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Review

Coffee consumption and risk of the metabolic syndrome: A meta-analysis

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Abstract

Aims. – The association between coffee consumption and risk of the metabolic syndrome (MetS) remains controversial. For this reason, a meta-analysis including dose–response analysis was conducted to quantitatively summarize the association between coffee intakes and MetS risk.

Methods. – A search was made of PubMed and the China National Knowledge Infrastructure (CNKI) for relevant articles published between 1 January 1999 and 31 May 2015. All observational studies related to the relationship of coffee consumption and risk of MetS were included in the meta-analysis. The result was estimated by a random-effects model, while the dose–response relationship was assessed by a restricted cubic spline model.

Results. – Eleven published reports including 13 studies with a total of 159,805 participants were eligible for our meta-analysis. The aggregated result (and 95% CI) for the highest *vs* lowest category of coffee consumption was 0.872 (0.781–0.975). After excluding one study with a relative risk (RR) < 0.300, the aggregated result (and 95% CI) was 0.889 (0.801–0.986). A non-linear relationship was found between coffee consumption and the MetS in the dose–response analysis.

Conclusion. – This meta-analysis suggests that coffee consumption is associated with a low risk of MetS, and further studies to address the question of causality are now needed.

Keywords: Coffee; Dose-response analysis; Observational study; Meta-analysis; Metabolic syndrome

1. Introduction

The metabolic syndrome (MetS) is a cluster of complex metabolic disorders [defined as the presence of three of the five following medical conditions: elevated fasting plasma glucose; abdominal obesity; elevated blood pressure; high serum triglycerides; and low high-density lipoprotein (HDL) levels] that affects about 20–25% of the world's adult population [1]. The Third National Health and Nutrition Examination Survey (NHANES III) reported a significant increase in the prevalence of MetS among US adults [2], while studies suggest that the MetS is associated with increased cardiovascular disease and common cancers [3–6]. Accumulating evidence also supports the idea that it is affected by genetic [7–9] and lifestyle factors (such as alcohol consumption, smoking, sedentary behaviours and sugar-sweetened beverage consumption) [10–13]. As dietary intakes have an impact on every component of the MetS, they are therefore considered the primary preventative interventions for the syndrome [14].

Coffee is now a popular beverage all over the world, with a consumption of 500 billion cups every year [15–17]. The constituents found in coffee, such as vitamin E, niacin, potassium, magnesium and caffeine, have many potential health benefits, including reducing the risk of type 2 diabetes mellitus (T2DM), an important component of MetS [18–20]. Caffeine might protect against T2DM incidence through increasing metabolic rate and thermogenesis, stimulating fat oxidation and free fatty acid (FFA) release from peripheral tissues, and mobilizing glycogen in muscles [21]. Therefore, epidemiological studies have investigated the association between coffee consumption and the risk of MetS, although the results have been inconsistent. Some studies [22–26] have found that coffee consumption was inversely associated with the MetS, while other studies [27,28] showed that coffee consumption was not associated with either the MetS

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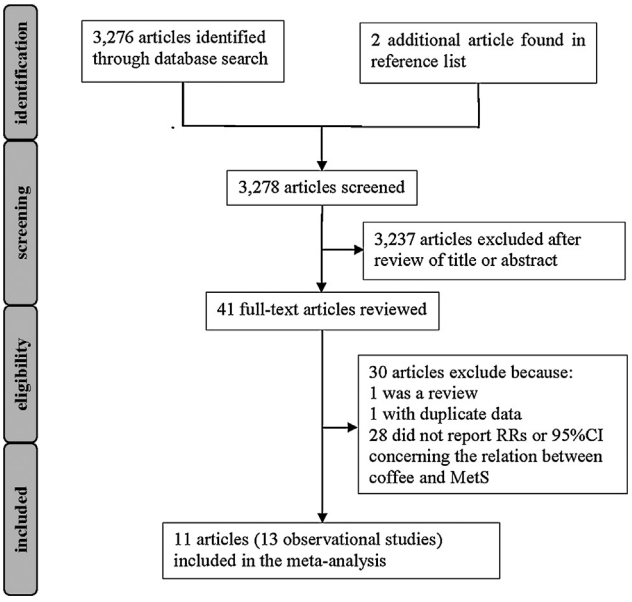

Fig. 1. Flow chart of the literature search for studies included in the meta-analysis.

or its components. In addition, the dose–response relationship between coffee consumption and MetS risk is still uncertain.

For this reason, a systematic meta-analysis combining all the available data from observational studies was conducted to:

- derive an estimation of the relationship between coffee consumption and MetS risk;
- evaluate the possible dose–response relationship of coffee consumption and MetS risk.

2. Methods

2.1. Literature search strategy

All of the relevant studies published in English and Chinese between 1 January 1999 and 31 May 2015 were identified from searches of PubMed and the China National Knowledge Infrastructure (CNKI). Search terms included 'metabolic syndrome', 'MetS', 'coffee', 'caffeine' and 'dietary factors'. Reference lists of the relevant articles were also reviewed to identify studies not captured by our search terms. A flow chart of our literature search is shown in Fig. 1.

2.2. Inclusion criteria

The study inclusion criteria were as follows:

- studies published since 1999, when the World Health Organization (WHO) first arrived at a definition of the MetS;
- observational studies published as original studies to evaluate the relationship between coffee consumption and risk of MetS;
- relative risks (RRs) with 95% confidence intervals (CIs) were given;
- the exposure was coffee consumption;
- the outcome was MetS.

For the dose–response meta-analysis, studies had to provide a quantitative measure of coffee consumption for at least three categories, along with estimates of RRs and 95% CIs that were category-specific with either person-years or total number of subjects and category-specific cases. If data were published more than once, the one that was most recently published or had the largest number of cases was included in our meta-analysis. Two investigators (F.S., X.L.) searched for the articles and reviewed all possible studies independently. If the eligibility of an article was controversial, it was resolved by consensus.

2.3. Data extraction

The following information was extracted from each study:

- the first author's name;
- publication year;
- location;
- study design;
- number of cases/sample size;
- gender;
- mean age in years at baseline;
- diagnostic criteria;
- cutoff points for coffee consumption;
- multivariate-adjusted RRs and 95% CIs for each coffee-consumption category;
- variables adjusted for in the analyses.

All data were independently extracted by two investigators (F.S., X.L.), and any disagreements were again resolved by consensus.

2.4. Statistical analysis

For highest *vs* lowest, the aggregated results and 95% CIs for effect size were calculated using inverse-variance weighted random-effects meta-analysis. I^2 was used to assess heterogeneity across studies [29], with I^2 values of 0%, 25%, 50% and 75% representing no, low, moderate and high heterogeneity, respectively. Meta-regression was conducted to investigate the potential covariates that might have substantial impacts on between-study heterogeneity [30]. Influence analysis [31] was also conducted to determine whether an individual study affected the aggregate result or not. Visual inspection of the funnel plot and Egger's linear regression test was done to assess publication bias [32]. Subgroup analyses were performed according to the type of study design.

For the dose–response analysis, a two-stage random-effects dose–response meta-analysis [33] was performed. In the first stage, a restricted cubic spline model with three knots, at the 25th, 50th and 75th centiles of levels of coffee consumption, was estimated using generalized least squares regression, taking into account the correlation within each set of published RRs. Study-specific estimates were then combined using the restricted