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Review Article

The role of nutrition in reducing the harmful effects of dust on human health: A review study

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Abstract

Introduction: The effect of dust on human health has been confirmed according to the geographical location of Iran and the existence of this phenomenon in most provinces, particularly the western and southern provinces. This review discusses the role of proper nutrition in reducing the harmful effects of dust on human health.

Methods: In this systematic review, the published articles were found through searching the electronic databases of the articles and books related to the topic. The relevant articles published from 1990 to 2015 were collected using the search keywords, including air pollution, particular matter, nutrition, etc.

Results: Epidemiological studies have shown that dust has harmful effects on the body's systems and vital organs, including the digestive system, heart and lungs. A diet containing adequate amounts of vitamins, minerals, antioxidants and omega-3 can reduce these effects.

Conclusion: Given the harmful effects of dust on human health, more studies are required to determine the dimensions of these effects and ways to deal with this phenomenon so that the policy makers will be able to manage the environmental effects of dust on human health in the best way possible.

Introduction

Air pollution is one of the most important environmental problems in today's world. To address its importance, the World Health Organization (WHO) published the statement "clean air is considered to be a basic requirement of human health and well-being" (1). Iran, due to its geographical location on the dry belt of the Earth, has been affected by the impacts of wind erosion with domestic and foreign origin, often causing losses and damages to biological, socio - economic and even cultural resources (2). The severity of this phenomenon is visible in the transfer of soil fine particles and dust, which has caused damages to the country most obviously through dust and air pollution, especially in the West of the country (3). What is most important about dust in the air is the role of air as the most vital substance for survival and its effects on human health. Moreover, different outcomes of air pollution especially its health effects, including skin, eye, allergic, cardiovascular and respiratory diseases have made the monitoring and control of air quality to be very important in all societies (4). Air pollutants consist of six main components: ozone, sulfide dioxide (SO2), nitrous oxide (NO), carbon monoxide (Co), and particulate matter (PM). One of the most important indicators of the air quality is concentration of particulate matter (PM) in the air. Several classifications have been proposed for aerosols or dust particles based on particle size, the most important of which are PM10 and PM2.5 that show the upper limit of particle and can be expressed in terms of unit. Accordingly, PM10s are particles with a diameter of 10 micrometers or less (5). Particles with a diameter of less than 10 micrometers have maximum effect on the health due to easily passing from the nose and throat and penetrating deeply into the lungs (6). Shahsavani et al showed the concentration of dust particles in windy days to be four times greater than ordinary days (7). Also, in a study in Kermanshah the air quality was shown to be average in 67.5 percent of days and dangerous in 1.6 percent of days. March and spring had the worst air quality due to the frequency and severity of dust (8). People who have a healthy diet are more resistant to diseases linked to environmental pollution compared to those who have an unhealthy diet. It has been shown that diet-related chronic diseases are the main cause of death in the world (9). Studies have provided strong evidence that healthy nutrition has protective effects against produced pre-inflammatory factors by environmental pollutants. Human studies have confirmed the protective effects of nutrients (10). Considering the harmful effects of dust on health and the emergence of these pollutants in the atmosphere of the western, southern and central provinces of Iran, it is essential to consider the role of nutrition in reducing the effects of this phenomenon.

Materials and Methods

In this systematic review, the related articles from 1990 to 2015 were gathered by searching the Medline, Iran medex, SID, Magiran, Pubmed, Scopus, and Google scholar databases using PM , air pollution , Nutrition , antioxidants , inflammation , cardiovascular disease, pneumonia , gastrointestinal, vitamin A , vitamin E , vitamin C , vitamin D , PUFA, ω_3, ω_6 ,stress oxidative , cancer , air pollution and health , infection , fatty liver , obesity and keywords and their Persian equivalents. After an initial search, 591 articles were found and a number of articles were excluded due to being non-Persian and English. After analyzing the titles and thematic relationship, only articles related to the effects of dust on the body's systems and useful nutrition in the time of occurrence of this phenomenon were considered, which finally yielded 35 related articles.

Results

Many studies have shown the effect of air pollutants on human health (11-13). There is strong evidence that environmental pollutants develop the risk of many diseases. Human studies show the increased incidence of cardiovascular diseases, hypertension and insulin resistance in the people living near polluted areas (14).

The effect of dust on the respiratory system

Dust particles can have a role in the incidence of several diseases the most common of which are asthma, pneumonia and respiratory tract infections. The rate of asthma and chronic obstructive pulmonary disease is increasing worldwide. Over the past few decades, many researches have been done on the diseases caused by environmental factors such as air pollution. Recent research also shows that air pollution significantly results in acute respiratory diseases and possibly tuberculosis (15). Air pollution is a risk factor for respiratory infections in children. Young children are prone to respiratory infections (16). The metal problems can also be attributed to dust particles and can impair the respiratory function (17).

The effect of dust on the digestive system

There is evidence that shows air pollution can affect the digestive system**.** Epidemiological studies have shown a relationship between exposure to environmental pollution and inflammatory bowel disease (IBD) (18, 19), appendicitis (20), irritable bowel syndrome and intestinal infections of the newborns (21). These particles can contaminate the food and water (22). The number of particles that a person eats with food on a daily basis in typical Western diet is estimated to be over 10^{12}-10^{14} particles (23).

The effect of dust on the cardiovascular system

New studies have reported that 3.5 million deaths occur annually due to cardiovascular diseases caused by PM2.5 particles (24)**.** Epidemiological studies have shown that increased levels of air pollutants augment cardiovascular morbidity and mortality due to ischemic events, more frequent hospitalizations, and worsening of a pre-existing cardiac disease such as heart failure and arrhythmias. In line with these observations, the World Health Organization (WHO) estimated that each year approximately 800,000 people die prematurely due to air pollution worldwide. Although the underlying biological mechanisms are still under investigation, there is some evidence that PM inhalation may cause hypercoagulability, platelet sensitization/activation, systemic inflammation and oxidative stress that can directly or indirectly lead to vascular injury, atherosclerosis and autonomic dysfunction (25). Short-term exposure to PM2.5 increases the blood pressure and impairs the endothelial function in healthy young adults, which consequently leads to the development of atherosclerosis. Also it is known that inflammation and oxidative stress mediate the adverse cardiovascular effects of exposure to air pollution (26, 27).

The effect of dust on the blood coagulation system

In recent years many studies have been done on air pollution, indicating that air pollution stimulates the inflammatory responses and subsequently causes heart and lung diseases and deaths. Imbalance between pro- and anti-coagulation system in dealing with dust may be a factor in the progression of the disease (28).

The effect of dust on the inflammatory responses

Dust can produce free radicals that can stimulate pro-inflammatory factors and are associated with inflammatory diseases such as atherosclerosis, diabetes, and hypertension (29, 30)**.** Assari et al studied the relationship between air pollution and serum level of thrombomodulin and tissue factor in adolescents aged 10-18 Years. The results showed a significant association between exposure to PM_{10} and level of tissue factor and thrombomodulin, which can be the grounds for initiation of inflammatory processes and subsequently processes of coagulation and atherosclerosis in early life (31)**.**

The effect of dust on oxidative stress

Recent studies have shown oxidative stress as one of the potential toxic effects of air pollutants, especially dust. Oxidative stress is caused by biological imbalance of oxidants and antioxidants that result in increased exposure to oxidants or disorder in antioxidant defense (32, 33). Particulate matter (PM) results in oxidative stress through increased production of reactive oxygen species (ROS), changes in mitochondrial function, reduced activity of nicotine amide adenine dinucleotide phosphate- oxidase (NADPH-oxidase), and activation of inflammatory cells, that are able to produce ROS and reactive nitrogen species (RNS) as agents of oxidative DNA damage (34,35).

The effect of dust on cancer

Studies have reported that 220,000 deaths occur per year due to lung cancer caused by PM2.5 particles (36). It has been argued that the production of reactive oxygen species plays an important role in the initial cytotoxic effects of inhaled PM in urban streets. Oxidative stress is generated from various sources including: 1. the direct production of ROS from the surface of the particles, 2. soluble compounds such as metals or organic compounds, 3. the change in mitochondrial function or NADPH- oxidase and 4. activation of inflammatory cells that are able to produce ROS and reactive nitrogen species (36).

The effect of dust on the development of obesity and metabolic syndrome

Studies have shown that air pollution can cause obesity. Obesity is now a worldwide problem. Air

pollutants, especially dust can increase the fat synthesis in the body through stimulation of the endocannabinoids signal path (It is something similar to the sympathetic and parasympathetic nervous systems, but its mediator substance is called anandamide that is made of fat. Endocannabinoid system is responsible for control of memory, mood, depression, appetite, fat metabolism, stress response and production of sleep, heat and pain. It has also a role in the incidence of obesity, especially abdominal obesity and subsequently metabolic syndrome. Interestingly, omega-3 in the diet can cause disorder in endocannabinoid system and lead to reduced insulin resistance and body fat (37). Although the overall obesity occurs when energy intake is more than energy consumption, accumulation of fat mass in people with the same energy can be different. This is not only because of genetic background but also because of exposure to environmental pollutants. Based on the hypothesis of obesogen pollutants, exposure of endocrine glands to some chemicals before or after birth can cause interference in adipose tissue homeostasis and the ability to control body weight, thereby leading to increased adipose tissue and obesity during the lifetime (38).

Table 1 presents the summary of the most important findings regarding the effect of dust on the body's systems.

Table 1. Summary of the most important studies on the effect of dust on health

The effect of dust on the body's systems	Type of study	Corresponding Author (year of publication)	The most important results of studies
Digestive system	Review	Saad Salim,2014	Particulate matter (PM) through food pollution can cause inflammatory bowel disease due to change of intestinal normal flora and immune function (39).
	Review	Dr.fares,2014	Exposure to dust, especially in the summer increases the prevalence of acute appendicitis (20).
	Descriptive - analytic	Ananthakrishnan AN,2011	There is a relationship between the amount of dust in the air and hospitalization due to inflammatory diseases of digestive system (19).
	Review	Orazzo F,2009	Air pollution increases intestinal infection in infants (21)
	Clinical trial	Lomer MC,2004	Exposure to dust causes corn disease (23)
Respiratory system	Review	Bateson T,2008	Air pollution is a risk factor for respiratory disease, especially in children (16, 17, 40)
	Cohort	Elaina A.MacIntyre,2014	
	Analytical	Hong Y,2010	
Cardiovascular system	Review	Massimo Franchini,2012	Dust is one of the risk factors for cardiovascular disease (25).
	Clinical trial	Haiyan Tong,2015	Olive oil consumption is beneficial for the vascular damage caused by dust (26).
	Clinical trial	Langrish, j,p,2015	Reducing the exposure to dust reduces the cardiovascular diseases (41).
Coagulation system	Experimental	Frederix, K,2008	Dust causes cardiovascular diseases by disrupting the balance of coagulation system (28).
Inflammatory responses	Cross-sectional	Assari,R.2010	Exposure to PM10 can provide the grounds for initiation of inflammatory processes and subsequently processes of coagulation and atherosclerosis in early life (31).
	Review	HectorsT,2011	Dust promotes diabetes due to production of inflammatory factors (29).
	Cross-sectional, Descriptive - analytic	Sergeev A, 2011	Dust causes hypertension due to production of free radicals and inflammatory factors (30).
Cancer	Analytical	Evans J,2013	Dust is associated with cancer (24, 42).
	Review	Straif, Kurt ,2013	
Oxidative stress	Review	Risom L,2005	Dust causes the production of free radicals and oxidative stress (32-35).
		Gonzalez-Flecha B,2004	
		Misso N,2005	
		Bowler R,2002	
Obesity and metabolic syndrome	Clinical trial	Kim J,2011	Air pollutants, especially dust can increase fat synthesis in the body through stimulation of endocannabinoids signal pathways.
	Mini review	Grün F,2009	Dust, as an obesogen combination, is the cause of obesity and subsequently metabolic syndrome (38).

Antioxidants and dust

Studies have shown that antioxidants such as vitamin E and flavonoids and increased ratio of ω3 to ω6 have a protective effect against damages caused by environmental pollutants on vascular endothelial cells (43).

Vitamin C

Vitamin C is a water-soluble vitamin that is widely distributed throughout the body, including lung epithelial extracellular fluid and has antioxidant role (44).

The invitro evidence suggests that vitamin C, as a chemical reducing agent, has both intracellular and extracellular roles. Intracellular vitamin C may prevent intracellular protein oxidation in tissues with millimolar ascorbate concentrations and high oxidant production, or oxygen concentration such as lungs, which are exposed to oxidative agents. Extracellular vitamin C prevents damage to oxidizing agents and their mediators (45).

Chung-Quan uo in a study on the relationship of dietary habits and air pollution with mortality rate in 23484 deaths in China showed that the effects of O3, PM10 and NO2 were significantly lower in the people who consumed more fruits and vegetables, owing to their antioxidant properties, than those who did not eat or consumed less nutrients (46).

Vitamin E

Today, it is known that vitamin E plays an essential role in protecting the body against free radicals. This vitamin in hydrophobic environment of biological membranes such as the cell membrane and mitochondrial membrane protects membranous unsaturated phospholipids against oxygen free radicals and other free radicals which are more reactive. Furthermore, it has protective effects against oxidative stress complications such as aging, arthritis, cancer, diabetes, cardiovascular disease, cataracts and infections. It has also a role in maintaining the integrity of cell membranes, DNA synthesis and stimulation of immune responses and anti-inflammatory effects (47).

Beta-carotene and flavonoids

Beta-carotene can have two important roles, one as a precursor of vitamin A and the other one as an antioxidant. Flavonoids are a group of nutrients that are found as pigments in vegetables and fruits. Beta-carotene, because of being an antioxidant, has an important role in the control of inflammation and immune responses (48). Also, flavonoids have an antioxidant role in modulation of cell signaling pathways (49).

Fatty acids with double bond

Fatty acids with unsaturated bonds are liquid at room temperature, due to the double bonds in its construction. Omega-3 fatty acid has three double bonds in its structure. Increased consumption of omega-3 can reduce the inflammatory response by changing the fat content of membranes and other substrates. Some fats such as olive oil and fish oil have anti-inflammatory and antioxidant effects. Olive oil, as the main compound in the Mediterranean diet, improves the function of vascular endothelial cells and blood lipid profile (50), decreases the platelet aggregation (51) and reduces the inflammation of vascular cells (52). Some components of olive oil have beneficial effects on the function of vascular endothelial cells, therefore it can be used to support the vascular damage caused by exposure to particulate matter (PM) (26). It has been shown that fish oil intake improves the function of endothelial cells in smokers and those who have high insulin, triglycerides and blood glucose (53). Haiyan Tong et al carried out a study to evaluate the effect of supplementation with fish oil and olive oil on vascular effects caused by particulate matter (PM). The participants (n=42) who were exposed to polluted air were divided into three groups, two groups received fish or olive oil supplementation and a control group received no supplement. The measured parameters were endothelin-1, fibrinolysis and inflammatory markers. The results showed those who received olive oil supplementation had less vascular adverse effects in comparison with the control group (26).

Selenium

Selenium has antioxidant properties and helps to prevent the oxidation of hemoglobin and red blood cell membrane (55, 56). The antioxidant effects of selenium and vitamin E may strengthen each other (55), thereby reducing the produced oxidative effects by dust particles.

Discussion and conclusion

This study was done to reduce the harmful effects of dust. As for nutrition and its role in reducing the effects of air pollution, few studies have been performed in Iran, and the exact statistics are not available. Perhaps the main problem from the perspective of nutrition experts is air pollution. Proper nutrition is one way of increasing the body's natural defense against environmental pollution.

It is estimated that about 1.4 percent of all deaths in the world are attributed to air pollution (24). In addition to human sources of air pollution, including industry and transportation, natural resources also play a significant role in air pollution (57). One of the most important natural sources of air pollution is dust storms that transfer about 800 trillion gram mineral particles to the Asian continent annually (58). The health effects of dust in the short- and long-term have attracted the attention of scientists. Epidemiological studies have shown that respiratory diseases, cardiovascular diseases, mortality of these diseases, pneumonia, asthma, bronchitis, COPD, lung inflammation, ischemic heart disease, hospitalization and emergency and clinic visits as well as reduced lung function are associated with dust storms (17, 24, 57-60). Therefore, given the harmful effects of this phenomenon, in addition to hygiene recommendations such as using a suitable mask, a special attention should be paid to dietary recommendations.

Many studies have suggested strengthening of antioxidant defense as an important nutritional strategy to reduce the harmful effects of dust such as oxidative stress and inflammatory responses. Therefore, consumption of antioxidant sources such as fresh and colorful vegetables and fruits can be useful to reduce these harmful effects. According to standard nutritional guidelines, adult individuals need to consume 4-5

servings of fruits and vegetables daily (). The omega-3 fatty acids (alpha-linoleic acid, eicosapentaenoic acid and docosahexaenoic acid), owing to their role in reducing the inflammatory response, can be effective in reducing the adverse effects of dust, especially inflammatory effects. The sources of these fatty acids include nuts, especially walnuts, fish and so on. Therefore, consumption of two servings of fish per week is recommend for people who are exposed to air pollution.

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