



Editorial

Eating patterns, diet quality and energy balance: An introduction to an international conference



Food intake is the primary behavioral driver of nutrient and energy balance. If consumption of nutrients and energy within healthful bounds is the definition of “normal” intake, then over half of the population nationally and globally do not engage in normal intake as more people are undernourished, overweight/or have eating disorders than eat within recommended ranges [1]. Thus, a better understanding of food intake is essential to improve health and well-being.

US agricultural and food systems have met and exceeded the needs of the population with respect to providing a safe, wholesome and affordable source of the nutrients and energy required for a long healthful life. However, this success has also offered most individuals the freedom to develop eating patterns that may compromise health. No acute use of a food or diet is problematic for health (except in cases of specific allergies, sensitivities or extraordinary abuse) because of the great flexibility and resilience of human physiology. Instead, problems arise when patterns of feeding that challenge the ability of individuals to respond appropriately are adopted on a chronic basis. Marked changes of feeding patterns have occurred over the past four decades including, but certainly not limited to, increased consumption of foods outside the home [2], increased ingestion of energy-yielding beverages [3,4], increased eating frequency [5–7], increased portion size [5, 8], and decreased fluid dairy intake [9]. These dietary trends have been associated with a rise in chronic health disorders such as obesity, diabetes and osteoporosis. However, controversy remains about the role (e.g., correlational or causal and to what degree) of these changes in intake in each of the above cases. Indeed, other data [10] indicate that some of these trends hold health benefits such as provision of needed nutrients and better appetite control with increased eating frequency and improved hydration with beverage consumption. Thus, an important place to focus research, education and engagement is on better characterization of trends in eating patterns and what their health implications may be.

Eating patterns are defined variously with foci on A) nutrients/energy, B) foods or food groups C) temporal dimensions (e.g., frequency, time of day, season, relative to activity patterns) or D) culture. Each approach generates important new information, but there is rarely any integration of the data when such patterns always co-occur, leaving open important questions. For example, portion size and eating frequency are both identified as contributors to the obesity problem, but there is no consensus on which is of greater importance and, thus, the most promising area for future investment to improve population health. Another

example is the lack of knowledge on the relationship between eating patterns and weight gain by individuals. If weight gain is the result of an eating pattern that leads to a consistent small positive energy balance, this may call for one type of dietary intervention; whereas, if weight gain stems from episodic marked positive energy balance (e.g. holiday eating that is not fully compensated), this would call for a different intervention strategy. Additionally, it must be recognized that eating patterns are often reflections of one's culture and circumstances and, as a result, they are susceptible to change with uncertain health implications. Examples of external influences are changes of domiciliary, work shift, stress or sleep patterns.

Many professional societies with an interest in ingestive behavior have included sessions within their annual meetings that address aspects of the topic of eating patterns and health such as snacking and obesity, cultural influences on food choice, the timing of food intake and various performance outcomes or methods for measurement of feeding under different conditions. However, there has not been a forum where researchers focusing on different eating patterns were assembled to explore existing knowledge across fields and approaches to identify promising new areas of investigation and to suggest novel approaches to better understand this complex issue which very directly influences the practices of the food industry, advice offered by clinicians and setting of public health policy. Such a meeting was hosted by the Ingestive Behavior Research Center (IBRC) at Purdue University September 24–26, 2013. It included presentations by 21 invited speakers from six countries divided into seven sessions. The first was a plenary lecture covering the evolution of eating patterns and their diversity which reflect varying global environments and cultures. It evaluated the trends in diet composition and lifestyle in relation to shifts in body weight.

Session two focused on eating patterns based on nutrients and foods/beverages. A large literature supports a hierarchy of the macronutrients with respect to their satiety value which, in the context of minimally processed foods, is: protein > carbohydrate > fat [11]. While it is now well established that weight loss can be achieved with diets of widely discrepant macronutrient profiles [12–15], this does not preclude advantages of one over another with respect to diet satisfaction and non-weight related health outcomes (e.g., cardiovascular disease risk, bone health, sarcopenia). Satisfaction is critical for chronic dietary compliance. Food choice is also guided by personal characteristics and environmental influences including economic, race/ethnic, culture, gender and age

categories with different health implications that govern nutrient availability and the incentives to consume particular items. Pricing manipulations are proposed as one approach to discourage high levels of intake of specific foods and beverages (e.g., taxing high fat items or sweet beverages) or greater intake of others (e.g., subsidizing fruit and vegetable intake). Issues related to nutrient content, economics and eating frequency/portion size were the focus of this session.

There are strong circadian patterns of intake, but marked changes have occurred recently in meal timing and eating frequency that are associated with various health issues. An active debate is underway on whether there is special importance to the first morning meal in terms of short-term performance on cognitive and activity tasks, appetitive sensations and energy balance over the day as well as physiological homeostasis [16,17]. Other works single out eating a high percentage of energy late in the day or evening and risk for weight gain [18] while this is not the conclusion of others [19]. There are data supporting and refuting the concept that to optimize anabolic processes and protein status, it would be better to modify the current practice of ingesting the preponderance of protein at the evening meal and, instead, parsing it out evenly over the day [20,21]. Additionally, meal skipping is a common eating-pattern based approach for weight management [22, 23]. Whether this is effective, advisable and/or sustainable are unresolved questions. These and related topics were the focus of session three of the conference.

Multiple infradian eating patterns (i.e., patterns with intervals greater than a day) have been described. Each poses unique health concerns and raises questions about the nature of dietary recommendations required to address them. While eating patterns over the course of a day undoubtedly contribute to energy balance, the preponderance of evidence suggests that energy regulation, to the extent that it occurs, plays out over longer intervals like weeks, months, seasons or year [24–31]. The roles played by daily and seasonal patterns serve to highlight the importance of understanding each pattern. The prevailing view is that weight is gained through a small, but sustained positive daily energy balance (i.e., disruption of a circadian regulatory pattern) [32–34]. However, this pattern has not been empirically established, and accumulating evidence suggests that weight gain over time may stem more from episodic periods of marked positive energy balance, like that commonly occurring during the major holidays rather than slow, incremental gains [30,35–41]. Establishing the patterns of weight change is vital to management of the problem. It is likely that those who gain primarily during the holiday period will benefit more from interventions that target just that high risk time, and any dietary restriction at other times will compromise quality of life and likely lead to poor dietary compliance. Alternatively, those who may be in daily positive energy balance would likely benefit more from interventions that address daily intake patterns through incremental changes of diet and lifestyle. Identification of such patterns would open new product development options, marketing strategies, clinical practice and public policy. Session four of the conference addressed issues related to temporal patterns of intake.

Eating patterns can result from or be altered by various lifestyle choices and health conditions. Marked modulatory effects of migration, exercise, sleep habits, shift work and eating disorders have been described. Session five included presentations on disruptors of eating patterns. The question of whether intake, as opposed to appetite, body weight, body composition or some other trait is regulated remains unresolved [42,43]. If not regulated, it might be hypothesized that external factors impinging on an individual's eating pattern may elicit easily observable responses. If there is regulation, identification of effects may be more difficult due to the blunting effect of regulatory processes

opposing an influencer's effect. However, even in the latter case, strong disruptors of eating patterns would be expected to alter ingestive behavior. Due to the clear and marked trend in weight gain over the past four decades, it has been posited that what regulation exists has been altered by a large array of environmental factors. Several examples may be enumerated. First, it is argued that sedentariness has increased leading to poor appetite control and energy intake in excess of need [44]. Second, the anorexia of exercise has been touted as a weight management aid [45,46]. Third, there is a trend for shorter sleep duration resulting in disrupted endocrine patterns with implications for feeding and risk for metabolic syndrome [47]. Fourth, changes in workforce practices have led to an increased proportion of workers engaged in part-time positions, often with variable working hours. Such shift work has been associated with weight gain and other health concerns [48]. Fifth, the population is increasingly mobile with high proportions of families emigrating to new countries. There, they face different cultural patterns that may not easily accommodate dietary practices from their host country and lead to stress at multiple levels. This, again, has been linked to weight change and adverse health outcomes [49]. Sixth, there are very strong cultural pressures promoting unrealistic expectations of thinness and body proportions. This may result in eating disorders of psychological origin that adversely alter eating patterns resulting in outcomes such as binge eating disorder and night eating syndrome [50]. Presentations covering each of these pattern disruptors constituted session five.

Eating patterns evolve from and influence physiological processes. Improved understanding of the interactions between environmental and biological systems with respect to eating patterns is required to characterize their implications. Reductionism has been a valuable approach in science as it aids identification of mechanisms and independent contributions of different components in a system. However, ultimately these isolated findings must be integrated to understand whole body function and interactions between the environment and physiology. This is extremely difficult work and often requires some degree of speculation and risk taking to move a field forward. A relevant example here stems from efforts to understand eating patterns based on various physiological indices. During the 1950s and 1960s there was considerable research focused on the metabolic control of feeding. Hypotheses were promoted for a glucostatic, lipostatic, aminostatic and other control systems for energy intake [51,52]. Evidence was generated supporting each, but in no case did it prove to be a reliable predictor of ingestive behavior. Over the past two decades, research has focused more on endocrine control of feeding, especially targeting gut peptides [53]. A tremendous amount of new knowledge has accrued but has, to-date, had little impact on feeding and weight management. Again, endocrine responses did not prove to be a strong predictor of intake. However, if it is recognized that intake is a function of eating frequency and portion size, the lack of success of these two approaches to independently control feeding comes as no surprise. The metabolic controls tended to identify factors that influence eating initiation (e.g., a regulator of eating frequency). In contrast, the endocrine focus tended to identify factors that influence meal duration (i.e., meal size). They are complementary, and it may prove that if used in conjunction, much better models of feeding patterns will result. More recently attention has focused on the impact of early (i.e., intrauterine and neonatal) life events on the etiology and manifestations of metabolic diseases and obesity. Such work raises question about the degree to which individuals are able to appropriately respond to and manage their environments to optimize health. These papers constituted session six.

The final session of the conference was designed to identify gaps in current knowledge based on the earlier presentations and promising directions for future studies. To ensure a consideration

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