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REVIEW ARTICLE

Lifestyle Indices and Cardiovascular Disease Risk: A Meta-analysis

Janett Barbaresko, Dr, Johanna Rienks, MSc, Ute Nöthlings, DrPH

Context: Several studies investigated lifestyle indices to account for interrelations between lifestyle behaviors and cardiovascular disease risk. So far, no systematic review has been conducted. Thus, the aim is to summarize the evidence of associations between lifestyle indices and cardiovascular disease risk in observational prospective studies.

Evidence acquisition: A systematic literature search was conducted in two databases in February 2018. Multivariable-adjusted risk estimates were combined using random effects models comparing the highest with the lowest healthy lifestyle score. Additionally, meta-analyses for cardiovascular disease types, such as stroke and heart failure, were conducted. Heterogeneity was assessed using I^2 index.

Evidence synthesis: The search identified 27 studies, of which 22 were included in the meta-analyses. Most lifestyle indices included physical activity, smoking, diet, alcohol consumption, and body weight. A healthy lifestyle was associated with a reduced risk of 66% for cardiovascular disease (95% CI=0.28, 0.41, I^2=79.1%), 60% for stroke, and 69% for heart failure. A dose−response effect for adherence to an increasing number of healthy behaviors and cardiovascular disease risk was observed. Statistical heterogeneity was found, suggesting that the definition of the lifestyle indices and components varied substantially between the studies.

Conclusions: Adherence to several healthy lifestyle behaviors simultaneously was associated with a 66% reduced cardiovascular disease risk compared with adopting none or only one behavior. Despite heterogeneity of indices, consistent inverse associations across studies underscore the relevance of adopting healthy behaviors at all. More research on other lifestyle behaviors, such as sleep duration or sedentary behavior in combination, is warranted.

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CONTEXT

Cardiovascular diseases (CVD) are still the most common causes of death worldwide, accounting for almost half of all deaths from noncommunicable diseases in 2012.[1] Of 17.5 million deaths, about 7.4 million occurred because of heart attack and 6.7 million because of stroke worldwide.[1] Thus, reducing the occurrence of CVD and subsequently reducing disease burden is of high public health importance.

Besides risk factors, such as sex, age, and ethnicity, modifiable lifestyle factors, including smoking, physical inactivity, an unhealthy diet, and high alcohol consumption, have been shown to increase the risk of CVD.[2] Most studies investigated the impact of a single lifestyle factor on disease risk. However, in the last decade, more and more studies have been published investigating lifestyle indices. The main advantage of using lifestyle indices is the multidimensional approach that takes into account interrelations between different lifestyle factors.[3,4] Recently, a meta-analysis showed that adherence

From the Department of Nutrition and Food Sciences, Group of Nutritional Epidemiology, University of Bonn, North Rhine-Westphalia, Bonn, Germany

Address correspondence to: Ute Nöthlings, DrPH, Department of Nutrition and Food Sciences, Nutritional Epidemiology, University of Bonn, Endenicher Allee 11-13, 53115 Bonn, Germany. E-mail: noethlings@uni-bonn.de.

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to at least four of the following healthy behaviors: nonsmoking, not being overweight, a healthy diet, and moderate alcohol consumption or regular physical activity, was associated with a 66% lower risk of all-cause mortality compared with zero or one healthy lifestyle factor.[5] This meta-analysis by Loef et al.[5] examined overall mortality. However, as lifestyle behaviors may influence outcomes to different magnitudes, it is of great importance to investigate them separately. Lifestyle behaviors may also be different in individuals with pre-existing CVD. Moreover, for primary prevention purposes, research on the potential impact of simultaneous adherence to healthy behaviors on incident CVD risk may be of public health interest. There are several studies investigating lifestyle indices in association with CVD risk, but so far, a systematic review has not been conducted to summarize the evidence.

Therefore, the aim of the present systematic literature review and meta-analysis is to investigate and summarize the current evidence on associations between the combined impact of healthy lifestyle factors and the risk of CVD in prospective epidemiologic studies. This study also intends to provide an overview of the different lifestyle indices and CVD endpoints that were investigated with respect to combined effects of healthy lifestyle behaviors.

EVIDENCE ACQUISITION

This systematic review and meta-analysis was conducted and reported according to the Preferred Reporting Items for Systematic Reviews and Meta-Analyses (PRISMA).[6]

Systematic Literature Search

A systematic literature search through February 2018 was conducted in the databases PubMed and Web of Science by combining the following search terms: (1) *combined*, *combination*, *joint impact*, *joint effects*, *joint association*, *adherence*, *adhering*, *pattern*, *score* or *index*; (2) *lifestyle behaviors*, *lifestyle factors*, *health factors*, *healthy lifestyle*, *health behaviors*, *healthy behaviors*, *lifestyle risk factors*, *unhealthy lifestyle*, *health risk factors*, *modifiable factors*, *risk behaviors*, *recommendations*; (3) *cardiovascular disease*, *cardiovascular diseases*, *CVD*, *heart disease*, *heart diseases*, *coronary artery disease*, *myocardial infarction*, *stroke*, *cerebrovascular disease*, *cerebrovascular diseases* or *heart failure*; and (4) *prospective*, *cohort* or *longitudinal*.

Study Selection

The titles and abstracts were independently screened by two researchers to identify relevant studies. Any disagreement was resolved by consensus. The following inclusion criteria were used: (1) studies investigating the association between lifestyle indices (at least three lifestyle behaviors) and risk of overall CVD or CVD types, such as coronary heart disease (CHD), stroke, heart failure (HF), or myocardial infarction (MI); (2) prospective observational studies; (3) studies in humans; (4) participants aged ≥18 years; (5) study populations without a history of chronic diseases at baseline; (6) full-text articles published in scientific journals; (7) studies based on primary data; and (8) articles published from January 2000 up to February 15, 2018. The full texts were retrieved from all eligible studies. Further exclusion criteria were applied: (1) studies investigating the impact of a single or a combination of only two lifestyle factors; (2) studies investigating CVD mortality; (3) studies investigating health indices, including other risk factors than lifestyle behaviors; (4) studies providing no risk estimate for the impact of lifestyle indices on CVD risk for the whole study population; (5) studies investigating high-risk populations with major chronic diseases; and (6) repeated publication of the same study population. In the latter case, the study with the largest sample size or providing effect estimates for the unstratified study population was retained. No constraints were put on publication languages. The reference lists of included studies were scanned to identify additional articles meeting the eligibility criteria.

Data Extraction and Assessment of Potential Risk of Bias

The following information of each study was extracted: first author, year of publication, study characteristics (study name, country, follow-up time), subject characteristics (number of participants, sex [% men], age range), composition of the lifestyle index, outcome of interest and number of cases, multivariable-adjusted risk estimates and corresponding 95% CIs, as well as potential confounders considered in the fully adjusted model. Authors were contacted to request additional data, (e.g., data displayed in figures only).[4,7–11] However, for one study, additional data were not available and 95% CIs had to be estimated from the published figure.[12] Study quality scores were ascertained using the Newcastle–Ottawa Scale (NOS) for cohort studies.[13] The NOS has been developed to assess the methodologic quality of nonrandomized studies with regard to design and conduct. Each study was assigned a maximum of four points for selection of the study population, two points for comparability and three points for assessment of the outcome. The criteria for ascertainment of the points and the allocation of points for each study are given in Appendix Table 4 (available online).

Statistical Analyses

The multivariable-adjusted hazard ratios (HR) of CVD risk were combined using DerSimonian–Laird random effects model to account for both within- and between-study variance.[14] The data were harmonized by comparing the effect of the study-specific healthy lifestyle scores from the highest to the lowest. Moreover, meta-analyses were conducted to investigate the associations between increasing numbers of healthy lifestyle factors and risk of CVD types compared with the lowest score of a healthy lifestyle. The lowest score was defined as zero in most studies. However, in some studies, the minimum lifestyle score was zero to one. Studies with a minimum score of zero were included to investigate the association between adherence to one healthy lifestyle behavior and risk of CVD. Studies using more than one healthy behavior as a reference were excluded from these analyses.

In the present study, statistical heterogeneity between the studies was tested using I^2 index.[15] Furthermore, funnel plots were used to visually test for publication biases. The Egger's linear