

# Healthy Lifestyle Characteristics and Their Joint Association With Cardiovascular Disease Biomarkers in US Adults

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## Abstract

**Objective:** To estimate the prevalence of healthy lifestyle characteristics and to examine the association between different combinations of healthy lifestyle characteristics and cardiovascular disease biomarkers.

**Patients and Methods:** The prevalence of healthy lifestyle characteristics was estimated for the US adult population (N=4745) using 2003-2006 National Health and Nutrition Examination Survey data for the following parameters: being sufficiently active (accelerometer), eating a healthy diet (Healthy Eating Index based on 24-hour recalls), being a nonsmoker (serum cotinine level), and having a recommended body fat percentage (dual-energy X-ray absorptiometry). Cardiovascular biomarkers included mean arterial pressure, C-reactive protein, white blood cells (WBCs), total cholesterol, high-density lipoprotein cholesterol (HDL-C), total cholesterol to HDL-C ratio, fasting low-density lipoprotein cholesterol, fasting triglycerides, fasting glucose, fasting insulin, insulin resistance, hemoglobin A<sub>1c</sub>, and homocysteine. The study was conducted from August 15, 2013, through January 5, 2016.

**Results:** Only 2.7% (95% CI, 1.9%-3.4%) of all adults had all 4 healthy lifestyle characteristics. Participants with 3 or 4 compared with 0 healthy lifestyle characteristics had more favorable biomarker levels except for mean arterial blood pressure, fasting glucose, and hemoglobin A<sub>1c</sub>. Having at least 1 or 2 compared with 0 healthy lifestyle characteristics was favorably associated with C-reactive protein, WBCs, HDL-C, total cholesterol, and homocysteine. For HDL-C and total cholesterol, the strongest correlate was body fat percentage. For homocysteine, a healthy diet and not smoking were strong correlates; for WBCs, diet was not a strong correlate.

**Conclusion:** Although multiple healthy lifestyle characteristics are important, specific health characteristics may be more important for particular cardiovascular disease risk factors.

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Maintaining a healthy body fat percentage and other fundamental healthy lifestyle characteristics, including consistent physical activity, refraining from smoking, and a nutritious diet, are known to play a pivotal role in reducing the risk of cardiovascular disease, type 2 diabetes, and some cancers.<sup>1</sup> The American Heart Association's Strategic Impact Goal for 2020 and Beyond emphasizes the simultaneous adoption of these ideal healthy lifestyle characteristics to improve serum cholesterol levels, blood pressure, and blood glucose levels for cardiovascular disease risk reduction.<sup>2</sup> Although multiple co-occurring healthy lifestyle characteristics should provide added benefit toward improving health

outcomes,<sup>3-8</sup> there is limited empirical research at the national level comparing health outcomes among people who adopt different subsets of healthy lifestyle characteristics. The few relevant past studies have focused on mortality as the outcome and have used subjective measures of physical activity and smoking.<sup>9,10</sup> In particular, few studies have examined the joint association between multiple healthy lifestyle characteristics (smoking, diet, physical activity, and weight status) and cardiovascular disease biomarkers (eg, cholesterol, blood pressure, and blood glucose).<sup>5</sup> Most of the related studies to date have examined the independent associations between health outcomes and these fundamental healthy lifestyle characteristics.<sup>10</sup> Herein,

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we examine the independent and combined associations of the 4 aforementioned healthy lifestyle characteristics on various cardiovascular disease biomarkers.

The purpose of this study was 2-fold. First was to estimate the prevalence of fundamental healthy lifestyle characteristics, namely, regular physical activity, normal body fat percentage, healthy diet, and abstaining from smoking, across age, sex, and race/ethnicity for adults living in the United States. Second was to examine the association between different subsets of jointly occurring healthy lifestyle characteristics and cardiovascular disease biomarkers related to cholesterol, blood pressure, and blood sugar. To enable generalizability of the results, data from the 2003-2006 National Health and Nutrition Examination Survey (NHANES), a nationally representative sample of noninstitutionalized US adults, were used in this study.

## METHODS

### Study Design

Data were restricted to the 2003-2006 NHANES cycles because these are the only present cycles with publically available objectively measured physical activity data (ie, accelerometry data). The NHANES project is an ongoing survey conducted by the Centers for Disease Control and Prevention that selects a representative sample of noninstitutionalized US civilians by using a complex, multi-stage, stratified, clustered probability design. The design consists of 4 stages, including the identification of counties and segments (city blocks) and the random selection of households within segments and individuals within households. Data for the 2003-2006 cycle were collected from participants who were sampled across 15 geographic areas in the United States during each 2-year period starting in 2003. Participants were interviewed in their homes and then subsequently were examined in a mobile examination center (MEC) by NHANES personnel. Further details about NHANES can be found elsewhere.<sup>11-14</sup> The NHANES study procedures were approved by the National Center for Health Statistics (NCHS) ethics review board, with informed consent obtained from all the participants before data collection. The study

duration was from August 15, 2013, through January 5, 2016.

### Measurement of Physical Activity

While attending the MEC, participants were instructed to wear an ActiGraph 7164 accelerometer (ActiGraph LLC) during all activities except water-based activities and while sleeping. The accelerometer measured the frequency, intensity, and duration of physical activity by generating an activity count proportional to the measured acceleration. Detailed information on the ActiGraph accelerometer can be found elsewhere.<sup>15</sup> Estimates for moderate to vigorous physical activity (MVPA) were summarized in 1-minute intervals.<sup>16,17</sup> Activity counts greater than or equal to 2020 were classified as MVPA intensity.<sup>18</sup> For the analyses described herein, and to represent habitual physical activity patterns, only participants with activity patterns for at least 4 days of 10 or more hours per day of monitoring data were included in the analyses.<sup>18</sup> The amount of time a monitor was not worn was determined by periods with a minimum of 60 consecutive minutes of zero activity counts, with the allowance of 1 to 2 minutes of activity counts between 0 and 100.<sup>18</sup>

Participants were classified as sufficiently active if they engaged in at least 150 minutes of MVPA weekly. All MVPA minutes were used due to the low adherence (<10%) to MVPA guidelines when considering bouts of MVPA (ie, MVPA lasting  $\geq 10$  minutes). In addition, emerging research demonstrates that nonbouted and bouted MVPA have been shown to be associated with cardiovascular disease risk<sup>19</sup> and mortality<sup>20</sup> to a similar degree. In addition, and consistent with government guidelines, we also used separate duration-intensity thresholds of 150 min/wk of moderate-intensity and 75 min/wk of vigorous-intensity physical activity, or some combination of the two, to define being sufficiently active. This approach, compared with 150 min/wk of MVPA, produced similar findings (data not shown), and, as a result, herein we defined sufficient activity as at least 150 min/wk of MVPA.

The SAS (version 9.2) code provided by the National Cancer Institute was used to summarize the accelerometry data. The average time that each participant spent per

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