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Original article

Metabolic dysfunction in late-puberty adolescent girls with type 1 diabetes: Relationship to physical activity and dietary intakes

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Abstract

Aims. – At puberty, type 1 diabetes (T1D) among young girls can lead to excess body weight, insulin resistance, deterioration of glycaemic control and dyslipidaemia. Although biological factors contribute largely to such metabolic dysfunction, little is known of the role of behavioural factors such as physical activity and diet.

Methods. – This study investigated the association between metabolic dysfunction measured after a 12-h overnight fast and behavioural factors, including diet (4-day diary) and physical activity (validated questionnaire), in 19 postmenarchal adolescent girls with T1D compared with 19 healthy girls.

Results. – T1D girls displayed higher levels of fat mass, insulin resistance (higher plasma glucose, serum leptin and waist-to-hip ratios) and dyslipidaemia (higher LDL-C and apolipoprotein B levels, lower HDL-C and apolipoprotein A-1 levels). Also, contrary to what is usually observed in T1D adults, serum adiponectin, an important vessel protector, was not raised in T1D adolescent girls compared with healthy controls. Quantity and quality of dietary macronutrient intakes as well as physical activity levels were comparable in both groups, although the T1D girls with the poorest metabolic profiles reported having the healthiest diets (fewer total calories, more protein and less carbohydrates). However, in T1D girls, less physical activity and more time spent watching television were associated with poorer metabolic profiles (higher waist-to-hip ratios, fat mass and leptin levels, and lower adiponectin, HDL-C and apolipoprotein A-1 levels).

Conclusion. – Collectively, these data suggest that physical inactivity is linked to metabolic dysfunction to a greater extent than unhealthy dietary habits in postmenarchal T1D adolescent girls.

Keywords: Adolescence; Diet; Metabolism; Exercise; Type 1 diabetes

Résumé

Dysfonctions métaboliques chez des adolescentes diabétiques de type 1 en fin de puberté : quelles relations avec le niveau d'activité physique et les apports alimentaires?

Objectifs. – Au moment de la puberté chez la femme, le diabète de type 1 (DT1) peut conduire à des dysfonctions métaboliques (surcharge pondérale, insulinorésistance, déséquilibre glycémique, dyslipidémie). Si de nombreux travaux explorent les mécanismes de ces dysfonctions métaboliques, le rôle des comportements liés à l'alimentation et l'activité physique reste à préciser.

Méthodes. – Les relations entre le profil métabolique à jeun et les facteurs comportementaux incluant l'alimentation (questionnaire sur quatre jours) et l'activité physique (questionnaire validé) ont été étudiées chez 19 adolescentes DT1 menstruées en comparaison de 19 adolescentes non diabétiques.

Résultats. – Les adolescentes DT1 présentaient un excès de masse grasse, des marqueurs et des facteurs de risques d'insulinorésistance (glucose, leptine et rapport taille/hanche supérieurs), et une dyslipidémie (LDL-C et apolipoprotéine-B plus élevés ; HDL-C et apolipoprotéine-A plus

Abbreviations: ApoA1, apolipoprotein A1; ApoB, apolipoprotein B; BMI, body mass index; HbA_{1c}g, lycated haemoglobin; T1D, type 1 diabetes.

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faibles). De plus, à la différence de ce qui est rapporté chez les adultes DT1, l'adiponectine, protecteur vasculaire majeur, n'était pas élevée chez les adolescentes DT1 en comparaison des témoins. L'apport en macronutriments (quantité et qualité) ainsi que les niveaux d'activité physique étaient comparables dans les deux groupes. Les adolescentes DT1 qui présentaient le profil métabolique le plus altéré rapportaient avoir une alimentation plus saine (moins de calories et de glucides ; davantage de protéines). Néanmoins, chez ces adolescentes DT1, les dysfonctions métaboliques (rapport taille/hanche, masse grasse, leptine plus élevés ; adiponectine, HDL-C, apolipoprotéine-A plus faibles) étaient associées à un investissement moindre dans l'activité physique et à des comportements plus sédentaires. **Conclusion**

L'altération du profil métabolique des adolescentes DT1 en fin de puberté semble davantage liée au manque d'activité physique qu'au déséquilibre de l'alimentation.

Mots clés : Adolescence ; Alimentation ; Diabète de Type 1 ; Exercice ; Métabolisme

1. Introduction

At puberty, and especially during the stages of late-puberty, type 1 diabetes (T1D) and female gender can often lead to excess body weight, insulin resistance, deterioration of glycaemic control and dyslipidaemia [1–3], all of which are important risk factors for cardiovascular diseases and long-term cardiovascular complications. Although biological factors, including hormonal changes associated with puberty in girls, and intensified insulin therapy contribute largely to metabolic dysfunction in T1D adolescent girls, little is known of the role of behavioural factors, such as physical activity and diet.

Studies published to date on the relationship between either of these behavioural factors and the metabolic profile of T1D adolescents [4–11] have included few metabolic profile markers, such as body mass index (BMI), glycated haemoglobin (HbA_{1c}), glycaemia, high-density lipoprotein cholesterol (HDL-C) and low-density lipoprotein cholesterol (LDL-C).

Although overweight occurs from the time of menarche in girls with T1D [12], the data are scanty for strictly selected late-puberty adolescent girls. Sarnbläd et al. [13] studied the link between physical activity and diet with HbA_{1c} and BMI in Tanner stages 4/5 T1D girls compared with healthy controls. However, their examinations were conducted over two seasons. Moreover, saturated and unsaturated fatty acids were not distinguished in their dietary analysis, and the BMI does not reflect body composition accurately. Schweiger et al. [10] found that the postmenarchal girls with T1D who had lower HbA_{1c} and BMI levels were also younger and less physically active. However, it was difficult to distinguish between the effects of age and physical activity in that study.

For this reason, the present study examined, in a well-characterized population of late-puberty T1D adolescent girls compared with healthy controls, the relationship of both physical activity and dietary composition with body composition, and markers of lipid and apolipoprotein profiles and insulin resistance.

2. Patients and methods

Nineteen Caucasian postmenarchal adolescent girls (aged < 18.5 years) at Tanner's pubic-hair stages 4/5 with T1D for at least 1 year (mean duration: 7.4 ± 4.5 [SD] years) were recruited from the regional Unit of Paediatric Endocrinology (Brittany, France). All were receiving multiple insulin injection regimens consisting of both rapid-acting (Novorapid® or Humalog®, 40.9 ± 2.0 U.day^{-1}) and long-acting (Lantus®, 27.4 ± 1.4 U.day^{-1}) insulin analogues, and all were free of microvascular diseases and had negative microalbuminuria screening and normal ophthalmoscopy tests. A control group of 19 healthy Caucasian girls was recruited from among the friends and classmates of the T1D girls. They were selected specifically to closely match the T1D group in terms of age and puberty development (Tanner's pubic-hair stages 4/5). All subjects were tested in November. Our study was approved by the ethics committee of Rennes (France), and written informed consent was obtained from all participants and their parents.

2.1. Metabolic profiles

These were investigated after a 12-h overnight fast and, in the case of T1D patients, before their morning insulin injections. Height and weight were measured, and subscapular and tricipital skinfolds from the right side were obtained in triplicate by one investigator, and the percentage of body fat mass calculated [14]. Waist and hip circumferences were measured in triplicate by the same investigator, measuring the waist at the level of the umbilicus and the hip at its widest point. The waist-to-hip ratio, an index of insulin sensitivity in T1D [15], was then calculated. Blood samples were collected in 7-mL heparinized containers (plasma) and 7-mL additive-free containers (serum) from an antecubital vein and centrifuged. Plasma was analyzed for glucose (automated hexokinase method, Beckman Coulter, Brea, CA, USA), total cholesterol and triglycerides (enzyme kits, Beckman Coulter, Roissy, France) and HDL-C (polyethylene glycol (PEG)-modified enzymes and dextran sulphate, Roche HDL-Cholesterol Plus, Roche Diagnostics Corporation, Indianapolis, IN, USA). Given that all patients had triglycerides less than 2 mM, LDL-C was computed using Friedewald's formula, which is validated for use in T1D [16]. Leptin and adiponectin (radioimmunoassay, Linco Research Inc., St. Louis, MO, USA), lipoprotein(a), apolipoproteins A-1 (ApoA1) and B (ApoB) (immunonephelometry, Dade Behring S.A.S, Paris, France) and total insulin-like growth factor (IGF)-1 (radioimmunoassay, CIS Bio International, Saclay, France) were assayed in duplicate using frozen serum. For all samples analyzed, the intra-assay and interassay coefficients of variation were less than 8.3% and less than 9.3%, respectively. An EDTA tube was also taken to analyze HbA_{1c} (high-performance liquid chromatography [HPLC], VARIANT^{TM}, Bio-Rad, Munich, Germany).