Nutrition, Metabolism & Cardiovascular Diseases (2018) xx, 1–8

Available online at www.sciencedirect.com

Nutrition, Metabolism & Cardiovascular Diseases

journal homepage: www.elsevier.com/locate/nmcd

Food intake and high-sensitivity C-reactive protein levels in adolescents

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Received 15 December 2017; received in revised form 4 June 2018; accepted 5 June 2018
Handling Editor: A. Siani
Available online ■ ■ ■

KEYWORDS
Food intake;
Inflammation;
High-sensitivity C-reactive protein;
Adolescents

Abstract *Background and aims:* Diet comprises factors with anti and pro-inflammatory potential that can contribute to modulate obesity-induced inflammation. We aimed to assess the association between food intake and high-sensitivity C-reactive protein (hsCRP) levels in adolescents.

Methods and results: A cross-sectional analysis of 991 adolescents aged 13 years old was conducted as part of the EPITeen cohort, Porto, Portugal. Food intake was assessed by a food frequency questionnaire and thirteen food groups were defined. Anthropometric assessment was performed and serum hsCRP was measured in a fasting blood sample. hsCRP concentrations above the 75th percentile were considered high. Logistic regression was fitted to estimate the association between the intake frequency of the food groups and hsCRP, stratified by BMI and adjusted for sex, parental education and total energy intake. Median (25–75th percentiles) hsCRP concentrations increased with increasing values of BMI [normal weight: 0.20 (0.10–0.50); overweight: 0.40 (0.20–0.80); obese: 1.10 (0.40–2.15) mg/l, $p < 0.001$]. After adjustment for sex, parental education and total energy intake, no statistically significant associations were found amongst normal weight and overweight participants. However, among obese individuals, having as reference the first frequency category (<1 per day), a higher frequency of vegetables/legumes intake showed a decreased odds of high hsCRP levels (OR: 0.10, 95%CI 0.03–0.38, 1–3 per day; and OR: 0.14, 95%CI 0.04–0.52, >3 per day).

Conclusion: Among participants with obesity-induced higher hsCRP levels, a higher frequency of vegetable/legume intake was inversely related to hsCRP.

Introduction

During the last decades, the prevalence of obesity in children and adolescents has drastically increased worldwide [1]. Obesity increases the risk of musculoskeletal disorders, cardiovascular disease, chronic disease and some cancers, and is thereby linked to losses in life expectancy [2]. This set of pathologies has also started to emerge in children, a scenario that was not expected a few decades ago [2].

Systemic low-grade inflammation has been described as an important biological pathway that can explain the link between obesity and its related disorders [3]. Considerable interest has been given to C-reactive protein (CRP), an inflammation marker that has been shown to predict

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https://doi.org/10.1016/j.numecd.2018.06.003
0939-4753/

cardiovascular risk [4]. Although there is controversy on whether CRP is merely a risk marker or a causal factor of cardiovascular vascular disease [5], it is the most widely used and best standardized inflammatory marker related to cardiovascular pathology [6,7]. The development of high-sensitivity assays has allowed the identification of more subtle elevations in CRP, enabling the earlier detection of an inflammatory state at a subclinical stage [8]. Although data in pediatric population is scarce, studies have shown higher values of high-sensitivity C-reactive protein (hsCRP) among obese children and adolescents, indicating that in early stages a certain level of inflammation already exists comparing to the non-obese population [9–11].

The role of diet as a key modifiable factor in regulating low-grade inflammation has been increasingly recognized, with recent evidence suggesting the existence of a relationship between numerous dietary exposures and cardiovascular disease (CVD) that might be mediated through the inflammatory pathway [12]. Nutrients and dietary components such as long-chain polyunsaturated fatty acids of the n-3 series (PUFA), vitamin D, antioxidant vitamins (C, E and carotenoids), alcohol, fiber, flavonoids and phytoestrogens have shown a protective role [13]. In contrast, foods with a high glycemic index or load, saturated fatty acids intake and industrially produced *trans*-fatty acids are amongst the pro-inflammatory dietary factors [12,13]. Despite this modulatory potential, the results of observational studies and randomized clinical trials (RCTs) can be discrepant, with some RCTs of dietary supplements paradoxically revealing adverse effects on CVD for nutrients that previously had shown to exert protective effects on observational studies [14].

Most studies have focused on nutrient intake and are, therefore, limited by the inability of considering the interactive or synergistic effects of nutrients [12]. By studying the food group effect, the resulting information could be more easily translated to the general public dietary habits, with a higher potential for intervention, namely at younger ages. Adolescence is characterized by an increase in autonomy, providing a unique opportunity for the appropriate transmission of health-related messages.

Based on a population based-cohort, the present study aimed to assess the potential role of diet in modulating the pro-inflammatory effect of adiposity by evaluating the relationship between intake frequency of different food groups and hsCRP levels in 13-year-old adolescents.

Methods

Subjects

Participants were adolescents from the Epidemiological Health Investigation of Teenagers in Porto (EPITeen). As reported elsewhere [15] we evaluated adolescents born in 1990, who were enrolled at public and private schools in Porto, Portugal, during the 2003/2004 school year. Data were collected using two self-administered questionnaires: one filled in at home with the help of parents or legal guardians, which included a food frequency questionnaire (FFQ); the other was filled at school during the research team visit and comprised information on physical activity, smoking and alcohol intake. Additionally, a physical examination was performed at school, by a team of trained health professionals. This study was conducted according to the guidelines laid down in the 1964 Declaration of Helsinki and its later amendments. The Ethics Committee of Hospital S. João approved the study and written consent was obtained from both legal guardians and adolescents.

As many as 2786 eligible participants were identified, of whom 2159 agreed to participate and provided information at least for part of the planned assessment. Of the 2159 participants, 247 did not return the home questionnaire and 297 did not fill in the FFQ or were excluded because no information was provided on more than 10% of food items. A further 119 participants were not considered for the current analysis because they presented moderate or extreme outliers for their total energy intake or food group consumption. Of the 1496 with data for food intake, 489 participants did not perform a blood collection, 13 were not considered as they presented hsCRP concentrations above the 10 mg/L, which might be indicative of acute infection, and 3 adolescents did not perform the anthropometric measurements. Thus, the analysis was based on the information of 991 participants.

Characteristics of participants included in this analysis were compared with the remaining participants of the cohort. Compared with the excluded adolescents, the sample included in this analysis significantly presented a higher proportion of girls, a higher parental educational level, and lower intensity in leisure-time activities. No significant differences were observed regarding BMI.

Data collection

Food intake

Food intake was recorded using a FFQ regarding the previous 12 months, filled in by the adolescents with the help of their parents or legal guardians. The FFQ was designed according to *Willett* and colleagues [16], adapted for the Portuguese population and validated for the adult population by comparison with four 7 daily food records (each one in a different season of the year) [17]. Then it was adapted for adolescents by including foods more frequently eaten by this age group [18]. The FFQ comprised 91 food items or food groups and a frequency section with 9 possible responses ranging from never to six or more times daily (never or $<$ than once a month, 1–3 times per month, once a week, 2–4 times per week, 5–6 times per week, once a day, 2–3 times per day, 4–5 times per day, $\geq$6 times per day). An open-ended section for foods not listed in the questionnaire, but eaten at least once weekly was also included. To estimate energy intake we used the software *Food Processor Plus*® (ESHA Research, Salem, OR, USA) based on values from the US Department of Agriculture. Values for Portuguese food were added, based on the Portuguese table of food composition, typical recipes and data from previous studies [17].

Please cite this article in press as: Cabral M, et al., Food intake and high-sensitivity C-reactive protein levels in adolescents, Nutrition, Metabolism & Cardiovascular Diseases (2018), https://doi.org/10.1016/j.numecd.2018.06.003