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Gene–environment contributions to energy and macronutrient intakes in 9-year-old children: Results from the Quebec Newborn Twin Study ☆

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HIGHLIGHTS

- Genetics contribute moderately to variations in children's energy intake.
- Genetics contribute moderately to variations in children's macronutrient intake (g).
- Genetic influences on energy and macronutrient intakes are partly independent.
- Environmental factors are the main contributors to variations in energy intake.

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ABSTRACT

Background: Few twin studies have examined nutrition-related phenotypes among children, and none has investigated energy and macronutrient intakes.
Objective: The objective was to quantify genetic and environmental influences on variations in energy and macronutrient intakes among children aged 9 years.
Design: We conducted a nutrition study among children participating in the Quebec Newborn Twin Study, a population-based birth cohort of twins. We derived dietary data from two multiple-pass 24-hour dietary recalls with a parent and his or her child. The analysis employed a classic twin study design and used data from 379 twin pairs.
Results: Univariate analyses indicate that heritability for mean daily energy (kcal) and macronutrient (g) intakes was moderate, ranging from 0.34 (95% CI: 0.22, 0.46) to 0.42 (0.31, 0.53). Genetic effects also accounted for 0.28 (0.16, 0.40) of the variance in percent of energy from lipids, while only environmental (shared and unique) effects accounted for the variance in percent of energy from proteins and carbohydrates. The shared environment did not contribute to variations in daily intakes for most of the nutritional variables under study. Multivariate analyses suggest the presence of macronutrient-specific genetic influences for lipids and carbohydrates, estimated at 0.12 (0.04, 0.19) and 0.20 (0.11, 0.29) respectively.

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Conclusions: The unique environment (i.e., not shared by family members) has the largest influence on variances in daily energy and macronutrient intakes in 9-year-old children. This finding underscores the need to take obesogenic environments into account when planning dietary interventions for younger populations.

1. Introduction

Diet is an important element of the obesogenic environment and is a modifiable risk factor for the prevention of obesity and related chronic conditions [1]. Because diet in childhood is related to obesity and chronic diseases later in life [2], it is important to identify the major determinants of children's diets and the strength of their influence. Various environmental factors, such as familial and cultural contexts [3,4], shape eating patterns during childhood. What humans eat and how much they eat on a daily basis are also influenced by genetic predispositions that could be related to taste abilities [4,5] and inner control mechanisms influencing food intake regulation [5,6]. Over the last thirty years, researchers have used data on twins to quantify the relative importance of genetic and environmental influences on nutrition-related phenotypes, although mainly in adults [7–13].

Energy and macronutrient intakes are major elements in the energy balance equation governing weight status. Most population twin studies examining daily intakes of energy or macronutrients reported moderate heritability (between 0.20 and 0.40) among adults [7,11,12], suggesting that environmental influences account for a large part of the variation in intakes. Since total energy ingested is the sum of energy from macronutrients, one might expect that genetic and environmental influences on intakes of energy and its major components would be common. However, a study of adult twins detected the presence of macronutrient-specific genetic influences [14]. These, although small in magnitude, suggest that genetic factors also influence specific macronutrient selection to some extent.

Whether these findings from twin studies among adults extend to children remains unknown. To our knowledge, no twin study has yet quantified the genetic and environmental influences on daily energy and macronutrient intakes during childhood. Nutritional requirements vary over the life course [15]. Moreover, most twin studies on energy and macronutrient intakes used dietary data collected in the 1990s or earlier. Since then, the obesogenic environment has expanded dramatically. Adult subjects in earlier studies had thus not been exposed as children to food environments similar to those in which children are living today. This disparity in exposure may have resulted in a different genetic–environmental etiology for nutritional intakes. The objective of the present study was therefore to examine genetic and environmental contributions to variations in energy and macronutrient intakes among twin children, using detailed dietary information collected in the mid-2000s.

2. Subjects and methods

We collected dietary information between September 2005 and December 2006 from twin children aged 8 to 10 years (mean age 9.0, SD = 0.5) participating in the Quebec Newborn Twin Study (QNTS). The QNTS is a population-based birth cohort of twins reared together. The cohort was based on all twin births in the Greater Montreal Area in the Province of Quebec, Canada, between April 1, 1995, and December 31, 1998. A total of 662 families (67%) initially enrolled in the study. QNTS criteria excluded twins with major diseases at birth from the cohort. The children were first seen at 5 months (adjusted for gestational age). Since then, they have been followed longitudinally on a regular basis, through various questionnaires, interviews, observations and laboratory measurements.

Zygosity was determined by the assessment of physical similarities between the twins at 5 months and 18 months of age, using an adapted version of the Zygosity Questionnaire for Young Twins [16]. Mouth swabs were also collected for a subsample of same-sex twins (123 pairs at 5 months; 113 pairs at 18 months). DNA was extracted from buccal cells and genetic marker analysis was performed. Comparisons of physical similarities and genotyping revealed concordances of 91.9% and 93.8% at 5 months and 18 months respectively [17]. The addition of chorionicity data obtained from the twins' medical files allowed classifying twin pairs with 96% accuracy [17].

A total of 379 families (758 children) were participating in the nutrition study when the twins were about to reach age 9. Interviewers saw children either at home (233 families) or in a research hospital center (146 families) if the children were participating in another substudy that required taking specific laboratory measurements. Interviews of twins took place separately, on different days, to minimize reporting biases about children's diets on the part of parents. Visits occurred on weekends, generally at one- or two-week intervals. We assigned twins randomly to the first interview. Both twins from a pair were seen on the same weekday in order to ensure identical reference periods for dietary interviews. Trained nutritionists collected data. Different interviewers saw each child in a twin pair in order to avoid potential biases related to perceived zygosity. Interviewers also had no access to other information about the twins, including zygosity.

We obtained detailed information on all food and drinks consumed by each child during the previous two days by conducting two multiple-pass 24-hour recalls with a parent and the child, starting with the most recent day. Several large-scale nutrition surveys [18,19] have used multiple-pass dietary recalls. They incorporate specific steps to help minimize missing information, especially for food items likely to be forgotten [20]. Under this method, study participants were first asked to make a quick list of what the children had consumed during the preceding day. Next, they were asked to describe the items listed in greater detail, including quantities, brand names of commercial products, and recipes, as well as time and place of eating. Interviewers used different probing techniques to gather the important information. The final step entailed reviewing the recall to check for omissions or forgotten food or drinks. Volume food models were used to help participants report quantities consumed. Interviewers also took height and weight measurements for children according to a standardized protocol.

As was the case in other components of the study, parents gave their informed consent before participating in the nutrition study. We also obtained approvals from ethics committees at the University of Ottawa and the Sainte-Justine Hospital Research Centre.

In the days following the nutrition visit, a nutritionist responsible for data coding reviewed the data collected to ensure that information was complete and correctly reported. When clarification was needed, interviewers were contacted and, if necessary, families were telephoned to obtain additional details. The information collected through dietary recalls was coded using Nutritional Evaluation (Évaluation nutritionnelle, version 1.1.84), nutrient analysis software developed by Micro Gesta Inc. (www.microgesta.com). Large-scale nutrition surveys conducted in Quebec have used this software, which incorporates the Canadian food composition database, Canadian Nutrient File, version 2005 [21], and the US Department of Agriculture recipe file [22]. The software converted quantities of food consumed on dietary recall days into quantities of energy and nutrients ingested. Data coding applied rules and guidelines so as to standardize procedures and to ensure rigorous quality control. These procedures include coding data independently for each twin in a pair to avoid potential biases.