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Research report

Habitual intake of fruit juice predicts central blood pressure ☆

Matthew P. Pase [a,*], Natalie Grima [b], Robyn Cockerell [a], Andrew Pipingas [a]

[a] Centre for Human Psychopharmacology, Swinburne University of Technology, Australia
[b] Faculty of Medicine, Nursing and Health Sciences, Monash University, Clayton, Australia

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A B S T R A C T

Despite a common perception that fruit juice is healthy, fruit juice contains high amounts of naturally occurring sugar without the fibre content of the whole fruit. Frequent fruit juice consumption may therefore contribute to excessive sugar consumption typical of the Western society. Although excess sugar intake is associated with high blood pressure (BP), the association between habitual fruit juice consumption and BP is unclear. The present study investigated the association of fruit juice consumption with brachial and central (aortic) BP in 160 community dwelling adults. Habitual fruit juice consumption was measured using a 12 month dietary recall questionnaire. On the same day, brachial BP was measured and central (aortic) BP was estimated through radial artery applanation. Frequency of fruit juice consumption was classified as rare, occasional or daily. Those who consumed fruit juice daily, versus rarely or occasionally, had significantly higher central systolic BP ($F(2, 134) = 6.09$, $p < 0.01$), central pulse pressure ($F(2, 134) = 4.16$, $p < 0.05$), central augmentation pressure ($F(2, 134) = 5.98$, $p < 0.01$) and central augmentation index ($F(2, 134) = 3.29$, $p < 0.05$) as well as lower pulse pressure amplification ($F(2, 134) = 4.36$, $p < 0.05$). There were no differences in brachial BP. Central systolic BP was 3–4 mmHg higher for those who consumed fruit juice daily rather than rarely or occasionally. In conclusion, more frequent fruit juice consumption was associated with higher central BPs.

Introduction

Fruit juice is generally considered to be a source of vitamins and antioxidants (Ruxton, Gardner, & Walker, 2006), creating a perception that fruit juice is healthy (Kim & House, 2014). Despite containing vitamins, fruit juice includes high amounts of naturally occurring sugar. Some fruit juices also contain added sugar. Along with sugar sweetened beverages such as soft drinks, fruit juice is a large contributor to daily sugar intake (Huth et al., 2013). According to the United States Department of Agriculture, a fresh medium size apple contains around 19 g of sugar (fructose/glucose ratio of 2) but also 4 g of dietary fibre (Agriculture USDo, 2012). A glass or bottle of apple juice may contain the natural sugar of multiple apples without the fibre content of the whole fruit, necessary to activate a satiety response.

The health consequences associated with fructose consumption in sugar sweetened beverages has been the subject of recent controversy. Some have argued that fructose has toxic effects on the body, comparable with that of ethanol (Lustig, 2013). It has also been suggested that excessive fructose consumption may cause detrimental health outcomes, such as metabolic syndrome and diabetes (Johnson et al., 2009). However, others have argued that the available evidence is insufficient to suggest that fructose consumption is responsible for metabolic diseases and obesity (van Buul, Tappy, & Brouns, 2014). There is thus a need for more research into the effects of sugar, and sugar containing products, on all aspects of human health.

The daily consumption of soft drinks, which are high in fructose, have been linked to higher blood pressure (BP) (Dhingra et al., 2007), raising the question as to whether daily fruit juice consumption is also linked to high BP. Randomized, controlled trials in the area have provided little information on the subject. A recent meta-analysis of randomized, controlled trials reported no effect of fruit juice supplementation on systolic BP, despite a small reduction in diastolic BP (Liu et al., 2013). However, the majority of the reviewed studies tended to be of very short duration (2 weeks to 3 months) and poor methodological quality. A previous observational study reported no association between fruit juice consumption and brachial BP in a Western population (Griep et al., 2013). However, to our knowledge, the association between fruit juice consumption and central (aortic) BP has not been investigated. This association is important to examine because higher central BP is associated with adverse health outcomes such as cardiovascular events and mortality (Vlachopoulos et al., 2010) as well as impaired brain function (Pase et al., 2013). Moreover, some dietary factors, such

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* Corresponding author.
E-mail address: matthewpase@gmail.com (M.P. Pase).

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as caffeine, cocoa and dark chocolate, have been associated with central BP without observable differences in brachial BP (Karatzis et al., 2005; Vlachopoulos et al., 2005, 2007).

The fish oil multivitamin (FMV) study is an Australian clinical trial that examined the health effects of dietary supplements in adults aged 50 to 70 years (N = 160). We used baseline data from this clinical trial to investigate whether fruit juice consumption was related to brachial BP and central BP, including indices of aortic stiffness and wave reflection. Information on fruit juice consumption was obtained from an in-house food frequency questionnaire asking about dietary patterns over the past 12 months. We hypothesized that those who consumed fruit juice on a daily basis would have higher BP (brachial and central) than those who consumed fruit juice occasionally or rarely.

Method

Participants

The sample comprised 160 community dwelling male and female volunteers aged 50 to 70 years. Participants were all recruited from the general population by way of newspaper and radio advertisements, flyer drops and word of mouth. All participants were independently living. Eligibility was dependent on not having a history of neurological or psychiatric illness (i.e. epilepsy, dementia, depression, schizophrenia, traumatic brain injury), cardiovascular disease (CVD; i.e. stroke, heart failure, coronary heart disease) or diabetes. Being a current smoker or having a history of alcohol or drug abuse were also grounds for exclusion. Full eligibility criteria has been detailed elsewhere (Pase et al., in press; Pipingas et al., 2014). Participants were screened for the exclusion criteria in a face-to-face interview by a research assistant.

Measures

Food frequency questionnaire

Information on dietary patterns was taken from an in-house food frequency questionnaire. Participants were required to recall and respond according to how often they consumed different foods and beverages over the previous 12 months. When making responses to the different items, participants were asked to think back over the last 12 months and to think carefully about all eating occasions; including their usual weekday and weekend eating patterns, foods and beverages consumed away from home and when on holiday as well as those foods prepared and consumed at home. Categories of food and beverages that were examined included dairy foods, breads and cereals, meat, fish and eggs, vegetables, fruit, baked goods and snacks, spreads and dressings, non-milk beverages and dietary supplements. In the non-milk beverage section, a single item asked participants to indicate how often they consumed fruit juice by responding never, less than once per month, 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, more than 3 times a day. This fruit juice item, and the range of possible responses, was consistent with another validated food frequency questionnaires (Hodge et al., 2000).

Responses for the fruit juice consumption item were then grouped into broader categories of:

(1) Rare use (combining scores from never use to no more than 3 times a month).
(2) Occasional use (combining scores from once per week to 5–6 times per week).
(3) Daily use (combining scores from once per day to more than 3 times a day).

Such categories were created to simplify the data and because they make theoretical sense. That is to say that it is easy to conceptualize the difference between consuming fruit juice daily versus no more than a few times a month.

Brachial BP

Brachial BP was measured using a standardized protocol and a validated automatic Omron, 705IT Sphygmomanometer (Omron Healthcare, Hoofddorp, The Netherlands) (Coleman et al., 2006; El Assaad, Topouchian, & Asmar, 2003). Participants were rested in a seated position for 5 minutes before having three sequential BP measurements taken from their left arm. The average of the three measurements was used in statistical analysis.

Central (aortic) BP

Central BP was measured because studies have shown that some dietary interventions can have measurable effects on central BP, without observable effects on brachial BP (Karatzis et al., 2005; Vlachopoulos et al., 2005, 2007). Central BPs also provide an indirect assessment of aortic stiffness (Laurent et al., 2006) and are useful predictors of CVD risk (Vlachopoulos et al., 2010). In the present study, central BP was measured using applanation tonometry of the radial artery (SphygmoCor device, AtCor Medical, Sydney, Australia) as follows: Immediately following the assessment of brachial BP, the participant remained seated. Brachial BP was then entered into the SphygmoCor software for calibration purposes. A small pressure sensitive pencil-like probe was then used to gently flatten (applanate) the radial artery, near the participant's wrist. After obtaining a good signal, the SphygmoCor system recorded and averaged the radial artery waveform over numerous heart beats. Central BP was then automatically estimated by the software through waveform analysis using a validated mathematical algorithm (Chen et al., 1997). Numerous indices were calculated including central systolic BP, central diastolic BP, central pulse pressure, pulse pressure amplification (PPA), augmentation pressure and augmentation index (AIx). These are described below.

As the heart beats, forward pressure waves travel from the aorta down to the arterial tree. Some of these pressure waves become reflected and travel back towards the heart. Aortic stiffness is directly proportional to the speed of these pressure waves (Nichols, O'Rourke, & Vlachopoulos, 2011). When aortic stiffness is low, the pressure waves travel slowly and arrive back at the heart during diastole. When aortic stiffness is high, the speed of wave propagation increases meaning that reflected pressure waves arrive back at the heart during the systolic part of the cardiac cycle. Such early returning pressure waves thus augment the central systolic BP and the central pulse pressure (central systolic – central diastolic BP) (Nichols et al., 2011). Augmentation pressure represents the amount the central systolic BP is augmented by reflected arterial pressure waves. AIx expresses the augmentation pressure as a percentage of the pulse pressure. It is thus a composite measure of wave reflection and aortic stiffness (Laurent et al., 2006). Higher AIx is associated with greater CVD risk (Vlachopoulos et al., 2010). Due to aortic stiffening, the systolic BP and pulse pressure increases more with age in the aorta than in the brachial artery (McEniery et al., 2005). PPA (brachial/aortic pulse pressure) captures the ratio between pulse pressure in the peripheral and central arteries. It is an indirect measure of aortic stiffness and arterial ageing and is a useful predictor of CVD risk (Benetos et al., 2010). As PPA diminishes with advancing age, due to the disproportion increase in central rather

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