foster long-term sickness. Worldwide, 39.5 million people died in 2015—70% of the total—from causes related to non-communicable diseases (NCDs). Worldwide, non-communicable diseases will affect 55 million people by 2030, costing the global economy more than USD 60 trillion, according to researchers. Because NCDs are so common, the World Health Organization has made their prevention a major focus. Potentially useful in preventing the advancement of NCDs is the early correction of reactive oxygen species. Specifically, this study looks at how lifestyle-related inflammation and oxidative stress contribute to the development of NCDs.

Keyword: Oxidative Stress, Non-Communicable Disease (NCDs), Western Lifestyle, Inflammation

1.Introduction:

The lifestyle prevalent in Western societies actually worsens age-related chronic illnesses, particularly non-communicable diseases (NCDs) such as diabetes, cancer, neurodegenerative dementia, and cardiovascular disease [122]. Implementing an efficient illness management approach may potentially extend the lifespan of individuals with any of these conditions [124]. Nevertheless, if unhealthy lifestyle choices are not addressed, they will promote long-term illness and heighten an individual's vulnerability to further non-communicable diseases

(NCDs) and continuous degenerative alterations [125]. Non-communicable diseases (NCDs) are the primary factors contributing to illness and death on a global scale. In 2015, there were 56.4 million fatalities recorded worldwide. Out of these, 39.5 million deaths, which is almost 70% of the total, were caused by non-communicable diseases (NCDs). Among these deaths, 14 million occurred before the age of 70. By 2030, experts predict that 55 million people would suffer from non-communicable diseases (NCDs) worldwide [126]. Between 2011 and 2030, the world economy is predicted to lose over USD 60 trillion due to the consequences of non-communicable diseases (NCDs). The consequence is expensive when considering both the out-of-pocket costs and the medical bills [127].

Preventing NCDs has been a top priority for the World Health Organization due to the prevalence of these illnesses across the world [126]. It is common for NCDs to have a prodromal stage that might continue for a long time. Consequently, NCDs (noncommunicable illnesses) are on the rise due to the aging population. As the world's population ages, health care systems face new and significant issues, such as a rise in disease morbidity [128]. Therefore, the best way to reduce or maybe eradicate degenerative processes caused by lifestyle choices is to implement an effective early preventive plan. In order to combat the NCD pandemic, it is crucial to incorporate this technology into healthcare systems that prioritize disease prevention above only treating ill individuals [126]. An effective strategy for preventative health could lead to substantial cost savings [129]. This is because a large portion of these diseases—including type 2 diabetes, 80% of premature heart attacks and strokes, and 40% of cancers—are avoidable. It is unclear how contemporary health care systems can effectively include a preventative approach for NCDs, despite the literature's long-standing emphasis on prevention. Infectious and noncommunicable diseases (NCDs) are on the rise across the world, and the World Health Organization is now trying to figure out how to stop them [126].

In this work, we examine the data from the literature that indicates the role of inflammation and oxidative stress caused by lifestyle choices in the pathogenesis of non-communicable diseases (NCDs) and propose that early reactive oxygen species correction may be helpful in halting the progression of NCDs.

2.1. Oxidative Stress is Prior to Typical Noncommunicable Disease(NCDs):

As a result, even after controlling for conventional CVD risk factors like LDL-C and FRS, research in otherwise healthy individuals has demonstrated robust associations between oxidative stress biomarkers and subclinical indicators of CVD progression, such as flow-mediated vasodilation (FMD) and carotid artery intima-media thickness (CIMT). These markers can be seen in the following examples: S-isoprostanes, malondialdehyde, cystine's oxidized disulphide form, 8-hydroxy deoxyguanosine, and glutathione salt (GSSG) from glutathione hydrochloride.[57]

Also, even accounting for FRS, the lipid peroxidation biomarkers hydroxy-eicosatetraenoic acids (HETEs) and F2-isoprostanes continue to exhibit strong and separate associations with angiographic indicators of cardiovascular disease. Adding these biomarkers to a multivariate

prediction model that already included the FRS greatly improved the prediction of coronary heart disease. Regarding inflammatory biomarkers, there is an independent correlation between plasma levels of C-reactive protein (CRP) and interleukin (IL)-6. Cardiovascular disease (CVD) has been shown in prior studies utilizing multivariate analysis using typical CVD risk factors.[58]

2.2.Oxidative Stress and Inflammation: A Correlation Analysis

Inflammation triggers the innate immune system's quick and generic response. Pathogens, chemical or physical damage, and free radical attack are just a few of the environmental threats that might set off this reaction [65,66].
There exists a strong correlation between the generation of free radicals, the occurrence of oxidative stress, and the presence of inflammation.

It is well-established that oxidative stress causes inflammation and harms tissues. Consequently, this may amplify the effects of oxidative stress [53,66]. According to experimental findings in this field of study, oxidative stress has the potential to activate transcription factors that are sensitive to redox, such as AP-1 and NF-κB [67]. These factors may kick off a chain reaction in the immune system, leading to the accumulation of inflammatory cells including macrophages, neutrophils, and leukocytes near the site of damage [68,69]. This kind of cell has the ability to produce inflammatory cytokines, chemokines, and arachidonic acid, including IL-1β, IL-6, and TNF-α [70,71].

The release of C-reactive protein (CRP) and other proteins involved in the acute phase may be triggered by pro-inflammatory cytokines. They may also entice inflammatory cells to the injured area [72,73].

The production of oxygen and/or nitrogen free radicals by stimulated immune cells allows them to eliminate invaders or other stimuli. The fundamental source of damage is free radicals, while cytokines and acute phase proteins serve as signaling molecules.

Importantly, cytokines do not directly destroy cells. Significant cellular damage results from chronic inflammation, which causes free radical production to rise and antioxidant levels to fall [14,66,74]. Therefore, the buildup of activated immune cells near the injury site accelerates the generation of free radicals and reactive oxygen species (ROS), exacerbating the ongoing oxidative stress.

Hence, oxidative stress triggers an inflammatory response, which amplifies oxidative stress even more [53,66].

2.2. The connection between redox imbalance and oxidative stress:

Many studies were conducted on the ability of hydrogen peroxide to oxidize organic molecules when combined with iron(II) ions after Fenton's groundbreaking discovery in 1894 [75], which coined the term "oxidative stress." Essential to oxidative processes, reactive oxidative species (ROS) are produced spontaneously by aerobic organisms. It reminds me of biochemists' study that animals can transform more than 95% of the oxygen they breathe into harmless compounds like carbon dioxide and water. Univalent reduction produces reactive oxygen species in an additional 5% of the sample, including hydroxyl radicals (OH−),

superoxide (O2−) radicals, hydrogen peroxide (H2O2), peroxynitrite (NADPH) oxidase [80], and cytochrome P450 enzymes [81]. In its fight against infections and damaged cells, as well as to help in the degradation of cell debris, the immune system generates reactive oxygen species (ROS) [53,66,82].
Neutrophils and macrophages, which are cells involved in inflammation, have the NADPH oxidase system. Superoxide and other harmful radical species are produced in large quantities while this mechanism is operating. Extensive collateral cellular damage may result in the setting of chronic inflammation. Thus, inflammation mostly causes cellular damage via free radical destruction [53,66,82,83].
Several free radical species also play an important role in regulating essential cellular processes as migration, cell division, and the synthesis of chemical mediators [67].

Because they include at least one unpaired electron in their atomic structure, free radicals may be toxic at doses beyond what is considered physiologically safe. But to counteract this, a sophisticated antioxidant defense mechanism is operational. Enzymatic sources like catalase, glutathione reductase, superoxide dismutase, and glutathione peroxidase are part of this system, but non-enzymatic sources including phytochemicals, dietary vitamins, and glutathione are also part of it [13].
There is a fine equilibrium in the body between the production of reactive oxygen species (ROS) by live cells and their subsequent removal by the antioxidant defense system. A "redox balance" is the name given to this idea. The typical causes of redox imbalances, according to previous research [84], include an excess of reactive oxygen species (ROS) or a malfunctioning antioxidant defense mechanism, which typically repairs damage caused by ROS and neutralizes them. Cellular oxidation occurs when redox mechanisms are imbalanced. This condition is characterized by a redox imbalance or oxidative stress.

The aforementioned cell damage and death, together with the subsequent alterations to tissues, have been associated with the onset of non-communicable illnesses [14, 16].
A radical known as OONO− is created [76]. Respiratory oxygen species (ROS) are mainly produced by the mitochondria, peroxisomal oxidase, xanthine oxidase, and nicotinamide adenine dinucleotide phosphate.

3. Oxidative Stress and Different Non-Communicable Disease (NCDs):

3.1.Relation between Oxidative Stress and Obesity:

Obesity, defined as a rise in body weight leading to an excessive buildup of fat, is a global social issue [11] and is acknowledged as a significant contributing factor to the development of several diseases.[12]. Regrettably, obesity is increasingly affecting a significant proportion of children in wealthy nations. Furthermore, research has indicated that children and adolescents who are fat have a higher probability of remaining heavy into adulthood [13], thereby increasing their susceptibility to health issues commonly associated with adults [14]. A particular study has found that children who developed obesity as early as the age of 2 were more prone to obesity in their adult years [15].Recent research has discovered a connection between obesity and a type of ongoing, mild inflammation in the fatty tissue of the body. This disease is caused by the activation of the innate immune system in adipose tissue, which leads to a proinflammatory state and oxidative stress. This, in turn, triggers a systemic acute-phase response. Obesity is known to cause several chronic diseases, such as metabolic syndrome, diabetes mellitus, liver and cardiovascular disorders, and cancer. These diseases are also connected with oxidative stress (OS) (12).Thus, it has been postulated that adipose tissue inflammation occurs in individuals who are fat. Plays a crucial role in the development of health problems associated with obesity [16].A study revealed that obese

individuals experience a notable rise in oxidative stress and inflammation as a result of consuming a diet rich in both fats and carbohydrates.
H2O2 is generated as a result of peroxisomal fatty acid metabolism, the presence of peroxisomes with significant catalase activity might lead to oxidative stress in specific clinical settings. [122] Cytochrome P450 microsomal processes catalyze the formation of xenobiotic metabolic byproducts, such as superoxide anion, which can lead to oxidative stress. [122].
Phagocyte cells employ a combination of reactive oxygen species (ROS) and other oxidants to combat invading infections.This is an immunological response that concurrently induces inflammation and harm to the neighboring tissues. [122]
The mitochondria's respiratory chain. The mitochondria are believed to be the primary location within the cell where the highest levels of reactive oxygen species (ROS) are generated, leading to mitochondrial dysfunction, illnesses, and metabolic disturbances. [122].
Oxidative stress (OS) biomarkers encompass malondialdehyde (MDA) and F-2 isoprostanes (F2IsoPs), which are indicators of peroxidation of polyunsaturated fatty acids. One study found a strong correlation between BMI and the concentration of F2-IsoPs.According to the study, females had higher levels of peroxidation compared to males, possibly due to their higher proportion of body fat. In addition, we have identified a correlation between lipid peroxidation and the levels of cholesterol in the plasma [17].Urinary levels of 8-iso Prostaglandin F2 (8-iso PGF) serve as an oxidative stress measure that is linked to obesity and insulin resistance in a positive manner [18]. Conversely, it is negatively correlated with plasma adiponectin concentration.

3.2.The relationship between obesity, oxidative stress, and cardiovascular diseases:

Oxidative stress plays a crucial role in obesity-related conditions, such as dyslipidemia and hypertension, which can lead to the development of cardiovascular disease (CVD). Dyslipidemia is characterized by elevated amounts of cholesterol and triglycerides in the bloodstream, which can heighten the likelihood of cardiovascular disease, stroke and other medical complications [19]. The coexistence of obesity and dyslipidemia has been associated with the occurrence of cardiovascular disease (CVD) [20]. This hyperlink is intricately connected to oxidative stress. The amounts in circulation are minimal. High-density lipoprotein (HDL), enhanced HDL particle removal, elevated levels of triglycerides after a meal, and increased plasma very low density lipoprotein (VLDL) levels all contribute to the production of reactive oxygen species (ROS) in the endothelium [21]. Reactive oxygen species (ROS) have the ability to harm lipids, proteins, and DNA directly. They can also influence intracellular signaling cascades, such as mitogen activated protein kinases and redox sensitive transcription factors. This leads to alterations in the expression of proteins and lipids, resulting in irreversible oxidative damage [21]. ROS-induced alterations in lipid expression might lead to an increased significance of oxidation-derived substances, such as oxidative low-density lipoprotein (Ox-LDL), in cardiovascular disease (CVD). Oxidized low-density lipoprotein (Ox-LDL) is formed from LDL in the bloodstream and may contain peroxides or their degradation products that are produced within the LDL molecule or elsewhere in the body. Ox-LDL stimulates the growth of adipocytes, either through direct mechanisms or indirectly by promoting the infiltration of monocytes and macrophages. It also enhances the expression of lipoprotein lipase (LPL) and leads to the accumulation of fatty acids in adipocytes. In addition, Ox-LDL modifies the generation of adipokines, potentially resulting in increased oxidative stress. For instance, Ox-LDL suppresses the release of adiponectin, which hinders the formation of ROS [25]. The elevated levels of Ox-LDL in obese patients with dyslipidemia may be attributed to a decrease in antioxidant

capacity resulting from reduced SOD serum activity [26] or diminished HDL-associated paraoxonase-1 (PON-1), an extracellular esterase that is attached to HDL and plays a role in HDL's antiatherogenic, antioxidant, and anti-inflammatory functions [27]. Moreover, the rise in Ox-LDL may be attributed to an escalation in oxidant capacity, such as an upsurge in NOX2 expression. This, in turn, leads to a reduction in adiponectin synthesis, an elevation in pro-inflammatory cytokine levels, and the development of reactive oxygen species (ROS) in vascular and immune cells present in the bloodstream. Also, additional enzymes that make nitrogen and reactive oxygen intermediates are activated by the reactive oxygen species (ROS) generated by NOX.

They also enhance the first response to shocks caused by free radicals (FR) [28].To summarize, many mechanisms have been suggested to connect obesity and dyslipidemia (elevated levels of triglycerides, oxidized low-density lipoproteins, and very low-density lipoproteins, as well as reduced levels of circulating high-density lipoproteins) to cardiovascular disease. However, oxidative stress remains a significant factor associated with vascular complications.

Research on humans has linked oxidative stress (OS) to the onset of hypertension, particularly in obese individuals [29].
Vascular relaxation is caused by the release of nitric oxide (NO) by the endothelium [30]. A potential cause of the reduced vasodilation might be an imbalance in the production of superoxide and NO, which could lead to the development of hypertension.

Nitric oxide (NO) has a brief half-life due to its quick degradation by the oxygen-derived free radical superoxide anion. This anion is generated by eNOS and functions as a vasoconstrictor. A study [31] examined the correlation between the extent of modifications caused by oxidative stress (OS) and blood pressure (BP) levels. This study aimed to investigate the oxidative status, antioxidant activity, and reactive oxygen species (ROS) byproducts in both whole blood and mononuclear peripheral cells of untreated hypertension people, in comparison to healthy subjects [32].Increased levels of hydrogen peroxide (H2O2) production have been seen in both treated and untreated individuals with hypertension, compared to those with normal blood pressure. There is a strong association between H2O2 levels and systolic blood pressure, as demonstrated by previous research [33].
In addition, both hypertensive individuals with malignant and nonmalignant conditions exhibited higher levels of lipid hydroperoxide [34].The renin-angiotensin-aldosterone system (RAAS), which encompasses the activation of renin release by the sympathetic nervous system (SNS), is probably also implicated. There is increasing evidence indicating that the production of reactive oxygen species (ROS) driven by NADPH and the activation of signaling cascades dependent on reduction-oxidation (redox) processes play a crucial role in the development of hypertension induced by Ang II. By attaching to the specific receptor Ang-II type 1 (AT1r), angiotensin II triggers the activation of nonphagocytic NADPH oxidase, resulting in the accumulation of peroxynitrite, hydrogen peroxide, and superoxide.

In addition, the presence of hyperinsulinemia can lead to salt retention and activation of the sympathetic nervous system (SNS), which in turn can further stimulate the renin-angiotensin-aldosterone system (RAAS) and contribute to the maintenance of hypertension [35]. Hypertension is associated with increased levels of reactive oxygen species (ROS) and OS-activity in the brain, according to experimental models [36,37].Reducing SNS function and arterial blood pressure are two additional benefits of antioxidants [37]. According to these results, obesity-related hypertension may be aided by oxidative stress's (OS) stimulation of the sympathetic nervous system (SNS) in the brain. The hypothesised mediators linking

adipose tissue, oxidative stress (OS), and hypertension include adipokines (ghrelin, adiponectin, and leptin), pro-inflammatory cytokines (TNF-, IL-6, and IL-1), and neuropeptides (melanocyte-stimulating hormone and neuropeptide Y) [38].

3.3. The relationship between obesity, oxidative stress, and Type 2 Diabetes Mellitus:

When the body develops a resistance to insulin, it causes high blood glucose levels, a medical condition known as type 2 diabetes mellitus [29]. Type 2 diabetes mellitus is mostly caused by obesity. Various cellular systems, including changes in insulin signaling, glucose transport, dysfunction of pancreatic β cells, and increased inflammation, are involved in the continuum that leads to diabetes, as shown by the relationship between obesity and impaired serum glycemic levels [39].

Hyperglycemia stimulates the excessive generation of reactive oxygen species (ROS) and causes damage to the DNA by creating single-strand breaks. Furthermore, excess free radicals (FR) and reactive oxygen species (ROS) linked to diabetes and its consequences are accelerated when obesity is present at the same time [29].

It seems that all mechanisms triggered by hyperglycemia in diabetes mellitus are mainly caused by excessive production of reactive oxygen species (ROS) in the mitochondria [41], despite the involvement of various systems such as the polyol pathway, PKC activation, accumulation of advanced glycation end products, and the hexosamine pathway [40]. When the concentration of glucose within cells is high, more glucose is used up and broken down by the Krebs cycle. This increases the flow of NADH and FADH2 into the electron transport chain in the mitochondria. When there are too many electrons going to coenzyme Q, superoxide is produced [42]. Extra pathways for superoxide synthesis may be activated by mitochondrial superoxide, which might worsen damage. Glucose may cause an increase in reactive oxygen species (ROS) and other mitochondrial enzymatic processes, including nitric oxide synthase uncoupling, xanthine oxidase stimulation, and NADPH oxidase activation, according to research [43].

Glycated proteins may serve as promoters of reactive oxygen species (ROS) formation [44].Furthermore, there is evidence suggesting that the excessive creation of reactive oxygen species (ROS) and the decreased effectiveness of antioxidant defenses initiate at an early stage and ultimately lead to the destruction of cells throughout the disease [41]. Afterwards, it was shown that adipocytes develop insulin resistance due to impaired insulin signaling brought on by mitochondrial dysfunction brought on by persistently high intracellular levels of reactive oxygen species (ROS) [45].

The development of type 2 diabetes is linked to β-cell malfunction, which may be prevented by oxidative stress, which in turn promotes the traits of glucotoxicity and lipotoxicityassociated with diabetes [46]. Furthermore, hyperglycemic conditions might cause pancreatic β-cells to release reactive oxygen species (ROS), which hinder the production of insulin in response to glucose [47]. In addition, several antioxidant molecules are often not expressed at high levels in β-cells, which makes them vulnerable to damage caused by reactive oxygen species (ROS) [48]. Several studies have shown that elevated levels of CRP, IL-6, and TNF-α, which indicate subclinical underlying inflammation in obese patients, predict the development of type 2 diabetes [49,50] and contribute to a decrease in insulin responsiveness in peripheral tissues [51], supporting these results. IL-6 may impede insulin signaling by stimulating proteins to bind to the insulin receptor, and CRP is linked to insulin resistance [49]. In addition, research has shown that the adipose and muscle tissues of non-diabetic people who are overweight and insulin resistant create an excess of TNF-α, and this excess is significantly linked to insulin resistance. Surprisingly, those who have type 2 diabetes also have higher levels of serum TNF-α [52].

In type 1 diabetes, IL-1 is recognized as an essential factor in the demise of pancreatic β-cells

[53]. Because persistent inflammation hinders β-cells' capacity to make enough insulin, IL-1 has also been linked to the onset of type 2 diabetes. In addition, pancreatic secretions from people with type 2 diabetes have been shown to contain IL-1 union. Raised plasma glucose levels also boost β-cell synthesis and IL-1 levels, which, in combination with TNF-a, encourage IL-6 development [54].
A study confirmed the role of IL-1 in type 2 diabetes by demonstrating that IL-1 exposure led to improved management of blood sugar levels in individuals with type 2 diabetes [55].In overweight or obese individuals, the occurrence of adiposopathy, which refers to the dysregulated capability of fat tissue, leads to glucotoxicity and lipotoxicity. These factors harm the pancreatic islet and liver, resulting in pancreatic β-cell dysfunction and liver insulin resistance. These are the main factors that contribute to the development of type 2 diabetes. Another possible relationship between obesity and diabetes is the way abnormalities in the serum cytokine profile lengthen the duration and severity of the disease.

3.4. The relationship between obesity, oxidative stress, andcancer:

Obesity and cancer have been linked in studies done all over the globe. A meta-analysis found that those with higher body mass indexes were more likely to acquire both common and rare cancers [57]. Rectal and prostate problems were positively correlated with this in males. Endometrial, gastrointestinal, and postmenopausal breast cancers were shown to be positively correlated in women [57].
The basic pathophysiological processes of cancer risk in obese persons have been the subject of many theories. Genetic variables, the insulin/IGF-I signaling axis, chronic low-grade inflammation, adipokine release, and the gut microbiota are usually involved in the complicated processes that are linked to these pathways [58].
The risk of many particular forms of cancer, such as gastrointestinal malignancies, breast cancer, prostate cancer, and thyroid tumors, is connected with a diverse body mass index (BMI), which is determined by genetic variables [59]. While some studies have shown a correlation between cancer and changes in the "macrophage advanced metabolic network genes" [60,61], others have failed to replicate similar results [62].

Considering the indications related to the hypothalamus, the liver produces insulin-like growth factor (IGF). Specifically, the human liver creates multiple variations of IGF, with IGF-I being the most abundant and readily available version. It is transported in the bloodstream by proteins known as IGF binding proteins (IGFBPs). The insulin receptor (IR) and IGF receptors (IGFRs), which are mostly expressed in the intestines, are bound by solvent IGFs (IGFs) [63].

IGF-I affects the uptake of supplements by influencing endocrine and brain connections. It stimulates cell division and inhibits apoptosis, promoting cell growth [64]. An elevated risk of tumorigenesis and metastasis is associated with an increase in IGF-I cell mobility [65].
There is an increase in oxidative stress results and a reduction in cell reinforcement chemicals in obese patients. The production of inflammatory molecules including IL-17, IL-22, TNF-α, IL-6, and monocyte chemoattractant protein 1 (MCP-1), tissue necrosis, and the ensuing buildup of activated macrophages are all consequences of obesity, which also causes an increase in the size and motility of adipocytes. This occurrence has multiple effects, including accelerating insulin resistance development [66], decreasing levels of anti-inflammatory factors (IL-10, IL-4, TGF-α, T-regs) [67], increasing production of reactive oxygen species (ROS), which modify important macromolecules through oxidative stress [68], and

eventually contributing to cancer development [64]. The increased frequency of neoplasia in obese people is explained by the fact that visceral fat compartments show more pronounced chronic inflammation than subcutaneous fat compartments.
A number of adipokines, produced and secreted by adipose tissue, may affect metabolic cellular activity [69]. Changes in leptin and adiponectin levels are associated with cancer initiation.
Leptin attaches to transmembrane receptors located on the stomach, colon, estrogen-dependent breast cancer [70], androgen-insensitive prostate [71], and thyroid cells [72]. This binding leads to the formation of new blood vessels (angiogenesis), the growth and division of cells (cellular proliferation), the movement of cells (migration), and the infiltration of tumor cells (invasion). Additionally, it hinders the process of cell death (apoptosis) [73]. Adiponectin, a substance with inhibitory effects on cell growth and blood vessel formation, blocks leptin's impact on cellular processes. Hypoadiponectinemia and carcinogenesis do, in fact, go hand in hand [76].
Intestinal inflammation, altered gene expression, and improved calorie extraction from indigestible food polysaccharides are all ways in which the gut microbiota contributes to obesity.

These factors collectively contribute to the development of obesity-related gastrointestinal carcinogenesis. Many different kinds of cancers may arise in the digestive tract, and the makeup of the microbiota in the small and large intestines, esophagus, stomach, and pancreas can play a role in this [77,78].

3.5. The relationship between obesity, oxidative stress, andmetabolic Syndrome:

The International Diabetes Federation defines metabolic syndrome (MS) as the presence of three or more of the following symptoms: obesity, hyperglycemia, hypertension, low levels of high-density lipoprotein (HDL) cholesterol, and/or hypertriglyceridemia [79]. Obesity is considered a critical component of multiple sclerosis (MS), even if the pathophysiologic processes underlying MS are still not completely understood. [80] TheOne possible mechanism by which obesity-related multiple sclerosis develops is the abnormal production of fat-derived cytokines (TNF- and IL-6) and adipocytokines (PAI-1, leptin, resistin, visfatin, and adiponectin). Insulin resistance [81] and thrombosis, respectively, are aided by elevated plasma levels of tumor necrosis factor- and platelet-activated inhibitor-1, respectively. Multiple studies have linked insulin resistance and body mass index (BMI) to increased IL-6 levels [82].
IL-6 in particular causes hepatic signalling to be impaired and the phosphorylation of seems to increase insulin resistance. Glucose transporter 4 (GLUT-4) [83], insulin receptor substrate 1 (IRS-1), and other distinct transcription-related elements [84].Leptin has been shown to play a role in the pathophysiology of MS; it impairs insulin sensitivity and causes insulin resistance and fat buildup [85]. Similarly to how leptin mediates insulin resistance, resistin seems to do the same [86].

Visfatin may also be important in the development of MS. Serum levels, linked to lipid metabolism and inflammatory response, play a role in pathogenesis.Leading to impaired pancreatic -cell activity [87].On the other hand, adiponectin has just been associated with a protective impact on multiple sclerosis. While reducing the activity and release of IL-6 and TNF-, this chemical stimulates the production of IL-10 and IL-1Ra in adipocytes and macrophages [88]. In addition, Apelin has multiple sclerosis.Obesity and risk factors are associated with elevated apelin levels in both adipose tissue and the bloodstream [88].

Although there is significant evidence that obese patients have dysregulated production of “offensive” adipocytokines OS is connected to MS [89] and is now known to play a significant role in the insulin production by pancreatic -cells is known to be impaired as part of the aetiology of MS. OS [90] and glucose transport in muscle [91] and adipose tissue [92]. Atherosclerosis, hypertension, and hepatic steatosis are all contributed to by an increase in OS in arterial walls [89].

Locally produced OS in each of the aforementioned tissues causes harm to cell membranes, proteins, and DNA Consequently, OS would seem to have a role in the development of each disease, which could lead to MS [93].First, through excess FFA and cytokines like TNF-, visceral fat storage causes an increase in systemic lipid peroxidation and damage, which then causes systemic oxidative damage [94]. Reduced anti-oxidant activity is another finding in multiple sclerosis patients [93].

In relation to hypertension is a well-known physiological regulator of antioxidant and oxidant imbalance.Recent investigations have indicated that OS induces endothelial dysfunction, which results in elevated arterial pressure.High blood pressure with coronary artery disease [93].Dyslipidemia has been linked to increased ROS release and decreased SOD and eNOS synthesis, according to many in vitro and in vivo studies [93]. Studies have shown strong associations between antioxidant status, MS, OS, and OS-related markers, leading some to speculate that OS may play a pivotal role or possibly be an early event in the development of MS [95]. In the pathogenesis of multiple sclerosis [93].Furthermore, those who are overweight or obese are at an even greater risk of developing multiple sclerosis (MS) because to increased OS in obesity [96]. New studies have looked at how mitochondrial dysfunction relates to OS.

Variables contributing to type 2 diabetes and MS’s cellular and tissue damage. Both type 2 diabetes and multiple sclerosis together This condition is characterized by alterations in the metabolism of fatty acids and the accumulation of these acids in tissues other than fat.It is believed that a considerable portion of the FFAs produced by lipolysis in the mitochondria are due to an anomaly in mitochondrial fuel metabolism, which is marked by an excess of -oxidation, an inefficient transition to carbohydrate substrate, and reduced TCA cycle activity. This increase in the production of partly oxidized products [97] occurs as a consequence of the electron transport system in the mitochondria.

Both rodents and people have high skeletal muscle mitochondria overproduce superoxide when there is a high dietary fat consumption textiles [97].Furthermore, the finding raises the possibility that mitochondrial overload is a direct mechanism by which an increased lipid supply results in oxidative stress damage in MS and T2D. Enhanced mitochondrial NADH/NAD+ ratio and increased intracellular fatty acid oxidation both result in activation of pathways involved in the production of ROS brought on by hyperglycemia, such as protein kinase C (PKC),NF-B and advanced glycation end products [98].ROS produced by hyperglycemia activate PKC, which in turn boosts NOX activity and promotes the creation of ROS and OS [99]. Additionally, endothelial cells show a reduction in eNOS upon PKC activation [100], smooth muscle cells show a rise in endothelium reduced NO synthesis [101], and vascular endothelial growth factor (VEFG) cells are seen in greater numbers in muscles [102]. Hyperglycemia-induced PKC activation also triggers NF-B and TGF-βB activation. Which relate OS brought on by hyperglycemia to inflammation [102]. Data on the consequences of advanced glycation end-products (AGEs) indicate that their buildup causes permanent alterations to cellular structure. Furthermore, it is thought that the primary mechanism by which AGEs promote OS is via the activation of pro-inflammatory pathways, cytokine production, and nuclear factor-B [103].

3.6. The relationship between obesity, oxidative stress, andliver disease:

Cirrhosis, inflammation, and fibrosis are all part of the range of disorders that make up nonalcoholic fatty liver disease (NAFLD). Instances of non-alcoholic steatohepatitis (NASH) and fatty accumulation (steatosis) are among these disorders [104]. Non-alcoholic fatty liver disease (NAFLD) has a significant role in multiple sclerosis (MS), particularly in those with obesity, hyperlipidemia, and diabetes. Despite the complexity of NAFLD's etiology, the "two-hit model" idea has gained widespread acceptance as the best explanation.First, insulin promotes hepatic fat storage; second, free fatty acids (FFAs) trigger reactive oxygen species (ROS) damage via a wide array of adipokines, including resistin, leptin, and adiponectin [105]. A key feature of non-alcoholic steatohepatitis (NASH), the main component of non-alcoholic fatty liver disease (NAFLD), is the buildup of triglycerides (TG) as lipid droplets inside the cytoplasm of liver cells (hepatocytes). Liver cytoplasm TG accumulation is caused by an increase in the transport of both free fatty acids (FFA) and triglycerides (TG) to the liver, a decrease in the liver's utilization of FFA, a decrease in the production of TG by the liver, and an inhibition of the breakdown of FFA by beta-oxidation inside liver cells [106,107]. The oxidative capability of mitochondria is impaired due to hepatocyte lipid buildup, which in turn reduces the functioning of electron transport chain complexes.

This, in turn, stimulates the peroxisomal and microsomal pathways of fat oxidation. The production of reactive oxygen species (ROS) is another direct outcome of mitochondrial malfunction. The generation of superoxide anions and H2O2 may occur if the electron stream is interrupted at any point in the respiratory chain, since the electrons can be transferred to sub-atomic oxygen by the preceding respiratory intermediates [108].

Thus, the generated ROS can stimulate the Fast ligand/Fast system, leading to the activation of structural proteins in the Fas death zone. This, in turn, triggers the downstream caspase family members to initiate the protease procascade reaction, ultimately causing cellular disarray. The enlarged age of reactive oxygen species (ROS) and reactive aldehydes leads to the advancement of oxidative stress and cell deterioration. This is caused by the consumption of ATP, NAD, and glutathione, as well as the damage to DNA, lipids, and proteins [109]. Liver dysfunction has been linked to a number of different cellular and extracellular variables, including mitochondrial malfunction, endoplasmic reticulum stress, iron buildup, and inflammation produced by gut flora.

The tramacenter facilitates the merging and arrival of layer proteins. To have this capability, it is necessary to have high concentrations of calcium within the emergency room. The presence of FFAs, unesterified cholesterol, diacylglyceride, and phospholipids leads to a decrease in calcium levels within the emergency room and an increase in "tramacenter pressure", promoting apoptosis and the recruitment of hepatic stellate or Kupffer cells [110].Elevated levels of free fatty acids (FFAs) in the blood stimulate the production of ketones and the oxidation of fatty acids in the mitochondria, peroxisomes, and microsomes. This process leads to the release of reactive oxygen species (ROS), which contribute to programmed cell death, as well as damage to the DNA in the nucleus and mitochondria in non-alcoholic steatohepatitis (NASH) [110]. Concerning the function of iron excess in overweight individuals suffering from non-alcoholic steatohepatitis (NASH), research has shown that iron contributes to the acceleration of reactive oxygen species (ROS) synthesis via the Fenton reaction [111]. In addition, the emergency department's overproduction of proteins that regulate iron levels causes localized adipose tissue iron buildup, which in turn sets the

stage for adverse consequences produced by reactive metal compounds. A person's oxidative stress, inflammation, trauma center pressure, and endocrine dysfunction may all be improved with iron. It is possible that iron-mediated toxicity factors have a role in obesity development and exacerbate obesity-related problems, including NASH [112]. Gastric microbiome is an important risk factor for nonalcoholic fatty liver disease and nonsmoking fatty liver, particularly in those who are overweight [110]. New research shows that the gut microbiota of obese persons is different from the microbiome of normal people. It may cause inflammation, increased permeability, and malfunction in the intestines as a result of broken intercellular junctions and other compounds produced by pro-inflammatory bacteria. This state is marked by reduced efficiency of anti-oxidant systems and enhanced support for oxidant species such Toll-like receptors (TLRs) and tumor necrosis factor-α. The rise in reactive oxygen species (ROS) has several associated causes [113]. Animal models of nonalcoholic steatohepatitis (NASH) have also shown that ROS production is increased in the presence of excessive free fatty acids (FFAs) [108]. Furthermore, human livers affected by NASH show elevated levels of FFAs byproducts from lipid peroxidation, further indicating increased oxidative stress [114]. Furthermore, lipid peroxidation and reactive oxygen species (ROS) may activate hepatic stellate cells, which in turn may promote fibrosis.

These cells then produce collagen and promote the inflammatory response, leading to a fibrogenic reaction [109].This syndrome can be exacerbated by low-grade chronic inflammation in patients who are fat. The development of NAFLD is facilitated by cytokines linked to obesity, including IL-6, TNF-α, adiponectin, visfatin, and leptin, which cause hepatocellular damage by ROS mediation. To be more specific, significant liver damage is linked to increased blood levels of TNF-α and reduced levels of adiponectin [116]. Additional research has shown that hepatic steatosis causes NF-κB to become more activated. Inflammatory agents such TGF-β, Fas ligand, TNF-α, leptin, adiponectin, IL-6, IL-1b, and IL-8 are stimulated to be produced by the last option.

These agents are involved in various aspects of NASH, such as the activation of Kupffer cells, macrophages, apoptosis, inflammation [117], and fibrosis [118]. Finally, a liver that has an excessive amount of fat is more susceptible to stressors because its antioxidant systems are reduced [119], making it more prone to obesity connected to the oxidative stress.

4. Lifestyle Choices, Oxidative Stress, and Inflammation: A Connected Web

Tissue acquires the disease phenotype due to cellular and metabolic alterations brought about by inflammation and oxidative damage. [14]. Therefore, it may be possible to improve illness stratification by assessing oxidative and inflammatory markers [57]. There is substantial evidence linking unhealthy lifestyle choices to the development of NCDs[1,3,22]. Therefore, the possibility of a link between these two potential causes is not out of the question. Numerous studies point to oxidative stress, inflammation, and other lifestyle choices as potential causes of chronic non-communicable illnesses [32, 85, 86].

4.1. The Consumption of Energy:

Calorie overload may exacerbate preexisting diseases including inflammation and oxidative stress, in addition to the indirect impacts of gaining weight and total body fat [89–91] and the direct contributions of a high-energy diet to these problems [102–106]. According to Boden et al. [102], a high-calorie diet (6000 kcal/day) given to healthy males for a week can cause systemic oxidative stress to start quickly, as shown by increased levels of the lipid peroxidation biomarker 8-iso-PGF2α and ROS-driven carbonylation and protein oxidation. In addition, our study has shown that high-calorie, low-nutrient meals such as sugar, milk, ice

cream, and the like may raise plasma lipid peroxidation and lower plasma total antioxidant capacity (TAC) for up to four hours after intake [107]. In another research, individuals who were obese saw a decrease in the lipid peroxidation biomarker F2-isoprostane after a 25% calorie restriction for 28 days [106]. Also, studies on healthy people have shown that fasting may lower levels of oxidative stress indicators in DNA and plasma lipid, protein, and amino acid markers, as well as tyrosine, m-tyrosine, and thiobarbituric acid-reactive species (TBARS) [104,105]. Additionally, studies have examined the production of reactive oxygen species (ROS) by leucocytes during short durations of caloric restriction (less than 48 hours) [103]. Another potential result of chronic caloric restriction is a decrease in plasma inflammatory C-reactive protein levels [109] and a reduction in the age-related rise in inflammatory IL-6 production by peripheral mononuclear cells [108].
extending energy consumption and decreasing calorie intake (10–50% below average ad libitum intakes) may be the key to delaying aging and extending longevity, according to both animal and human research [110]. These findings provide credence to the idea that low-calorie dieting may influence transcripts linked to longevity via the insulin/FOXO/insulin-like growth factor 1 (IGF-1) pathway [111].
However, our understanding of the exact mechanism responsible for these outcomes is still limited.

4.2. Preserved Meat:

Research has shown that there is a negative correlation between plasma antioxidant capacity and a high intake of animal proteins, especially red meat-derived proteins, and a positive correlation with plasma lipid peroxidation biomarkers, TBARs [126]. A complex medium, red meat contains large levels of saturated fat, trans fat, and heme-iron; the pro-oxidant qualities of these components may contribute to its influence on oxidative stress, at least in part [126,127].
In addition, advanced glycation end products (AGE), heterocyclic amines (HCAs), and polycyclic aromatic hydrocarbons (PAHs) are strongly pro-oxidant byproducts of high-temperature meat preparation techniques, such frying [128]. Also found in abundance in red meat are the nutrients choline and L-carnitine, which may be converted to trimethlyamine-N-oxide (TMAO) in the liver after being metabolized to trimethylamine (TMA) by the gut bacteria in the colon [130]. Eating a lot of red meat raises your TMAO levels, which in turn increases your risk of oxidative stress and vascular inflammation [131].

4.3. Low-Nutrient Foods :

Dietary factors may have a stronger correlation with oxidative stress and inflammatory profiles than individual dietary factors, which is now well recognized [28]. Thus, considering the operation of meals with complicated matrices is crucial from this perspective. Examples of processed foods with low nutritional densities that could nonetheless have a complex matrix rich in sugar, omega-6 PUFAs, saturated and trans fats, and AGEs include sugary soft drinks and fast food. Inflammation, oxidative stress, and cell damage may all be outcomes of these factors, as mentioned before [133]. Regular use of these nutrient-poor foods may increase the risk of oxidative damage and micronutrient deficiencies, such as zinc, selenium, vitamins A, E, and D. The body's inherent capacity to fight free radicals, which are generated by metabolic activities, may be hampered by these deficiencies [134].

4.4. Substance Abuse in the General Public

The conversion of acetaldehyde is mostly carried out by liver alcohol dehydrogenase [132]. On the other hand, excessive alcohol usage over an extended period of time may activate the cytochrome P450 2E1 oxidase system, which is responsible for its metabolism . Reactive oxygen species (ROS) and highly reactive free radicals, such as hydroxyl radicals and superoxide anions, may be produced during this process [135]. A decrease in cell glutathione (GSH) levels and an accumulation of malondialdehyde (MDA) and hydroxyethyl radicals in the liver are consequences of chronic alcohol use, according to rat studies [136]. Further animal investigations have shown that excessive alcohol usage is associated with a greater concentration of 8-iso prostaglandin-F2α in the urine [137] and 8-oxoguanine in the liver [138]. Human studies suggest that excessive alcohol consumption may lead to elevated plasma levels of acetaldehyde-protein adducts, advanced glycoxidation end products (AGE) [139], and oxidized low-density lipoprotein (LDL-C) [138].

Cigarette smoke is a classic example of a substance that causes oxidative stress since it includes over 4000 different compounds, many of which have harmful consequences. In this category include chemicals such as free radicals and oxidants [141]. Smoking activates NF-κB, which in turn sends pro-inflammatory signals to the body and exposes it to free radicals and oxidants, potentially exacerbating oxidative stress [142]. So, it's not surprising that smoking is associated with higher levels of inflammatory and oxidative stress markers in the blood, such as IL-1β, IL-6, IL-8, hs-CRP, and soluble adhesion molecules [143].

Conclusion:

Recent research lends credence to the idea that inflammation and oxidative stress brought on by unhealthy lifestyle choices are key factors in the metabolic abnormalities that lead to noncommunicable diseases. A preclinical condition of increasing tissue damage is produced by oxidative stress and inflammation; if this state persists, it will lead to certain system failures and the diseases that accompany them. By quantifying and monitoring levels of key oxidative stress and inflammatory biomarkers and identifying their relationship to an individual's unique set of lifestylebehaviors, it may be feasible to effectively treat or avoid the chronic subclinical tissue damage.
An early warning system for the seemingly healthy person on the road to illness may be included into such a wellness assessment profile. This evaluation of oxidative and inflammatory indicators might also serve as a starting point for tracking the effectiveness of any intervention. Current public health initiatives aimed at preventing and reversing NCDs and their associated economic burden may benefit from such a changed therapeutic strategy.

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