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Randomized control trials

Growth velocity in infancy influences resting energy expenditure in 12–14 year-old obese adolescents

M. Batisse-Lignier [a,b], S. Rousset [a,b], A. Labbé [c], Y. Boirie [a,b,d,*]

[a] Clermont Université, Université d'Auvergne, Unité de Nutrition Humaine, BP 10448, F-63000 Clermont-Ferrand, France
[b] INRA, UMR 1019, UNH, CRNH Auvergne, F-63000 Clermont-Ferrand, France
[c] CHU Clermont-Ferrand, Pediatrics Department, F-63003 Clermont-Ferrand, France
[d] CHU Clermont-Ferrand, Clinical Nutrition Department, F-63003 Clermont-Ferrand, France

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SUMMARY

Background & aims: : To determine if rapid growth between 0 and 2 years of life influences body composition and resting energy expenditure (REE) measured at 12–14 years in a population of obese children.
Methods: REE and body composition were measured in 107 obese children aged 12–14 years in whom weight at birth and 2 years was recorded.
Results: 46 obese children had a rapid growth between birth and 2 years (>0.67 SD). Rapid weight gain was positively correlated with weight and height at 12–14 years but not with body mass index (BMI). Fat mass (FM) to fat free mass (FFM) ratio was not significantly different at 12–14 years in children with rapid or normal growth velocity. REE in 12–14 year-old children with rapid growth (1765 ± 222 kcal/24 h) was significantly higher than children with normal growth velocity (1586 ± 216 kcal/24 h) ($P < 0.001$). REE adjusted for FFM was similar in the two groups.
Conclusions: Rapid weight gain between 0 and 2 years of life is associated with higher weight, height, FFM, FM and REE in 12–14 year-old obese children despite identical BMI. These data demonstrate that growth velocity affects later body composition and REE in obese adolescents but relationship between REE and FFM is preserved.

1. Introduction

Prevalence of obesity in children has dramatically increased in developed and developing countries during the last decades.[1] The development of childhood obesity likely results from multiple environment and lifestyle modifications.[2] More recently, early metabolic alterations during prenatal or neonatal life have been involved in later overweight and obesity in children and adults. For instance, perinatal life is now considered as a crucial period for adult obesity development. Low birth weight has been reported to increase risk for many disorders in young adults leading ultimately to various disease states such as type 2 diabetes, cardiovascular and metabolic syndrome.[3,4] More than low birth weight, weight gain in the first years of life also called "catch-up" growth as a consequence of intrauterine restriction, has been identified as a strong predictor of childhood obesity.[5,6] Recent systematical reviews have clearly pointed out an association between rapid growth in infancy and later overweight and fat mass (FM) percentage.[7–11] Very few publications have been focused on the effects of postnatal growth on fat free mass (FFM) and this association still remains unclear.[9,12–14] In addition, the impact of rapid growth during infancy on weight gain and body composition at later childhood has not been investigated within a population of only obese children. Finally, despite possible changes in body composition, the impact of rapid weight gain during the first years of life upon energy expenditure in later childhood is unknown. We hypothesized in the present study that an early and rapid postnatal growth could modulate energy expenditure through modifications in body composition in obese adolescents. Therefore, the aim of our work was to study the consequences of rapid growth between birth and two years of life on body composition and resting energy expenditure (REE) in a population of 12–14 year-old obese children.

Abbreviations: REE, resting energy expenditure; FM, fat mass; FFM, fat free mass; BMI, body mass index.

* Corresponding author. Service de Nutrition Clinique, BP 69, 58 rue Montalembert, 63003 Clermont-Ferrand cedex 1, France. Tel.: +33 4 73 75 49 37; fax: +33 4 73 60 82 55.
E-mail addresses: mbatisse@chu-clermontferrand.fr (M. Batisse-Lignier), yves.boirie@clermont.inra.fr (Y. Boirie).

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2. Materials and methods

2.1. Participants

A cohort of 107 children was recruited from the Paediatric Department of the University of Clermont-Ferrand, France, between 2000 and 2007. The patients included were aged 12–14 years and all had overweight and obesity according to international definitions. As a definition for child obesity, we used cut-off points recently recommended by the International Obesity Task Force (IOTF).[15] Children with birth weight <2500 g or inappropriate-for-gestational-age were excluded of our analysis. Children were checked for not having any weight reduction program, any evolving disease, or any treatment that could modify energy expenditure. REE was measured at the Human Nutrition Laboratory (Clermont-Ferrand, France). We collected anthropometric data from their individual health records which were filled in by practitioners throughout childhood. The group was then separated in two sub-groups of obese children, those who had normal weight growth between 0 and 2 years and those who had rapid weight growth velocity (>0.67 SD).[7]

Children and parents must agree to the nutritional follow-up with REE and body composition measurements. Informed consent was obtained in accordance with the Helsinki Declaration of 1975.

2.2. Measurements in children

2.2.1. Anthropometrics data

Weight and height at birth and two years were recorded from individual health booklet (*Carnet de Santé*). The heights and weights were measured by standard clinical procedure during the consultation. Standing height was measured to the nearest 0.1 cm with a height gauge and body weight was measured to the nearest 0.1 kg on a mechanical scale (709; SECA, Hamburg, Germany). Body mass index (BMI) was determined as weight/height^2 (kg/m^2) and compared with the international references (IOTF).[15]

Body composition was obtained with bioelectrical impedance analysis (BIA) in the post absorptive state, after 10 min of rest in supine position and while the patient had empty bladder. The measurements were always performed by the same investigator. FM and FFM were determined using the equation of Wabitsch et al.[16]

2.2.2. Resting energy expenditure measurement

REE was measured by an open-circuit indirect calorimetry procedure for 45 min by using a Deltatrac II apparatus (Datex Engstrom, Helsinki). Before each test, the gas analyzers were calibrated with a reference gas mixture (95.0% O_2 and 5% CO_2). REE was measured after on overnight fast. The subjects were monitored during the exam to prevent any movement or sleeping under the hood. The first 5 min of each study were excluded to account for environmental adjustments by children and gas adaptation in the hood. Then REE was calculated from oxygen consumption and carbon dioxide production by using the equation of De Weir (1949).

2.3. Measurements in parents

Parents were weighted and measured by the study nurse on their child's admission day of the study. Their BMI was determined as weight/height^2 (kg/m^2).

2.4. Calculations and statistical analyses

Sex- and age-independent SD scores (SDSs) were calculated with the 2006 World Health Organization (WHO) growth standard for weight at birth and 2 years. Rapid growth was defined as an increase in weight SD > 0.67 between birth and two years, as recommended by Monteiro and Victora.[7] 0.67 SD scores represent the wide of each percentile band on standard growth charts.

Statistical analyses were performed to compare children who had normal weight growth between 0 and 2 years (group 1) and those who had rapid weight growth velocity (group 2). All the results are expressed as means ± SD. Data were compared between both groups by a student *t*-test using SAS. The level of significant difference was set at $P < 0.05$ for all statistical tests. Then, a two-way analysis of variance was performed to determine the effect of gender and growth velocity on REE/FFM using SAS software. Finally, an analysis of covariance with BMI and gender was carried out.

3. Results

3.1. Descriptive analysis of the group

The main characteristics of the children are shown in Table 1. A group of 107 obese children (BMI 27.28 ± 4.16 kg/m^2) composed of 46 boys and 61 girls (sex ratio M/F 0.75), aged 12.85 ± 0.80 years, was included in the study. There were no significant differences in birth weight, weight, BMI and body composition between the girls and the boys (P = NS). Despite a similar FFM in boys and girls, REE was significantly higher in boys than in girls ($P < 0.001$).

The analysis of variance showed that both the BMI covariate and the gender variable had a significant effect on REE/FFM ($P < 0.0001$, $P < 0.05$ respectively). Thus, boys had a REE/FFM ratio higher than girls. Moreover, higher the BMI lower REE/FFM was. Unlike the gender, growth velocity did not affect REE/FFM ($P = 0.57$).

No correlation between parents and child BMI was found. 88.2% of children had a parent with overweight (54.1% overweight mother and 68.7% overweight father).

Table 1
Characteristics of the participants.

	All	Boys	Girls	*P*-value
N	107	46	61	NS
Birth weight (kg)	3.38 ± 0.45	3.43 ± 0.48	3.36 ± 0.44	NS
2 year-old children weight (kg)	12.98 ± 1.79	13.23 ± 2.03	12.79 ± 1.58	NS
Age (years)	12.85 ± 0.80	12.91 ± 0.78	12.81 ± 0.83	NS
Height (m)	1.59 ± 0.08	1.58 ± 0.07	1.59 ± 0.08	NS
Weight (kg)	70.75 ± 13.94	69.85 ± 14.53	71.43 ± 13.57	NS
BMI (kg/m^2)	27.28 ± 4.16	27.68 ± 4.26	27.87 ± 4.26	NS
FM (kg)	30.7 ± 8.7	29.73 ± 8.85	31.42 ± 8.63	NS
FFM (kg)	40.1 ± 6.2	40.12 ± 6.58	40.01 ± 5.9	NS
REE meas (kcal/d)	1663.27 ± 235.77	1756.52 ± 43.34	1592.95 ± 205.19	≤0.001
REE/FFM	41.83 ± 4.71	44.15 ± 4.83	40.08 ± 3.81	≤0.001

BMI: body mass index; FM: fat mass; FFM: fat free mass; REE meas: resting energy expenditure measurement.