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Obesity Epidemic: Genes, Sedentary Life Style or Over Nutrition to Blame?

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ABSTRACT

The proximate cause of obesity is an imbalance in the energy input and energy expenditure. It was believed that the sedentary life style of Western Societies which resulted in grossly reduced energy expenditure was the main cause of the imbalance. Studies carried out in recent years have challenged this belief, and have shown that the energy expenditure even in a sedentary life style is not grossly reduced. Although obesity has a genetic basis, it cannot be attributed to a signal gene or even to a few genes. Even though fat storage has an advantage in the animal kingdom, it appears to pose a greater risk for many metabolic diseases in humans. Epigenetic effects particularly fetal and infant nutrition also play a significant role in adult obesity. Over nutrition appears to be the major cause for the current epidemic of obesity. Fast food and soft drinks, coupled with aggressive marketing by food marketers have contributed to over eating. Consequently the energy balance is tilted in favor of excess energy storage.

INTRODUCTION

The total human biomass was estimated to be approximately 287 million tonnes. Of this, about 15 million tonnes was due to overweight. This weight amounted to an additional 242 million people of normal weight or an additional 5% of the population [1]. Overweight and obesity were never a problem in the 19th century. They began to progressively increase in the beginning of the 20th century. By 1930, the Insurance Companies were using body weight to determine premiums since the association between obesity and premature death was identified by them [2]. The obesity rates began to increase from 1960 onwards. By 2000, about 65% of the US population was overweight [3].

Ever since humans began to walk on the earth their main survival strategy was to overcome food scarcity. Hence, our prehistoric ancestors had to store excess energy in times of abundance to survive periods of famine. Thus in the evolutionary sense a 'fit' ancestor was a 'fat' ancestor. The prehistoric statuette of the famous Venus of Willendorf depicts an abdominally obese woman suggesting that being fat was also considered beautiful [4].

However, in the present day scenario, there is no need to store excess energy for times of famine. Food is now abundantly available round the year. Then why do humans continue to store excess energy? The answer may be in our genes.

Genes and Obesity

The search for human obesity genes began several decades ago. Although several genetic factors contribute to obesity, it is not confined to any single gene. In 1962, Neel proposed the concept of "Thrifty genes" [5]. He proposed that genetic tendency to store fat in times of plenty would be advantageous to the population particularly child bearing women. Studies have shown decrease in fertility rates during famine [6].

Speakman (2007) proposed that early humans would have been subjected to stabilizing selection for body fatness. Obesity would be selected against through predation by large carnivores. However, with the development of social behavior, weapons and fire the risk of predation would be reduced and the body fatness would drift upwards. He used the models of random genetic drift to explain the current obesity in United States [7,8].

From the evolutionary perspective obesity poses a challenge. Obesity puts us at a greater risk for many metabolic diseases like diabetes, cardio vascular diseases and cancer [9,10]. According to the theory of natural selection, evolution favors genes that give an advantage. Since obesity appears to be a negative trait, it should have been eliminated.

Obesity has a survival role in the animal kingdom. Hibernating animals and migratory birds store excess fat to be used during hibernation or long flights at high altitude. Which all the hibernating animals and migratory birds store fat, all humans do not. In the US which is the most obese nation, with over 60 years of plentiful food, only about 35% of the people are overweight [11].

Advances taking place in genome wide analysis has renewed the interest in the identification of genes responsible for obesity. Several genes and their variants have been identified in the last two decades to have some role in obesity. The leptin gene was identified in 1994, [12] and studies showed that individuals with defective leptin or its receptor become obese [13]. Melanocortin 4 receptor gene was linked to human obesity [14]. Genome wide analysis identified other genes like FTO [15] (Fredriksson et al., 2008) In recent years another gene CRT3 was also identified to be responsible for obesity [16]. It is now evident that obesity cannot be attributed to a single gene or even a few genes. Moreover environmental effects on gene expression can also modulate the expression of genes responsible for obesity. Studies carried out on twins have shown that about 65% of the variation in obesity is genetic and the remaining is due to environmental factors [17].

Epigenetic effects have also contributed to obesity. For example, fetal over nutrition has been shown to be a significant risk factor for developing obesity in later life [18-20]. Early life also has a profound influence on the health of the adult [21]. For example breast fed babies showed a lower risk of obesity when they grow up [22]. Breast fed babies gain weight slowly in infancy slower infant weight gain has been associated with lower risk of later obesity [23,24].

What causes Obesity?

The proximate cause of obesity is the imbalance in energy input and energy expenditure. Lower body mass index (BMI) and lower prevalence of obesity in developing societies compared with industrialized societies has led to the assumption that industrialized societies lead a sedentary life style. Availability of mechanized transportation and labor saving devices have reduced the energy expenditure on daily activities [25].

In order to test whether individuals from countries with higher human development index spend lower energy Westerterp and Speakman used double labeled water to measure the energy expenditure through physical activity and formed that energy expenditure in these societies had not changed between 1980s and 2005 [26].

A meta-analysis of 98 studies representing 183 cohorts and 4972 individuals was carried out to find out the energy expenditure of individual from developed and developing societies. In these studies after adjusting for age and bodyweight, there was no significant difference in the total energy expenditure [27].

In a recent study the total energy expenditure and physical activity levels of three communities was compared. One community were the Hadza foragers whose life style is similar to that of the Hunter-gatherers of Pleistocene ancestors [28]. The second community was the Western population and the third was Bolivian farmers. The study utilized double-labeled water to measure the energy expenditure. Surprisingly, this study challenged the belief that the Western life style resulted in abnormally low energy expenditure. The study confirmed that even dramatic differences in lifestyles may have little effect on the total energy expenditure [29].

There are three components of daily energy expenditure. They are: basal metabolic rate (BMR) thermic effects of foods and activity related thermogenesis. In a sedentary person, BMR accounts for 60-70% of the total daily energy expenditure. The variability in the BMR, is accounted for by variability in body size. Bigger the person, greater their BMR [30].

The thermic effect of food is the energy spent in digestion absorption, transport and metabolism of foods [31]. This accounts for about 10% of the total energy expenditure and does not vary between individuals. The variability depends only on the type of food consumed [32].

The third component of daily energy expenditure is the activity thermogenesis which is highly variable. Highly active people spend three times more energy per day than inactive people [33]. It is estimated that the difference in energy expenditure between an active and a sedentary person is about 2000 Kcal/day [34].

The activity thermogenesis can be divided into exercise thermogenesis and non exercise activity thermogenesis. The exercise thermogenesis refers to the physical activity associated with purposeful exercise, whereas non exercise activity refers to the activities of every day living [35]. Typically an individual working in an office in a chair – bound job spends about 300 Kcal/day in non exercise activity thermogenesis [33]. However, if this same worker is in an environment where agriculture is the main work related activity, then he would spend about 2300 Kcal/day [25,33].

Leisure time activities also have a significant role in non-exercise activity thermogenesis. Even trivial activities can contribute to the total energy expenditure. For example chewing gum can spend about 20 Kcal/hr [36]. Hence, these low level activities carried out throughout the day can significantly increase the total energy spend in a day [37].

There are some activities which are high-effect activities. For example, as soon as one begins to walk even at a very slow rate the person doubles the metabolic rate [38]. At a purposeful walk as in going to a meeting, 150 – 200 Kcal/hr are spend. A rushed walk as in racing to catch a train or rushing to an airport gate increases the metabolic rate threefold [35].

Thus at the population level a lack of energy expenditure among people with sedentary life style may not be a contributing factor to obesity. Hence, if energy expenditure is not the cause of obesity then energy input will have to be the cause since obesity is an imbalance between energy input and energy expenditure.

Over Nutrition

The voluntary food consumption in humans will never exactly match the demand. It is therefore a good strategy to store a small excess of nutrients to supplement during times of need. Hence, 'over Nutrition' is a good strategy [39]. However a small daily increase in calories can lead to obesity on the long run. In the 70s and 80s it was widely believed that excess food consumption was the real cause of obesity. Swinburn accounted obesity to increased food supply [40]. According to FAO, the per capita energy production in 2002 was 2600 Kcal/day. This is more than the total daily energy required for many around the globe.

Humans have developed strong food preferences [41]. By catering to these food preferences and also stimulating the interest, food marketers have been accused of contributing to global obesity [42]. Food accounts for 11% of the global trade. Developing global brand names, marketing strategies, global sourcing of supplies and adaptation to local taste have all contributed to increased food sales and consumption [43]. Fast food restaurants and soft drink vending machines have changed the eating habits of people all over the world. An average restaurant meal provides anywhere from 1000 to 2000 Kcal. This would be the daily energy requirement for an adult for the whole day provided by a single meal. In addition to this, there is an increasing tendency to snack between meals [44]. The increased tendency to snack is promoted by television. Food advertisements represent one third of Television advertisements in children's TV programs. Consequently children are exposed to over 40,000 food related advertisements per year [45,46]. Most of the advertisements are for candy, cereal, fast food and soft drinks [45,46]. Also eating in front of the TV decreases the awareness of satiety leading to over eating [47].

Palatability of food also increases its consumption since people choose to eat what they like [48]. pricing is another important factor that causes increased consumption. Lower the prices greater the consumption [49,50]. Even images of food and smell of food can increase hunger and consumption [51]. Eating environment can also influence food consumption. Dim lights and soft music have been shown to enhance consumption [52].

Several studies have shown that people are unable to estimate the quantity of food they consume. Small sized servings are accurately estimated, the large sized servings are under estimated [53].

CONCLUSION

Over nutrition appears to be the proximate cause for the current epidemic of obesity. This together with genetic predisposition may make some people overweight much more readily than others. Since over weight and obesity is the underlying cause for many diseases like diabetes, cardio vascular diseases and cancer, controlling the body weight is always in the interest of the health of the individual.

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