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Genetic and environmental contributions to body mass index in a Spanish adolescent twin sample☆

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ABSTRACT

Background and objective: Twin and family studies support large genetic influences on variability in body mass index (BMI), with heritability estimates ranging from 47% to over 90%. Our objective was to study the relative contributions of genetics and environment to BMI, evaluating sex differences, in an adolescent twin sample from Valencia, Spain.
Material and methods: Five hundred eighty-four pairs of adolescent twins between 13 and 18 years of age completed the study (82 monozygotic [MZ] and 87 dizygotic [DZ] pairs of male twins, 118 MZ and 102 DZ pairs of female twins, and 195 opposite-sex pairs of DZ twins). To determine zygosity, teachers responded a questionnaire on physical similarity. They also measured the participant's height and weight. BMI was calculated and weight status was determined according to age. We used twin models to assess genetic and environmental (common and unique) factors affecting BMI.
Results: There was a 7.1% frequency of overweight and 2.8% of obesity. The estimated heritability of BMI was 88.0% in boys and 72.1% in girls, with the remaining variance attributable to non-shared environment in boys (12.0%) and 8.8% in girls. It was only in girls that common environment had an effect on BMI.
Conclusions: Genetics appears to play an important role in explaining the variability in BMI in the adolescence, with slight variations between boys and girls. Common environmental factors exert their influence on BMI only in girls.

Influencias genéticas y ambientales sobre el índice de masa corporal en una población española adolescente gemelar

Palabras clave:
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RESUMEN

Fundamento y objetivo: Los estudios familiares y gemelares han demostrado que los factores genéticos son responsables del 47–90% de la variancia interindividual del índice de masa corporal (IMC). El objetivo de la presente investigación fue evaluar los factores genéticos y ambientales que contribuyen a las diferencias en el IMC, y en función del sexo, en una muestra gemelar de escolares de la Comunidad Valenciana.
Material y método: Quinientas ochenta y cuatro parejas de gemelos de 13 a 18 años de edad completaron el estudio: 82 parejas monocigóticas (MC) y 87 dicigóticas (DC) varones, 118 (MC) y 102 (DC) mujeres, y

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195 parejas (DC) de sexo opuesto. Para determinar la cigosidad, los profesores rellenaron un cuestionario de similitud física y pesaron y tallaron a los participantes. Se calculó el IMC y se estableció el estado nutricional según la edad. Se llevó a cabo una modelización del IMC que permitió establecer los componentes genéticos y ambientales (comunes y específicos) de su variancia.

Resultados: Se observó un 7,1% de sobrepeso y un 2,8% de obesidad. La heredabilidad del IMC se estimó en un 88% en niños y en un 72,1% en niñas. Los factores ambientales específicos explicaron el resto de la variancia del IMC (en niños el 12% y en niñas el 8,8%). Solo en las niñas apareció una contribución de los factores ambientales comunes.

Conclusiones: La influencia genética sobre el IMC es intensa durante la adolescencia, con ligeras variaciones en función del sexo, siendo solo las niñas vulnerables a las influencias ambientales comunes.

Introduction

Body Mass Index (BMI) or Quetelet index relates weight to body surface. It is frequently used as a measure of nutritional status. It varies with age, sex, pubertal status, race/ethnicity and growth. Its percentiles help define underweight, normal weight, overweight and obesity in adults. The definition of overweight and obesity in children is based on percentiles for their age.[1,2]

Contribution of genetics is 47–90% in the BMI interindividual variance[3–6]; as well as in its fluctuations throughout life.[7]

Overweight and obesity in childhood and adolescence are recognized as a public health problem. It is estimated that one out of 10 children is overweight.[8] The obese child and youth population has increased since the 1970s, affecting, at the beginning of this century 37.2% of children aged 6–11 years and 34.3% of adolescents aged 12–19 years.[9] These figures are alarming since obesity has been associated with a variety of both somatic and psychosocial disorders.[8,10,11]

No studies are available in our country assessing the differential impact that genetic and environmental factors have on BMI in children or adolescents. This knowledge can contribute to planning specific preventive strategies on overweight and obesity. Samples with monozygotic (MZ) and dizygotic (DZ) twins, who share, respectively, 100% and 50% of their genes, allow, applying complex statistical models, to disaggregate the effects of heredity, common environment and specific experiences in any phenotypic expression, such as the BMI. This is precisely the purpose of this study, conducted from a twin sample of schoolchildren in Valencia.

Material and methodology

Sample

The population and data of this study come from an institutional project on eating disorder diagnosis and treatment (DITCA Project) that the Department of Public Health and the Department of Education of the Autonomous Community of Valencia (Spain) have been conducting since academic year 2003–2004. Participation in this program is voluntary and has been offered to all public and private schools in this geographical area. The program has been repeated throughout the academic years 2004–2005 to 2007–2008. The overall purpose of the DICTA project is primary prevention and early detection of eating disorders (anorexia nervosa, bulimia nervosa or nonspecific eating disorders) in the adolescent population of the Autonomous Community of Valencia. The participants, with the consent of their parents or legal representatives, were weighed and measured with reliable measurement instruments (scale and measuring rod) delivered to the participating schools. The project has already been described in previous Publications.[12] A total of 571 schools participated during the academic years in which the project was repeated. The target school population was aged 13 to 17 years (mean [SD] 14.4 [1.8] years). In this sample, the pairs of twins participating in this research were identified from their initials, date of birth and school. It is easy to obtain pairs of twins from large population samples as long as information on names, date of birth and sex is available.[13]

Zygosity determination

The school psycopedagogy departments confirmed that the pairs included were siblings and collaborated in determining their zygosity. This was carried out with the help of teachers who completed a questionnaire on physical similarity previously used in other twin studies, which allows to correctly classify 98% of the pairs of twins regarding their zygosity.[14] The questions were about their physical resemblance and similarity on hair color and wave, eye color, etc. The zygosity determination from the data provided by the teachers was evaluated in 108 pairs of twins where the questionnaire was completed. The questionnaire was provided to both teachers and parents (by telephone) of each pair of twins, who were contacted by the school and agreed to cooperate in this process. In 8 cases (7.4%) there were discrepancies in the answer to a question. In such cases the questionnaire was repeated and the discrepancy was resolved in 6 cases, 5 supporting the initial response by the teacher and one supporting the initial response by the father/mother. Cohen's kappa test was 0.94 ($p < 0.001$). This statistic measures the inter-rater agreement when raters are rating the same object. A value of 1 indicates perfect agreement. The result obtained shows a significant agreement between tutors and parents. This let us accept the methodology of zygosity assessment as valid.

Body mass index

BMI is an indicator of a person's weight in relation to height. BMI is defined as the body mass in kilograms divided by the square of the body height expressed in meters.

The schools were recommended to weigh and measure the students during physical education and in light clothing. The physical education teacher was in charge of recording data of each student. The adolescents were grouped by nutritional status for their age, classified according to their BMI as underweight (BMI below the 10th percentile for their age), normal weight (BMI between percentiles 10 and 89 for their age), overweight (BMI between 90 and 97 percentiles for their age) and obesity (BMI by age > 97).[2]

Statistical analysis

Descriptive statistics

By means of the SPSS v.17 (SPSS, 2007) the descriptive statistics for numerical variables and the absolute and relative frequencies