Review Article

EXERCISE AND OBESITY: ACTIVATION OF ANTIOXIDATIVE PATHWAY AGAINST OXIDATIVE STRESS

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ABSTRACT

Obesity is now acknowledged as a primary health burden which impact quality of life heavily due to its various complications. It is a chronic disease of multifactorial origin. Growing evidence proposes that one of the critical factors linking obesity with its associated complications is oxidative stress. Obesity induces systemic oxidative stress which causing the disordered production of adipokines that contributes to the metabolic syndrome development. They are more sensitive towards C-reactive protein (CRP) and other oxidative damage biomarkers. In contrast, the level of antioxidant defence markers is lower based on the total body fat as well as central obesity. One of the antioxidants is glutathione (GSH), which acts against free radicals and reactive oxygen species (ROS) in detoxification of xenobiotic compounds. Moreover, glutathione peroxidase (GPx), one of the most abundant in its family is the most effectual one against oxidant stress in erythrocytes and has some essential functions in phagocytic cells. Besides, it is also in charge of the removal of intracellular hydroperoxides. Therefore, this review attempts to evidence (i) the role of oxidative stress due to obesity as well as (ii) antioxidants as the potential opposition to this event as promising interventional therapy to manage obesity.

INTRODUCTION

Obesity: Incidence and Global Scenario

Based on World Health Organization (WHO) 2021, about 13% of the world's adult population (11% of men and 15% of women) were obese in 2016. The worldwide prevalence of obesity significantly increased between 1975 and 2016. In 2019, approximately 38.2 million children younger than 5 years were overweight or obese. Beforehand, it is viewed as a high-income country problem, however, overweight and obesity are escalating in low- and middle-income countries, particularly in urban settings. In Africa, since 2000, the number of overweight children under 5 has risen by almost 24%. Practically 50% of the children under 5 who were overweight or obese in 2019 lived in Asia. More than 340 million children and adolescents aged 5 -19 were overweight or obese in 2016 [1].

As stated by a systematic analysis of global data on the prevalence of overweight and obesity in adults [2], the prevalence of obesity in Malaysia (11.4% in males; 16.7% in females) was lower than that reported in Western countries, such as Australia (27.5% in males; 29.8% in females) and the United States (31.7% in males; 33.9% in females). Nonetheless, it was almost three to four times higher than in other Asian countries, such as India (3.7% in males; 4.2% in females), China (3.8% in males; 5.0% in females), Taiwan (4.3% in males; 6.4% in females) and Japan (4.5% in males; 3.3% in females).

Based on the statistic from World Population Review in 2019, Malaysia has the highest prevalence of obesity (15.6%) followed by Brunei (14.1%), Thailand (10%) and Indonesia (6.9%) [3]. According to the National Health and Morbidity Survey Malaysia (NHMS) in 2019 reported that 30.4% of overweight and 19.7% in adults, specifically high among women (54.7%). NMHS also revealed that 29.8% of children between 5-17 years old were overweight/obese [4]. On top of that, the health consequences of overweight and obesity are extensively associated with comorbidities and a high prevalence of cardiovascular diseases, diabetes, hypertension and several cancers [5]. This shows how supreme obesity is as one of the conditions that have a global impact with Malaysia is of no exception reinforcing the need to address it and manage it to the core.

Risk factor for obesity

Overweight and obesity are defined as an anomalous accumulation of excessive body fat [6] which may jeopardize health (WHO,2020). The World Health Organization (WHO) described overweight as a body mass index (BMI) of 25.0 to 29.9 kg/m^2 and obesity as a BMI of ≥30 kg/m^2 [7]. Obesity is a complex health issue that now has been considered as a disease. It results from an amalgam of individual factors and causes involving modifiable and non-modifiable factors. Habitual or

non-habitual behaviors which are all modifiable factors comprise inactivity, physical activity, medication use, dietary patterns, and other exposures. Other contributing factors are the food and physical activity environment, food marketing and promotion, as well as education and skills (CDC, 2020). On the other hand, hereditary factors such as genetics, family history, racial/ethnic differences are the non-modifiable factors that also play an important role in causing obesity. However, in general, obesity is undeniable to be greatly caused by those modifiable factors.

Over the years, the role of physical activity and diet remains the centre of attention in reducing the prevalence and risk of obesity worldwide. In order to maintain a healthy weight in the long run, observational cohorts evidently point out that "healthier" diets bring about better results. For instance, averaged 4-year weight gain throughout middle age is indicated by research in US health professionals as being closely linked to increased intake of sugar-sweetened beverages, processed and unprocessed red meats and potato chips and potatoes, but inversely linked to the intake of fruits, whole grain, vegetables, fruits, yoghurt and nuts [9]. Certain food groups like sugar-sweetened beverages, earn abundant attention as consumption of added sugar has been on the rise concurrently with prevalent obesity [10]. On a related point, Malaysia as a middle-income country is now experiencing rapid urbanisation and industrialisation which have brought significant changes to the dietary patterns and lifestyle of Malaysians [11]. At the same time, the introduction of modern fusion food has transformed the Malaysian diet from low calories of plant-based products to a diet rich in calories, fats and sugar [12].

Upper levels of physical activity correlate with both long-term weight maintenance after intentional weight loss and weight gain prevention. Among the vital findings in Nurse`s Health Studies (NHS) II are that women who performed less physical activity (e.g., < 30 min/day) then increased it (≥ 30 min/day) had remarkably reduced weight gain. Inversely, if physical activity is maintained at a low level, or fell from high to low, women had a higher risk of putting on weight [13]. Moreover, sedentariness has a hand in obesity; watching television and other sedentary activities at work or home escalated the risk of becoming obese [14].

Previous research revealed that Indians has the highest risk of being overweight and obese compared to other ethnicities which are suggestive of a role of genetics in obesity [15]. However, it does not rule out environmental factors like cultural influences and behavioural on food preparation and consumption [16]. Besides, the population with lower education levels had a higher prevalence of overweight as well as obesity. Unawareness to these people of good habits due to absence or little exposure to the right education subsequently prompt sedentary lifestyles, unhealthy eating, and impact them negatively in terms of chronic illness. Besides, obesity occurs similarly in the urban and rural areas which heavily suggests that it is not restricted to those loaded ones, but is also widely spread to the rural due to rapid urbanization along with growing numbers of highly processed food advertising and food media in promoting fast food outlets and supermarkets [15] in contrast to the traditional home cooked-meals which contain healthy fibre with fruits and vegetables [17].

Obesity-induced oxidative stress

Oxidative stress (OS) occurs due to an imbalance between the generation and degradation of reactive oxygen species (ROS) or reactive nitrogen species (RNS). They are partially reduced, oxygen-containing metabolites (some of them are free radicals) which are immensely reactive with the potential of oxidizing proteins, lipids and DNA. ROS are produced by mitochondria because of normal cellular metabolism and environmental factors but are exceptionally abundant in pathological conditions. Hydrogen peroxide (H_2O_2), superoxide radicals ($O_2^{\bullet -}$), singlet oxygen ($^1O_2$) and hydroxyl radicals (•OH) are examples of ROS which are produced as metabolic by products [18]. However, proper ROS generation affects several processes like activation of transcriptional factors, protein phosphorylation, immunity, apoptosis and differentiation. Furthermore, they are involved directly and indirectly in immune-mediated defence mechanisms against pathogenic microorganisms [19].

Obesity is found to be related to low-grade chronic systemic inflammation that occurs in adipose tissues. Activation of the innate immune system influence this condition by promoting pro-inflammatory responses while a systemic acute -phase response triggered by OS takes place. Adipose tissue, and endocrine and storage organ which is essential for homeostatic control of energy balance, is predominantly composed of adipocytes. It secretes hormones and cytokines (adipokines or adipocytokines) which act for paracrine, endocrine and autocrine action. However, in obese people, the adipocytes limit the normal functioning level thus unable to function properly as an energy storage organ. The excessive adipose tissue also has been recognized as a source of pro-inflammatory cytokines including interleukin (IL) -1β, IL-6 and tumour necrosis factor-alpha (TNF-α) [20], which are the most prominent mediators involved during the early inflammatory response. In addition, it results in fat being inappropriately accumulated in important organs; heart, liver, pancreas which can cause the dysfunction of this organ. In physiological and hazardously in pathological conditions, adipokines (MCP-1,-2,-4 along with MIP -1a, -1b,-2a) trigger infiltration of macrophage and subsequent excess production of ROS and inflammatory cytokines, give rise to OS and, eventually, a major, erratic production of other adipokines [21, 22] ROS itself also induces the release of pro-inflammatory cytokines and expression of growth factors (e.g., insulin-like growth factor-1 (IGF-I) and connective tissue growth factor,) and adhesion molecules [23] through redox-sensitive transcription factors, specifically the NADPH oxidase (NOX) and NF-κB pathway [24].

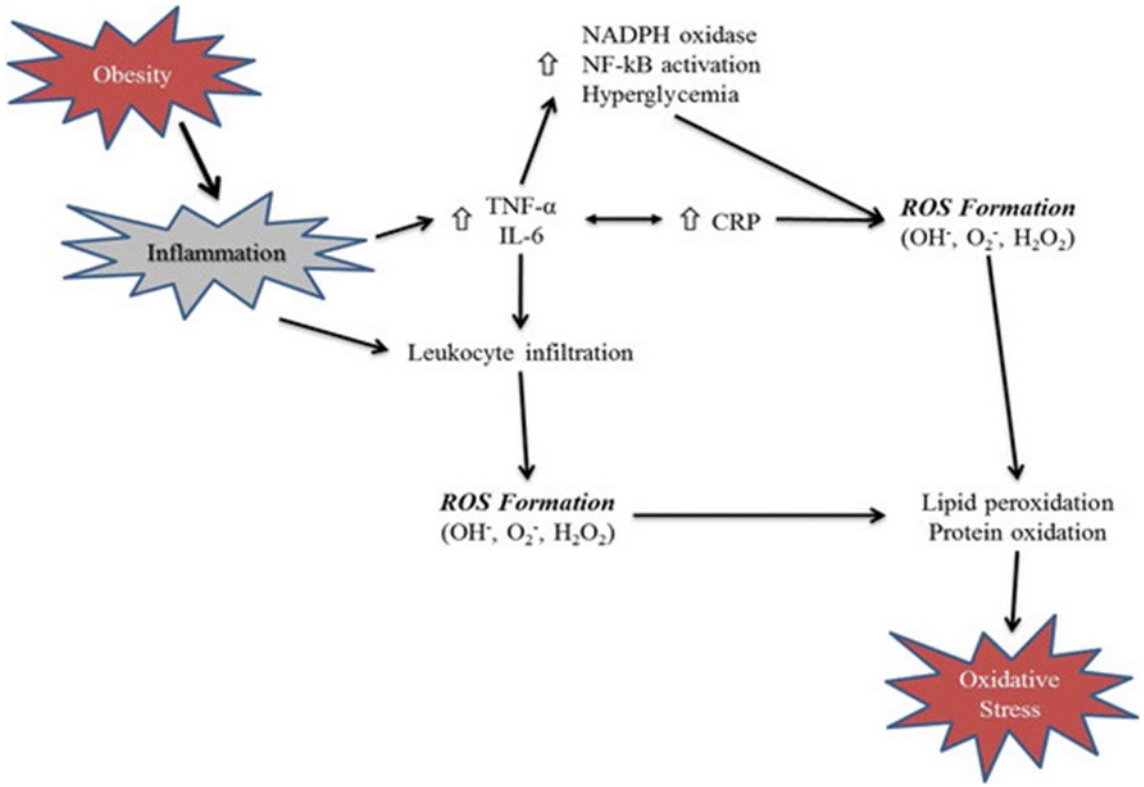

Figure 1. The illustration summarizes the obesity-induced oxidative stress in general, in which obesity is proven to cause inflammation thus bringing about a series of pathways involving pro-inflammatory cytokines and increased production of reactive oxygen species (ROS) which end up with oxidative stress [25].

At the same time, impairment of the activity of nuclear factor E2-related factor 2 (Nrf2) occurs. This results in an impediment of the expression of Nrf2 downstream targets (antioxidant and phase II detoxifying enzymes) leading to debilitated body antioxidant defences [26]. In addition, antioxidant sources are depleted including glutathione peroxidase (GPx), superoxide dismutase (SOD), catalase (CAT), vitamin A, vitamin E, β-carotene and vitamin C [27]. The latter is through modulation of expression of sodium-dependent vitamin C transporters believed to be caused by metabolic and/ or OS, thus adversely affecting cellular uptake and in the bigger picture, vitamin C homeostasis. All of these contribute to greater susceptibility to oxidative damage in obese subjects [28].

Obesity correlates highly with hyperglycemia and insulin resistance. Overabundant intracellular glucose escalates the tricarboxylic acid cycle and the glycolytic pathway which leads to the overproduction of nicotinamide adenine dinucleotide hydride(NADH) and flavin adenine dinucleotide hydride ($FADH_2$). It results in increasing proton gradient across the mitochondrial inner membrane which further causes leakage of an electron at complex III, leading to the formation of superoxide. Glyceraldehyde-3-phosphate dehydrogenase is inhibited by these free radicals thereby diverting upstream metabolites into four alternative pathways [29]: (1) shifting of glucose to the polyol pathway ; (2) shifting of fructose-6-phosphate to the hexosamine pathway; (3) production of methylglyoxal, the vital precursor of advanced glycation end products (AGE) by triose phosphates; and (4) conversion of dihydroxyacetone phosphate to diacylglycol which activates the Protein Kinase C (PKC) pathway. Activation of all these pathways generate oxidative stress either by; impairing antioxidant defences or amplifying the production of free radical. Moreover, polyol pathway activation causes depletion of nicotinamide adenine dinucleotide phosphate hydride (NADPH) as well as enhancement of glucose conversion to sorbitol which is responsible for activation of various stress genes causing oxidative stress [30].

Another well-known point is hyperleptinemia. Leptin, one of the adipocyte-derived factors, is positively associated with obesity, showing that it plays a part in obesity-induced oxidative stress [31]. Leptin activates nitrogen oxides (NOX) and induces the production of reactive intermediates like hydroxyl radical and H_2O_2 [32]. Secondly, hyperleptinemia also escalates the process of oxidation of mitochondrial and peroxisomal fatty acid, with consequential stimulation of ROS production via the mitochondrial respiratory chain [33]. It also triggers the proliferation of monocytes as well as macrophages thus promoting the production of proinflammatory cytokines which fortify OS [34]. Increased C-reactive protein (CRP) levels are also reported during the administration of leptin, further verifying inflammatory effects. As per these data, during weight loss, there is a reduction of obesity-associated inflammatory

markers and circulating leptin levels (Figure 1) [35].

In obese subjects, accumulation of excessive fat leads to a pathological rise of serum-free fatty acids (FFA) levels sequentially impairs glucose metabolism [36], favours adipose, muscular and hepatic accumulation of energy substrates; fats and glucose [37] and elevates higher mitochondrial and peroxisomal oxidation. This gives rise to significant synthesis of free radicals, depletion of adenosine triphosphate (ATP), mitochondrial DNA injury, OS [38] and, in the end, lipotoxicity. Besides, upbuilding of free radicals is majorly involved in vascular endothelium damaging, triggering endothelial dysfunction (ED) and development of cardiovascular complications related to obesity. Notoriously, cardiovascular events determine high premature mortality rates of obese patients (Figure 2).

CONCEPT OF ANTIOXIDATIVE PATHWAY

Activation of the antioxidative pathway

As overproduction of reactive oxidants is harmful, they are balanced out by complex antioxidant defence systems regulated by a series of pathways which is the Kelch-like ECH-associated protein 1 (Keap1) - nuclear factor erythroid 2-related factor 2 (Nrf2) - anti-oxidant response elements (ARE) pathway which occurs on a day-to-day basis to maintain the homeo-stasis in general by regulating the transcription of numerous detoxification genes and antioxidant genes. Under normal physiological conditions, bonding of Nfr2 with its negative regulator Keap1 (Kelch-like ECH -associated protein 1), which is a redox regulator substrate adaptor for the Cullin (Cul)3-RING-box protein (Rbx)1 ubiquitin ligase causes Nfr2 to remain idle as it directs Nrf2 to be sequestrated in cytosol by ubiquitination [39]. Keap1, a cysteine-rich protein is oxidized by ROS, consequentially, altering its conformational state, freeing Nrf2 [39] [40]. Thus, increasing OS encourages the dissociation of Nrf2 from Keap1, which activates a series of pathways to occur from initially bring about to Nrf2 translocation in the nucleus for it to heterodimerize with musculoaponeurotic fibrosarcoma proteins (MAF proteins), to bond with a specific DNA sequence known as the anti-oxidant response element (ARE, 5′-TGACNNNGC -3′) [41]. This results in the activation of a large number of genes associated with the production of antioxidative and cytoprotective proteins including NADPH dehydrogenase, quinone 1 (NQO1), heme oxygenase-1 (HO-1), glutathionine S-transferase (GST), c-glutamylcysteine synthetase, superoxide dismutase (SOD) glutathione peroxi-dase 1(GPx-1) and glutathione reductase (GR) (Figure 3) [42].

How antioxidative pathways act on obesity-induced oxidative stress

In accordance with the increasing prevalence of obesity, governmental and non–governmental organizations recommend a broad range of strategies to combat it. For instance, various health programs had been initiated by the Malaysian Government such as ‘My Weight My Health’, ‘Mysihat’ and ‘Eat Right, Move Right:

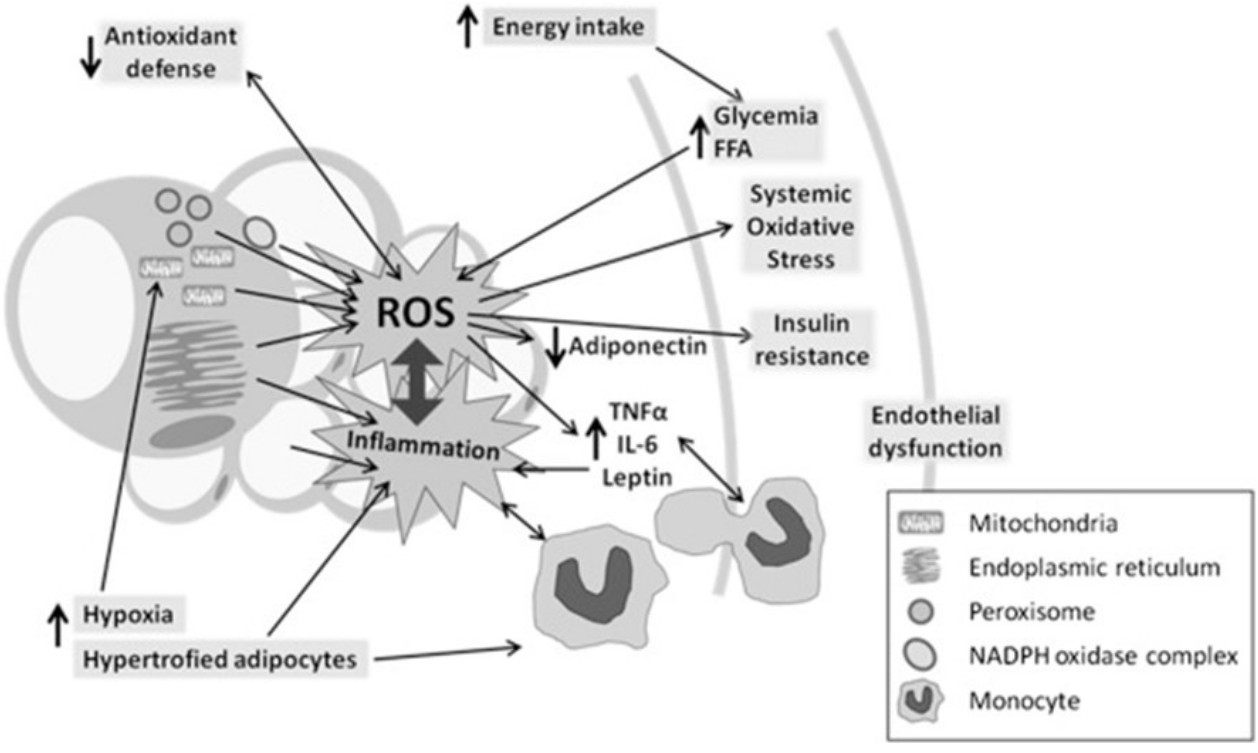

Figure 2: Illustration depicts how obesity induces oxidative stress at subcellular levels, by excessive production of ROS and reduced antioxidant defence through several mechanisms [38].

Fight Obesity to promote a healthy lifestyle among Malaysian citizens by disseminating information regarding proper dietary practices, nutrition and fitness through physical activities or exercises [43]. This is important in order to curb morbidity and mortality rates as well as health care expenses. A study by [43] exhibited that there was a significant additional increase in medical expenditure due to obesity and the actual cost that a patient should pay is very less due to being heavily subsidised by the Malaysian government. At present, emerging studies are aiming in modulating redox homeostasis as tools to forestall or slow down the progression of obesity-associated pathologies. Antioxidants are being looked into keenly as a possible option in controlling obesity and its associated complications.

In short, obesity-induced oxidative stress is briefly by several mechanisms; dysfunction adipose tissue, hyperglycemia, hyperleptinemia and hyperlipidemia resulting in oxidative stress due to an imbalance between ROS generation and its detoxification by antioxidant systems, in favour of the former. On the other side, antioxidants nullify the effect of highly reactive ROS by converting them into less reactive species and eliminating the byproducts through various reactions, preserving cells from oxidative damage, which will be discussed in many details.

Antioxidants can be classed into enzymatic and non-enzymatic types, in which the latter, its exogenous form is found mainly in the diet. Besides the other beneficial reactions through modulations of Keap1-Nrf2 signalling axis in response to ROS, the antioxidant enzymes produced during the pathway also play their role in the antioxidant defence system. They are effective in deactivating or stabilizing free radicals before the free radicals attack cellular components. These enzymatic antioxidants function by giving up part of their electrons to make the free radicals stable or by reducing their energy. Innumerable studies have been focused on the advantageous effects of antioxidant enzymes. Among the popular enzymatic antioxidants are catalase (CAT), gluthathione peroxidase (GPx) and superoxide dismutase (SOD). However, they also work interactively and synergistically with non-enzymatic ones in order to perform their function [44].

Catalase (CAT)

CAT is well known for its key role in controlling H_2O_2 concentration and other cytotoxic oxygen derivatives. It acts by breaking down two hydrogen peroxide molecules into one oxygen molecule and two water molecules in a two-step reaction. Basically, the first step of the reaction mechanism involves a high spin ferric (FeIII) state that reacts with peroxide molecules to form compound I intermediate, a porphyrin π-cation radical containing Fe^{IV}. H_2O_2 removes one of the protons from one end of the molecule and place it at the one end. The transferring of the proton is via histidine residue in the active site. This action polarizes and breaks the O-O bond in hydrogen peroxide. Secondly, the regeneration of enzymes by H_2O_2 which is used as a reductant produces oxygen and water. The native resting-state Fe (III) is formed by oxidation of an electron donor (here second H_2O_2) in compound I, a highly-oxidizing Fe (IV) species (Figure 4) [45].

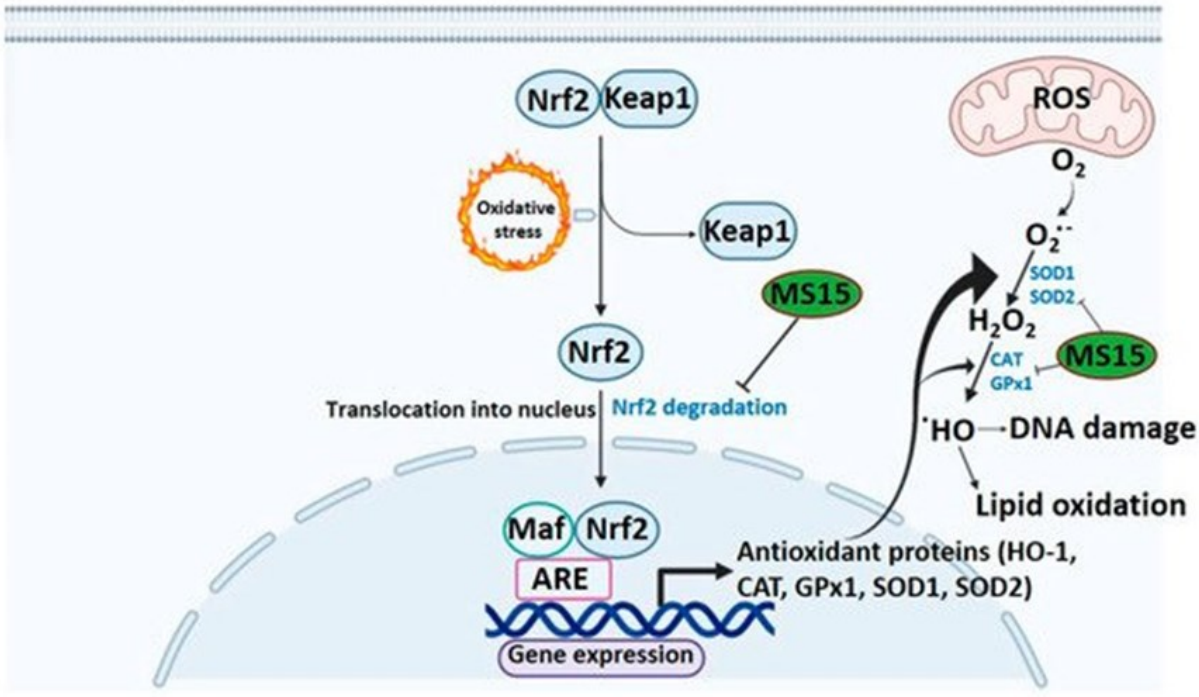

Figure 3: The activation of the antioxidative pathway mediated by oxidative stress causing abnormality to Keap1 configuration causing activation of Nrf2 pathway. This lead to the production of enzymatic antioxidants which play the role to reduced free radicals before they cause damage to cells particularly to protein, lipid or DNA [47].

Glutathione peroxidase (GPx)
Secondly, GPx, an enzyme-containing four selenium-cofactors catalyses the formation of oxidized glutathione (GSSG) from glutathione (GSH) by creating a disulfide bridge with another glutathione molecule while detoxifying these molecules by reacting with hydrogen peroxides or lipid peroxidation [46]. It is partly responsible for hydroperoxides reduction. The involvement of GPx in the detoxification of xenobiotics showed that this anti-oxidant enzyme provides the most important defence against the peroxidative damage of biological membranes in the mammalian cell (Figure 5) [47].

Superoxide dismutase (SOD)
The third one is SOD, which contains metal ion co-factors, that, depending on the isozyme, can be of various elements such as zinc, copper, iron or manganese. The role of these cofactors is to donate an electron to ROS and regenerate throughout the catalytic mechanism where SOD acts as the initial defence against reactive oxygen species (ROS)-mediated injury [48]. Furthermore, it catalyzes the dismutation of superoxide anion free radical (O_2•) into molecular H_2O_2 and oxygen. This reaction is followed by alternate oxidation-reduction of metal ions present in the active site of SODs (Figure 6) [49].

Apart from these enzymatic antioxidants, non-enzymatic antioxidants like lipoic acid also takes a lead. Being classed as “thiol” or “biothiol”, these sulphur-containing molecules catalyze the oxidative decarboxylation of alpha-keto acids, for example, α-ketoglutarate and pyruvate in Krebs cycle [50]. Lipoic acid and dihydrolipoic acid (DHLA), its reduced form, counteract the free radicals in both aqueous and lipid domains, hence, the nickname “universal antioxidant” [51]

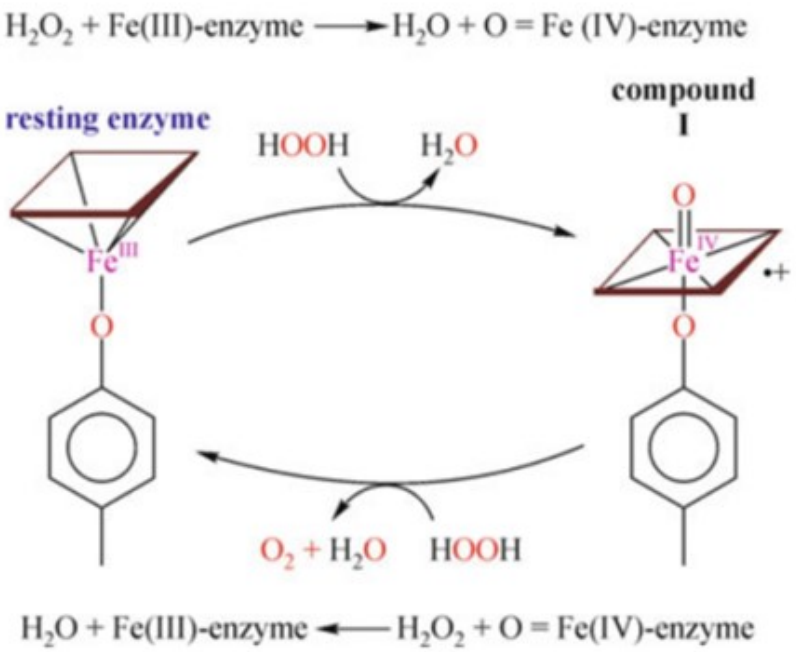

Figure 4 : Two-stage mechanism of catalase action [45].

$$H_2O_2 + 2GSH \xrightarrow{GP_x} 2H_2O + GSSG \quad (1)$$

$$ROOH + 2GSH \xrightarrow{GP_x} ROH + GSSG + H_2O \quad (2)$$

Figure 5: Glutathione oxidation process [48].

Additionally, the exogenous ones such as dietary micronutrients also take part in the antioxidant defence system. These include b-carotene, Vitamins C (ascorbic acid) and Vitamin E (tocopherols and tocotrienols). Vitamin E can protect against lipid peroxidation and stabilize biological membranes [52]. Vitamin C operates as a free radical scavenger in the aqueous phase of cytoplasm and can regenerate reduced tocopherol [53]. On the other hand, Vitamin E and b-carotene act as antioxidants in the lipid environment. In one study, cotreatment with vitamins C and E demonstrated a synergistic antioxidant effect [54]. Other important elements include selenium, copper, zinc and manganese since they serve as cofactors for enzymatic antioxidants.

Thus, it becomes much clearer that antioxidants are beneficial in tackling obesity which opens up to different discussions on how to enhance antioxidants outweighing its reduced level in obesity-induced OS. To no surprise, lifestyle modifications; exercise/ physical activities, weight reduction and a balanced natural diet are proven to have an advantageous effect on antioxidant levels.

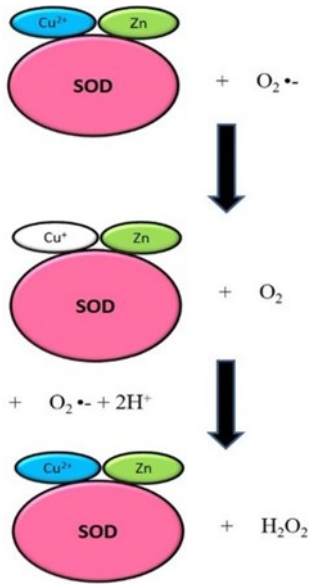

Figure 6: The general catalytic mechanism for dismutation of O_2 by Cu-ZnSOD [50].

Exercise stimulates an antioxidative pathway

It is found that during physical exercise, the energy requirement of the muscular system rises the oxygen consumption to a level 10–20 times above that of the [53]; this prompts the escalation of ROS flow in the muscle fibres [54]. Skeletal muscle is the chief ROS manufacturer during exercise, and the cellular sites of abundant production comprising the mitochondria, xanthine oxidase, phospholipase A2, (NADPH) oxidase, and some immune-system cells, such as neutrophils, eosinophils, monocytes and macro-phages [55]. In addition, increased body temperature and decreased blood pH due to the presence of lactic acid has been reported to speed up the production of ROS, increasing OS [56]. Nonetheless, during physical training, in response to the abundance of ROS, peculiarly when it is not exhaustive, activation of the enzymatic Endogenous Antioxidant System (EAS) is stimulated, which modulates enzymes such as GR, CAT and GPx along with the non-enzymatic EAS, including alpha lipoic acid, glutathione, and so forth.

Based on a cross-sectional study conducted on over-weight/obese postmenopausal women of age 45-64, an active lifestyle (aerobic exercise for at least 30 minutes, three times per week) was linked to enhanced antioxidant enzyme activities, particularly, CAT and SOD, in peripheral blood mononuclear cells [57]. Acute training and chronic training were proven to have different responses to OS. Moderate regular training is postulated to induce EAS, protect the body from OS-induced damage and reduce the probability of cardiovascular diseases as well as death. Conversely, acute exhaustive training has been observed to markedly increase free radical production [58]. It is demonstrated that occasionally, sedentary individuals with preceding cardiovascular disease have sudden cardiac death due to vigorous exercise, though, not in the case with moderate exercise as accustomed practice [59]. Therefore, regular exercise does act as an anti-inflammatory strategy and a natural antioxidant in combating obesity and its associated complications, whilst, it is also necessary to take into account the intensity, modality and duration of training along with individuals` clinical antecedents.

Besides, weight reduction is shown to escalate the antioxidants level. It is known that weight reduction increases antioxidant defences, diminishes oxidation markers and improves cardiovascular and metabolic risks associated with human obesity [60]. A study by Hermsdorff et al (2011) that the values of antioxidants in plasma increases considerably as a result of replacing balloons in the stomach of obese people for six months as well as the reduction in the BMI and weight [61]. This study also confirmed the effect of weight loss with the enhanced antioxidants capacity. Another study by Del Rio et al. (2011) proved that with dietary intervention and 10% of weight loss, the correlation of enzymatic antioxi-dants and their synergistic action to eliminate free radicals had increased especially glutathione peroxidase which is the focus of this study [62]. In a study by Stephenie et al. (2020), a 10% reduction in weight resulted in increased Vitamin D concentrations in previously vitamin D-insufficient obese individuals [63]. Besides, obesity was an independent risk factor in draining protective enzymes in erythrocytes; individuals with normal BMI had higher SOD and GPX activities in comparison with obese people [64]. Therefore, weight loss can bring about an increase in antioxidant enzymes activities. In a study conducted by Mattmiller et al. (2013), a 10% reduction in weight resulted in increased Vitamin D concentrations in previously vitamin D-insufficient

obese individuals [64]. Besides, obesity was an independent risk factor in draining protective enzymes in erythrocytes; individuals with normal BMI had higher SOD and GPX activities in comparison with obese people [65]. Therefore, weight loss can bring about an increase in antioxidant enzymes activities.

CONCLUSION

Obesity is a worrying prevalence which spiked up in numbers not only in developed countries but also in underdeveloped countries resulting from main changes in dietary pattern and lifestyle such as sedentary lifestyle, lack of exercise or physical inactivity as well as increasing numbers of fast-food chain and highly processed food while metabolic and genetic studies disclose that there are individuals who are more liable to gain weight compared to others. Obesity induces oxidative stress through several mechanisms; excessive and dysfunction adipose tissue, hyperglycemia, hyperleptinemia, and hyperlipidemia which all has been described to escalate ROS-generation systems and to reduce its detoxification by antioxidant systems, in favour of the former. In accordance with this issue, the Malaysian Government had started various health programs such as 'My Weight My Health', 'Mysihat' and 'Eat Right, Move Right: Fight Obesity to promote a healthy lifestyle among Malaysian citizens by disseminating information regarding proper dietary practices, nutrition and fitness through physical activities or exercises. One of the rising subjects which garnered much attention recently is antioxidants. The activation of antioxidants in obesity -induced oxidative stress is being keenly analyzed as a possible option in combating obesity and its associated complication. At the moment, modification of lifestyle including increased physical activity, weight reduction and practice of healthy diet especially ones rich in antioxidants, including vegetables, fruits and balanced micronutrients, have been proposed as beneficial strategies as they are all proven to have linked in increasing antioxidants level.

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