**Association between high consumption of phytochemical-rich foods and anthropometric measures: a systematic review**

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**ABSTRACT**

Phytochemical-rich foods consumption may be a valid nutritional strategy to reduce the risk of weight gain and obesity. The phytochemical index (PI) is a simple and nonspecific method to evaluate the phytochemical intake, defined as the percentage of dietary calories derived from foods rich in phytochemicals. We aimed to conduct a systematic review to evaluate whether high consumption of phytochemical-rich foods evaluated by the PI is associated with lower values of anthropometric measurements. The available literature suggests that the PI seems to be inversely associated with body weight and waist circumference. Analyzing the longitudinal changes in anthropometric variables, individuals with high intake of phytochemicals gained less weight and fat mass when compared to those with lower PI. Our findings suggest that higher PI is associated with lower body mass index, waist circumference and adiposity. Whether the results are a reflex of a lower calorie intake or the anti-obesity properties of phytochemicals remains to be elucidated.

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**Introduction**

Non-communicable diseases (NCDs), including cardiovascular diseases, diabetes, chronic respiratory diseases and cancer, represent one of the major public health problems exerting a strong impact in the economy and accountable for an increasingly large number of deaths per year. Obesity is a potential risk factor for the development of NCDs and increases the risk of death (Wyatt et al. 2006; Bray et al. 2009; Mathieu et al. 2010; Nguyen & El-Serag 2010; Walls et al. 2012). This is particularly concerning, given the fact that the prevalence of overweight and obesity has increased in all countries. In 2014, 39% of adults aged 18 years and older were overweight, and more than half a billion adults worldwide are classified as obese. The Americas region has the highest prevalence of overweight and obesity worldwide – 61% of the population is overweight or obese in both sexes, and 27% are obese (WHO 2015).

Beyond the excessive energy intake and decreased energy expenditure, obesity is a multifactorial disease caused by a complex interaction between the environment, genetic predisposition, biological factors and human behavior (Das 2010; Wolfe & Boylan 2014; Yumuk et al. 2014; Huang & Hu 2015). The obesogenic environment significantly contributes to the increase of obesity (Das 2010; Wolfe & Boylan 2014; Yumuk et al. 2014; Lipek et al. 2015), and nutritional strategies including plant foods should be considered, since a higher consumption of phytochemical-rich foods has been inversely associated with risk of weight gain, obesity and many chronic disease (Thedford & Raj 2011; Zhang et al. 2015; Green et al. 2016).

The recommendation of plant foods intake to reduce the risk of obesity and NCDs is mainly due to these food groups being rich in phytochemicals. Phytochemicals are natural non-nutritive bioactive compounds that vary tremendously in chemical structure and function and include phenolic compounds (flavanols, flavones, flavanones, anthocyanins, isoflavones, phenolic acids, hydroxycinnamic acids, lignans, tyrosol esters, stilbenoids), isoprenoids, organosulfur compounds (allyl sulfurs, isothiocyanates) and soluble...
and insoluble fibers (Manach et al. 2004; Han et al. 2010). These compounds can be found in fruits, vegetables, whole grains, nuts and other plant foods and they may potentially reduce the risk of developing chronic disease and obesity by acting simultaneously on different cellular targets exerting antioxidant and anti-inflammatory activities (Potter & Steinmetz 1996; Tucci 2010; Ricordi et al. 2015; Joseph et al. 2016).

Given the key role of phytochemicals in reducing the risk of chronic diseases and health promotion, McCarty proposed a “phytochemical index” (PI), defined as the percentage of dietary calories derived from foods rich in phytochemicals (McCarty 2004). This index is a simple and nonspecific method to evaluate the phytochemical intake that, despite its limitations (such as not including phytochemical-rich non-caloric beverages and the fact that some phytochemicals have more potentially beneficial effects than others), could be an important diet quality indicator for obesity research. In this study, we aimed at conducting a systematic review to evaluate whether high consumption of phytochemical-rich foods evaluated by PI is associated with lower values of anthropometric measurements.

Methods

Search strategy

The population, intervention, comparison and outcome (PICO) question was as follows: In humans, is a higher intake of phytochemical-rich foods, evaluated by the phytochemical index, associated with lower values of anthropometric measurements?

The study protocol has been registered in PROSPERO International Prospective Register of Systematic Reviews (crd.york.ac.uk/prospero/index.asp, identifier: CRD42015027949). We searched Medline (http://www.ncbi.nlm.nih.gov/pubmed), the Cochrane Central Register of Controlled Trials (http://www.cochranelibrary.com/), Embase (http://www.embase.com), Literatura Latinoamericana y del Caribe en Ciencias de la Salud (http://lilacs.bvsalud.org/) and Food Science and Technology Abstracts via Ovid for studies published until August 2015 with the use of the following search term: (Phytochemicals or phytonutrients or plant-derived compounds or compounds, plant-derived or plant derived compounds or dietary phytochemicals or phytochemicals, dietary or plant-derived chemicals or chemicals, plant-derived or plant derived chemicals or dietary phytochemical index) and (body weights and measures or body measures or body measure or measure, body or measures, body).

The development of search strategies was performed independently by RAC and DFSC (Supplemental data). These two reviewers independently performed the two phases of subsequent study selection. In the first phase, the title and abstract of each article were examined for relevance to the PICO question, and citations not meeting the inclusion criteria were discarded. In the second phase, full texts of any relevant references were obtained to assess whether exclusion and inclusion criteria were met. Independent results from the selection phase were compared. The reference lists from relevant studies were inspected to identify any additional published studies not identified in the literature searches.

Selection of studies

Inclusion criteria

All included studies had to meet the following criteria: (1) mention of phytochemical-rich food consumption; (2) study design: observational studies; (3) human subjects aged 18–70 years old; (4) anthropometric data. There was no language or publication year restriction.

Exclusion criteria

Studies where the consumption of phytochemical-rich food was not analyzed by PI were excluded. In case of multiple articles whose participants were drawn from the same study, we included only the article that provided the most comprehensive information. Letters to the editor, abstracts and proceedings from scientific meetings were also excluded.

Data extraction

Data were extracted from eligible studies by RAC and DFSC. Any disagreements between the two reviewers were resolved by consulting a third reviewer. We recorded the following information about each of the studies: the name of the first author, year of publication, study design, study sample/population characteristics, setting, inclusion/exclusion criteria, instrument used for food consumption evaluation, confounding factors and methods used to control for confoundings, measured outcome, method of measuring the outcome and other data regarding the outcome measured.

Risk of bias assessment

For observational cohort and case control studies, we used the Newcastle–Ottawa Scale (Wells et al. 2011).
date unknown) to assess the risk of bias. This scale uses a star system (with a maximum of nine stars) to evaluate a study in three domains: selection of participants, comparability of study groups and the ascertainment of outcomes (in case of cohort studies) and exposure (in case of case control studies). We judged studies that received a score of nine or eight stars to be at low risk of bias; studies that scored seven, six or five stars to be at medium risk; and those which scored four or less stars to be at high risk of bias. For the cross-sectional study, we used the Prevalence Critical Appraisal Instrument developed by Munn et al. (2014). This instrument evaluates the risk of bias through ten objective questions about the sample, data analysis and the condition measured. These questions can be answered either with yes, no, unclear or not applicable, and we classified the study into low, medium or high risk of bias.

Results

Literature search

A PRISMA flow diagram of the study selection process is shown in Figure 1. The following 286 articles were identified: 201 articles from PubMed, 38 articles from EMBASE, 18 articles from The Cochrane Library, and 24 articles from Food Science and Technology Abstracts. Five articles were identified through manual searches. Once duplicates, a total of 268 articles were removed based on title and abstract. Seven potentially eligible studies were selected and fully reviewed. From that, four articles were excluded due to the sample of these studies being drawn from the same cohort. Thus, three articles providing information on three different studies were included in our systematic review.

Characteristics of studies

The characteristics of the included studies and its populations are presented in Table 1. The present systematic review included three observational studies (one case control, one longitudinal and one cross-sectional) totaling 2167 participants. Two studies were conducted in Iran (Mirmiran et al. 2012; Bahadoran et al. 2013), and one study was conducted in the USA (Vincent et al. 2010). The sample size ranged from 54 to 1938 and the age of participants from 18 to 70 years in all three studies. One study recruited female participants exclusively (Bahadoran et al. 2013), while the other two studies

![Figure 1. Flow diagram of study-selection process.](image-url)
recruited both sexes (Vincent et al. 2010; Mirmiran et al. 2012).

The outcome of interest of the studies was diverse. In the case-control study, the outcome was breast cancer – the authors aimed at investigating the association between PI and the risk of breast cancer (Bahadoran et al. 2013). In the longitudinal study, the investigators evaluated the association between PI and 3-year change in weight, waist circumference (WC) and body adiposity index (BAI) (Mirmiran et al. 2012). In the third study, the outcome was the annual weight gain, adiposity, oxidative stress and inflammation (Vincent et al. 2010).

**Evaluation of food consumption and phytochemical exposure**

In both studies from Tehran, food consumption was evaluated using a validated semi-quantitative food frequency questionnaire (FFQ). Trained dietitians interviewed participants to access their intake frequency for each food item consumed during the past year on a daily, weekly, or monthly basis (Mirmiran et al. 2012; Bahadoran et al. 2013). In the study from USA, three-day dietary records were provided to each participant and they received standard instructions to estimate servings of foods (household measurements) (Vincent et al. 2010). The PI was calculated based on a method developed by McCarty (2004) in all included studies. In the two studies from Tehran (Mirmiran et al. 2012; Bahadoran et al. 2013), the foods included in the phytochemical-rich category were the same (Table 2). In the third study, these foods were also considered as high-phytochemical content; however, three others were also classified as such: wine, beer and cider (Vincent et al. 2010).

The anthropometric measurement of weight was reported in all included studies and body mass index (BMI) calculation was reported in two studies (Mirmiran et al. 2012; Bahadoran et al. 2013). Mirmiran et al. (2012) did not inform the participants’ BMI, although it was mentioned that the calculation was performed. In their study, the authors reported WC and BAI values. The study of Vincent et al. (2010) reported the most comprehensive data: weight, height, BMI, WC, waist-to-hip ratio (WHR), body fat mass (FM) and body fat free mass (FFM).

The quality assessment of the included studies ranged from low to high risk of bias. The Bahadoran et al. (2013) study was classified as “moderate risk of bias”. Through quality assessment by Newcastle–Ottawa Scale, this study received five stars (corresponding to “case definition”, “representativeness of the cases”, “definition of controls”, “comparability”, and “method of ascertainment for cases and controls”). Using the similar quality assessment scale, the Mirmiran et al. (2012) study received eight stars and was classified as “low risk of bias”. The “representativeness of the exposed cohort” was the only category considered not appropriate. Finally, the Vincent et al. (2010) study was considered as “high risk of bias”, mainly due to the subjectivity of baseline information and the lack of data about the sample and potential confounding factors.

**Phytochemical index, characteristics of subjects and dietary intake**

In studies, which compared participants across quartile categories of PI, there was a higher intake of phytochemical-rich foods and dietary PI in older participants (Mirmiran et al. 2012; Bahadoran et al. 2013). In addition, the physical activity levels (expressed as metabolic equivalent hours per week – METs h/wk) decreased across increasing PI (Vincent et al. 2010; Mirmiran et al. 2012). In all studies,
dietary energy and fat intakes decreased across increasing PI (Vincent et al. 2010; Mirmiran et al. 2012; Bahadoran et al. 2013). Participants with higher PI present greater dietary intake of carbohydrate, protein, fiber, vitamin E, vitamin C, manganese, β-carotene and β-cryptoxanthin (Vincent et al. 2010; Mirmiran et al. 2012). Dietary intakes of fruits and vegetables were significantly higher in participants who had greater PI. One study showed that participants in the upper quartile had dietary intakes of whole grains, legumes, seeds, nuts, olive oil and soy sources significantly higher than those in the lower quartile of PI (Mirmiran et al. 2012). The association between dietary intake of whole grains and higher PI values was also supported by another study included in this review (Vincent et al. 2010).

**Phytochemical index and weight, BI and waist circumference**

In all included studies, body weight values of participants were reported. In the Bahadoran et al. (2013) study, although the outcome of interest was not the same of this systematic review, the participants’ characteristics were compared across quartile categories of the PI. Compared with the first PI quartile (mean of PI 13.9), participants in the upper quartile (mean of PI 41.6) had lower weight (76.2 versus 73.1 kg) and BMI (30.8 versus 28.6 kg/m²). However, the third quartile, with PI mean of 26.7, showed the lowest values of weight (67.1 kg) and BMI (27.6 kg/m²).

Another study found similar results. Participants in the upper quartile (PI mean of PI 42.7), in comparison to the first PI quartile (mean 17.4), had lower weight (74.3 versus 71.6 kg) at baseline. The authors of this large longitudinal study did not inform the BMI of participants. The waist circumference was measured. As observed in the analysis of weight, WC values at baseline decreased significantly across increasing PI (Vincent et al. 2010).

In another included study, participants were not divided into groups according to the level of phytochemicals exposure, but were placed into one of two groups based on BMI (normal weight and overweight group). The authors found that the overweight group had a PI mean significantly lower than participants in normal weight group (PI of 13.2 versus 23.5). As expected, values of weight, BMI, WC and WHR were significantly higher in the overweight/obese group. Additionally, when a sub analysis was performed for separate BMI quartiles, PI values were progressively lower for each increase in the BMI quartile. However, it is important to note that this study did not adjust

| Study first author and year | Dietary assessment | Method used | Phytochemical assessment | Food included in the phytochemical-rich category | Anthropometric variables | Risk of bias |
|----------------------------|-------------------|-------------|--------------------------|-----------------------------------------------|-------------------------|-------------|
| Bahadoran et al. (2013)    | Semi-quantitative FFQ | Trained dietitians interviewed the participants | Calculated as proposed by McCarty | Fruits, vegetables (except potatoes), natural fruit and vegetables juice, tomato sauces, whole grains, nuts, soy products, olives and olive oil, tea, coffee and spices. | Weight, height and BMI | Medium risk of bias |
| Mirmiran et al. (2012)     | Semi-quantitative FFQ | Trained dietitians interviewed the participants | Calculated as proposed by McCarty | Fruits, vegetables (except potatoes), natural fruit and vegetables juice, tomato sauces, whole grains, nuts, soy products, olives and olive oil. | Weight, height, WC, BMI and BAI | Low risk of bias |
| Vincent et al. (2010)      | Three-day dietary records | Participants received standard instructions on how to complete it | Calculated as proposed by McCarty | Fruits and vegetables (and prepared foods derived from these), whole grains, seeds, nuts, fruit or vegetable juices, olive oil, soy sources, wine, beer and cider. | Weight, height, BMI, WC, WHR, body fat (%), body fat mass and body fat free mass | High risk of bias |

FFQ: food-frequency questionnaire; BMI: body mass index; WC: waist circumference; BAI: body adiposity index; HC: hip circumference; NR: not reported.
for potential confounding factors, such as physical activity levels, which may have strongly biased the results (Vincent et al. 2010).

**Phytochemical index and weight and body fat**

Two studies evaluated the percentage of body fat. In one, BAI values at baseline were similar in all quartiles of PI intake (Mirmiran et al. 2012). In the other, participants with higher body fat (%) and FM (kg) had significantly lower PI (Vincent et al. 2010).

**Phytochemical index and longitudinal changes in anthropometric variables**

The association between longitudinal 3-year changes in weight, WC and BAI and PI of 1938 participants was reported. There was a weight gain across all quartile categories of PI. However, the three-year weight gain in participants with the highest dietary PI was significantly lower than for those in the lower quartile of PI (Mirmiran et al. 2012).

With regard to BAI, participants in the upper quartile had lower change in BAI during the study follow-up (3 years) – those with higher consumption of phytochemical-rich foods had 1.47% decrease in BAI as compared with the lowest category of PI. The three-year WC gain was similar across all quartile categories (Vincent et al. 2010).

In another study, self-reported weight gain within the last year was recorded from each participant. There was a significantly lower weight gain in participants with higher PI mean (Vincent et al. 2010).

Thus, in the Mirmiran et al. (2012) study, associations between dietary intakes of specific phytochemical-rich food groups at baseline and 3-year change in WC and BAI were performed. A significant inverse association between dietary intake of fruits and nuts and 3-years changes in weight, WC and BAI were stronger across the quartile categories. Also, dietary intake of whole grains was associated with lower weight, WC and BAI during the study period.

**Discussion**

In our systematic review, we found that the PI was inversely associated with body weight, BMI, WC and FM. Regarding the longitudinal changes in anthropometric variables, those with high intake of phytochemicals gained less weight and had reduced fat compared to individuals with lower PI. This may be due to the fact that plant foods have lower calories, and the high consumption of phytochemical-rich foods can contribute to a lower adiposity and weight gain as a consequence of the reduced caloric intake. Thus, there are several mechanisms that may explain the anti-obesity effects of diets rich in phytochemicals. Obesity is characterized by chronic low-grade inflammation that can be attenuated through various mechanisms, such as reducing oxidative stress and the synthesis of proinflammatory cytokines (Cao 2014; Marseglia et al. 2014; Ohashi et al. 2014; Minihane et al. 2015) by phytochemicals, such as catechin (Higdon & Frei 2003), epicatechin (Vazquez-Prieto et al. 2012), naringin, hesperidin (Coelho et al. 2013), quercetin (Nabavi et al. 2015), and anthocyanin (Skrovankova et al. 2015). In addition, many phytochemicals, such as gingerol (from ginger) (Ebrahimzadeh Attari et al. 2016), catechins (from green tea) (Huang et al. 2014), capsacin (from hot peppers) (Whiting et al. 2014; Saito 2015) and resveratrol (from red grapes) (Kim et al. 2011; Li et al. 2016) can promote thermogenesis, inhibit adipocyte differentiation and/or decrease adipogenesis in both animal models and humans studies.

The consumptions of fruits, whole grains and nuts were inversely associated with weight gain and WC. These foods, besides containing phytochemicals, have a low-glycemic index and provide vitamins, minerals and mono and polyunsaturated fatty acids, which provide diverse beneficial effects and may contribute to weight maintenance and reduced risk of obesity (Ye et al. 2012; Jackson & Hu 2014; Bertoia et al. 2015). A meta-analysis which included 14 prospective studies showed that fruit consumption was associated with less weight gain and WC (Schwingshackl et al. 2015). Similarly, longitudinal studies reported an inverse association between whole grains and nuts consumption, and weight gain and adiposity (Mozaffarian et al. 2011; Jackson & Hu 2014).

There was a positive association between the PI and carbohydrate intake. The type of carbohydrate found in plant foods is healthier than the one found in sweetened beverages, white breads and other foods made from refined flour (Jenkins et al. 2003). Further, phytochemical-rich foods have components that can modulate carbohydrate metabolism, such as dietary fibers. Dietary fibers can decrease the glycemic index of foods; therefore, reduce carbohydrate absorption rate and promote lower insulin secretion, influencing more satisfactory physiological responses (van Dam & Seidell 2007; Ye et al. 2012).

We showed that subjects with higher intakes of phytochemical-rich foods were older, suggesting that older subjects are more likely to have healthier dietary patterns than younger subjects. Corroborating with this, a study showed that eating patterns improve with
age (León-Muñoz et al. 2015). This is especially important taking into account that older subjects with dietary patterns with a higher intake of fruits, whole grains, nuts and vegetables were less cognitively impaired and depressed (Granick et al. 2015).

One of the included studies considered wine, beer and cider as phytochemical-rich foods. Although McCarty (2004) suggests that these beverages could be included in phytochemical-rich food category, we suggest that these beverages should be cautiously considered in the dietary PI calculation, except for red wine (due to the large number of studies showing the beneficial effects of resveratrol) (Fischer-Posovszky et al. 2010; Kennedy et al. 2010; Liu et al. 2014; Ornstrup et al. 2014; Gambini et al. 2015; Liu et al. 2015; Samsami-Kor et al. 2015; Turner et al. 2015). There are insufficient data showing beneficial effects of beer and cider consumption, despite their phytochemical content, such as chalcones, flavones and flavanones (Quiñé-Rada et al. 2015). This is particularly relevant taking into consideration that the dietary PI evaluates the percentage of dietary calories derived from phytochemical-rich foods, and alcohol has more calories per gram than carbohydrate and protein. The alcohol content of these beverages should be considered, since beer consumption is associated with increase of total energy intake (Mullie & Clarys 2015).

It is important to note the different PI values between studies from Tehran and USA. In Bahadoran’s and Mirmiran’s studies, the PI means at the lowest quartiles were <17.7 and <20.9, respectively. In Vincent et al.’s study, the PI mean in the regular weight group was 23.5, and in the overweight group, 13.2. Thus, the average values of PI in the American study are much lower than in the other two studies. This difference is due to the dietary patterns of the two countries. The American population eats a typical Western diet, in which the PI value ranges around 20 (McCarty 2004), while in Iran, like in any other Middle East country, the dietary pattern is characterized by plant foods, such as fruits, vegetables and whole grains that contribute to the higher PI (Musai et al. 2002).

Among the study highlights are the several anthropometric variables included and the large sample size. Another strength of the present systematic review is the comprehensive search strategy in five different databases.

On the other side, this systematic review has some limitations, such as the low quality of the studies and the heterogeneity between them. Two included studies present results stratified by quartiles of PI, while the third study stratifies the results into two groups according to BMI. Another limitation was the small number of researches on this topic, which makes these data preliminary that need to be confirmed in future studies. The PI has also some limitations, such as the non-inclusion of phytochemical-rich non-caloric beverages, such as coffee, green and black tea. This is especially relevant, taking into account the number of studies showing the beneficial effects of catechins from Camellia sinensis on weight loss (Phung et al. 2010; Liu et al. 2013; Baladia et al. 2014). Additionally, some phytochemicals have potentially more beneficial effects than others and the index does not take into account these considerations.

In conclusion, this study provides some evidence that the consumption of foods rich in phytochemicals is associated with lower weight, abdominal obesity and adiposity. However, due to the small number of researches on this topic, this evidence needs to be strengthened with well-conducted experimental studies, so that the PI is considered as a valid dietary approach aiming the maintenance of a healthy body weight or reduction of adiposity.

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References

Bahadoran Z, Karimi Z, Houshiar-Rad A. 2013. Dietary phytochemical index and the risk of breast cancer: a case control study in a population of Iranian women. Asian Pac J Cancer Prev. 14:2747–2751.

Baladia E, Basulto J, Manera M, Martín R, Calbet D. 2014. Effect of green tea or green tea extract consumption on body weight and body composition; systematic review and meta-analysis. Nutr Hosp. 29:479–490.

Bertoia ML, Mukamel KJ, Cahill LE, Hou T, Ludwig DS, Mozaffarian D, Willett WC, Hu FB, Rimm EB. 2015. Changes in intake of fruits and vegetables and weight change in United States men and women followed for up to 24 years: analysis from three prospective cohort studies. PLoS Med. 12:e1001878.

Bray GA, Clearfield MB, Fintel DJ, Nelinson DS. 2009. Overweight and obesity: the pathogenesis of cardiometabolic risk. Clin Cornerstone. 9:30–40.

Cao H. 2014. Adipocytokines in obesity and metabolic disease. J Endocrinol. 220:T47–T59.

Coelho RC, Hermesdorff HH, Bressan J. 2013. Anti-inflammatory properties of orange juice: possible
favorable molecular and metabolic effects. Plant Foods Hum Nutr. 68:1–10.

Das UN. 2010. Obesity: genes, brain, gut, and environment. Nutrition. 26:459–473.

Ebrahimzadeh Attari V, Ostadrahimi A, Asghari Jafarabadi M, Mehralizadeh S, Mahlui S. 2016. Changes of serum adipocytokines and body weight following Zingiber officinalis supplementation in obese women: a RCT. Eur J Nutr. 55:2129–2136.

Fischer-Posovszky P, Kukulcs V, Tews D, Unterkircher T, Debatin KM, Fulda S, Wabitsch M. 2010. Resveratrol regulates human adipocyte number and function in a Sirt1-dependent manner. Am J Clin Nutr. 92:5–15.

Gambini J, Ingles M, Olaso G, Lopez-Grueso R, Bonet-Costa V, Gimeno-Mallench I, Mas-Bargues C, Abdelaziz KM, Gomez-Cabrer a MC, Vina J, Borras C. 2015. Properties of resveratrol: in vitro and in vivo studies about metabolism, bioavailability, and biological effects in animal models and humans. Oxid Med Cell Longev. 2015:837042.

Granic A, Davies K, Adamson A, Kirkwood T, Hill TR, Siervo M, Mathers JC, Jagger C. 2015. Dietary patterns and socioeconomic status in the very old: the Newcastle 85+ Study. PLoS One e0139713.

Green R, Sutherland J, Dangour AD, Shankar B, Webb P. 2016. Global dietary quality, undernutrition and non-communicable disease: a longitudinal modelling study. BMJ Open. 6:e009331.

Han X, Shen T, Lou H. 2010. Dietary polyphenols and their biological significance. Int J of Mol Sci. 8:950–988.

Higdon JV, Frei B. 2003. Tea catechins and polyphenols: health effects, metabolism, and antioxidant functions. Crit Rev Food Sci Nutr. 43:89–143.

Huang J, Wang Y, Xie Z, Zhou Y, Zhang Y, Wan X. 2014. Type 2 diabetes and the vegetarian diet. Am J Clin Nutr. 99:1510–1519.

Huang T, Hu FB. 2015. Gene-environment interactions and obesity: recent developments and future directions. BMC Med Genomics. 8:52.

Huang T, Wang Y, Xie Z, Zhou Y, Zhang Y, Wan X. 2014. The anti-obesity effects of green tea in human intervention and basic molecular studies. Eur J Clin Nutr. 68:1075–1087.

Jackson CL, Hu FB. 2014. Long-term associations of nut consumption with body weight and obesity. Am J Clin Nutr. 100:408S–411S.

Jenkins DJA, Kendall CWC, Marchie A, Jenkins AL, Augustin LSA, Ludwig DS, Barnard ND, Anderson JW. 2003. Type 2 diabetes and the vegetarian diet. Am J Clin Nutr. 78:610S–616S.

Joseph SV, Edirisinghe I, Burton-Freeman BM. 2016. Fruit polyphenols: a review of anti-inflammatory effects in humans. Crit Rev Rev Food Sci Nutr. 56:419–444.

Kennedy DO, Wightman EL, Rayl Jl, Lietz G, Okello EJ, Wilde A, Haskell CF. 2010. Effects of resveratrol on cerebral blood flow variables and cognitive performance in humans: a double-blind, placebo-controlled, crossover investigation. Am J Clin Nutr. 91:1590–1597.

Kim S, Jin Y, Choi Y, Park T. 2011. Resveratrol exerts anti-obesity effects via mechanisms involving down-regulation of adipogenic and inflammatory processes in mice. Biochem Pharmacol. 81:1343–1351.

León-Muñoz LM, García-Esquinas E, López-García E, Banegas JR, Rodriguez-Artalejo F. 2015. Major dietary patterns and risk of frailty in older adults: a prospective cohort study. BMC Med. 13:11.

Li S, Bouzar C, Cottet-Rousselle C, Zagotta I, Lamarche F, Wabitsch M, Tokarska-Schlattner M, Fischer-Posovszky P, Schlattner U, Rousseau D. 2016. Resveratrol inhibits lipogenesis of 3 T3-L1 and SGBS cells by inhibition of insulin signaling and mitochondrial mass increase. Biochim Biophys Acta.1857:643–652.

Lipek T, Igel U, Gausche R, Kiess W, Grande G. 2015. Obesogenic environments: environmental approaches to obesity prevention. J Pediatr Endocrinol Metab. 28:485–495.

Liu K, Zhou R, Hou R, Wang B, Mi MT. 2014. Effect of resveratrol on glucose control and insulin sensitivity: a meta-analysis of 11 randomized controlled trials. Am J Clin Nutr. 99:1510–1519.

Liu K, Zhou R, Wang B, Chen K, Shi LY, Zhu JD, Mi MT. 2013. Effect of green tea on glucose control and insulin sensitivity: a meta-analysis of 17 randomized controlled trials. Am J Clin Nutr. 98:340–348.

Liu Y, Ma W, Zhang P, He S, Huang D. 2015. Effect of resveratrol on blood pressure: a meta-analysis of randomized controlled trials. Clin Nutr. 34:27–34.

Manach C, Scalbert A, Morand C, Remesy C, Jimenez L. 2004. Polyphenols: food sources and bioavailability. Am J Clin Nutr. 79:727–747.

Marsegilia L, Manti S, D’angelo G, Nicotera A, Parisi E, Di Rosa G, Gatto E, Arrigo T. 2014. Oxidative stress in obesity: a critical component in human diseases. Int J Mol Sci. 16:378–400.

Mathieu P, Lemieux I, Després JP. 2010. Obesity, inflammation, and cardiovascular risk. Clin Pharmacol Ther. 87:407–416.

McCarty MF. 2004. Proposal for a dietary “phytochemical index”. Med Hypotheses. 63:813–817.

Minihane AM, Vinoy S, Russell WR, Baka A, Roche HM, Tuohy KM, Teeling JL, Blaak EE, Fenech M, Vauzour D, et al. 2015. Low-grade inflammation, diet composition and health: current research evidence and its translation. Br J Nutr. 114:999–1012.

Mirmiran P, Bahadoran Z, Golzarand M, Shiva N, Azizi F. 2012. Association between dietary phytochemical index and 3-year changes in weight, waist circumference and body adiposity index in adults: Tehran Lipid and Glucose study. Nutr Metab (Lond). 9:108–116.

Mozaffarian D, Hao T, Rimm EB, Willett WC, Hu FB. 2011. Changes in diet and lifestyle and long-term weight gain in women and men. N Engl J Med. 364:2392–2404.

Mullie P, Clarys P. 2015. Beer, wine and lifestyle: a cross-sectional study of the Belgian military population. Mil Med Res. 2:33.

Munn Z, Moola S, Riitano D, Lisy K. 2014. The development of a critical appraisal tool for use in systematic reviews addressing questions of prevalence. Int J Health Policy Manag. 3:123–128.

Musaiger AO. 2002. Diet and prevention of coronary heart disease in the Arab Middle East countries. Med Princ Policy Manag. 3:128.

Musaiger AO. 2002. Diet and prevention of coronary heart disease in the Arab Middle East countries. Med Princ Policy Manag. 3:128.

Nabavi SF, Russo GL, Daglia M, Nabavi SM. 2015. Role of quercetin as an alternative for obesity treatment: you are what you eat. Food Chem. 179:305–310.
