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A systematic review of food composition tools used for determining dietary polyphenol intake in estimated intake studies

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ABSTRACT

Translating food intake data into phytochemical outcomes is a crucial step in investigating potential health benefits. The aim of this review was to examine the tools for determining dietary-derived polyphenol intakes for estimated intake studies. Published studies from 2004 to 2014 reporting polyphenol food composition information were sourced with 157 studies included. Six polyphenol subclasses were identified. One quarter of studies (n = 39) reported total flavonoids intake with 27% reporting individual flavonoid compounds. Assessing multiple compounds was common with approximately 10% of studies assessing seven (n = 13), six (n = 12) and five (n = 14) subclasses of polyphenol. There was no pattern between reported flavonoids compounds and subclass studied. Approximately 60% of studies relied on publicly accessible food composition data to estimate dietary polyphenols intake with 33% using two or more tools. This review highlights the importance of publicly accessible composition databases for estimating polyphenol intake and provides a reference for tools available globally.

1. Introduction

The evidence underpinning the Australian Dietary Guidelines specifically relates the consumption of core plant based food groups (Beecher, 2003) - fruit, vegetables and grains - to phytochemicals (carotenoids, flavonoids and isoflavonoids, polyphenols, xanthin, etc.) consumption (Department of Health and Ageing & National Health and Medical Research Council, 2011). Despite this, the 2011–13 Australian Health Survey indicates that only 5.6% of Australian adults achieved the recommended two and five servings of fruit and vegetables, respectively (Australian Bureau of Statistics, 2012), a pattern that has persisted for many decades (Australian Institute of Health and Welfare, 2013; Magarey, McKean, & Daniels, 2006). In parallel, research also is looking to define how plant based foods truly impact on health outcomes (Tapsell, Dunning, Warensjo, Lyons-Wall, & Dehlsen, 2014). Consumption of total phytochemical intake is consistently linked with protection against chronic diseases (Knekt et al., 2002), including cardiovascular disease (Hooper et al., 2008), cancer (Park & Pezzuto, 2012) and neurodegenerative diseases (Commenges et al., 2000).

Application of food composition data remains at the forefront of dietetic practice (Dietitians Association of Australia, 2010), though translation from the nutrient to the food information needs to be strengthened to better support public health messages. In order to associate phytochemical consumption with positive health outcomes, a fundamental step is to accurately estimate dietary phytochemical intake.

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Despite the first estimations of phytochemical intake at a population level being reported more than a decade ago, the numerous methods employed have evident flaws (Dwyer & Peterson, 2002). Dietary phytochemical intake is difficult to quantify and consequently numerous methods have been developed for application in various settings. With the absence of a gold standard approach, the methods utilised include various techniques within the fields of dietary assessment and biomarker analyses. Specifically for translation to occur at a nutrient level or at the grouped food level to create advice strategies, an up-to-date and geographically appropriate food composition database is required. Translating food data specifically to phytochemical intakes is further complicated due the number of phytochemicals found intrinsically in foods, their bioavailability when consumed and their interactions with other foods or nutrients when consumed as part of the whole diet.

The limitations associated with current methods hinder the interpretation of research outcomes that associate dietary phytochemical intake and specific health outcomes. An evaluation and comparison of the tools to measure phytochemical intake is imperative to interpret current findings across the literature and to provide recommendations for methods to apply in future research.

As phytochemicals is the term used to group a vast range of chemical compounds which are hieratically grouped into classes and subclasses, unlike other known nutrients in foods, the complexity and variability must also be carefully considered. Traditional methods of dietary assessment require a recall or documentation of food intake from a given time period in either a prospective or retrospective manner. To determine the nutrient composition of either individual or group intakes, this dietary intake data must have tools applied to it to allow a food to nutrient translation to occur. These tools may food composition databases, limited for phytochemicals, or relate directly to the intake data or the use of known biomarkers detected in the plasma, urine or faecal samples of the person giving the recall to confirm the plausibility of the intake data that has been provided.

1.1. Dietary assessment of phytochemical intake

The most common method of estimating phytochemical intake at a population level relies on dietary assessment of intake. Generally, assessment of usual diet may be performed using repeated 24-h diet recalls, diet history interview or food frequency questionnaires. These methods are then cross-referenced with a phytochemical food composition database. However, there are very few phytochemical specific food composition databases that exist globally. Aside from the limitations inherent to each dietary assessment method, there are several well documented problems associated with utilising food composition databases not specific to the geographic area to assign phytochemical content to selected foods, resulting in large variations in estimates of intake (Chun, Lee, Wang, Vance, & Song, 2012).

Firstly, estimation of dietary phytochemical intake is only as comprehensive as the composition database utilised. If, for example, a composition database does not have an extensive list of foods and the phytochemical content of a food in an individual's diet cannot be assigned or matched to its closes equivalent, and in turn an individual's intake will be underestimated. This is particularly challenging when analysing food intake data from a country that does not have a specific composition database for that population. Secondly, the phytochemical content of specific foods is highly variable and largely influenced by a foods growth, harvesting and processing conditions. A phytochemical food composition database is unable to account for this variability and can only provide an estimate for each food consumed. Lastly, estimating dietary phytochemical intake through dietary assessment is unable to account for the high intra-individual variation associated with phytochemical metabolism and absorption, which is influenced by factors other than intake, such as bioavailability and genetic factors. Until the bioavailability of all phytochemicals are understood and the individual variations in metabolism are accounted for, estimations of phytochemical intake and their correlation with health outcomes should be interpreted with caution.

1.2. Biomarker analyses for phytochemical intake

Dietary phytochemical intake can be determined by quantifying biomarkers which include intact phytochemicals and their derivatives (e.g. phenolic acids) found in plasma, urine and faecal water. Many methods of measuring phytochemical biomarkers in human biological samples exist, with no standardised protocol of how to perform this analysis. Consequently researchers must develop and validate their own methods, limiting the ability to compare studies that have used different methods to measure certain biomarkers. Generally, laboratories use chromatography and spectrometry to quantify the biomarker of interest. However, there many thousands of phytochemicals identified and after consumption they are quickly and extensively metabolised into various metabolites. Consequently, there are thousands of potential biomarkers and there is no consensus around which phytochemicals or metabolites are indicative of total dietary intake.

More recently the use of metabolomics, the analysis of all metabolites contained in a given biofluid at a given time, in combination with pattern recognition analyses and advancements in analytical have been employed to search for relevant biomarkers. This approach provides improved specificity though is also limited by the biological measures it can address (Monteiro, Carvalho, Bastos, & Guedes de Pinho, 2013; O'Gorman, Gibbons, & Brennan, 2013). A recent metabolomics-based study into biomarkers of high and low flavonoid intakes from fruit and vegetables identified abscisic acid glucuronide for the first time in relation to low flavonoid dietary intakes while confirming phenolic acids and their derivatives in relation to high intakes (Ulaszewska et al., 2016), demonstrating that biomarkers may need to be suited to both the component being metabolized and the context in which is it being considered.

In addition, it is currently unknown which biological sample (plasma, urine or faecal water) should be selected and research suggests each may be indicative of different consumption patterns. Previous research shows urinary biomarkers may be more reflective of short-term intake (Radtke, Linseisen, & Wolfram, 2002). The phytochemical content in fasting plasma or faecal water samples seems to be a suitable biomarker of short-term intake and a possible biomarker of the medium-term intake (Radtke et al., 2002). However, biomarkers of long-term intake are not yet identified and may be unlikely due to the short half-lives of dietary phytochemicals in vivo. Most of the biomarker analyses are expensive and often cannot be performed as part of large epidemiological studies (Yokota, Miyazaki, & Ito, 2010). Future research needs to focus on identifying specific biomarkers of phytochemical intake and confirm the best methods in which to quantify these biomarkers in biological specimens, to inform population research.

With no gold standard method for measuring phytochemical intake, it is unclear which method for measuring or estimating dietary phytochemical intake is most useful. To improve methodological quality of research, a clear understanding of appropriate methods for measuring phytochemical intake is required. This review aims to provide an overview of available strategies for estimating dietary phytochemical intake and to provide an important resource for researchers.