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Disruptions in energy balance: Does nature overcome nurture?

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Abstract

Fat accumulation, in general, is the result of a breakdown in the homeostatic regulation of energy balance. Although, the specific factors influencing the disruption of energy balance and why these factors affect individuals differently are not completely understood, numerous studies have identified multiple contributors. Environmental components influence food acquisition, eating, and lifestyle habits. However, the variability in obesity-related outcomes observed among individuals placed in similar controlled environments supports the notion that genetic components also wield some control. Multiple genetic regions have been associated with measures related to energy balance; however, the replication of these genetic contributors to energy intake and energy expenditure in humans is relatively small perhaps because of the heterogeneity of human populations. Genetic tools such as genetic admixture account for individual's genetic background in gene association studies, reducing the confounding effect of population stratification, and promise to be a relevant tool on the identification of genetic contributions to energy balance, particularly among individuals of diverse racial/ethnic backgrounds. Although it has been recognized that genes are expressed according to environmental influences, the search toward the understanding of nature and nurture in obesity will require the detailed study of the effect of genes under diverse physiologic and behavioral environments. It is evident that more research is needed to elucidate the methodological and statistical issues that underlie the interactions between genes and environments in obesity and its related comorbidities.

Keywords: Genes; Environment; Admixture; Energy balance; Gene-environment interactions

1. Introduction

Overweight and obesity are the results of a disruption in energy balance. The prevalence of overweight and obesity in the United States is alarming. It has been estimated that approximately 30% of the US adult population have a body mass index (BMI = kg/m^2) greater than 30 [1], a cut off used to classify adults as obese. Studies evaluating samples from the Union Army veterans have documented an increase in the percentage of individuals with a BMI of at least 30 since the beginning of the 20th century [2], supporting that the concerning increases in body size has been a gradual problem for an extended period of time. Perhaps the most remarkable public health concern is the increased trend of overweight and obesity among children and adolescents. Data from the National Health and Nutrition Examination Survey (NHANES) has demonstrated that children as young as 13 years of age exceed the waist circumference cutoff value for obesity-related disease risk in adults. A dramatic increase in adverse metabolic outcomes, particularly insulin resistance and adverse lipid profiles [3], parallels the increase in overweight and obesity in children. The understanding of the factors contributing to the etiology of obesity and its comorbidities is imperative.

The disproportional prevalence of obesity-related metabolic risks in children of diverse ethnic backgrounds has been an area of concern and investigation. The prevalence of being overweight and becoming overweight at any age during adolescence is approximately twice as high among African and Hispanic

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Americans when compared to European American (EA) children [4]. New incidence of type 2 diabetes among children and adolescents ranges from 8–45% depending upon the geographic location with African American (AA) and Hispanic American (HA) children at higher risk of developing the condition [5]. It is believed that inherent ethnic differences in metabolism and fat accumulation in combination with the obesigenic environment may put different populations at greater risk for disease.

It is generally accepted that fat accumulation is a result of a breakdown in the homeostatic regulation of energy balance. However, neither the specific factors influencing the disruption of energy balance nor why these factors affect individuals differently are completely understood. Scientific data has demonstrated that the accumulation of body fat is a complex process. In humans, social, dietary, physical activity, and other environmental factors have been considered as possible causes for the obesity epidemic. However, a wide collection of scientific literature supports the contributions of genes to various aspects related to obesity and fat accumulation. The overall consensus of the scientific community is that excessive body fat is the end of a cascade of interactions among environmental, behavioral and genetic factors. At a time when the life expectancy of individuals is increasing, the detrimental consequences that body fat accumulation will have in health outcomes becomes a concern to scientists, epidemiologists, health professionals and policy makers. It is evident that the understanding of the interactions between nature and nurture is an area in need of research as the scientific community continues to investigate the etiology of this complex disease.

2. Environmental components to energy balance

Our inability to accurately define "environment" presents the greatest challenge of studying the influence of "nurture" in the development of obesity and its comorbidities. The term environment encompasses a wide variety of components, which include (but are not limited to) variations in family structure, socioeconomic status (SES), area of residence, community dynamics, occupation, health status, and individual experiences. These components influence contexts of food acquisition, eating, and lifestyle habits, playing a role in the development of obesity [6]. Environmental components encompass direct and indirect influences in a person's past or present experiences and have the potential to affect the balance between energy intake and expenditure.

The contributions of environmental factors to obesity have been the focus of numerous research initiatives. For example, Papas and colleagues performed a meta-analysis of studies attempting to link the environment to obesity and found statistically significant relationships between factors that scientists defined as "environment" and the risk for the development of obesity in 17 out of 20 studies [7]. An interesting aspect of the meta-analysis was that in all these studies, the environment was defined in different terms, including food consumption patterns, physical activity and economic factors. Because the disruption of energy balance that leads to obesity is greatly influenced by energy intake, eating practices and behaviors have been a big focus of the exploration of environmental factors in obesity. It has been suggested that most eating behaviors are defined within the family context, and eating in the absence of hunger, a behavior defined as "environmental" perhaps because of the way it reflects social, cultural and individual responsiveness to portion size, has been documented to promote excessive energy intake among young children [8]. In addition, adaptation of new patterns of dieting that reflect changes in dietary composition and increases in caloric intake have been proposed as determinants of overweight and obesity among children, as exemplified by the increased weight gain experience by children who have recently migrated to the US.

Sedentary behaviors have also been evaluated as environmental contributors to the obesity epidemic in children and adolescents and have been a matter of interesting controversy. For example, several studies have reported that the increase in the amount of time spent viewing television (with reports suggesting that children and adolescents watch an estimated 3 h of television per day) have displaced physical activity and, consequently, increase BMI in the youth [9–11]. However, others have suggested that alternative to television viewing it is the snacking that occurs during television viewing that may be a more plausible cause for increased obesity [5]. This observation is supported by those believing that snacking has increased the total daily energy and fat intake during the last decade and that, consequently, has contributed greatly to the recent obesity epidemic [12]. However, while some longitudinal studies have shown that snacking has a significant correlation with increases in body weight [13], other studies have concluded that the consumption of snacks does not seem to influence weight change among children and adolescents [13]. Such conflicting findings demonstrate the need to further explore the complexity of behavioral aspects evaluated as environment and the extent to which these aspects may differ among individuals.

Other environmental factors besides physical activity and food intake have been explored as plausible contributors to the obesity epidemic. In a review of the literature, Keith and colleagues documented that other 'non-traditional' factors such as ambient temperature, amount of hours of sleeping at night, and increasing gravida age are contributors to the obesity epidemic [14]. It has recently been shown that maternal characteristics and behaviors can influence prenatal development of food choices [15]. Mennella and Beauchamp [16] have demonstrated that food preferences in children are related to early exposure to foods in utero and in mother's milk, a remarkable finding that reflects that appropriate environmental control at early stages might result in an early intervention. Nevertheless, because it is the interaction of the individual with the environment that actually influences obesity-related outcomes, additional research is necessary to understand the mechanisms to which this interaction occurs, particularly among individuals of diverse racial/ethnic backgrounds who might have different cultural and behavioral practices that might differentially impact obesity.