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Glycemic index, glycemic load, and pulse wave reflection in adults

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KEYWORDS
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Abstract *Background and aims:* Diets with a high glycemic index (GI), high glycemic load (GL), or both, increase the risk of cardiovascular disease. This study examined the association of GI and GL in a regular diet with the peripheral augmentation index (i.e., a marker of vascular aging) in a sample of adults.

Methods and Results: Cross-sectional study. The findings presented in this manuscript are a sub-analysis of the EVIDENT study whose purpose was to analyze the relationship between lifestyle and arterial aging. For the sample population, 1553 individuals aged 20–80 years were selected through random sampling from the patients of general practitioners at six health centers in Spain. GI and GL for each patient's diet were calculated from a previously validated, semi-quantitative, 137-item food frequency questionnaire. The peripheral augmentation index corrected for a heart rate of 75 bpm (PAIx75) was measured with pulse-wave application software (A-Pulse CASP). Based on a risk factor adjusted regression model, for every 5 unit increase in GI, the PAIx75 increased by 0.11 units (95% CI: 0.04–0.19). Similarly, for every increase in 10 units in GL, the PAIx75 increased by 1.13 (95% CI: 0.21–2.05). High PAIx75 values were observed in individuals with diets in the third GI tertile (i.e., the highest), and lower PAIx75 values in those with diets in the first tertile (i.e., the lowest), (93.1 vs. 87.5, respectively, $p = 0.001$).

Conclusions: GI and GL were directly associated with PAIx75 values in adults without cardiovascular diseases regardless of age, gender, physical activity, and other confounders.

Introduction

Glycemic index (GI) measures how a carbohydrate-containing food raises blood glucose. Foods are ranked based on how they are compared to a reference food — glucose [1,2]. Glycemic load (GL) estimates the impact of carbohydrate consumption using the GI while taking into account the amount of carbohydrate that is consumed. It is

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calculated by multiplying the GI of a food by its carbohydrate content and represents both quality and quantity of carbohydrates [3].

Diets with a high GI, high GL, or both increase the risk of chronic lifestyle-related diseases, such as type 2 diabetes mellitus [4–6]. Diets with high GL, not GI, are associated with a 19% increased risk for stroke [7], while a reduction in the GI and GL may favorably affect coronary heart disease outcomes in women and overweight [8,9]. A recent meta-analysis of 14 prospective studies found that high GL or GI diets are associated with an increased risk of cardiovascular disease [10].

The augmentation index is a ratio calculated from the blood pressure waveform, it is a measure of wave reflection and arterial stiffness and it has been shown to be a predictor of both future cardiovascular events and all-cause mortality and can be used to predict clinical events [11]. To date, the literature does not contain studies that link parameters of vascular aging with GI and GL in the regular diet. In our study, we analyzed the peripheral augmentation index (PAIx) (i.e., also known as the radial augmentation index), which is a marker of vascular aging and pulse wave reflection [12]. We hypothesized that diets with increased GI and GL are associated with worsening vascular function after adjusting for potential confounders. Several authors have proposed that age, sex, blood pressure, and the presence of obesity, hypertension, diabetes and dyslipidemia are the main determinants of the parameters that assess vascular function [13–15]. Moreover, the effects of diets with high GI may be either reduced or magnified due to other conditions, such as adiposity and physical activity [16].

The findings presented in this manuscript are a subanalysis of the EVIDENT study. The main results were published recently [17,18]. The purpose of the EVIDENT study was to analyze the relationship between lifestyle and arterial aging in a cohort of healthy patients.

The aim of this work was to analyze the association of GI and GL in regular diets with the PAIx in a sample of adults with no cardiovascular disease.

Methods

Study design and population

A cross-sectional study was conducted. The protocol for the EVIDENT study (NCT01083082) can be found in a previously published study [19]. For the sample population, 1553 subjects aged 20–80 years were selected through random sampling from the patients of general practitioners at 6 health centers in Spain. The exclusion criteria for the study included the following factors: known coronary or cerebrovascular atherosclerotic disease; heart failure; moderate or severe chronic obstructive pulmonary disease; musculoskeletal disease that limited walking; advanced respiratory, renal, or hepatic disease; severe mental disease; treated oncological disease diagnosed in the 5 years before the beginning of the study; terminal illness; and pregnancy. The recruitment and data collection period for the study was June of 2010 to June of 2012. A sample-size calculation indicated that the population of 1553 patients included in the study was sufficient sample for detecting a correlation coefficient of 0.10 between GI and PAIx in a two-sided test with a 95% level of significance and a power of 95% (EPIDAT 4.0). The study was approved by the independent ethics committee of Salamanca University Hospital, and all participants gave written informed consent for the study according to the general recommendations of the Declaration of Helsinki.

Variables and measurement instruments

Glycemic index and glycemic load

GI,GL, and total calories for each participant's diet was calculated from data obtained in a previously validated, semi-quantitative, 137-item food frequency questionnaire (FFQ) collected at the time of the interview [20].The FFQ included 137 food items, and the participants indicated the frequencies of consuming the food items using an incremental scale with nine levels (i.e., never or almost never, 1–3 times per month, once per week, 2–4 times per week, 5–6 times per week, once per day, 2–3 times per day, 4–6 times per day, and more than six times per day). The reported frequencies of food consumption were converted to number of daily intakes and multiplied by the weight of the portion size indicated. GI is expressed as a percentage and represents the relative rate at which blood glucose levels rise after consuming 1 g of the food in question as compared to pure glucose. GL is calculated from the GI and reflects the whole day's intake on expected postprandial blood glucose changes. The mean dietary GL for each participant was calculated by summing the products of the carbohydrate content per serving of each consumed food, the average number of servings of that food per day, and the GI for that food. The overall GI for each participant was computed by dividing the GL by the total carbohydrate intake per day [21].

Peripheral or radial augmentation index

Central blood pressure (BP) was measured using pulse-wave application software (A-Pulse, HealthSTATS International, Singapore) tonometry to capture the radial-artery pulse, and a patented equation to estimate central BP. This determination is based on the N-point moving-average method and derives central aortic pressures from the waveform of the radial-artery pressure, thereby eliminating the effects of the relative timings of incidents and reflected pressure waves and thus of non-uniform elasticity and viscous damping within the arterial system; ultimately, this reveals the amplitude of the original signal and therefore the central aortic systolic pressure [22]. The PAIx is a measurement taken directly from the late systolic shoulder of the peripheral arterial waveform and is defined as the ratio of the difference in amplitude between the second peak and diastolic pressure to the difference between the first peak and diastolic pressure [23]. PAIx was calculated as the second peak of systolic blood pressure (SBP2) − diastolic blood pressure (DBP)/first peak SBP