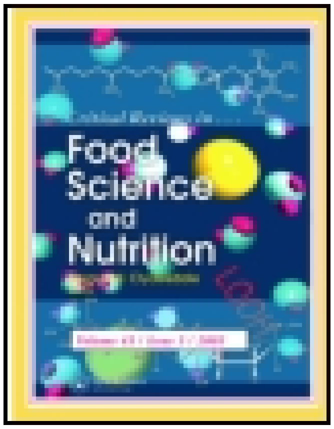

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Impact of 100% Fruit Juice Consumption on Diet and Weight Status of Children: An Evidence-based Review

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ABSTRACT

Consumption of 100% fruit juice (FJ) remains controversial for its potential adverse impact on weight and displacement of essential foods in the diets of children.

A systematic review of the literature published from 1995-2013 was conducted using the PubMed database to evaluate associations between intake of 100% FJ and weight/adiposity and nutrient intake/adequacy among children one to 18 years of age. Weight status outcome measures included body mass index (BMI), BMI z-score, ponderal index, obesity, weight gain, adiposity measures, and body composition. Nutrient outcome measures included intake and adequacy of shortfall nutrients. Data extraction and analysis was conducted according to the Academy of Nutrition and Dietetics Evidence Analysis Process. Twenty-two studies on weight status provided evidence that did not support an association between 100% FJ consumption and weight/adiposity in children after controlling for energy intake. Limited evidence from eight studies suggests that children consuming100% FJ have higher intake and adequacy of dietary fiber, vitamin C, magnesium, and potassium. Differences in methodology and study designs preclude causal determination of 100% FJ as sole influencer of weight status or nutrient intake/adequacy of shortfall nutrients. In context of a healthy dietary pattern, evidence suggests that consumption of 100% FJ may provide beneficial nutrients without contributing to pediatric obesity.

INTRODUCTION

The severity of the childhood obesity epidemic and its potential health consequences have led scientists and clinicians to look for immediate and simple solutions. A common approach to solve this complex problem is to identify and target single foods for elimination from the diet. With the exception of low-fat or fat-free white fluid milk, all beverages containing sugar in any form, whether naturally occurring or added, including 100% fruit juice (FJ), have been under attack by some scientists, clinicians, and the general public. One hundred percent FJ has been referred to as a nutrient-poor beverage that has contributed to the obesity epidemic in children and there are recommendations that it should be limited or omitted from the diets of children (Wojcicki and Heyman, 2012). However, results from studies examining consumption of 100% FJ and obesity have been contradictory, yet generally supported no association.

The Dietary Guidelines for Americans (2010) defined eight ounces of 100% FJ, but not other types of fruit beverages, including fruit drinks or juice cocktails, as an equivalent serving to whole fruit. With the exception of dietary fiber, 100% FJ retains many of the nutrients, phytochemicals, and antioxidants of its whole fruit counterpart (Ruxton et al., 2006; Crowe and Murray, 2013). According to a recently published systematic review, multiple plausible mechanisms exist to support a positive relationship between consumption of specific types of 100% FJ and human health or disease prevention (Hyson, 2015). Thus, 100% FJ is a nutrient-dense food with potential to benefit human health including maximizing growth and development in children (Rampersaud, 2007).

Additionally, when consumed in context of a total diet pattern guided by the Dietary Guidelines for Americans (2010), 100% FJ may help individuals and populations meet the Dietary Reference Intakes for nutrients, especially micronutrients (United States Department of Agriculture National Agricultural Library, 2015). The purposes of this review were to evaluate associations between consumption of 100% FJ and weight status or adiposity, as well as to assess nutrient intake and nutrient adequacy among children who consumed 100% FJ.

METHODS

Evidence Analysis Team and Process

The workgroup included six registered dietitians or registered dietitian-nutritionists with clinical or research experience. A thorough recruitment procedure was undertaken with requests for participation posted on the Academy of Nutrition and Dietetics' website and via email correspondence which targeted all Academy members, Academy Dietetic Practice Groups, and known experts in the field. The applicants were rubric-scored using a set of quantitative and qualitative criteria and potential for conflict of interest. All workgroup members signed a conflict of interest disclosure form as well as verbally declared any conflicts of interests prior to the start of each workgroup meeting. A trained and experienced project manager facilitated these meetings with the assistance of the lead analyst. A complete description of the Evidence Analysis Process is available at the Academy's Evidence Analysis Library (EAL) website (2014). Briefly, articles meeting the inclusion criteria were abstracted using the EAL data extraction tool and reviewed for accuracy by EAL analysts. A summary evidence table was constructed for each question along with narrative summaries of evidence.

Literature Search and Application of Inclusion/Exclusion Criteria

Full-length studies meeting the eligibility criteria included human studies that were published in English from 1995 to 2013 and reported outcomes related to weight or adiposity measures and dietary intake among healthy, free-living children one to 18 years of age consuming 100% FJ. To evaluate the published literature comprehensively, no preference was given to the type of study design. For a study to be included in this systematic review, the Food and Drug Administration's definition of 100% FJ was used: "juices directly expressed from a fruit or vegetable (i.e., not concentrated and reconstituted) shall be considered to be 100% juice and shall be declared as 100 percent juice" (United States Food and Drug Administration Code of Federal Regulations, 2013). For this review, the above definition was expanded to include juices from concentrate which were reconstituted to their original volume. Additional inclusion criteria were a minimum of 10 participants in the study and drop-out rate under 20% with at least one adiposity measure (body mass index [BMI], BMI percentile, rate of weight gain, BMI Z-score, body composition, body fat, waist-to-hip-ratio and waist circumference) or one nutrient of interest (dietary fiber, vitamins A, C, D, or E, calcium, iron, magnesium, or potassium, or) reported. Articles were excluded from consideration if it was not clear that 100% FJ was used in the study, if the participants were outside of the specified age range, or if the article appeared in non-peer-reviewed journals; only full-length articles were considered.

All studies identified in the PubMed search were assessed for relevance by the workgroup members and lead analysts. These articles were then reassessed for eligibility by analysts and lead analysts who worked on data extraction. This systematic process yielded a total of 22 studies that examined the relationship between weight status or adiposity and consumption of 100% FJ (Figure 1) and 10 studies that examined nutrient intake or adequacy and consumption of 100% FJ (Figure 2). The Academy's online Data Extraction Tool was used to extract and store data from the research articles. Trained analysts or methodology experts extracted the following data from each eligible research article: title, year and journal of publication, study design, intervention and control groups (if applicable), details of interventions (type of intervention, who delivered the intervention, duration of intervention, mode of intervention) (if applicable), confounding variables considered in the analysis, and outcomes of interest (i.e. weight/adiposity outcomes or measures or nutrients of interest). A second reviewer (Lead Analyst) verified the accuracy of data entered into the Data Extraction Tool.

Data Analysis

Data were collected from each article with the intention of carrying out meta-analyses on outcomes associated with consumption of 100% FJ and weight status or adiposity as well as nutrient intake and nutrient adequacy among children consuming 100% FJ. However, the following study characteristics prevented the calculation of a reliable pooled effect size of the relationship between 100% fruit juice intake and outcomes: fruit juices examined were inconsistent across studies, method by which intake was specified or measured was inconsistent (e.g., intake change versus intake at one point in time, method of intake assessment, intake level grouped according to different criteria), and outcome measures were reported in incommensurate ways. Thus, patterns of association between intake of 100% fruit juice and outcome measures was assessed qualitatively.

Of particular concern among research reviewed was adjustment for intake of other foods and macronutrients within the diet. With observational research, adjustment for potential or known confounding variables is critical for accurate parameter estimates. The lack of consistency in confounders controlled for (or, more critically, the lack of any adjustment in several studies) rendered the effort to compute a single meaningful pooled effect size impossible. Subgroup meta-analyses were used, however, to illustrate the importance of controlling for one critical confounder: energy intake. For weight status outcomes, a random effects meta-analysis of reported or computed (when data were available) weight status log transformed odds ratios was carried out to illustrate the importance of model adjustment. STATA 13.0 was used and methods for computing statistical measures followed those described in the Cochrane Handbook (2011).

Development of Conclusion Statements

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Evidence summary and conclusion statements on the impact of 100% FJ consumption on diet and weight status of children were drafted by the workgroup and lead analyst based on evidence analysis after completion of the data extraction process. The EAL Manual for Grading the Strength of the Evidence (2014) was used for grading the conclusion statements according to the following grades: I (good/strong), II (fair), III (limited/weak), IV (expert opinion only), or V (grade not assignable).

ASSOCIATION BETWEEN INTAKE OF 100% FRUIT JUICE AND WEIGHT STATUS OR ADIPOSITY

Research Reviewed

Among the 22 studies meeting the inclusion criteria, 12 were cross-sectional (Dennison et al., 1997; Dennison et al., 1999; Skinner et al., 1999; Nelson et al., 2006; O'Connor et al., 2006; LaRowe et al., 2007; Nicklas et al., 2008; O'Neil et al., 2010; Makkes et al., 2011; O'Neil et al., 2011a; Danyliw et al., 2012; Wang et al., 2012). Eight were prospective cohort studies (Alexy et al., 1999; Skinner et al., 2001; Field et al., 2003; Berkey et al., 2004; Newby et al., 2004; Streigel-Moore et al., 2006; Libuda et al., 2008; Fiorito et al., 2009). One retrospective cohort design was evaluated (Welsh et al., 2005) along with one time-series study (Taber et al., 2012).

Weight Status and Energy Adjustment

Ten studies reported information on 16 separate groups sufficient to compute odds ratios of being either overweight or obese comparing the highest fruit juice consumers to lowest consumer group (Dennison et al., 1997; Skinner et al., 1999; Welsh et al., 2005; Nelson et al., 2006; Nicklas et al., 2008; O'Neil et al., 2010; Makkes et al., 2011; O'Neil et al., 2011a; Wang et al., 2012; Danyliw et al., 2012). Definitions of highest and lowest consumption groups varied by study (Table 1). Where the definition of weight status group differed from current Center for Disease Control and Prevention definitions (2015), the BMI percentile cutoff is reported. The results of the meta-analysis of study groups sub-grouped by energy intake is presented in Figure 3.

Variations in intake measurement and definition of fruit juice group rendered the estimate of pooled effect untrustworthy, so the subgroup meta-analysis was used primarily to identify patterns among findings. However, a critical pattern is evident in Figure 3. Statistically significant differences between higher and lower fruit juice consumers in terms of weight status were reported *only* in studies that did not adjust for total energy intake. None of the 11 comparisons that adjusted for total energy intake reported a statistically significant difference between higher and lower fruit juice consumers in terms of weight status. This indicates that consumption of 100% fruit juice has no independent effect on weight status apart from energy intake. Notably, neither of the two earliest studies that were evaluated adjusted for total energy intake, yet both reported the highest odds ratios (Dennison et al., 1997; Skinner et al., 1999).

Body Mass Index and Ponderal Index

Body mass index (weight [kg]/height [m]^2), a predominant measure of overweight and obesity used in children, was reported in 18 studies (Dennison et al., 1997; Alexy et al., 1999; Dennison et al., 1999; Skinner et al., 1999; Skinner and Caruth, 2001; Berkey et al., 2004; Newby et al., 2004; Welsh et al., 2005; Nelson et al., 2006; O'Connor et al., 2006; Stiegel-Moore et al., 2006; LaRowe et al., 2007; Nicklas et al., 2008; O'Neil et al., 2010; Makkes et al., 2011; O'Neil et al., 2011a; Danyliw et al., 2012; Wang et al., 2012).

The majority (15/18, 83%) of studies found no significant association between 100% FJ intake and BMI. Only three studies reported a positive relationship with consumption of 100% FJ and BMI, BMI percentile, or the likelihood of being obese in children (Dennison et al., 1997; Dennison et al., 1999; Makkes et al., 2011). These studies had significant limitations. Only one of the three adjusted for total energy intake (Dennison et al., 1999); however, the effect size was minimal (e.g., every additional gram of 100% apple juice consumed per day was associated with a 3/1000ths of a point higher BMI). It is also important to note that each of these three studies were small regional studies (combined n < 360) with limited racial/ethnic and socioeconomic diversity among participants. Thus, the findings reported therein cannot be generalized to a larger, more diverse population. None of the large nationally representative studies reported any association between intake of 100% FJ and BMI (Newby et al., 2004; Welsh et al., 2005; O'Connor et al., 2006; Striegel-Moore et al., 2006; LaRowe et al., 2007; Nicklas et al., 2008; O'Neil et al., 2010; O'Neil et al., 2011a; Danyliw et al., 2012; Wang et al., 2012).

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Ponderal index (PI) (weight [kg]/height [m]^3) is another measure of overweight and obesity used in children. Four studies examined the association of 100% FJ consumption and weight status using PI, yet results were conflicting (Dennison et al., 1997; Dennison et al., 1999; Skinner et al., 1999; Skinner et al., 2001). For example, Dennison et al. (1997) reported that children two (n = 15) and five (n = 4) years who consumed at least 12 ounces of 100% FJ per day were more likely (P = 0.0001) to be ≥ 90th PI percentile than children of the same age who consumed less than 12 ounces of 100% FJ daily. However, in a similar study of slightly younger children ages two and three years old (n = 105), Skinner et al. (1999) reported no association between PI and consumption of 100% FJ. Neither study controlled for total energy intake. In a study that did control for total energy intake (minus energy from 100%FJ), Dennison et al. (1999) reported that PI was significantly (P < 0.002) related to consumption of 100% apple juice in a small sample of children (n = 104 apple juice consumers) two and five years; however, the effect size was very small (β = 0.0054) indicating that for every additional gram of 100% apple juice consumed per day on average, PI was associated with a 5/1000ths of a point higher. The authors found no association with PI and consumption of other types of 100% FJ. In contrast, a prospective cohort study of children between two and 3 years (n = 72) reported a small but statistically significant (P = 0.05, β = -0.065) inverse relationship between 100% FJ consumers and PI (P < 0.05) after adjusting for energy intake (Skinner et al., 2001). These results suggest that higher longitudinal intake of 100% FJ was associated with lower PI. Taken collectively, results of all four studies suggest the lack of a clear association between consumption of 100% FJ and PI in children.

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BMI z-scores

With children BMI varies with age and gender due to individual growth rates and changes in body composition during developmental stages; since BMI z-scores account for these factors, this measure is often used to assess weight status in children. Five studies examined the relationship between 100% FJ and BMI z-scores (Field et al., 2003; Libuda et al., 2008; Nicklas et al., 2008; O'Neil et al., 2010; Taber et al., 2012). Among these, two studies used data from the National Health and Nutrition Examination Survey (NHANES), a nationally representative population, and neither showed an association between consumption of 100% FJ and BMI z-scores (Nicklas et al., 2008; O'Neil et al., 2010). Three longitudinal studies examined changes in BMI z-scores over time (Field et al., 2003; Libuda et al., 2008; Taber et al., 2012). Field et al. (2003) reported on children nine to 14 years (n = 16,886; 68% female) using intake data from at least two food frequency questionnaires. Results of that study suggested a significant (P = 0.003) relationship between consumption of 100% FJ and subsequent changes in BMI z-score for females when the model was adjusted for total energy intake; however, the effect size was very small (β=0.003). There was no association between 100% FJ intake and changes in BMI z-score in males. In a smaller study of children (n = 244, nine to 18 years; 49% female) by Libuda et al. (2008), only females showed a significant increase (P = 0.013) in BMI z-scores with increased consumption of 100% FJ over a five year period (β = 0.096). According to Taber et al. (2012) in a time series design of the Youth Risk Behavior Study (n = 272,044; 49% female) that combined cross-sectional samples from the 2001, 2003, 2005, and 2007 surveys of children 14 to 18 years, consumption of 100% FJ was inversely associated with BMI z-score ($P < 0.05$) among females only. Self-reported height and weight and use of food frequency questionnaires were notable limitations of this study. Conflicting results in a small number of studies make it difficult to determine the overall relationship between consumption of 100% FJ and BMI z-scores.

Fat Mass

Five studies examined the relationship between consumption of 100% FJ in children and different measures of fat mass including waist circumference, triceps or subscapular skin folds, or percent body fat (Libuda et al., 2008; Nicklas et al., 2008; Fiorito et al., 2009; O'Neil et al., 2010; Wang et al., 2012). Among these, three cross-sectional studies used NHANES data to examine skin folds or waist circumference and found no association with consumption of 100% FJ (Nicklas et al., 2008; O'Neil et al., 2010; Wang et al., 2012). The two longitudinal studies showed that consumption of 100% FJ was not associated with changes in triceps and subscapular skinfolds, waist circumference, or percent body fat as determined by dual-energy X-ray absorptiometry (Libuda et al., 2008; Fiorito et al., 2009;) In summary, the evidence reviewed does not support an association between 100% FJ consumption and weight status or adiposity (e.g., BMI percentile, weight gain, BMI Z-score and fat mass) in children two to 18 years. In summary, the overall strength of the reviewed evidence regarding 100% FJ consumption and weight status or adiposity was scored as a Grade II (fair) as the currently available evidence lacks a clear association.

ASSOCIATION BETWEEN CONSUMPTION OF 100% FRUIT JUICE AND THE DIETARY INTAKE AND NUTRIENT ADEQUACY OF SELECT SHORTFALL NUTRIENTS

Research Reviewed

Selection of nutrients investigated in this review was based on identification of the following as shortfall nutrients by the Dietary Guidelines for Americans (2010): dietary fiber, vitamins A, C, and D; calcium; potassium, and magnesium. Additionally, the relationship between consumption of 100% FJ and nutrient intake/adequacy of vitamin E and iron were evaluated. To investigate the relationship between consumption of 100% FJ and nutrients, assessment of nutrient intake or nutrient adequacy were used. These two assessment measures of dietary intake differ in that the former does not compare intake to dietary recommendations. To determine nutrient adequacy, usual intake must be available. For population-based studies, nutrient adequacy is based on the percentage of individuals meeting the estimated average requirement (EAR) (United States Department of Agriculture National Agricultural Library, 2015). For those nutrients that do not have an established EAR (e.g. dietary fiber and potassium), nutrient adequacy is based on the percentage of individuals above the adequate intake levels (AI) for those nutrients.

Ten cross-sectional studies evaluating the association of 100% FJ consumption and nutrient intake or nutrient adequacy of the selected shortfall nutrients met the inclusion criteria (Dennison et al., 1998; Stroehla et al., 2005; Forshee et al., 2006; LaRowe et al., 2007; Nicklas et al., 2008; O'Neil et al., 2010; O'Neil et al., 2011a; O'Neil et al., 2011b; O'Neil et al., 2012; Fulgoni et al., 2012); however, only eight studies were used in data analysis. The other two studies were excluded from evidence analysis as they either looked at a comparison of averages among years (Fulgoni et al., 2012) or the contribution of food sources to micronutrient intake (as a percentage of each micronutrient and dietary fiber) and did not include specific data on dietary intake or nutrient adequacy of 100% FJ (Stroehla et al., 2005).

Vitamin A

Vitamin A intake was assessed in six cross-sectional studies (Dennison et al., 1998; LaRowe et al., 2007; Nicklas et al., 2008; O'Neil et al., 2010; O'Neil et al., 2011a; O'Neil et al. 2012). Three of these six studies also reported on adequacy of vitamin A intake (O'Neil et al., 2010; O'Neil et al., 2011a; O'Neil et al. 2012). LaRowe et al. (2007) reported that children in a 100% FJ cluster consumed 68 more ($P < 0.05$) µg retinol activity equivalents (RAE) of vitamin A compared with children in a mix-lite beverage (all beverages except milk, water, and 100% FJ) cluster. Similarly, in another study, 100% FJ consumers were also reported to consume 47.4 more ($P = 0.05$) RAE of vitamin A than non-consumers (O'Neil et al., 2012). The three studies that reported on nutrient adequacy demonstrated that consumption of 100% FJ was associated with greater ($P < 0.05$) adequacy of vitamin A intake when compared with non-consumers (O'Neil et al., 2010; O'Neil et al., 2011a; O'Neil et al. 2012). In these studies,

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consumers of 100% FJ were between 10% and 18% less likely to fall below the EAR for vitamin A than non-consumers. One limiting factor in interpreting these outcomes is that retinol or beta-carotene intake were not reported relative to 100% FJ consumption; however, the studies that used the RAE for vitamin A accounted for the different bioactivities of retinol and pro-vitamin A carotenoids. The overall strength of the available evidence was scored as Grade III (limited). Thus, there is limited evidence that children who consume 100% fruit juice may have higher intake and adequacy of vitamin A.

Vitamin C

Six studies met the inclusion criteria for evaluating vitamin C intake and consumption of 100%FJ (Dennison et al., 1998; LaRowe et al., 2007; Nicklas et al., 2008; O'Neil et al., 2010; O'Neil et al., 2011a; O'Neil et al. 2012). Two of these studies also reported on adequacy of vitamin C intake (O'Neil et al., 2011a; O'Neil et al., 2012). On the basis of intake, all six studies reported that consumption of 100% FJ was associated with higher ($P < 0.05$) vitamin C intake compared to non-consumers. More specifically, Nicklas et al. (2008) and O'Neil et al. (2010) compared different levels of 100% FJ consumption (0 to >12 fl. oz./d) with non-consumers and observed a significantly higher ($P < 0.05$) vitamin C intake with each level of 100% FJ consumption. In both of these studies, intake of vitamin C varied directly with the amount of juice consumed such that children consuming higher quantities of 100% FJ (> 12 fl. oz./d) had intake levels of 120-179 mg vitamin C higher than non-consumers. Children consuming between 6-12 fl. oz./d of

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100% FJ had intake levels that were 60-75 mg vitamin C higher than non-consumers. In the two studies that assessed vitamin C adequacy, consumers of 100% FJ were more ($P < 0.05$) likely to meet the EAR for vitamin C than non-consumers (O'Neil et al., 2011a; O'Neil et al., 2012). Although approximately 30-40% of non-consumers fell below the EAR for vitamin C, only < 0.1% of the 100% FJ consumers fell below the EAR for vitamin C. The overall strength of the available evidence was scored as Grade I (good). Evidence suggests that children who consume 100% FJ have higher levels of vitamin C intake and lower levels of vitamin C inadequacy.

Vitamin D

One hundred percent FJ can be fortified with vitamin D, yet no articles evaluating vitamin D intake or adequacy and a potential association with 100% FJ consumption were identified. The lack of research evaluating this association may be due, in part, to the fact that the special database for vitamin D only became available in 2005. A Grade V (not assignable) was scored indicating that no evidence was found.

Vitamin E

Three studies assessed the relationship between 100% FJ consumption and vitamin E intake (Nicklas et al., 2008; O'Neil et al., 2010; O'Neil et al., 2012). Additionally, one of these also reported on adequacy of vitamin E intake (O'Neil et al., 2012). None of the studies reported a significant association between 100% FJ consumption and vitamin E intake or adequacy. However, it must be acknowledged that 100% FJ is not a good source of vitamin E. The overall strength of the available evidence was scored as Grade II (fair). In conclusion, consumption of 100% FJ is not associated with intake or adequacy of vitamin E in children.

Calcium

Five studies were identified that assessed calcium intake and its relationship with 100% fruit juice consumption (Dennison et al., 1998; Forshee et al., 2006; LaRowe et al., 2007; Nicklas et al., 2008; O'Neil et al., 2010). Forshee et al. (2006) observed that in males and females 6-11 years calcium intake was higher ($P < 0.05$) in those consuming 100% FJ; however, among children 12-19 years, calcium intake was only higher ($P = 0.05$) among males consuming 100% FJ. LaRowe et al. (2007) reported that consumers of 100% FJ had a higher ($P < 0.05$) intake of calcium by 125mg compared with subjects who consumed a mix-lite beverage. Others have observed no effect on calcium intake between consumers of 100% FJ compared with non-consumers (Nicklas et al., 2008; O'Neil et al., 2010; Dennison et al., 1998). The overall strength of the available evidence was scored as Grade III (limited). Based on the limited and somewhat conflicting evidence, consumption of 100% FJ may not be associated with higher intake of calcium.

Iron

Three studies were identified which reported iron intake while no studies were identified which reported the adequacy of iron intake (LaRowe et al., 2007; Nicklas et al., 2008; O'Neil et al., 2010). All three studies observed higher ($P < 0.05$) iron intake (mg) with

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higher levels of 100% FJ consumption. LaRowe et al. (2007) observed that consumers of 100% FJ had higher ($P < 0.05$) iron intakes than children who consumed a mix-lite beverage or milk. Two studies using NHANES data showed that significantly higher iron intake ($P < 0.05$) only occurred with consumption of 100% FJ in amounts greater than 6 fl. oz./d (Nicklas et al., 2008; O'Neil et al., 2010). These results suggest that there was an association between consumption of 100% FJ and iron intake. The overall strength of the available evidence was scored as Grade III (limited). Children who consume 100% FJ may have marginally higher levels of iron intake compared to children not consuming 100% FJ. However, since 100% FJ is not a good source of dietary iron, the association reported may be related to an overall healthy diet.

Magnesium

Two studies reported on the association between magnesium intake and 100% FJ consumption (Nicklas et al., 2008; O'Neil et al., 2010) and two studies reported on adequacy of magnesium intake associated with consumption of 100%FJ (O'Neil et al., 2011a; O'Neil et al., 2012). All four studies reported that consumers of 100% FJ had higher ($P < 0.05$) magnesium intake than non-consumers. Children who consumed more than 12 fl. oz./d had an average intake of magnesium between 28.5-50 mg higher ($P < 0.05$) than non-consumers while children who consumed between 6-12 fl. oz./d of 100% fruit juice had an average intake of 18-28 mg more ($P < 0.05$) magnesium than non-consumers (Nicklas et al., 2008; O'Neil et al., 2010). With regard to adequacy of magnesium intake, O'Neil et al. (2011a) and O'Neil et al. (2012) reported that 100% FJ consumers were 13-20% more ($P < 0.05$) likely to meet the EAR for magnesium intake than non-consumers. The overall strength of the available evidence was scored as Grade III (limited). Children who consumed 100% FJ may have higher magnesium intake and adequacy of this nutrient.

Potassium

Five studies met the inclusion criteria for assessing the relationship between potassium intake or adequacy and 100% FJ consumption (Dennison et al., 1998; Nicklas et al., 2008; O'Neil et al., 2010; O'Neil et al., 2011a; O'Neil et al., 2012). Potassium intake was reported in all studies while only one of the studies reported on adequacy of potassium intake (O'Neil et al., 2012). All five studies reported that consumers of 100% FJ had significantly higher ($P < 0.05$) potassium intake than non-consumers. Children who consumed more than 12 fl. oz./d had an average intake of 770-1,056 mg potassium higher ($P < 0.05$) than non-consumers while children who consumed between 6-12 fl. oz./day of 100% fruit juice consumed 405-468 mg more ($P < 0.05$) potassium than non-consumers (Nicklas et al., 2008; O'Neil et al., 2010). With regard to adequacy of intake, consumption of 100% FJ was associated with greater ($P = 0.05$) adequacy of potassium intake (1.9% higher in consumers) (O'Neil et al., 2012). The overall strength of the available evidence was scored as Grade II (fair). Children who consumed 100% FJ had higher levels of potassium intake and adequacy. This was not surprising since many of the frequently consumed juices are rich sources of potassium.

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Dietary Fiber

Five studies identified reported on an association between intake of dietary fiber and consumption of 100% FJ (LaRowe et al., 2007; O'Neil et al., 2010; O'Neil et al., 2011a; O'Neil et al., 2011b; O'Neil et al., 2012). One of the studies also reported on the adequacy of dietary fiber intake (O'Neil et al., 2012). Three of the five studies reported that consumers of 100% FJ had higher ($P < 0.05$) dietary fiber intake than non-consumers (O'Neil et al., 2010; O'Neil et al., 2011a; O'Neil et al., 2011b). Additionally, O'Neil et al. (2010) reported that children who drank at least 6 fl. oz./d of 100% fruit juice had 1-2 g higher intake of dietary fiber than children who did not consume 100% FJ. In terms of adequacy of dietary fiber intake and 100% FJ consumption, no association was shown (O'Neil et al., 2012). The overall strength of the available evidence was scored as Grade III (limited). It should be acknowledged that 100% FJ is not a good source of dietary fiber. Nevertheless, children who consume 100% FJ may have higher levels of dietary fiber intake, in part since consumption of 100% FJ has been associated with greater intake of whole fruit.

ASSUMPTIONS AND LIMITATIONS

Since study designs and methodologies for evaluating 100% FJ intake and outcomes varied greatly, several assumptions and limitations were associated with this review, and hence with the conclusions that were drawn. First, different dietary assessment and clinical measures methodology were used in these studies. In turn, each method used had inherent limitations. For example, one limitation of dietary records and recalls is the ability of responders to report accurately intake and estimate portion sizes. This is especially true for the proxies that report intake of young children; the proxies (usually parents) may know what their child ate at home, but may not know what the child ate outside the home. With 100% FJ, another limitation is the possibility that self-reported data may include juice drinks or juice cocktails that are not by definition “100% FJ." Additionally, among the studies evaluated, varying amounts of juice were consumed with results analyzed collectively. Therefore, evidence summaries are based on the relationship between a range of 100% FJ intake levels and specific outcomes. Lastly, evidence from cross-sectional studies does not allow for causal determination of individual outcomes being solely attributed to consumption of 100% FJ.

CLINICAL APPLICATIONS AND CONCLUSIONS

Overall, the evidence did not support an association between 100% FJ consumption and weight status or adiposity in children after controlling for total energy intake and other covariates. Although a significant association was not observed, it should be emphasized that practitioners need to assess weight status and dietary intake on a case-by-case basis to monitor these associations at an individual level given the fact that over-consumption of any food may lead to weight gain. It can also be concluded that consumption of 100% FJ has a varied impact on the intake and adequacy of shortfall nutrients. On the basis of the data, consumption of 100% FJ potentially contributed to the intake and adequacy of dietary fiber, vitamin C, magnesium, and potassium among children. Differences in methodology and study design were present among the studies reviewed, thus causal determination and identification of 100% FJ as the sole impact factor influencing weight status or the intake and adequacy of shortfall nutrients among children may not be concluded.

In summary, consumption of 100% FJ within the context of an overall healthy dietary pattern may play a role in preventing nutrient deficiency without contributing to excess weight gain. Nevertheless, 100% FJ should not replace all whole fruit in the diet and these findings do not negate the effects of whole fruit consumption in promoting the same outcomes.

CONFLICT OF INTEREST

The following authors reported potential conflicts of interest pertaining to this review:

- Carol O'Neil participates in a working group that has received current and past funding from Juice Products Association.
- Paula Ziegler based on employment at the Academy of Nutrition and Dietetics
- Taylor Wolfram based on employment at the Academy of Nutrition and Dietetics

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REFERENCES

Academy of Nutrition and Dietetics. Evidence Analysis Library. (2014). http://www.andeal.org. Accessed February 27, 2015.

Academy of Nutrition and Dietetics. Evidence Analysis Library Manual. (2014). http://www.andeal.org/evidence-analysis-manual Accessed February 27, 2015.

Academy of Nutrition and Dietetics. Evidence Analysis Library Manual – Grading the Strength of the Evidence. (2014). http://www.andeal.org/topic.cfm?cat=4516&highlight=grade%20definitions&home=1 Accessed January 1, 2014.

Alexy, U., Sichert-Hellert, W., Kersting, M., Manz, F., Schöch, G. (1999). Fruit juice consumption and the prevalence of obesity and short stature in german preschool children: results of the DONALD Study. Dortmund Nutritional and Anthropometrical Longitudinally Designed. *J Pediatr Gastroenterol Nutr*. **29**(3):343-349.

Berkey, C.S., Rockett, H.R., Gillman, M.W., Colditz, G.A. (2004). Sugar-added beverages and adolescent weight change. *Obes Res*. **12**(5):778-788.

Center for Disease Control and Protection. (2015). About BMI for children and teens. http://www.cdc.gov/healthyweight/assessing/bmi/childrens_bmi/about_childrens_bmi.html Updated April 17, 2015. Accessed May 2, 2014.

Cochrane Handbook for Systematic Reviews of Interventions. The Cochrane Collaboration. www.handbook.cochrane.org Updated March 1, 2011. Accessed February 1, 2014.

Crowe, K.M., and Murray, E. (2013). Deconstructing a fruit serving: comparing the antioxidant density of whole fruit versus 100% fruit juice. *J Acad Nutr Diet*. 2013;113(10):1354-1358.

Danyliw, A.D., Vatanparast, H., Nikpartow, N., Whiting, S.J. (2012). Beverage patterns among Canadian children and relationship to overweight and obesity. *Appl Physiol Nutr Metab*. **37**(5): 900-906.

Dennison, B.A., Rockwell, H.L., Baker, S.L. (1997). Excess fruit juice consumption by preschool-aged children is associated with short stature and obesity. *Pediatrics*. **99**(1):15-22.

Dennison, B.A., Rockwell, H.L., Baker, S.L. (1998). Fruit and vegetable intake in young children. *J Am Coll Nutr*. **17**(4):371-378.

Dennison, B.A., Rockwell, H.L., Nichols, M.J., Jenkins, P. (1999). Children's growth parameters vary by type of fruit juice consumed. *J Am Coll Nutr*. **18**(4): 346-352.

Field, A.E., Gillman, M.W., Rosner, B., Rockett, H.R., Colditz, G.A. (2003). Association between fruit and vegetable intake and change in body mass index among a large sample of children and adolescents in the United States. *Int J Obes Relat Metab Disord*. **27**(7):821-826.

Fiorito, L.M., Marini, M., Francis, L.A., Smiciklas-Wright, H., Birch, L.L. (2009). Beverage intake of girls at age 5 y predicts adiposity and weight status in childhood and adolescence. *Am J Clin Nutr*. **90**(4):935-942.

Forshee, R.A., Anderson, P.A., Storey, M.L. (2006). Changes in calcium intake and association with beverage consumption and demographics: comparing data from CSFII 1994-1996, 1998 and NHANES 1999-2002. *J Am Coll Nutr*. **25**(2):108-116.

Fulgoni III, V.L., and Quann, E.E. (2012). National trends in beverage consumption in children from birth to 5 years: analysis of NHANES across three decades. *Nutr J*. **11**:92-103.

Hyson, D. (2015). A review and critical analysis of the scientific literature related to 100% fruit juice and human health. *Adv Nutr*. **6**:37-51.

LaRowe, T.L., Moeller, S.M., Adams, A.K. (2007). Beverage patterns, diet quality, and body mass index of US preschool and school-aged children. *J Am Diet Assoc*. **107**(7): 1124-1133.

Libuda, L., Alexy, U., Sichert-Hellert, W., Stehle, P., Karaolis-Danckert, N., Buyken, A.E., Kersting, M. (2008). Pattern of beverage consumption and long-term association with body-weight status in German adolescents - results from the DONALD study. *Br J Nutri*. **99**(6):1370-1379.

Makkes, S., Montenegro-Bethancourt, G., Groeneveld, I.F., Doak, C.M., Solomons, N.W. (2011). Beverage consumption and anthropometric outcomes among schoolchildren in Guatemala. *Matern Child Nutr*. **7**(4): 410-420

Nelson, J.A., Carpenter, K., Chiasson, M.A. (2006). Diet, activity, and overweight among preschool-age children enrolled in the Special Supplemental Nutrition Program for Women, Infants, and Children (WIC). *Prev Chronic Dis*. **3**(2):49-61.

Newby, P.K., Peterson, K.E., Berkey, C.S., Leppert, J., Willett, W.C., Colditz, G.A. (2004). Beverage consumption is not associated with changes in weight and body mass index among low-income preschool children in North Dakota. *J Am Diet Assoc*. **104**(7):1086-1094.

Nicklas, T.A., O'Neil, C.E., Kleinman, R. (2008). Association between 100% juice consumption and nutrient intake and weight of children aged 2 to 11 years. *Arch Pediatr Adolesc Med*. **162**(6):557-565.

O'Connor, T.M., Yang, S.J., Nicklas, T.A. (2006). Beverage intake among preschool children and its effect on weight status. *Pediatrics*. **118**(4):e1010-e1018.

O'Neil, C.E., Nicklas, T.A., Kleinman, R. (2010). Relationship between 100% juice consumption and nutrient intake and weight of adolescents. *Am J Health Promot*. **24**(4):231-237.

O'Neil, C.E., Nicklas, T.A., Rampersaud, G.C., Fulgoni III, V.L. (2011a). One hundred percent orange juice consumption is associated with better diet quality, improved nutrient adequacy, and no increased risk for overweight/obesity in children. *Nutr Res*. **31**(9):673-682.

O'Neil, C.E., Nicklas, T.A., Zanovec, M., Fulgoni III, V.L. (2011b). Diet quality is positively associated with 100% fruit juice consumption in children and adults in the United States: NHANES 2003-2006. *Nutr J*. **10**:17-27.

O'Neil, C.E., Nicklas, T.A., Zanovec, M., Kleinman, R.E., Fulgoni III, V.L. (2012). Fruit juice consumption is associated with improved nutrient adequacy in children and adolescents: the National Health and Nutrition Examination Survey (NHANES) 2003-2006. *Public Health Nutr*. **15**(10):1871-1878.

Rampersaud, G.C. (2007). A comparison of nutrient density scores for 100% fruit juices. *J Food Sci*. **72**:S261-S266.

Ruxton CH, Gardner E, Walker D. Can pure fruit and vegetable juices protect against cancer and cardiovascular disease too? A review of the evidence. *Int J Food Sci Nutr*. **57**:249-272.

Skinner, J.D., Carruth, B.R., Moran III, J., Houck, K., Coletta, F. (1999). Fruit juice intake is not related to children's growth. *Pediatrics*. **103**(1):58-64.

Skinner, J.D., and Carruth, B.R. (2001). A longitudinal study of children's juice intake and growth: the juice controversy revisited. *J Am Diet Assoc*. **101**(4):432-437.

Striegel-Moore, R.H., Thompson, D., Affenito, S.G., Franko, D.L., Obarzanek, E., Barton, B.A., Schreiber, G.B., Daniels, S.R., Schmidt, M., Crawford, P.B. (2006). Correlates of beverage intake in adolescent girls: the National Heart, Lung, and Blood Institute Growth and Health Study. *J Pediatr*. **148**(2):183-187.

Stroehla, B.C., Malcoe, L.H., Velie, E.M. (2005). Dietary sources of nutrients among rural Native American and wh5ite children. *J Am Diet Assoc*. **105**(12):1908-1916.

Taber, D.R., Stevens, J., Poole, C., Maciejewski, M.L., Evenson, K.R., Ward, D.S. (2012). State disparities in time trends of adolescent body mass index percentile and weight-related behaviors in the United States. *Community Health*. **37**(1):242-252.

United States Department of Agriculture and United States Department of Health and Human Services. Dietary Guidelines for Americans, 2010. 7th ed. http://www.health.gov/dietaryguidelines/dga2010/DietaryGuidelines2010.pdf. Accessed February 27, 2015.

United States Department of Agriculture National Agricultural Library. Interactive DRI Glossary. 2015. http://fnic.nal.usda.gov/interactive-dri-glossary. Updated February 25, 2015. Accessed February 25, 2015.

United States Food and Drug Administration Code of Federal Regulations. Title 21. Department of Health and Human Services website. http://www.accessdata.fda.gov/scripts/cdrh/cfdocs/cfcfr/CFRSearch.cfm?fr=101.30 Published April 1, 2013. Updated June 1, 2013. Accessed February 21, 2014.

Wang, Y., Lloyd, B., Yang, M., Davisa, C.G., Leea, S., Leea, W., Chunga, S., Chuna1, O.K. (2012). Impact of orange juice consumption on macronutrient and energy intakes and body composition in the US population. *Public Health Nutr*. **15**(12):2220-2227.

Welsh, J.A., Cogswell, M.E., Rogers, S., Rockett, H., Mei, Z., Grummer-Strawn, L.M. (2005). Overweight among low-income preschool children associated with the consumption of sweet drinks: Missouri, 1999-2002. *Pediatr.* **115**(2):e223-e229.

Wojcicki, J.M., and Heyman, M.B. (2012). Reducing childhood obesity by eliminating 100% fruit juice. *Am J Public Health.* **102**(9):1630-1633.

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Table 1 Studies on weight status or adiposity and 100% fruit juice consumption among children

Study Population	Study Design	Type of 100% Fruit Juice	Measure of Consumption	Outcomes	References
German *n*=205 (49% F) 3-5 years Race: NR	Prospective cohort	Not specified	• 3-d weighed food record • Oz./d categorized as less than 12 oz./d or ≥ 12 oz./d	BMI = NS	Alexy et al. (1999)
USA *n*=10,769 (57% F) 9 – 14 years Race: White, Black, Hispanic, Asian	Prospective cohort	Orange, apple, 'other'	• Semi-quantitative FFQ • Serving size: Can, glass, bottle or cup tailored to the particular beverage	BMI = NS	Berkey et al. (2004)
USA *n*=16,886 (68% F) 9 - 14 years Race: NR	Prospective cohort	Not specified	• FFQ with serving sizes based on USDA National Nutrient Database for ages 9 - 18 years	<u>BMI z-score</u> Females = *P* = 0.003 Males = NS	Field et al. (2003)
USA *n*=170 (100% F) 5 - 15 years Race: White;	Prospective cohort	Not specified	• (3) 24-hr dietary recalls • Servings/d based on 8-oz. serving size	Fat mass = NS	Fiorito et al. (2009)

Non-Hispanic					
German *n*=244 (49% F) 9 - 18 years Race: NR	Prospective cohort	Not specified	• 3-day weighed diet record • g/d	BMI Z-score Girls = *P* < 0.05 Boys = NS Fat Mass = NS	Libuda et al. (2008)
USA *n*=2,371 (100% F) 9 - 19 years Race: White, Black	Prospective cohort	Not specified	• (1) 3-day Diet Record* • g/d	BMI = NS	Striegel-Moore et al. (2006)
USA *n*=1,345 (50% F) 2 - 5 years Race: White, Black, Hispanic, Asian, Other	Prospective cohort cross-sectional	Not specified	• FFQ with 84 foods and beverages • Oz./d	BMI = NS	Newby et al. (2004)
Canadian *n*=10,038 (% F NR) 2 - 18 years Race: NR	Cross-sectional	Not specified	• (1) 24-hr dietary recall • g/d	BMI = NS	Danylіw et al. (2012)
USA *n*=168 (% F NR) 2 years (n=94) 5 years (n=74) Race: White (97%)	Cross-sectional	Not specified	• 7-d diet record • Oz./d categorized as less than 12 oz./d or ≥ 12 oz./d	BMI ≥ 75th percentile = NS BMI ≥ 90th percentile = *P* <0.05 PI (2 years, 5 years) = *P* < 0.05	Dennison et al. (1997)
USA *n*=163 (48% F) 2 years (n=111)	Cross-sectional	Apple, orange, grape, 'other'	• (7) 24-hr dietary recalls • (1) 7-d diet record • Oz./d	BMI = *P* < 0.05 for 100% apple juice PI = *P* < 0.05	Dennison et al. (1999)

5 years (n=107) Race: White					
USA *n*=1,334 (45% F) 2 - 5 years (n=541) 6-10 years (n=793) Race: White, Black, Mexican-American, Other	Cross-sectional	Not specified	• (1) 24-hr dietary recall • g/d	BMI = NS	LaRowe et al. (2007)
Guatemalan *n*=356 (% F NR) 8 - 10 years Race: Mestizos (mixed ethnicities)	Cross-sectional	Not specified	• One day intake using a pictorial workbook and dietitian-assisted recall • g/d	BMI = $P < 0.05$	Makkes et al. (2011)
USA *n*=526 (45% F) 2 - 4 years Race: White, Black, Hispanic, Asian, Other	Cross-sectional	Not specified	• Parents were asked questions about diet • Servings/d or week with serving sizes not specified	BMI = NS	Nelson et al. (2006)
USA *n*=3,618 (% F NR) 2 - 11 years Race: White, Black Mexican-American, Asian	Cross-sectional	Not specified	• (1) 24-hr dietary recall • Oz./d categorized as 0 oz./d, $\leq$ 6 oz./d, 6-12 oz./d, or $\geq$ 12 oz./d	BMI = NS BMI Z-score = NS Fat Mass = NS	Nicklas et al. (2008)
USA	Cross-sectional	Not	• (1) 24-hr	BMI = NS	O'Connor et

n=1,160 (50% F) 2 - 5 years Race: White, Black, Mexican-American, Asian		specified	dietary recall • Oz./d		al. (2006)
USA *n*=3,939 12 - 18 years Race: White, Black, Hispanic, Other	Cross-sectional	Not specified	• (1) 24-hr dietary recall • Oz./d categorized as 0 oz./d, ≤ 6 oz./d, 6-12 oz./d, or ≥ 12 oz./d	BMI = NS BMI Z-score = NS	O'Neil et al. (2010)
USA *n*=7,250 (% F NR) 2 - 18 years Race: White, Black, Hispanic, Asian	Cross-sectional	Orange	• (2) 24-hr dietary recalls • Oz./d categorized as: 0 oz./d, > 0 oz./d	BMI = NS Fat Mass = NS	O'Neil et al. (2011a)
USA *n*=72 (49% F) 2 - 6 years Race: White	Cross-sectional	Not specified	• In-home interviews including (2) 24-hr dietary recalls and (2) diet records • Oz./d	BMI = NS PI = $P < 0.05$	Skinner et al. (2001)
USA *n*=105 (48% F) 2 - 3 years Race: White	Cross-sectional	Not specified	• In-home interviews including (2) 24-hr dietary recalls and (2) diet records with one weekend day	BMI = NS PI = NS	Skinner et al. (1999)

			• Oz/d categorized as < 12 oz/d or >12 oz/d		
USA *n*=13,971 (50% F) 4 - 18 years Race: White, Black, Mexican-American, Asian	Cross-sectional	Orange	• (2) 24-hr dietary recalls • Oz./d categorized as 0 oz./d, < 4.1 oz/d, 4.1 to 7.5 oz./d, or > 7.5 oz./d	BMI = NS Fat Mass = NS	Wang et al. (2012)
USA *n*=272,044 (49% F) 14 - 18 years Race: White, Black, Hispanic, Other	Time series design	Not specified	• Youth Risk Behavior Survey using servings/d with serving size not specified	BMI Z-score Females = $P < 0.05$ Males = NS	Taber et al. (2012)
USA *n*=10,904 2 - 3 years Race: White, Black, Other	Retrospective cohort	Orange, not specified	• FFQ with serving size defined by parent	BMI = NS	Welsh et al. (2005)

F, female; NR, not reported; NS, not significant ($P > 0.05$); g/d, grams/day

[*]Although eight three-day diet records were collected over the course of 10 years, the regression models were built on one visit where a three-day diet record was collected.

Table 2 Studies on dietary nutrient intake and adequacy of shortfall nutrients and 100% fruit juice consumption among children

Study Population	Study Design	Type of 100% Fruit Juice	Measurement of Consumption	Intake	Adequacy	Reference
USA *n*=168 (47%F) 2 years (n=94) 5 years (n=74) Race: NR	Cross-sectional	Apple, orange, mixed fruit juice, grape, pear, pear-apple	servings/d	*P* = 0.01 • Vitamin C NS • Calcium • Potassium • Vitamin A	NA	Dennison et al. (1998)
USA 6-11 years male (n=1,073) 6-11 years female (n=1,051) 12-19 years male (n=2,251) 12-19 years female (n=2,263) Race: NR	Cross-sectional	Not specified	g	*P*=0.01 • 6-11y males, calcium *P*=0.05 • 6-11y females, calcium • 12-19 y males, calcium NS • 12-19 y females, calcium	NA	Forshee et al. (2006)

NHANES 1999-2002; CSFII 1994-96/1998						
USA *n*=1,334 (45% F) 2 - 5 years Race: White, Black, Mexican-American, Other NHANES 2001-2002 n=1992 FJ cluster=73	Cross-sectional	Not specified	(1) 24-hr dietary recall g/d	*P*<0.0001 • Vitamin C • Vitamin A *P*<0.05 • Calcium • Iron NS • Fiber	NA	LaRowe et al. (2007)
USA *n*=3,618 (% F NR) 2 - 11 years Race: White, Black Mexican-American, Asian NHANES 1999 - 2002	Cross-sectional	Not specified	(1) 24-hr dietary recall Oz./d categorized as 0 oz./d, ≤ 6 oz./d, 6-12 oz./d, or ≥ 12 oz./d	*P*<0.001 • Potassium • Vitamin C • Magnesium (for intakes > 6 oz./d) • Iron (for intakes > 6 oz./d) NS • Calcium • Phosphorus • Vitamin A • Vitamin E	NA	Nicklas et al. (2008)
USA	Cross-	Not	(1) 24-hr	*P*<0.05	NS	O'Neil

n=3,939 12 - 18 years Race: White, Black, Hispanic, Other NHANES 1999-2002	section al	specifi ed	dietary recall Oz./d categorized as 0 oz./d, ≤ 6 oz./d, 6-12 oz./d, or ≥ 12 oz./d	• Fiber • Magnesium • Potassium • Vitamin C NS • Calcium • Phosphorus • Vitamin A • Vitamin E	• Vitamin A	et al. (2010)
USA *n*=7,250 (% F NR) 2 - 18 years Race: White, Black, Hispanic, Asian NHANES 2003-2006	Cross-section al	Orange	(2) 24-hr dietary recalls Oz./d categorized as 0 oz./d or > 0 oz./d	$P<0.05$ • Dietary fiber • Magnesium • Potassium • Vitamin C NS • Vitamin A	$P<0.05$ • Vitamin A • Vitamin C	O'Neil et al. (2011a)
USA %F NR 2-5 years (n=1665) 6-12 years (n=2446) 13-18 years (n=3139) Race: NR NHANES 2003 - 2006	Cross-section al	Not specifi ed	Oz./d (2) 24-hr dietary recalls	Dietary Fiber • 2-5 y $P=0.06$ • 6-12 y $P<0.0001$ • 13-18 y $P<0.0001$	NA	O'Neil et al. (2011b)

USA *n*=7250 (49 %F) 2 - 18 years Race: NR NHANES 2003 - 2006	Cross-sectional	Not specified	Oz./d categorized as 0 oz./d, ≤ 6 oz/d, 6-12 oz./d, or ≥ 12 oz./d	*P*<0.05 • Vitamin A • Vitamin C • Phosphorus • Magnesium • Potassium NS • Dietary fiber • Vitamin E	*P*<0.05 • Vitamin A • Vitamin C • Phosphorus • Magnesium	O'Neil et al. (2012)

F, female; NA, not accessed; NS, not significant; NR, not reported; g, grams

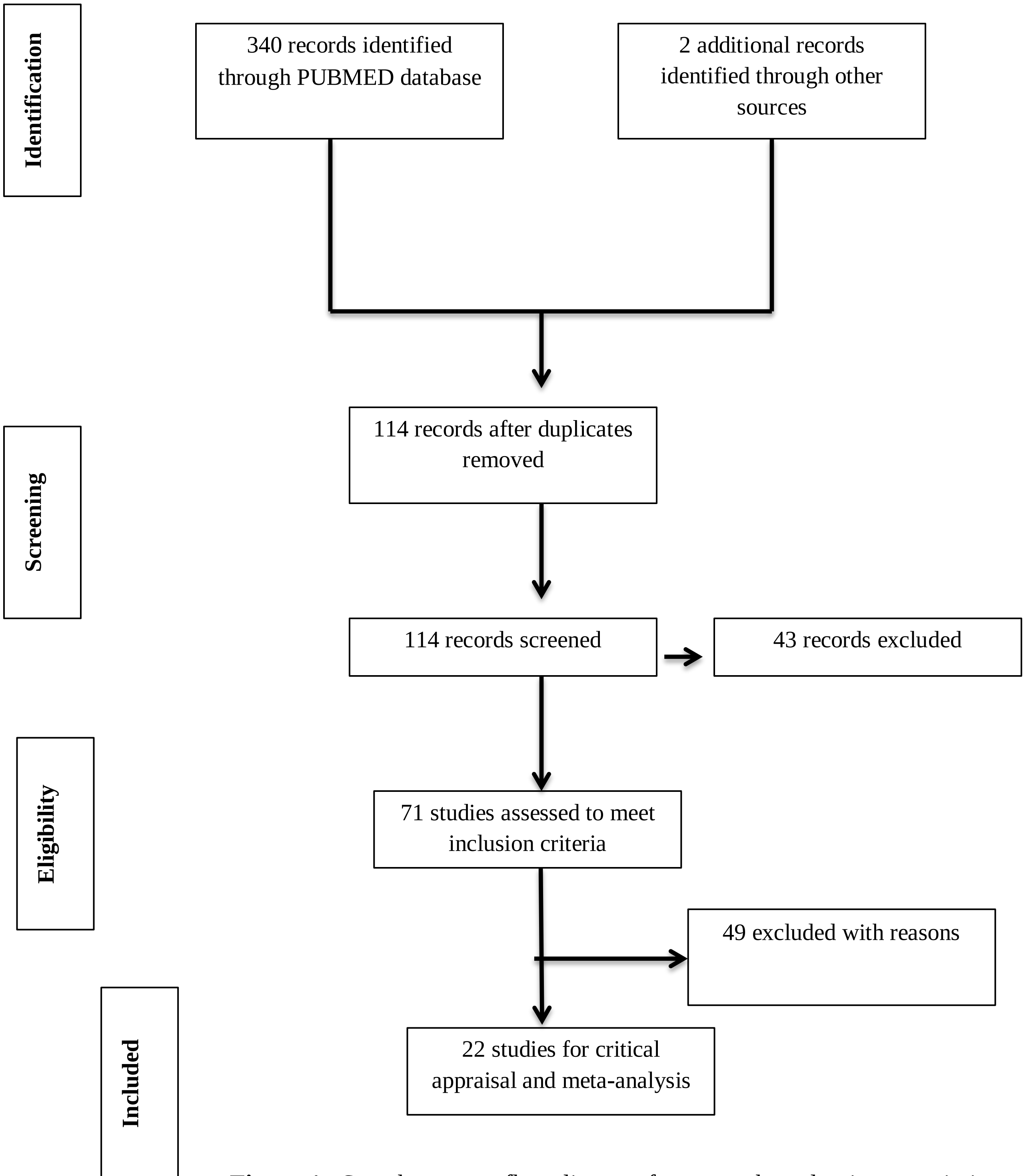

Figure 1 Search strategy flow diagram for research evaluating associations between 100% fruit juice intake and weight status or adiposity among children

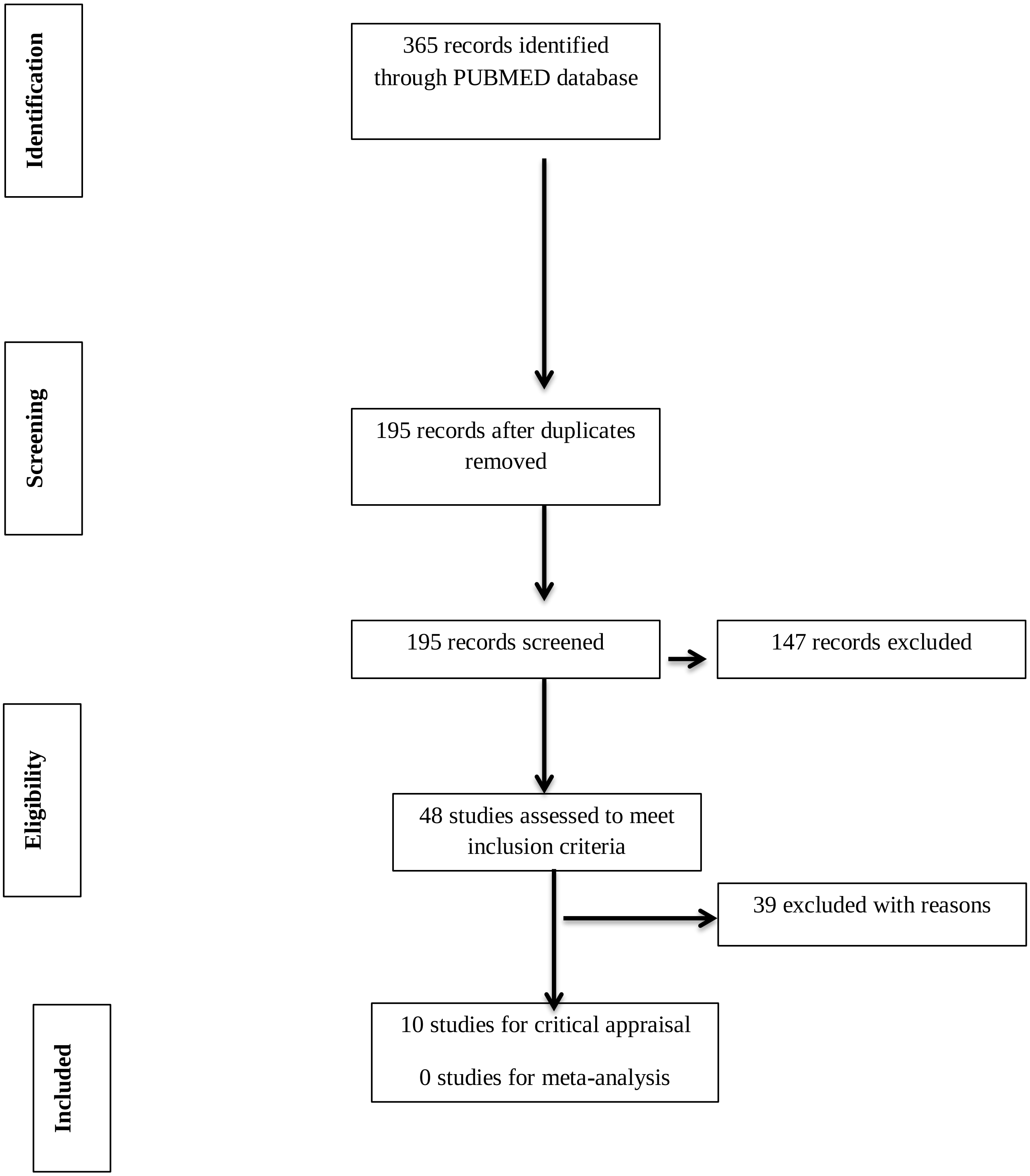

Figure 2 Search strategy flow diagram for research evaluating associations between onsumption of 100% fruit juice and nutrient intake and adequacy among children

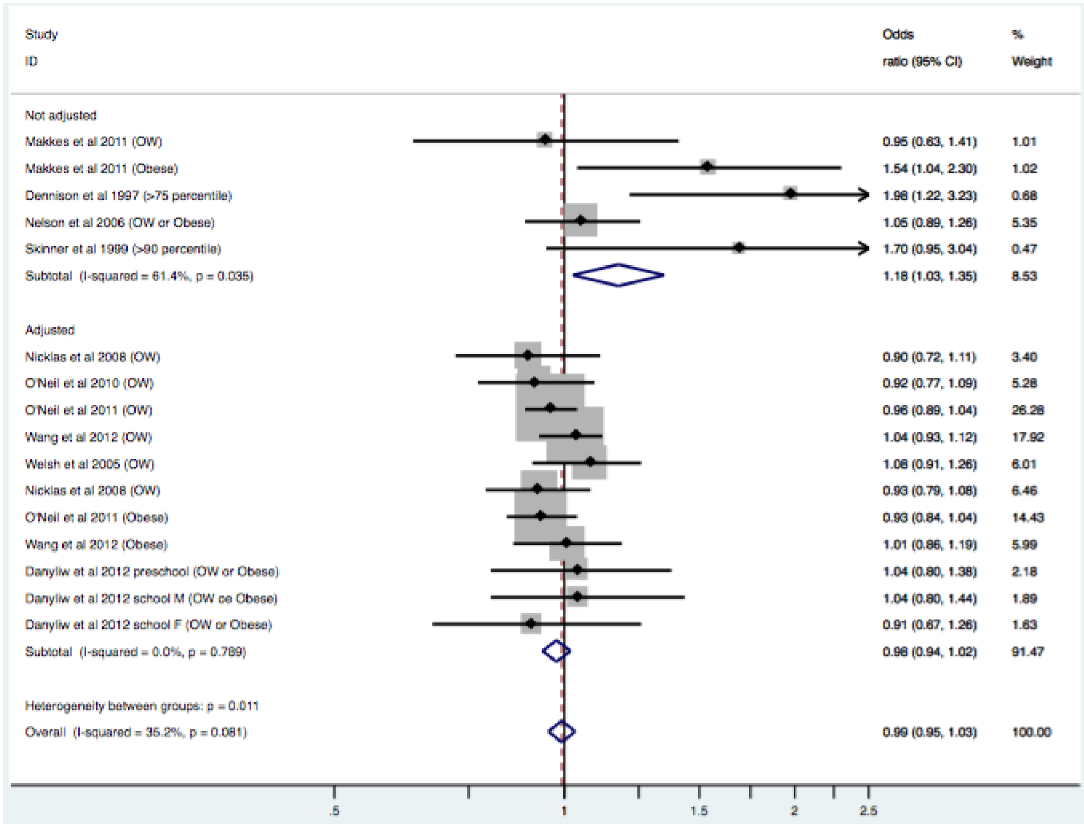

Figure 3 Odds ratio of overweight or obese (or both): highest versus lowest 100% FJ consumers

sub-grouped by energy intake adjustment

