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Chemical Toxins: A Hypothesis to Explain the Global Obesity Epidemic

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ABSTRACT

The number of obese people worldwide has escalated recently, revealing a complex picture of significant variations among nations and different profiles among adults and children, regions, and occupations. The commonly held causes of obesity—overeating and inactivity—do not explain the current obesity epidemic. There is evidence of a general decrease in food consumption by humans and a significant decline in their overall levels of physical activity. There is also more evidence to indicate that the body's natural weight-control mechanisms are not functioning properly in obesity. Because the obesity epidemic occurred relatively quickly, it has been suggested that environmental causes instead of genetic factors maybe largely responsible.

What has, up to now, been overlooked is that the earth's environment has changed significantly during the last few decades because of the exponential production and usage of synthetic organic and inorganic chemicals. Many of these chemicals are better known for causing weight loss at high levels of exposure but much lower concentrations of these same chemicals have powerful weight-promoting actions. This property has already been widely exploited commercially to produce growth hormones that fatten livestock and pharmaceuticals that induce weight gain in grossly underweight patients.

This paper presents a hypothesis that the current level of human exposure to these chemicals may have damaged many of the body's natural weight-control mechanisms. Furthermore, it is posited here that these effects, together with a wide range of additional, possibly synergistic, factors may play a significant role in the worldwide obesity epidemic.

INTRODUCTION

Excess body weight is a growing global health care concern that affects adults and children in all socioeconomic groups (Bundred et al., 2001; Flegal et al., 1998). Although there are many theories about the causes of today's obesity epidemic, to date, there is still much uncertainty about obesity's etiology. Although many non–lifestyle factors are known to influence weight, such as genetic predisposition, carbohydrate craving, and weight cycling, the main causes are thought to be overeating and a lack of physical activity (Bray et al., 1992; Prentice, 2001).

WHY THE OLD EXPLANATIONS ARE NOT VALID

Overeating

Overeating has been suggested as an important cause of modern obesity, particularly because highly palatable convenience foods are

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much more prevalent (Prentice and Jebb, 1995). However, despite a general increase in the intake of these foods, evidence suggests that, although there is a perception among members of the general public that people are consuming more calories in modern times, overall levels of daily caloric consumption have declined substantially thoughout the twentieth century. (Department for Environment, Food and Rural Affairs, 2001).

Inactivity

Because a *fall* in food intake obviously would not account for an increase in the incidence of obesity, it may be that that the modern sedentary lifestyle is mainly responsible (Prentice and Jebb, 1995). However, despite the advent of television, motorized transport, and energy-saving domestic appliances (which has resulted in an overall reduction in manual labor) since the middle of the twentieth century, hard evidence does not show that levels of physical activity have plummeted sufficiently to cause such a high incidence of obesity during this time period (Morris, 1995; Rasvussin, 1995). Indeed, a report by the British Sports Council (now known as Sport England), London, England, on physical activity noted the opposite phenomenon, stating that "participation is increasing across all age bands and all social groupings" (Sports Council, 1993).

Genetic predisposition

Weight control is not simply about energy intake and energy expenditure; these comprise a superficial part of a very complex situation (Miller and Mumford, 1966). Body weight is generally thought to be homostatically regulated at a certain predetermined level or "set point" by, largely genetically determined, feedback-control mechanisms that enable the body to maintain a stable weight for relatively long periods of time (Harris, 1990). Because of the genetic basis posited for these mechanisms, the "set point" theory has not been widely used to explain today's incidence of obesity, which has occurred over a relatively short period of time. Thus, dramatic changes in the gene pool that would have been sufficient to cause the current problem can effectively be ruled out (Prentice and Jebb, 1995).

However despite the stability of the human gene pool, many largely genetically determined, underlying controlling mechanisms that set body weight and metabolic efficiency (e.g., hormones, neural pathways, various brain nuclei, and many neurotransmitters), appear to be malfunctioning frequently in patients who are obese (Baptista, 1999; Harris, 1990; Wang et al., 2001). If genetic alterations are not responsible for such changes in metabolic functioning, perhaps there is another cause for them. Indeed, it has been suggested that perhaps they have been caused by some environmental factor or factors (Rasvussin, 1995).

ARE ENVIROMENTAL CHEMICALS RESPONSIBLE?

Toxic chemicals and their effects on weight

Although diet and behavioral changes have been considered to be major causative factors, it is difficult to see how they could produce many of these metabolic malfunctions.

However, the levels of certain substances—synthetic organic/inorganic chemicals–in the environment have coincided with the increasing incidence of obesity that has been documented. These substances are known to damage many of the mechanisms involved in weight control.

Since the creation, and subsequent introduction, of synthetic organic/inorganic chemicals in the late nineteenth century, the global community has been increasingly exposed to an exponential rise in the production of these substances (see Figure 1; Flegal et al., 1998; United States Tariff Commission, [various documents] 1918–1994). In their daily lives, human beings are now exposed to tens of thousands of these chemicals, in the forms of pesticides, dyes, pigments, medicines, flavorings, perfumes, plastics, resins, rubber-processing chemicals, intermediate chemicals, plasticizers, solvents, and surface-active agents (United States Tariff Commission, [various documents] 1918–1994).

Pesticide residues, preservatives and additives are ingested with foods and contaminated water, inhaled from polluted indoor and out-

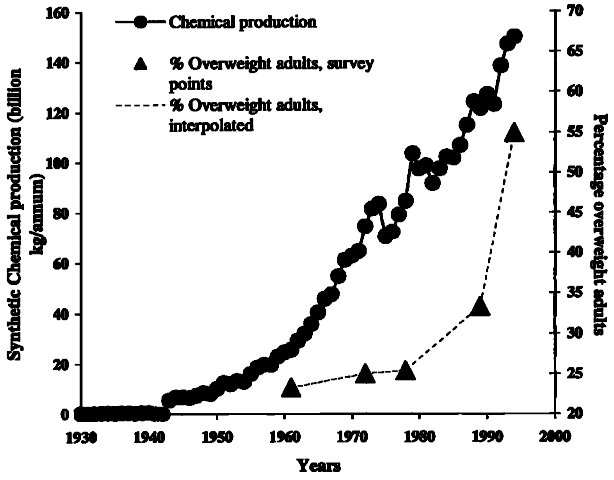

FIG. 1. The production of synthetic organic chemicals and the percentage of overweight adults in the United States during the twentieth century. The illustration is taken from *The Detox Diet*, by Paula Baillie-Hamilton, M.B., B.S. D.Phil. (to be published by Penguin Books, London, in April 2002).

door air, and absorbed cutaneously via personal-care products. As a result, the average person now has many hundreds of industrial chemicals lodged in his or her body, with many of these toxins being transferred across the fetal–maternal blood barrier (Jacobson and Jacobson, 1996). Many of these toxins are also appearing in women's breast milk, thus, probably transferring their effects to children who are breast fed (Alleva et al., 1998; Bordet et al., 1993).

One of the toxic effects of these chemicals appears to be weight gain. Unlike the well-known weight loss resulting from high exposure to toxins, this weight gain tends to occur at much lower levels of exposure, which fail to make animals or humans obviously ill (Takahama et al., 1972). However, as a result of a long-held idea in some cultures that weight gain must be evidence of "good health," a significant amount of evidence showing these chemicals to cause weight gain has been virtually ignored, explained away, or even, on occasion, apologized for (Lamb et al., 1987; Takahama et al., 1972).

Although it has been generally accepted, in recent years, that weight gain can be evidence of chemotoxicity, much of the evidence presented in earlier scientific papers was rarely mentioned in their abstracts. Being that current computer-search mechanisms depend on information contained in abstracts, this may explain why the scale of this chemically caused weight gain has effectively been "missed," by some researchers.

Numerous widely used synthetic and other industrial chemicals produce weight gain. These chemicals—which human beings are exposed to quite regularly—include:

- Pesticides, for example, organochlorines, such as dichlorodiphenyltrichloroethane (DDT), endrin, lindane, and hexachlorobenzene (Chadwick et al., 1988; Deichmann et al., 1972; Deichmann et al., 1975; Dorgan et al., 1999; Hovinga et al., 1993; Stellman et al., 1997; Takahama et al., 1972; Villeneuve et al., 1977)
- Organophosphates (Breslin et al., 1996; Cranmer et al., 1978; Nicolau, 1983; Trankina et al., 1985)
- Carbamates, including dithiocarbamates (Walker et al., 1994; Yen et al., 1984)
- Polychlorinated biphenyls (Clark, 1981; Dar et al., 1992; Hovinga et al., 1993)
- Polybrominated biphenyls, which are commonly used as fire retardants (Gupta et al., 1983)
- Plastics, such as phthalates and bisphenol A (Ashby et al., 1999; Ema et al., 1990; Field et al., 1993; Howdeshell et al., 1999; Lamb et al., 1987)
- Heavy metals, such as cadmium and lead (Antonio et al., 1999; Hovinga et al., 1993)
- Solvents (Chu et al., 1986; Gaworski et al., 1985; Hardin et al., 1987; Moser et al., 1995; Wahlberg and Boman, 1979).

The example of organochlorine pesticides: Studies and biochemistry

The organochlorine pesticides illustrate how chemotoxicity can promote weight gain. Because of previous extensive usage as pesticides, inherent structural stability, persistence in body systems, and ability to concentrate in animals that are higher up on the food chain, many organochlorine pesticides are currently present in human fat in relatively high levels (Hovinga et al., 1993; Stellman et al., 1997).

Much of the observed organochlorine-induced weight gain appears to come from increases in the overall proportion of body fat. In one animal study, the pesticide dieldrin more

than doubled the total body-fat content of treated mice (Deichmann et al., 1972). Another study showed that a pesticide, commonly known as lindane, induced obesity in animals (Chadwick et al., 1988). Indeed, in yet another study, the overall weight-gain effect of another pesticide, hexachlorobenzene, appeared to be so powerful that a group of treated animals still managed to gain significantly more weight—despite the fact that their food intake was cut by 50%—than untreated controls who were on full food rations (Villeneuve et al., 1977).

Organochlorines, and other types of synthetic and industrial chemicals, appear to cause weight gain by interfering with most of the different elements that comprise the human weight control system. In particular, these chemicals have been shown to:

- Disrupt the major weight controlling hormones, such as catecholamines, thyroid hormones, estrogens, testosterone, corticosteroids, insulin, growth hormone, and leptin (Yamagishi et al., 2001)
- Alter levels of, and sensitivity to, neurotransmitters (in particular dopamine, noradrenaline, and serotonin)
- Interfere with many metabolic processes
- Cause widespread damage to body tissues (nerve and muscle tissue in particular), often at levels that human beings are currently exposed to.

This interference results in changes in appetite; food efficiency; and fat, carbohydrate, and protein metabolism. The desire, and ability, to exercise are also affected. These changes have been thought to be responsible for increases in body weight (Chadwick et al., 1988; Gupta et al., 1983; Howdeshell et al., 1999; Moser et al., 1995; Pearson & Dutson, 1991; Takahama et al., 1972; Trankina et al., 1985; Yen et al., 1984).

Effects of toxic chemicals on the sympathetic nervous system

To illustrate this, it is worthwhile to consider the effects of many toxic chemicals on what is possibly the key weight-controlling system (the sympathetic nervous system (Bray, 1993). The sympathetic nervous system, in conjunction with the monoamine hormones it produces (noradrenaline, dopamine, adrenaline), plays a key role in controlling weight, body-fat levels, and nutrition partitioning (Bray, 1993). The sympathetic nervous system may do this by suppressing appetite, particularly the appetite for fats (Leibowitz, 1992); by enabling the body to mobilize fat stores for use (Hamann et al., 1998; Paoletti et al., 1961); and by stimulating physical activity levels powerfully (van Praag et al., 1990). Thus, it is not surprising that abnormalities in the sympathetic nervous system are very common in most forms of obesity (Dulloo and Miller, 1986). Indeed, most of the drugs commonly used to treat patients who are obese, or who have eating disorders, primarily alter these patients' monoamine hormones levels. (Leibowitz, 1992).

Unfortunately, many of the commonest synthetic chemicals in the environment appear to target the sympathetic nervous system. This can lower its effectiveness dramatically, not only in the short term but also permanently (Goldman et al., 1997; Knoth-Anderson and Abou-Donia, 1993; Seegal et al., 1994). One study of pesticide factory workers, revealed that those who were exposed to pesticides excreted 50% more catecholamines then control workers. Another study showed that pesticide workers who were chronically exposed to DDT, organophosphates, and carbamates had plasma levels of adrenaline and noradrenaline that were approximately 40% and 20% (respectively) lower than nonexposed individuals (Embry et al., 1972; Richardson et al., 1975).

Growth promoters

The ability to manipulate the underlying systems that control body weight has resulted in many synthetic chemicals being used by the agricultural community to promote animal fattening and growth. These substances, generally known as growth promoters, include such synthetic chemicals as antithyroid drugs, corticosteroids, anabolic steroids, organophosphate pesticides, carbamates, antibacterials, and ionophores (Pearson & Dutson, 1991; Trankina et al., 1985; Yen et al., 1984). Although many of these substances are now illegal for use as growth promoters, they still are consumed in foods that human beings eat because this prac-

tice has not been stopped effectively. Similar chemicals also are retained in foods as pesticide or chemical residues (Pearson & Dutson, 1991). Many treated nonfood products also confer exposure to human beings (Alleva et al., 1998).

Pharmaceuticals

Synthetic chemicals are heavily used in medicine to treat certain illnesses because such chemicals can strongly alter hormone systems, levels of neurotransmitters, and other aspects of general body metabolism. Not surprisingly, in altering these systems, synthetic chemicals can effectively alter the weight set point. This has resulted in their previous usage for promoting weight gain in patients with anorexia (Morley, 1996). And more evidence that synthetic chemicals promote weight gain in humans arises from the extremely high number of synthetic pharmaceuticals that make patients gain weight, an obviously unwanted side-effect. Such pharmaceuticals include some medicines commonly used in cardiology, oncology, psychiatry, and immunology (Baptista, 1999; Chrysant et al, 1991; Simpson et al, 2001; Varsano et al, 1993; Wiseman and Adkins, 1998).

SUMMARY OF THE HYPOTHESIS

Being that the levels of synthetic chemicals required to cause weight gain are relatively low and that they have been administered deliberately to livestock and patients to produce this effect, it may well be that nondeliberate exposure to low levels of contaminants in food and the environment could have similar results. This would not be too surprising because, despite being generally many times less potent than natural hormones, many environmental contaminants with endocrine-disrupting properties are currently present in wildlife, in laboratory animals, and in living human tissues at concentrations that are thousands of times higher than the natural hormones they are designed to mimic (Alleva et al., 1998).

Evidence that this could be the case comes from several studies of adults and children in free-living populations. Researchers have reportedly found a positive association between levels of certain toxic chemicals in the childrens' and adults body tissues and increased body weight in these subjects (Dar et al., 1992; Hovinga et al., 1993; Schildkraut et al., 1999; Stellman et al., 1997).

Therefore, it can be posited that the relatively recent presence of synthetic chemicals in the environment may be a significant causative factor in the current worldwide obesity epidemic. These chemicals may be causing weight gain via toxic effects on the body's natural weight-control mechanisms. The very speed of the marked increases in the numbers of overweight people, as clearly shown in Figure 1, indicates that changes in the environment are more likely to be the source of the obesity epidemic than genetic changes in human beings.

While a link between human exposure to ever-greater numbers and amounts of synthetic chemicals, which are known to promote weight gain, has not yet been established, the coincidence of the obesity epidemic with the appearance of these chemicals in the environment indicates the possibility of a causative relationship.

The idea that many toxic chemicals in foods and the environment have, in effect, poisoned the body's natural weight-control mechanisms would help to explain many of the functional differences found in the weight-control systems of patients who are obese (Wang et al., 2001). This concept would also explain the incongruity of continuing weight gain in humans despite falling food intakes and no excessive reductions in exercise. The concept also may shed light on the marked failure of food-restriction diets to effect long-term weight loss. The extent to which each individual is affected could also be significantly related to a given individual's genetic ability to deal with these toxins.

The high levels of chemotoxins shown to be present in human fat and breast milk, the ease of transfer through the fetal-maternal blood barrier and the increased sensitivity of developing systems to these toxins may also help to explain the increasingly early age at which this problem is evident in infants and children and the increasing extent to which individuals are now affected (Alleva et al., 1998; Bundred et al., 2001; Flegal et al., 1998).

Research is now needed to investigate which of the many chemicals in the environment are probably causing the greatest damage to the human weight-control system. A possible way to move forward would be to study the effects of increasing industrialization, and subsequent increases in chemical exposures, in the human population. This could be done by studying subsets of the population, for example, by comparing farmers who farm organically to farmers who farm conventionally or people who work with plastics and pharmaceuticals to people who work in offices.

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