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Fruit, vegetable consumption and blood pressure in healthy adolescents: A longitudinal analysis from the LabMed study

R. Rosário [a,b,*], R. Santos [c,d], L. Lopes [c], C. Agostinis-Sobrinho [c,e,f], C. Moreira [c], J. Mota [c], S. Póvoas [g], A. Oliveira [c], P. Padrão [h,i], P. Moreira [c,h,i], S. Abreu [c,j]

[a] School of Nursing, University of Minho, Portugal
[b] Health Sciences Research Unit-Nursing, Escola Superior de Enfermagem de Coimbra, Portugal
[c] Research Centre in Physical Activity, Health and Leisure, Faculty of Sport, University of Porto, Portugal
[d] Early Start, Faculty of Social Sciences, School of Education, University of Wollongong, Australia
[e] Faculty of health Sciences, Klaipeda University, Lithuania
[f] Physical Education, Physiotherapy and Dance, Federal University of the South of Brazil, Porto Alegre, Rio Grande do Sul, Brazil
[g] Research Center in Sports Sciences, Health Sciences and Human Development, CIDESD, University Institute of Maia, ISMAI, Maia, Portugal
[h] Faculty of Nutrition and Food Sciences, University of Porto, Portugal
[i] Institute of Public Health, University of Porto, Portugal
[j] Universidade Lusófona do Porto, Portugal

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Abstract *Background and aims:* The associations between fruit and vegetable consumption and high blood pressure among adults are well studied. Nonetheless, data on the influence of a low consumption of fruit and vegetables on cardiovascular disease risk, particularly blood pressure, among healthy adolescents are scarce. Therefore, we aim to analyse the associations between fruit and/or vegetable intake and blood pressure over a two-year period in healthy adolescents. *Methods and results:* As part of a cohort, 606 adolescents from the LabMed Physical Activity study were evaluated in 2011 (baseline) and 2013 (follow-up). Blood pressure was measured according to standardized procedures and fruit and vegetable consumption was assessed with a food frequency questionnaire. Anthropometric variables, socioeconomic status, pubertal stage and lifestyle determinants were gathered and used as confounders. Prospective associations between fruit and/or vegetable intake and blood pressure were examined using generalized linear models. Girls who consumed more fruit at baseline had a significant decrease in diastolic blood pressure at follow-up [unstandardized beta: −0.005 mmHg (95%CI: −0.01; −0.0002) (p = 0.038)]. *Conclusion:* In apparently healthy adolescents, fruit intake may already start to have an effect in blood pressure. Girls who consumed more fruit exhibited lower levels of diastolic blood pressure.

Introduction

Increased blood pressure (BP) is a modifiable risk factor of cardiovascular diseases and its growing importance aligns with its rising prevalence. In children and adolescents, elevated BP prevalence ranges between 8% and 19% [1] and increases the risk of hypertension in adulthood [2].

Adolescence is considered a vulnerable period of high BP development, because the highest peak of BP occurs

* Corresponding author. Universidade do Minho, Escola Superior de Enfermagem, 3º Piso - Edif. da Biblioteca Geral (BGUM), Campus de Gualtar, 4710-057, Braga, Portugal. Fax: +351 253 601319.
E-mail address: rrosario@uminho.pt (R. Rosário).

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during puberty [3,4] and most of the lifestyle habits are established during this period [5]. Therefore, it is important to find the modifiable determinants of elevated BP in order to implement lifestyle programs in youth to prevent the development of hypertension.

The relationship between nutritional intake and BP has been studied [6], but this approach does not account for the complexity of food consumption. Research found that higher consumption of certain foods, such as fruit and vegetables, is associated with lower systolic BP (SBP) [7,8], in pre-puberty [9] and mainly in females [10]. Nonetheless, the exact mechanisms behind this association are not clear. Fruit and vegetables are high in potassium and magnesium, which have been associated with BP reductions [6]. In addition, fruit and vegetable consumption may reflect an overall healthier dietary pattern. Therefore, changes in BP may not be attributed to the effect of a single mineral [7,11].

A previous prospective study on 95 children, aged 3–6 years, showed that higher consumption of fruit and vegetables during early childhood, especially when combined with dairy products, was associated with lower increases of BP during adolescence [7]. Similar results were found in a larger sample of pre-pubertal adolescents [9] and in older female children [12]. In a recent study, vegetable and fruit intake was negatively associated to SBP and DBP, respectively [8]. Likewise, longitudinal studies in adolescence have found that fruit and vegetable intake [10] and vegetable (but not fruit) [13] were associated with decreases in BP in young adulthood. Nonetheless, none of these studies investigated the independent effects of fruit and/or vegetables on BP in a large sample of healthy adolescents, nor considered other important confounders such as cardiorespiratory fitness.

We hypothesized that in adolescents, higher intake of fruit and/or vegetables at baseline is negatively associated with BP at follow-up. Therefore, we aimed to analyse the association between fruit and/or vegetable intake and BP over a two-year period in healthy adolescents.

Methods

Study design and participants

Data for the present study was derived from the "Longitudinal Analysis of Biomarkers and Environmental Determinants of Physical Activity (LabMed Physical Activity Study)". This is a school-based prospective study carried out in the North Region of Portugal aiming at evaluating the combined effects of fitness and dietary intake on BP. The full description of the study is reported elsewhere [14]. Briefly, 1229 adolescents aged 12–18 years participated in the study and 1017 completed baseline assessments in 2011; of those, 893 (87.8% participation) and 734 subjects (72.2% participation) were re-evaluated one and two years later, respectively. The present study considered a sub-sample of adolescents (n = 734) with information on BP measured at baseline and at two-year follow-up (in 2013). After exclusion of the participants with missing information of dietary intake (n = 128), 606 adolescents (314 males) aged 12 to 18 years-old were included in the final analysis (please see supplementary figure).

Ethical and legal requirements

The study was conducted in accordance with the World Medical Association's Helsinki Declaration for Human Studies. The Portuguese Data Protection Authority (1112434/2011), the Portuguese Ministry of Science and Education (0246200001/2011) and the Faculty of Sport, University of Porto, approved the study. All participants in this study were informed of the study goals, and written informed consent was obtained from adolescents and their parents or guardians.

Assessments

Dietary intake

Dietary intake was measured with a self-administered semi-quantitative food frequency questionnaire (FFQ), which was designed in accordance with criteria laid out by Willett [15] and adapted to include a variety of typical Portuguese food items. This version of the questionnaire covered the previous twelve months and comprised ninety-one food items or beverage categories. For each item, the questionnaire offered nine frequency response options, ranging from 'never' to 'six or more times per day', and standard portion size and seasonality. In a free-response section, participants could list any foods not listed in the questionnaire. Energy and nutritional intake were estimated regarding to respondents' ratings of the frequency, portion and seasonality of each item, using the software Food Processor Plus (ESHA Research Inc., Salem, OR, US) and including typical Portuguese foods and beverages.

Total fruit and vegetable intake was calculated as the sum of fruit and vegetables consumed. Regarding fruit consumption, only whole fruit was included and fruit juice was excluded, because there may be an adverse association between fruit juice consumption and BP [16]. Vegetable intake included vegetables, legumes and vegetable soup, aggregated according to their nutritional similarities.

Anthropometrics

Anthropometric evaluation, was performed using standardized procedures [17]. For weight and height measurements, we used a digital scale (Tanita Inner Scan BC 532, Tokyo, Japan) and a portable stadiometer (Seca 213, Hamburg, Germany), respectively. Height was measured according to the Frankfort plane to the nearest 0.1 cm, and body weight was measured to the nearest 0.1 kg, with the participants lightly dressed and without shoes. Body mass index (BMI) was then computed as weight (kg)/height(m)^2. Waist circumference measurement was taken with the adolescent in a standing position, to the nearest 0.1 cm, with a tape measure midway between the lower

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