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Original article

Dietary indices, cardiovascular risk factors and mortality in middle-aged adults: findings from the Aerobics Center Longitudinal Study

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ABSTRACT

Purpose: We examined the association between three predefined dietary indices and both cardiovascular disease (CVD) risk factors and long-term mortality in adult Aerobics Center Longitudinal Study's participants.
Methods: Between 1987 and 1999, 12,449 (77% male) participants aged 20–84 years completed a clinical examination, which included dietary assessment by 3-day diet records. Three dietary indices were calculated: the Ideal Diet Index, the Diet Quality Index, and the Mediterranean Diet Score. CVD risk factors measurements included body mass index, total cholesterol, fasting glucose, blood pressure, and cardiorespiratory fitness. We calculated hazard ratios from Cox regression analyses, adjusting for potential confounders including physical fitness.
Results: Higher Ideal Diet Index, Diet Quality Index, and Mediterranean Diet Score scores were consistently associated with lower body mass index, cholesterol and glucose levels, and diastolic blood pressure, and higher cardiorespiratory fitness (all $P < .05$). However, after adjusting for age, sex, energy intake, and baseline examination year, the indices were not significantly related to all-cause, CVD, or cancer mortality. No association was observed in fully adjusted models, which controlled for fitness.
Conclusions: Although these dietary indices based on 3-day diet records are strongly associated cross-sectionally to CVD risk profile of middle-aged men and women, they do not add to ability to predict long-term mortality in follow-up.

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Introduction

Nutritional epidemiology studies support the use of dietary patterns or dietary indices as measures of overall dietary quality rather than focusing on single dietary components [1,2]. Dietary indices usually have been developed to describe patterns of intake according to (1) compliance with currents dietary guidelines (some focus on foods or food groups, others on nutrients, whereas some combine both); (2) groupings derived empirically from available nutrient or/and food data using factor, principal component or cluster analysis; and (3) a hybrid of the previous two methods, based on the predictive ability of food and nutrients or biomarkers in association with health outcomes [3].

Predefined dietary indices, such as Dietary Approaches to Stop Hypertension (DASH), Diet Quality Index (DQI), or Healthy Eating Index, which are based on U.S. guidelines focusing on a combination of nutrients and foods, have been associated with health outcomes, including major chronic diseases and mortality [4]. In particular, these indices have generally shown no or only weak associations with mortality in U.S. studies. However, the Mediterranean-style diet has been related to all-cause mortality in both Mediterranean and non-Mediterranean populations [1], including the United States [5]. These dietary indices or patterns are the "original" diet scores because many versions of them exist, and they have been validated and cited extensively [4,6]. On the other hand, fewer studies have shown the relation of dietary patterns derived from empirical methods (e.g., factor or cluster analysis) with mortality; and results are inconsistent in the U.S. population [3]. Similarly, dietary patterns

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derived from the hybrid method show inconsistent results regarding their ability to predict mortality [7]. For example, the dietary pattern based on energy from macronutrients and disease biomarkers (e.g., blood lipids) in European populations was associated with a lower risk of all-cause mortality and incidence of cardiovascular disease (CVD) [8,9]. We observed, however, that the derived dietary pattern was not a significant predictor of all-cause, CVD or cancer mortality in multivariate models that included physical activity and fitness at baseline [10]. This highlighted that the diet-mortality relationship could be largely confounded by cardiorespiratory fitness. We were the first to include cardiorespiratory fitness as a confounder in diet-mortality relationship, based on evidence of cardiorespiratory fitness as a potential marker of CVD [11,12].

In the present study, we focus on three different predefined dietary indices as measures of overall dietary quality based on a combination of nutrients and foods. These are as follows: the DASH index used in the definition of Ideal Cardiovascular Health [13] (hereafter called, Ideal Diet Index [IDI]), the DQI [14], and the Mediterranean Diet Score (MDS) [15]. All of them have been studied in relation with markers of CVD [16,17] and mortality [5,18–20] in the U.S. population; however, these studies did not include cardiorespiratory fitness as a potential confounder of this association. We focus only on predefined dietary indices because they can be used in different populations, whereas the empirical indices are specific to the population in which they were developed.

This study was designed to investigate the relation of three predefined dietary indices with markers of CVD at baseline and their ability to predict long-term all-cause, CVD, and cancer mortality in U.S. adults from the Aerobics Center Longitudinal Study (ACLS).

Materials and methods

Study design

The ACLS is a prospective study of men and women who received a preventive medical examination at the Cooper Clinic, Dallas, TX [21]. Participants were predominantly non-Hispanic white (>95%), well educated, and within the middle to upper socioeconomic strata [21]. All participants completed a standardized medical history questionnaire and underwent an extensive clinical evaluation, including a physical examination, body composition, fasting blood chemistry analyses, personal and family health history (physician-diagnosed myocardial infarction, stroke, cancer, hypertension, diabetes mellitus, hypercholesterolemia, and premature parental history of CVD), smoking and alcohol use, physical activity, a maximal exercise treadmill test, and demographic information.

The study was approved annually by the Cooper Institute Institutional Review Board and written informed consent for the examinations and follow-up study was required of all participants.

This analysis was restricted to participants who completed a 3-day dietary record at the time of their medical examination (between 1987 and 1999) (n = 15,355). Participants were excluded if they presented a personal history of CVD (heart attack or stroke) (n = 322) or cancer (n = 1,610), did not achieve at least 85% of their age-predicted maximal heart rate during the graded modified Balke treadmill exercise testing (n = 963), or had less than 1 year of follow-up (n = 11). Participants included in the study had complete and valid data for all the main exposures (dietary data) and confounders studied. The final sample included 12,449 participants (22% women) aged 20–82 years at the time of their clinical examination, who were followed up until the date of death or December 31, 2003, whichever came first. The 12,449 included participants were younger, more likely to be male, were thinner, more fit, had lower blood cholesterol and glucose levels, lower blood pressure and were less likely to have unfavorable cardiovascular health factors compared with the 2906 excluded participants, who had more CVD, cancer, or undetected underlying medical conditions at baseline (Supplementary Table 1).

Diet

Study participants completed a 3-day diet record on two preassigned weekdays and one weekend day; they recorded their food and beverage consumption on all 3 days. Before completing the records, participants were provided with written instructions on how to accurately describe foods and estimate portion sizes. Foods consumed were recorded as they were eaten and included portion size estimation using common household measures. Diet records were coded and analyzed by dieticians using the Cooper Clinic Nutrition and Exercise Evaluation system [22].

We applied three previously defined dietary indices to investigate the risk of mortality; the IDI and the DQI originally developed in U.S. population and the MDS based on a European population. Food-based scores were calculated based on average intakes across the 3 days of the dietary record. We adapted the IDI from DASH following the American Heart Association (AHA) definition of Ideal Cardiovascular Health [13]. The IDI includes eight dietary components: fruits and vegetables, fish, whole grains, sodium, added sugar, nuts/seeds and legumes, processed meat, and energy percentage from saturated fat. Added sugar was adapted to new AHA recommendations; 5 and 9 tsp equivalents of added sugar for women and men, respectively [23]. We used the previously established healthy cutoffs for each component to assign the scoring (Supplementary Table 2 for details of classification). Healthy intakes were assigned a score of "1," otherwise they were scored as "0." Points were summed across eight dietary components, ranging from 0 (poor diet) to 8 (excellent diet).

The DQI also consists of eight dietary components including percentage of energy from total fat and saturated fat, cholesterol, fruits and vegetables, breads/cereals and legumes, protein, sodium, and calcium [14]. Cutoffs were based on U.S. recommendations from Diet and Health [24]. Cutoffs for protein and calcium intake were adapted to new Dietary Reference Intake guidelines. The Recommended Dietary Allowance for protein is 46 g for women and 56 g for men [25]. The Dietary Reference Intake for calcium is 1000 mg among people aged 50 years or younger and 1200 mg for those aged older than 50 years [26]. Healthiest intakes were scored as "2," unhealthiest were scored as "0," and intermediate as "1." Scores for the individual components were summed and ranged from 0 (poor diet) to 16 (excellent diet).

The MDS is based on the index by Trichopoulou et al. [15] and includes vegetables, legumes, fruits and nuts, cereals, fish and seafood, monounsaturated/saturated fats ratio, dairy products, meat and meat products, and alcohol. We used sex-specific median intakes as cutoffs for each component except for alcohol intake. Intakes above the median were assigned a score of 1 and intakes below the median scored 0; dairy products and meat/meat products were reverse scored. Alcohol intake 2 drinks/d or less in men and 1 drink/d or less in women was assigned a score of 1 and intakes above were scored as 0. The total score was calculated as the sum of nine dietary components, ranging from 0 to 9 (higher adherence to the Mediterranean-style diet). More details of the components and cutoffs used to calculate the indices are shown in Supplementary Table 2.

Cardiovascular risk factors

Height and weight were measured using a standard stadiometer and used to calculate body mass index [BMI = weight (kg)/height

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