2013 AHA/ACC Guideline on Lifestyle Management to Reduce Cardiovascular Risk

A Report of the American College of Cardiology/American Heart Association Task Force on Practice Guidelines

Endorsed by the American Association of Cardiovascular and Pulmonary Rehabilitation, American Pharmacists Association, American Society for Nutrition, American Society for Preventive Cardiology, American Society of Hypertension, Association of Black Cardiologists, National Lipid Association, Preventive Cardiovascular Nurses Association, and WomenHeart: The National Coalition for Women with Heart Disease

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Preamble and Transition to ACC/AHA Guidelines to Reduce Cardiovascular Risk

The goals of the American College of Cardiology (ACC) and the American Heart Association (AHA) are to prevent cardiovascular (CV) diseases, improve the management of people who have these diseases through professional education and research, and develop guidelines, standards and policies that promote optimal patient care and CV health. Toward these objectives, the ACC and AHA have collaborated with the National Heart, Lung, and Blood Institute (NHLBI) and stakeholder and professional organizations to develop clinical practice guidelines for assessment of CV risk, lifestyle modifications to reduce CV risk, and management of blood cholesterol, overweight and obesity in adults.

In 2008, the NHLBI initiated these guidelines by sponsoring rigorous systematic evidence reviews for each topic by expert panels convened to develop critical questions (CQs), interpret the evidence and craft recommendations. In response to the 2011 report of the Institute of Medicine on the development of trustworthy clinical guidelines (1), the NHLBI Advisory Council (NHLBAC) recommended that the NHLBI focus specifically on reviewing the highest quality evidence and partner with other organizations to develop recommendations (2,3). Accordingly, in June 2013 the NHLBI initiated collaboration with the ACC and AHA to work with other organizations to complete and publish the 4 guidelines noted above and make them available to the widest possible constituency. Recognizing that the expert panels did not consider evidence beyond 2011 (except as specified in the methodology), the ACC, AHA and collaborating societies plan to begin updating these guidelines starting in 2014.

The joint ACC/AHA Task Force on Practice Guidelines (Task Force) appointed a subcommittee to shepherd this transition, communicate the rationale and expectations to the writing panels and partnering organizations and expeditiously publish the documents. The ACC/AHA and partner organizations recruited a limited number of expert reviewers for fiduciary examination of content, recognizing that each document had undergone extensive peer review by representatives of the NHLBAC, key Federal agencies and scientific experts. Each writing panel responded to comments from these reviewers. Clarifications were incorporated where appropriate, but there were no substantive changes as the bulk of the content was undisputed.

Although the Task Force led the final development of these prevention guidelines, they differ from other ACC/AHA guidelines. First, as opposed to an extensive compendium of clinical information, these documents are significantly more limited in scope and focus on selected CQs in each topic, based on the highest quality evidence available. Recommendations were derived from randomized trials, meta-analyses, and observational studies evaluated for quality, and were not formulated when sufficient evidence was not available. Second, the text accompanying each recommendation is succinct, summarizing the evidence for each question. The Full Panel Reports include more detailed information about the evidence statements (ESs) that serves as the basis for

recommendations. Third, the format of the recommendations differs from other ACC/AHA guidelines. Each recommendation has been mapped from the NHLBI grading format to the ACC/AHA Class of Recommendation/Level of Evidence (COR/LOE) construct (Table 1) and is expressed in both formats. Because of the inherent differences in grading systems and the clinical questions driving the recommendations, alignment between the NHLBI and ACC/AHA formats is in some cases imperfect. Explanations of these variations are noted in the recommendation tables, where applicable.

Table 1. Applying Classification of Recommendation and Level of Evidence

SIZE OF TREATMENT EFFECT

ESTIMATE OF CERTAINTY (PRECISION) OF TREATMENT EFFECT	CLASS I *Benefit >>> Risk* Procedure/Treatment **SHOULD** be performed/ administered	CLASS IIa *Benefit >> Risk* *Additional studies with focused objectives needed* **IT IS REASONABLE** to perform procedure/administer treatment	CLASS IIb *Benefit ≥ Risk* *Additional studies with broad objectives needed; additional registry data would be helpful* Procedure/Treatment **MAY BE CONSIDERED**	CLASS III *No Benefit* or CLASS III *Harm* Procedure/Test: COR III: No benefit — Not Helpful; COR III: Harm — Excess Cost w/o Benefit or Harmful Treatment: No Proven Benefit; Harmful to Patients
LEVEL A Multiple populations evaluated* Data derived from multiple randomized clinical trials or meta-analyses	■ Recommendation that procedure or treatment is useful/effective ■ Sufficient evidence from multiple randomized trials or meta-analyses	■ Recommendation in favor of treatment or procedure being useful/effective ■ Some conflicting evidence from multiple randomized trials or meta-analyses	■ Recommendation's usefulness/efficacy less well established ■ Greater conflicting evidence from multiple randomized trials or meta-analyses	■ Recommendation that procedure or treatment is not useful/effective and may be harmful ■ Sufficient evidence from multiple randomized trials or meta-analyses
LEVEL B Limited populations evaluated* Data derived from a single randomized trial or nonrandomized studies	■ Recommendation that procedure or treatment is useful/effective ■ Evidence from single randomized trial or nonrandomized studies	■ Recommendation in favor of treatment or procedure being useful/effective ■ Some conflicting evidence from single randomized trial or nonrandomized studies	■ Recommendation's usefulness/efficacy less well established ■ Greater conflicting evidence from single randomized trial or nonrandomized studies	■ Recommendation that procedure or treatment is not useful/effective and may be harmful ■ Evidence from single randomized trial or nonrandomized studies
LEVEL C Very limited populations evaluated* Only consensus opinion of experts, case studies, or standard of care	■ Recommendation that procedure or treatment is useful/effective ■ Only expert opinion, case studies, or standard of care	■ Recommendation in favor of treatment or procedure being useful/effective ■ Only diverging expert opinion, case studies, or standard of care	■ Recommendation's usefulness/efficacy less well established ■ Only diverging expert opinion, case studies, or standard of care	■ Recommendation that procedure or treatment is not useful/effective and may be harmful ■ Only expert opinion, case studies, or standard of care
Suggested phrases for writing recommendations	should is recommended is indicated is useful/effective/beneficial	is reasonable can be useful/effective/beneficial is probably recommended or indicated	may/might be considered may/might be reasonable usefulness/effectiveness is unknown/unclear/uncertain or not well established	COR III: No Benefit: is not recommended; is not indicated; should not be performed/ administered/ other; is not useful/ beneficial/ effective COR III: Harm: potentially harmful; causes harm; associated with excess morbid-ity/mortality; should not be performed/ administered/ other
Comparative effectiveness phrases†	treatment/strategy A is recommended/indicated in preference to treatment B treatment A should be chosen over treatment B	treatment/strategy A is probably recommended/indicated in preference to treatment B it is reasonable to choose treatment A over treatment B		

A recommendation with Level of Evidence B or C does not imply that the recommendation is weak. Many important clinical questions addressed in the guidelines do not lend themselves to clinical trials. Even when randomized trials are unavailable, there may be a very clear clinical consensus that a particular test or therapy is useful or effective.

*Data available from clinical trials or registries about the usefulness/efficacy in different subpopulations, such as sex, age, history of diabetes, history of prior myocardial infarction, history of heart failure, and prior aspirin use.

†For comparative effectiveness recommendations (Class I and IIa; Level of Evidence A and B only), studies that support the use of comparator verbs should involve direct comparisons of the treatments or strategies being evaluated.

In consultation with NHLBI, the policies adopted by the writing panels to manage relationships of authors with industry and other entities (RWI) are outlined in the methods section of each panel report. These policies were in effect when this effort began in 2008 and throughout the writing process and voting on recommendations, until the process was transferred to ACC/AHA in 2013. In the interest of transparency, the ACC/AHA requested that panel authors resubmit RWI disclosures as of July 2013. Relationships relevant to this guideline are disclosed in Appendix 1. None of the ACC/AHA expert reviewers had relevant RWI (Appendix 2).

Systematic evidence reports and accompanying summary tables were developed by the expert panels and NHLBI. The guideline was reviewed by the ACC/AHA Task Force and approved by the ACC Board of Trustees, the AHA Science Advisory and Coordinating Committee, and the governing bodies of partnering organizations. In addition, ACC/AHA sought endorsement by other stakeholders, including professional organizations. It is the hope of the writing panels, stakeholders, professional organizations, NHLBI, and the Task Force that the guidelines will garner the widest possible readership for the benefit of patients, providers and the public health.

Guidelines attempt to define practices that meet the needs of patients in most circumstances and are not a replacement for clinical judgment. The ultimate decision about care of a particular patient must be made by the healthcare provider and patient in light of the circumstances presented by that patient. As a result, situations might arise in which deviations from these guidelines may be appropriate. These considerations notwithstanding, in caring for most patients, clinicians can employ the recommendations confidently to reduce the risks of atherosclerotic cardiovascular disease (CVD) events.

See Tables 2 and 3 for an explanation of the NHLBI recommendation grading methodology.

Table 2. NHLBI Grading the Strength of Recommendations

Grade	Strength of Recommendation*
A	**Strong recommendation** There is high certainty based on evidence that the net benefit† is substantial.
B	**Moderate recommendation** There is moderate certainty based on evidence that the net benefit is moderate to substantial, or there is high certainty that the net benefit is moderate.
C	**Weak recommendation** There is at least moderate certainty based on evidence that there is a small net benefit.
D	**Recommendation against** There is at least moderate certainty based on evidence that it has no net benefit or that risks/harms outweigh benefits.

E	**Expert opinion ("There is insufficient evidence or evidence is unclear or conflicting, but this is what the Work Group recommends.")** Net benefit is unclear. Balance of benefits and harms cannot be determined because of no evidence, insufficient evidence, unclear evidence, or conflicting evidence, but the Work Group thought it was important to provide clinical guidance and make a recommendation. Further research is recommended in this area.
N	**No recommendation for or against ("There is insufficient evidence or evidence is unclear or conflicting.")** Net benefit is unclear. Balance of benefits and harms cannot be determined because of no evidence, insufficient evidence, unclear evidence, or conflicting evidence, and the Work Group thought no recommendation should be made. Further research is recommended in this area.

*In most cases, the strength of the recommendation should be closely aligned with the quality of the evidence; however, under some circumstances, there may be valid reasons for making recommendations that are not closely aligned with the quality of the evidence (e.g., strong recommendation when the evidence quality is moderate, like smoking cessation to reduce CVD risk or ordering an ECG as part of the initial diagnostic work-up for a patient presenting with possible MI). Those situations should be limited and the rationale explained clearly by the Work Group.
†Net benefit is defined as benefits minus risks/harms of the service/intervention.
CVD indicates cardiovascular risk; ECG, electrocardiography; MI, myocardial infarction; and NHLBI, National Heart, Lung, and Blood Institute.

Table 3. Quality Rating the Strength of Evidence

Type of Evidence	Quality Rating*
• Well-designed, well-executed† RCTs that adequately represent populations to which the results are applied and directly assess effects on health outcomes. • MAs of such studies. Highly certain about the estimate of effect. Further research is unlikely to change our confidence in the estimate of effect.	High
• RCTs with minor limitations‡ affecting confidence in, or applicability of, the results. • Well-designed, well-executed nonrandomized controlled studies§ and well-designed, well-executed observational studies‖. • MAs of such studies. Moderately certain about the estimate of effect. Further research may have an impact on our confidence in the estimate of effect and may change the estimate.	Moderate
• RCTs with major limitations. • Nonrandomized controlled studies and observational studies with major limitations affecting confidence in, or applicability of, the results. • Uncontrolled clinical observations without an appropriate comparison group (e.g., case series, case reports). • Physiological studies in humans. • MAs of such studies. Low certainty about the estimate of effect. Further research is likely to have an impact on	Low

our confidence in the estimate of effect and is likely to change the estimate.	

*In some cases, other evidence, such as large all-or-none case series (e.g., jumping from airplanes or tall structures), can represent high or moderate quality evidence. In such cases, the rationale for the evidence rating exception should be explained by the Work Group and clearly justified.
†Well-designed, well-executed refers to studies that directly address the question, use adequate randomization, blinding, allocation concealment, are adequately powered, use ITT analyses, and have high follow-up rates.
‡Limitations include concerns with the design and execution of a study that result in decreased confidence in the true estimate of the effect. Examples of such limitations include, but are not limited to: inadequate randomization, lack of blinding of study participants or outcome assessors, inadequate power, outcomes of interest are not prespecified or the primary outcomes, low follow-up rates, or findings based on subgroup analyses. Whether the limitations are considered minor or major is based on the number and severity of flaws in design or execution. Rules for determining whether the limitations are considered minor or major and how they will affect rating of the individual studies will be developed collaboratively with the methodology team.
§Nonrandomized controlled studies refer to intervention studies where assignment to intervention and comparison groups is not random (e.g., quasi-experimental study design)
‖Observational studies include prospective and retrospective cohort, case-control, and cross sectional studies.

ITT indicates intention-to-treat; MA, meta-analysis; and RCT, randomized controlled trial.

1. Introduction

1.1. Scope of Guideline

See Table 4 for the Lifestyle Expert Work Group's CQs.

A healthy lifestyle is important in the prevention of CVD, the leading cause of morbidity and mortality worldwide. The intent of the Lifestyle Work Group (Work Group) was to evaluate evidence that particular dietary patterns, nutrient intake, and levels and types of physical activity can play a major role in CVD prevention and treatment through effects on modifiable CVD risk factors (i.e., blood pressure [BP] and lipids). These ESs and recommendations may be used as appropriate in the management of hypercholesterolemia and hypertension (HTN). The target audience of the report is primary care providers.

This guideline is based on the Full Work Group Report which is provided as a supplement to the guideline. The Full Work Group Report contains background and additional material related to content, methodology, evidence synthesis, rationale, and references and is supported by the NHLBI Systematic Evidence Review which can be found at http://www.nhlbi.nih.gov/guidelines/cvd_adult/lifestyle/.

Diet and physical activity interventions of interest to the Work Group that were not included in this report due to time and resource limitations were: calcium, magnesium, alcohol, cardiorespiratory fitness, single behavioral intervention or multicomponent lifestyle interventions, the addition of lifestyle intervention to pharmacotherapy, and smoking. Outcomes of interest not covered in this evidence review were the following risk factors: diabetes mellitus- and obesity-related measurements, incident diabetes mellitus, metabolic syndrome, high-sensitivity C-reactive protein, and other inflammatory markers. The Work Group was interested in reviewing

the evidence for CVD outcomes in all of the CQs; however, the evidence for mortality and CVD outcomes was only reviewed in CQ2.

Table 4. Critical Questions

Critical Questions:	
CQ1.	Among adults*, what is the effect of dietary patterns and/or macronutrient composition on CVD risk factors, when compared to no treatment or to other types of interventions?
CQ2.	Among adults, what is the effect of dietary intake of sodium and potassium on CVD risk factors and outcomes, when compared to no treatment or to other types of interventions?
CQ3.	Among adults, what is the effect of physical activity on BP and lipids when compared to no treatment, or to other types of interventions?

*Those ≥18 years of age and <80 years of age.

BP indicates blood pressure; CQ, critical question; and CVD, cardiovascular disease.

1.2. Methodology and Evidence Review

1.2.1. Scope of the Evidence Review

To formulate the nutrition recommendations, the Work Group used randomized controlled trials (RCTs), observational studies, meta-analyses, and systematic reviews of studies carried out in adults (≥18 years) with or without established coronary heart disease (CHD)/CVD, with or without CHD/CVD risk factors, and who were of normal weight, overweight, or obese. The evidence review date range was 1998 to 2009. In order to capture historic data or more recent evidence, there were instances in which date ranges were changed for subquestions. The evidence date ranges are clearly described in each CQ section. The Work Group assessed the impact of both dietary patterns and macronutrient composition on plasma low-density lipoprotein cholesterol (LDL–C), high-density lipoprotein cholesterol (HDL–C), and triglycerides and on systolic BP and diastolic BP over a minimum RCT intervention period of 1 month in studies performed in any geographic location and research setting.

Overall, the Work Group emphasized dietary patterns rather than individual dietary components. Patterns were characterized by habitual or prescribed combinations of daily food intake. Dietary patterns offer the opportunity to characterize the overall composition and quality of the eating behaviors of a population (e.g., Mediterranean-style dietary [MED] pattern). Eating patterns consist of various combinations of foods that may differ in macronutrient, vitamin, and mineral compositions. The macronutrients saturated, *trans*, monounsaturated, and polyunsaturated fatty acids are particularly relevant for their effects on plasma lipids and lipoproteins. Dietary sodium and potassium are particularly relevant for their effects on BP. Epidemiological research has examined the dietary patterns of populations and identified associations between various patterns and CVD risk factors and outcomes. Intervention studies have tested *a priori* hypotheses involving prescribed dietary patterns specifically formulated on the basis of these data (e.g., Dietary Approaches to Stop Hypertension [DASH] or MED patterns). Population-based prospective cohort studies and RCTs suggest that there are healthier

overall dietary patterns (foods and/or their constituent macronutrient, vitamin, and mineral combinations) that are associated with lower chronic disease risk, including CVD and risk factors such as type 2 diabetes mellitus and HTN. We reviewed data exclusively on dietary intake rather than nutritional supplements provided in pharmaceutical preparations (e.g., potassium pills), because nutritional supplements may not have similar effects and are not considered "lifestyle" interventions.

The Work Group focused on CVD risk factors to provide a free-standing Lifestyle document and to inform the Blood Cholesterol guideline and the hypertension panel. It also recognized that RCTs examining the effects on hard outcomes (myocardial infarction, stroke, heart failure, and CVD related death) are difficult if not impossible to conduct for a number of reasons (e.g., long-term adherence to dietary changes). However, the Work Group also supplemented this evidence on risk factors with observational data on hard outcomes for sodium. The Work Group prioritized topics for the evidence review and was unable to review the evidence on hard outcomes for dietary patterns or physical activity.

For physical activity, substantial epidemiologic evidence links higher levels of aerobic physical activity to lower rates of CVD and other chronic diseases like type 2 diabetes mellitus. Evidence indicates there is a dose-dependent inverse relationship between levels of physical activity and rates of CVD. The proposed mechanisms mediating the relationship between physical activity and decreased CVD rates include beneficial effects on lipids, lipoproteins, BP, and type 2 diabetes mellitus. The search for evidence related to physical activity and CVD health included only systematic reviews and meta-analyses of RCTs or individual controlled clinical trials in adults (≥18 years) that were published from 2001–2011. For this CQ, the intervention was defined as physical activity interventions of any type.

Weight loss and maintenance are critical for prevention and control of CVD risk factors. The Obesity Expert Panel is simultaneously performing a systematic review of the evidence for weight management and CVD risk factors and outcomes. The primary intent of the Work Group's systematic review was to focus on the effects of diet and physical activity on CVD risk factors independent of effects on weight. Therefore, studies in which the primary outcome was weight loss or in which treatment was associated with more than 3% change in weight were excluded from the review. However, the Work Group expects that recommendations from both evidence reviews will apply to many patients.

Because of limited resources and time, the Work Group could not review every study pertaining to lifestyle and CVD risk factors and outcomes. Priority was given to strong study design and a contemporaneous timeframe (1998–2009). However, there were instances when the evidence review was extended beyond this timeframe. Landmark evidence on the effect of fatty acids on lipids was included back to 1990. The sodium evidence review included evidence through April 2012 and the physical activity meta-analysis review was extended to May 2011. Given the expertise of Work Group members and their familiarity with the literature in

this field, the Work Group is confident that a broader review would not substantially change our conclusions or recommendations.

The results of the Work Group systematic review are the 10 lifestyle recommendations (8 dietary and 2 physical activity recommendations) (Table 5). Because the Work Group was convened to inform the development of clinical guidelines and most data meeting our criteria for review were derived from studies of high-risk populations, these recommendations are directed at patients with CVD risk factors (i.e., abnormal lipids and/or pre-HTN and HTN). The majority of adults in the United States currently have 1 or more of these risk factors (33.5% with elevated LDL–C; 27.3% with HTN, and 31% pre-HTN; 11.3% with diabetes mellitus), with risk factors increasing with age (4). The Work Group encourages heart healthy nutrition and physical activity behaviors for all adults (Section 5.6) (Table 17).

For both BP and lipids, most studies of diet and/or physical activity exclude people taking antihypertensive or lipid-lowering medications. Although there is no direct evidence, it is reasonable to expect that the beneficial effects of these lifestyle recommendations apply to those taking these medications, and that following these recommendations can potentially lead to better BP and lipid control in those taking medications and/or reduced medication needs. The recommendations apply to adults <80 years old with and without CVD.

1.2.2. CQ-Based Approach

The Work Group developed an initial set of questions based on their expertise and a brief literature review to identify topics of the greatest relevance and impact for the target audience of the guideline, primary care providers. Due to time and resource limitations, the Work Group prioritized the 3 CQs in Table 4.

The body of this report is organized by CQ. For each CQ:

- The rationale for its selection is provided and methods are described.
- The ESs are presented which include a rating for quality, a rationale that supports each evidence, and a statement. A detailed description of methods is provided in the Lifestyle Systematic Evidence Review Report. The Lifestyle Full Work Group Report Supplement appendix presents documentation for search strategies and results from the search of the published literature. Recommendations including recommendation strength, accompanied by a summary of how the recommendation derives from the evidence and a discussion of issues considered by the Work Group in formulating the recommendation. The ACC/ AHA Class of Recommendation/Level of Evidence rating have also been added.

The ESs and recommendations are presented by CQ and grouped by topic:

- CQ1 presents evidence on dietary patterns and macronutrients and their effect on BP and lipids. The dietary recommendations for LDL–C lowering are described at the end of CQ1. CQ2 presents the evidence on the effect of dietary sodium and potassium intake on BP and CVD outcomes. The dietary recommendations for BP lowering are located at the end of CQ2. Finally, CQ3 presents evidence on the effect of physical activity on lipids and BP and physical activity recommendations for BP and lipid lowering. The physical activity recommendations for BP and lipid lowering are located at the end of CQ3.

It should be recognized that formulating recommendations derived from evidence reviews in response to CQs has some advantages as well as limitations. In the desire to adhere to the highest quality of evidence (Table 3), the Work Group was restricted to utilizing evidence that met inclusion/exclusion and quality criteria established by the Work Group in partnership with the methodologists. When the phrase "there is insufficient evidence" is used, the reader must distinguish between "insufficient" evidence because no studies met I/E and quality criteria were found to answer a CQ versus "insufficient" evidence where RCTs/observational studies were conducted and the available data do not provide sufficient information to formulate a recommendation. This perspective is important because clinicians could see fewer recommendations derived from expert opinion. Given this perspective, the clinical and research community can identify research questions that need to be answered in the future to refine recommendations when updates to the guideline are written (Section 6).

1.3. Organization of Panel

The Work Group was composed of 12 members and 4 ex-officio members, which included physicians and experts in BP, blood cholesterol, obesity, and lifestyle management. The authors came from primary care, nursing, pharmacology, nutrition, exercise, behavioral science, and epidemiology disciplines and also included senior scientific staff from NHLBI and the National Institutes of Health.

1.4. Document Reviews and Approval

A formal peer review process was initially completed under the auspices of the NHLBI which included 6 expert reviewers and representatives of Federal agencies. This document was also reviewed by 4 expert reviewers nominated by the ACC and the AHA when the management of the guideline transitioned to the ACC/AHA. The ACC and AHA Reviewers' RWI information is published in this document (Appendix 2).

This document was approved for publication by the governing bodies of the ACC and AHA and endorsed by the American Association of Cardiovascular and Pulmonary Rehabilitation, American Pharmacists Association, American Society for Nutrition, American Society for Preventive Cardiology, American Society of Hypertension, Association of Black Cardiologists, National Lipid Association, Preventive Cardiovascular Nurses Association, and WomenHeart: The National Coalition for Women with Heart Disease.

2. Lifestyle Management Recommendations

See Table 5 for the Lifestyle Recommendations.

Table 5. Summary of Recommendations for Lifestyle Management

Recommendations	NHLBI Grade	NHLBI Evidence Statements	ACC/AHA COR	ACC/AHA LOE
DIET				

LDL–C - Advise adults who would benefit from LDL–C lowering* to:				
1. Consume a dietary pattern that emphasizes intake of vegetables, fruits, and whole grains; includes low-fat dairy products, poultry, fish, legumes, nontropical vegetable oils and nuts; and limits intake of sweets, sugar-sweetened beverages and red meats. a. Adapt this dietary pattern to appropriate calorie requirements, personal and cultural food preferences, and nutrition therapy for other medical conditions (including diabetes mellitus). b. Achieve this pattern by following plans such as the DASH dietary pattern, the USDA Food Pattern, or the AHA Diet.	A (Strong)	**CQ1:** ES4 (high), ES6 (low), ES8 (moderate), ES9 (moderate)	I	A
2. Aim for a dietary pattern that achieves 5% to 6% of calories from saturated fat.	A (Strong)	**CQ1:** ES11(high)	I	A
3. Reduce percent of calories from saturated fat.	A (Strong)	**CQ1:** ES11(high), ES12 (moderate), ES13 (moderate)	I	A
4. Reduce percent of calories from *trans* fat.	A (Strong)	**CQ1:** ES14 (moderate), ES15 (moderate)	I	A
BP - Advise adults who would benefit from BP lowering to:				
1. Consume a dietary pattern that emphasizes intake of vegetables, fruits, and whole grains; includes low-fat dairy products, poultry, fish, legumes, nontropical vegetable oils and nuts; and limits intake of sweets, sugar-sweetened beverages and red meats. a. Adapt this dietary pattern to appropriate calorie requirements, personal and cultural food preferences, and nutrition therapy for other medical conditions (including diabetes mellitus). b. Achieve this pattern by following plans such as the DASH dietary pattern, the USDA Food Pattern, or the AHA Diet.	A (Strong)	**CQ1:** ES1 (low) ES3 (high), ES5 (high), ES6 (low), ES7 (low), ES8 (moderate)	I	A
2. Lower sodium intake.	A (Strong)	**CQ2:** ES1 (high), ES2 (moderate), ES3 (high), ES4 (high), ES5 (high), ES8 (low), ES9 (low)	I	A
3. a. Consume no more than 2,400 mg of sodium/day; b. Further reduction of sodium intake to 1,500 mg/day is desirable since it is associated with even greater reduction in BP; and c. Reduce intake by at least 1,000 mg/day since that will lower BP, even if the desired daily sodium	B (Moderate)	**CQ2:** ES2 (moderate), ES3 (high)	IIa	B

intake is not yet achieved.				
4. Combine the DASH dietary pattern with lower sodium intake.	A (Strong)	**CQ1:** ES3 (high), ES5 (high), ES8 (moderate) **CQ2:** ES1 (high), ES2 (moderate), ES3 (high), ES4 (high), ES5 (high), ES6 (moderate)	I	A
PHYSICAL ACTIVITY				
Lipids 1. In general, advise adults to engage in aerobic physical activity to reduce LDL–C and non-HDL–C: 3 to 4 sessions a week, lasting on average 40 minutes per session, and involving moderate-to-vigorous intensity physical activity.	B (Moderate)	**CQ3:** ES1 (moderate), ES2 (moderate), ES5 (low)	IIa	A
BP 1. In general, advise adults to engage in aerobic physical activity to lower BP: 3 to 4 sessions a week, lasting on average 40 minutes per session, and involving moderate-to-vigorous intensity physical activity.	B (Moderate)	**CQ3:** ES1 (high)	IIa	A

*Refer to 2013 Blood Cholesterol Guideline for guidance on who would benefit from LDL–C lowering (5).

ACC indicates American College of Cardiology; AHA, American Heart Association; BP, blood pressure; COR, Class of Recommendation; CQ, critical question; DASH, Dietary Approaches to Stop Hypertension; ES, evidence statement; HDL–C, high-density lipoprotein cholesterol; LDL–C, low-density lipoprotein cholesterol; LOE, Level of Evidence; NHLBI, National Heart, Lung, and Blood Institute; and USDA, U.S. Department of Agriculture.

3. CQ1—Dietary Patterns and Macronutrients: BP and Lipids

See Table 6 for the CQs for BP and lipids with dietary patterns and macronutrients.

Table 6. CQ for Dietary Patterns and Macronutrients: BP and Lipids

CQ1:
Among adults, what is the effect of dietary patterns and/or macronutrient composition on CVD risk factors, when compared to no treatment or to other types of interventions?

BP indicates blood pressure; CQ, critical question and CVD, cardiovascular disease.

3.1. Introduction/Rationale

The importance of nutrition in modifying the risk of CVD has been repeatedly emphasized (6-10). Historically, the role of dietary components has been the predominant focus; however, foods are typically consumed in combinations rather than individually. Over the last few years, increasing attention has been given to dietary patterns and their relationship to health outcomes such as CVD (11-19).

In intervention studies, specific dietary patterns of defined macronutrient composition are identified based upon expert evidence and *a priori* hypothesis (such as the DASH or MED patterns) and then evaluated in RCTs.

In observational studies, associations between intake and risk factors are assessed. Due to resource limitations, CVD morbidity and mortality outcomes were not included in the evidence review of this question. The charge of the Work Group was to inform the treatment of lipids and BP; therefore, those risk factors were the outcomes of focus.

3.2. Inclusion/Exclusion Criteria

Work Group members developed eligibility criteria based on a Population, Intervention, Comparator, Outcomes, Timing, and Setting (PICOTS) approach for screening potential studies for inclusion in this evidence review. The details of the PICOTS approach for CQ1 and Literature Search Yield, including summary tables, are available in the Lifestyle Full Work Group Report Supplement.

3.3. Literature Search Yield

3.3.1. Dietary Pattern/Macronutrient Composition Evidence

In all, 17 studies (28 articles) satisfied the final inclusion criteria and were rated good or fair quality (20-47).

The Dietary Pattern Summary Tables (tables B–1 through B–8) are available in the Lifestyle Full Work Group Report Supplement. The tables present summary data on the included studies organized by dietary pattern/macronutrient composition or subpopulations of interest, defined by age, sex, race, or comorbid condition. Some studies appear in more than 1 summary table because they address more than 1 corresponding macronutrient composition or dietary pattern comparison.

3.4. CQ1 Evidence Statements

3.4.1. Dietary Patterns

3.4.1.1. MED Pattern

MED pattern description (Table 7): There is no uniform definition of the MED diet in the RCTs and cohort studies examined. The most common features in these studies were diets that were: higher in fruits (particularly fresh), vegetables (emphasizing root and green varieties), whole grains (cereals, breads, rice, or pasta), and fatty fish (rich in omega–3 fatty acids); lower in red meat (and emphasizing lean meats); substituted lower-fat or fat-free dairy products for higher-fat dairy foods; and used oils (olive or canola), nuts (walnuts, almonds, or hazelnuts) or margarines blended with rapeseed or flaxseed oils in lieu of butter and other fats. The MED patterns examined tended to be moderate in total fat (32% to 35% of total calories), relatively low in saturated fat (9% to 10% of total calories), high in fiber (27 to 37 g/day), and high in polyunsaturated fatty acids (particularly omega–3s).

Table 7. ESs for BP and Lipids With the MED Pattern

Blood Pressure

ES1. • Counseling to eat a MED pattern compared to minimal advice to consume a low-fat dietary pattern in free-living middle-aged or older adults (with type 2 diabetes mellitus or at least 3 CVD risk factors) reduced BP by 6–7/2–3 mm Hg. In an observational study of healthy younger adults, adherence to a MED pattern was associated with lower BP (2–3/1–2 mm Hg).
Strength of Evidence: Low
Lipids
ES2. • Counseling to eat a MED pattern compared to minimal or no dietary advice in free-living middle aged or older adults (with or without CVD or at high risk for CVD) resulted in no consistent effect on plasma LDL–C, HDL–C, and TG, in part due to substantial differences and limitations in the studies.
Strength of Evidence: Low

BP indicates blood pressure; CVD, cardiovascular disease; ES, evidence statement; HDL–C, high-density lipoprotein cholesterol; LDL–C, low-density lipoprotein cholesterol; MED, Mediterranean style dietary; and TG, triglycerides.

3.4.1.2. DASH Dietary Pattern

DASH dietary pattern description (Table 8): The DASH dietary pattern is high in vegetables, fruits, low-fat dairy products, whole grains, poultry, fish, and nuts; and low in sweets, sugar-sweetened beverages, and red meats. The DASH dietary pattern is low in saturated fat, total fat, and cholesterol. It is rich in potassium, magnesium, and calcium, as well as protein and fiber.

Table 8. ESs for BP and Lipids With the DASH Pattern

Blood Pressure
ES3. • When all food was supplied to adults with BP 120–159/80–95 mm Hg and both body weight and sodium intake were kept stable, the DASH dietary pattern, when compared to a typical American diet of the 1990s, lowered BP by 5–6/3 mm Hg.
Strength of Evidence: High
Lipids
ES4. • When food was supplied to adults with a total cholesterol level <260 mg/dL, LDL–C <160 mg/dL, and body weight was kept stable, the DASH dietary pattern, when compared to a typical American diet of the 1990s, lowered LDL–C by 11 mg/dL, lowered HDL–C by 4 mg/dL, and had no effect on TG.
Strength of Evidence: High
DASH DIETARY PATTERN SUBPOPULATIONS
Subpopulations and BP
ES5. • When all food was supplied to adults with BP 120–159/80–95 mm Hg and body weight was kept stable, the DASH dietary pattern, when compared with the typical American diet of the 1990s, lowered BP in women and men; African-American and nonAfrican American adults; older and younger adults; and hypertensive and nonhypertensive adults.
Strength of Evidence: High
Subpopulations and Lipids
ES6. • When all food was supplied to adults with a total cholesterol level <260 mg/dL, LDL–C <160 mg/dL, and body weight was kept stable, the DASH dietary pattern, as compared to a typical American diet of the 1990s, lowered LDL–C similarly in subgroups: African American and nonAfrican American, and hypertensive and nonhypertensive.
Strength of Evidence: Low
ES7.

• When all food was supplied to adults with a total cholesterol level <260 mg/dL, LDL–C <160 mg/dL, and body weight was kept stable, the DASH dietary pattern, as compared to a typical American diet of the 1990s, lowered HDL–C similarly in subgroups: African American and nonAfrican American; hypertensive and nonhypertensive; and men and women.
Strength of Evidence: Low

BP indicates blood pressure; DASH, Dietary Approaches to Stop Hypertension; ES, evidence statement; HDL–C, high-density lipoprotein cholesterol; LDL–C, low-density lipoprotein cholesterol; and TG, triglycerides.

3.4.1.3. DASH Variations

DASH variations description (Table 9): In OmniHeart (Optimal Macronutrient Intake Trial for Heart Health), 2 variations of the DASH dietary pattern were compared to DASH: one which replaced 10% of total daily energy from carbohydrate with protein; the other which replaced the same amount of carbohydrate with unsaturated fat. These patterns were studied in an adequately powered crossover trial of 164 adults in which the participants were given all of their daily food.

Table 9. ESs for DASH Variations/Glycemic Index/Load Dietary Approaches

Blood Pressure
ES8. • In adults with BP of 120–159/80–95 mm Hg, modifying the DASH dietary pattern by replacing 10% of calories from carbohydrates with the same amount of either protein or unsaturated fat (8% monounsaturated and 2% polyunsaturated) lowered systolic BP by 1 mm Hg compared to the DASH dietary pattern. Among adults with BP 140–159/90–95 mm Hg, these replacements lowered systolic BP by 3 mm Hg relative to DASH.
Strength of Evidence: Moderate
Lipids
ES9. • In adults with average baseline LDL–C 130 mg/dL, HDL–C 50 mg/dL, and TG 100 mg/dL, modifying the DASH dietary pattern by replacing 10% of calories from carbohydrates with 10% of calories from protein lowered LDL–C by 3 mg/dL, HDL–C by 1 mg/dL, and TG by 16 mg/dL compared to the DASH dietary pattern. Replacing 10% of calories from carbohydrates with 10% of calories from unsaturated fat (8% monounsaturated and 2% polyunsaturated) lowered LDL–C similarly, increased HDL–C by 1 mg/dL, and lowered TG by 10 mg/dL compared to the DASH dietary pattern.
Strength of Evidence: Moderate
ES10. • There is insufficient evidence to determine whether low-glycemic diets versus high-glycemic diets affect lipids or BP for adults without diabetes mellitus. The evidence for this relationship in adults with diabetes mellitus was not reviewed.
Strength of Evidence: Insufficient

BP indicates blood pressure; DASH, Dietary Approaches to Stop Hypertension; ES, evidence statement; HDL–C, high-density lipoprotein cholesterol; LDL–C, low-density lipoprotein cholesterol; and TG, triglycerides.

3.4.2. Dietary Fat and Cholesterol

See Table 10 for ESs for saturated fat, *trans* fat, and dietary cholesterol.

Table 10. ESs for Dietary Fat and Cholesterol

Saturated Fat
ES11. • When food was supplied to adults in a dietary pattern that achieved a macronutrient composition of 5% to 6% saturated fat, 26% to 27% total fat, 15% to 18% protein, and 55% to 59% carbohydrate compared to the control diet (14% to 15%

saturated fat, 34% to 38% total fat, 13% to 15% protein, and 48% to 51% carbohydrate) LDL–C was lowered 11–13 mg/dL in 2 studies, and 11% in another study.
Strength of Evidence: High

ES12.
• In controlled feeding trials among adults, for every 1% of energy from SFA that is replaced by 1% of energy from carbohydrate, MUFA, or PUFA:
  • LDL–C is lowered by an estimated 1.2, 1.3, and 1.8 mg/dL, respectively.
  • HDL–C is lowered by an estimated 0.4, 1.2, and 0.2 mg/dL, respectively.
• For every 1% of energy from SFA that is replaced by 1% of energy from:
  • Carbohydrate and MUFA, TG are raised by an estimated 1.9 and 0.2 mg/dL, respectively.
  • PUFA, TG are lowered by an estimated 0.4 mg/dL.

Strength of Evidence: Moderate

ES13.
• In controlled feeding trials among adults, for every 1% of energy from carbohydrate that is replaced by 1% of energy from:
  • MUFA, LDL–C is lowered by 0.3 mg/dL, HDL–C is raised by 0.3 mg/dL, and TG are lowered by 1.7 mg/dL.
  • PUFA, LDL–C is lowered by 0.7 mg/dL, HDL–C is raised by 0.2 mg/dL, and TG are lowered by 2.3 mg/dL.

Strength of Evidence: Moderate
Trans Fat

ES14.
• In controlled feeding trials among adults, for every 1% of energy from *trans* monounsaturated fatty acids replaced with 1% of energy from:
  • MUFA or PUFA, LDL–C is lowered by 1.5 mg/dL and 2.0 mg/dL, respectively.
  • SFA, MUFA, or PUFA, HDL–C is increased by an estimated 0.5, 0.4 and 0.5 mg/dL, respectively. MUFA or PUFA, TG is decreased by an estimated 1.2 and 1.3 mg/dL.

Strength of Evidence: Moderate
ES15. • In controlled feeding trials among adults, the replacement of 1% of energy as *trans* monounsaturated fatty acids with carbohydrate decreased LDL–C cholesterol levels by 1.5 mg/dL, and had no effect on HDL–C cholesterol and TG levels.
Strength of Evidence: Moderate
Dietary Cholesterol
ES16. • There is insufficient evidence to determine whether lowering dietary cholesterol reduces LDL–C.
Strength of Evidence: Insufficient

ES indicates evidence statement; HDL–C, high-density lipoprotein cholesterol; LDL–C, low-density lipoprotein cholesterol; MUFA, monounsaturated fatty acids; PUFA, polyunsaturated fatty acids; SFA, saturated fatty acid; and TG, triglycerides.

3.5. Diet Recommendations for LDL–C Lowering*

The following diet recommendations for LDL–C-lowering are based on the ESs from CQ1 on dietary patterns and fatty acids. Diet recommendations for BP lowering are based on CQ1 and CQ2 and located after the CQ2 ESs. The physical activity and lipids ESs and recommendations are located in CQ3.

1. Advise adults who would benefit from LDL–C lowering to:

* Refer to 2013 Blood Cholesterol Guideline for guidance on who would benefit from LDL–C lowering.

- **Consume a dietary pattern that emphasizes intake of vegetables, fruits, and whole grains; includes low-fat dairy products, poultry, fish, legumes, nontropical vegetable oils, and nuts; and limits intake of sweets, sugar-sweetened beverages, and red meats.**
    - **Adapt this dietary pattern to appropriate calorie requirements, personal and cultural food preferences, and nutrition therapy for other medical conditions (including diabetes mellitus).**
    - **Achieve this pattern by following plans such as the DASH dietary pattern, the USDA Food Pattern, or the AHA Diet.**

NHLBI Grade: A (Strong); *ACC/AHA COR: I, LOE: A*

Rationale: This recommendation is based largely on studies of the DASH dietary pattern (DASH and DASH-Sodium), which provided the highest quality evidence for a dietary pattern causing improvements in BP and lipid profiles (Tables 8 and 9). The LDL–C lowering effect has been demonstrated in men and women, African Americans and non-African Americans, and in adults of all ages (ES6 Table 8). The evidence suggests that the effects of the recommended dietary pattern persist as long as the pattern is consumed.

The caloric (energy) intake should be appropriate for the individual–e.g., restricted for those attempting weight loss. Patients should also be encouraged to adapt the recommended dietary pattern to their personal and cultural preferences. Materials are available to assist patients in achieving the recommended dietary pattern at different calorie levels (Table 9). The 2010 U.S. Department of Health and Human Services Dietary Guidelines for Americans recommend the USDA food pattern and the DASH eating plan (48). Overall, the recommended dietary pattern is consistent with the AHA diet (49) and the USDA Food Pattern (48). The USDA Food Pattern offers lacto-ovo vegetarian and vegan adaptations. Therefore, this recommendation is consistent with other national guidelines. Clinicians should be familiar with the recommendations, advise their patients to adopt them, and provide easy access to information (Table 11). Dietary planning and nutritional counseling is often facilitated by referral to a nutrition professional.

Table 11. Resources and Information for Dietary Planning

DASH Eating Plan
Your Guide to Lowering Your Blood Pressure With DASH
Your Guide to Lowering Your Blood Pressure With DASH Brochure
AHA Diet and Lifestyle Recommendations
AHA Diet and Lifestyle Recommendations Article
AHA Diet and Lifestyle Recommendations 2006 Scientific Statement (10)
Dietary Guidelines for Americans
2010 Dietary Guidelines for Americans (48)
2011 Dietary Guidelines for Americans Brochure
USDA Food Patterns

AHA indicates American Heart Association; DASH, Dietary Approaches to Stop Hypertension; and USDA, U.S. Department of Agriculture.

2. Advise adults who would benefit from LDL–C lowering to:

- **Aim for a dietary pattern that achieves 5% to 6% of calories from saturated fat.**

NHLBI Grade: A (strong); *ACC/AHA COR: I, LOE: A*

Rationale: As described in ES11 Table 10, there is strong evidence that the reductions in LDL–C were achieved when consuming dietary patterns in which saturated fat intake was reduced from 14% to 15% of calories to 5% to 6%. As previously noted, these studies did not isolate the effect of saturated fat on LDL–C lowering. Intakes of saturated fat have decreased in the United States over the last few decades, currently estimated at 11% of energy in the U.S. population ≥2 years of age (50). However, this level of saturated fat is higher than that tested in the DASH and DELTA (Dietary Effects on Lipoproteins and Thrombogenic Activity) trials (5% to 6%) and is not consistent with consuming a diet rich in vegetables, fruits, low-fat dairy products, whole grains, poultry, fish, legumes and nuts, and vegetable oils; and limited in sweets, sugar-sweetened beverages, and red meat. Given the current average intake of saturated fat at 11%, it would be beneficial for those who would benefit from LDL–C lowering to decrease saturated fat intake to 5% to 6% of calories.

3. Advise adults who would benefit from LDL–C lowering to:

- **Reduce percent of calories from saturated fat.**

NHLBI Grade: A (strong); *ACC/AHA COR: I, LOE: A*

Rationale: Reducing saturated fat intake lowers both LDL–C and HDL–C. Since the absolute effect tends to be greater for LDL–C than HDL–C, reducing saturated fat intake has a beneficial effect on the lipid profile. Given that reducing saturated fat intake lowers LDL–C regardless of whether the saturated fat is replaced by carbohydrate, monounsaturated fatty acids, or polyunsaturated fatty acids, the Work Group does not specify which of these 3 macronutrients should be substituted in place of saturated fat. However, favorable effects on lipid profiles are greater when saturated fat is replaced by polyunsaturated fatty acids, followed by monounsaturated fatty acids, and then carbohydrates. It is important to note that there are various types and degrees of refinement of carbohydrates. Substitution of saturated fat with whole grains is preferable to refined carbohydrates. For American adults who eat more saturated fat than the current average, some reduction is warranted, and adhering to a “heart healthy” dietary pattern from the dietary recommendation #1 for LDL–C lowering will likely result in a reduction of saturated fat.

4. Advise adults who would benefit from LDL–C lowering to:

- **Reduce percent of calories from *trans* fat.**

NHLBI Grade: A (strong); *ACC/AHA COR: I, LOE: A*

Rationale: Reducing intake of *trans* fatty acids lowers LDL–C, with little or no effect on HDL–C or triglycerides levels. The direction of the relationship between *trans* fatty acids and LDL–C is consistent, regardless of whether the *trans* fatty acids replace carbohydrates, monounsaturated fatty acids, or polyunsaturated fatty acids. Using 2003–2006 NHANES (National Health and Nutrition Examination Survey) data, intake of trans fat from partially

hydrogenated oils was estimated at a mean of 1.3 to 1.6 g/day among the U.S. population ≥2 years of age (51). Although the intake level appears low, certain subgroups within the U.S. population may still be consuming relatively high levels of *trans* fatty acids. For this reason, the Work Group recommends that emphasis continue to be placed on the reduction of *trans* fat in the diet. Even if intake of *trans* fat from partially hydrogenated oils decreases, naturally occurring *trans* fatty acids in the form of ruminant fat from meat and dairy products may still be present in small amounts in the U.S. diet. Adhering to the recommendation to reduce dietary sources of saturated fat (meat and dairy fat) will result in additional reductions in *trans*-fat intake.

4. CQ2—Sodium and Potassium: BP and CVD Outcomes

See Table 12 for the CQs on BP and CVD outcomes with sodium and potassium.

Table 12. CQ for Sodium and Potassium: BP and CVD Outcomes

CQ2:
Among adults, what is the effect of dietary intake of sodium and potassium on CVD risk factors and outcomes, when compared to no treatment or to other types of interventions?

BP indicates blood pressure; CQ, critical question; and CVD, cardiovascular disease.

4.1. Introduction and Rationale

Vitamins and minerals typically are consumed in foods. However, it is sometimes possible to isolate the effect of individual minerals to determine the effects on health outcomes. Therefore, the Work Group decided that a systematic review was warranted to determine the individual effects of the minerals sodium and potassium, which have been associated with CVD risk factors and outcomes. Other minerals like calcium and magnesium were also considered, but were not included in the systematic review because their consumption is limited to relatively few specific foods or food groups (e.g., calcium and dairy products); further, it was unlikely that a recommendation to increase or decrease consumption of the mineral rather than the food could be implemented.

In contrast, sodium was reviewed as a single nutrient because little sodium is found naturally in food, and it is primarily added to foods in preparation, preservation, and/or at the time of consumption. Therefore, it is theoretically possible to alter sodium intake without altering intake of specific foods or overall dietary pattern. In addition, potassium was reviewed as a single nutrient because it has been hypothesized that dietary potassium intake may lower BP independent of other nutrients or foods. In addition, the effect of sodium on BP may be modulated by concomitant potassium intake.

Most of the clinical trial evidence pertains to effects of minerals on risk factors (i.e., BP and plasma lipids) that are relevant, intermediate outcomes for CVD. In addition, data primarily from observational studies provide evidence on the effects of dietary sodium and potassium on outcomes that are CVD events.

4.2. Selection of Inclusion/Exclusion Criteria

Work Group members developed eligibility criteria based on a PICOTS approach for screening potential studies for inclusion in the evidence review. The PICOTS approach for CQ2 and other detailed methods are in the Lifestyle Work Group Systematic Evidence Review report.

CQ2 was established to examine studies that assessed the impact of sodium and potassium on BP and CV morbidity and mortality. The studies included adults with or without established CVD, with or without CVD risk factors, with or without tobacco use, and who were of normal weight, overweight, or obese. In addition an intervention sample size must be at least 50 for biomarker and risk factor studies and 500 for CV morbidity and mortality. Because there is a separate Obesity Expert Panel reviewing evidence on the effect of weight loss on CVD risk factors and outcomes, the Work Group excluded studies in which weight change was >3%.

4.3. Literature Search Yield

In all, 34 studies (47 citations) satisfied the CQ2 inclusion criteria and were rated good or fair quality (30,31,45,46,52-93).

The CQ2 summary tables are available in the Lifestyle Full Work Group Report Supplement. The tables present data on the studies used in the evidence review organized by mineral (sodium or potassium), outcomes (BP or CVD outcomes), sodium subquestions (overall results, different levels of sodium, sodium and other dietary changes), and subpopulations (sex, Summary Table C–4a; race/ethnicity, Summary Table C–4b; age, Summary Table C–4c; and HTN-status, Summary Table C–4d). Some studies appear in more than one summary table because they address more than one corresponding mineral or subquestion.

4.4. CQ2 Evidence Statements

See Table 13 for the CQ2 ESs for sodium and BP.

4.4.1. Sodium and BP

A note about the unit of measure presented for dietary and urinary sodium: sodium is presented in studies in millimoles (mmols), grams, and milligrams (mg). The Work Group chose to convert the sodium results to milligrams for the ESs, recommendations, and rationales so data from different studies would be displayed in a consistent unit. Also, U.S. dietary recommendations and the Nutrition Facts label display sodium in milligrams, and this unit (mg) will be easier for health care providers to communicate with patients. Urinary and dietary sodium are portrayed in the original units from each published study in the CQ2 summary tables (C–1 to C–8.

Table 13. CQ2 ESs for Sodium and BP

Overall Results of Sodium and the Effect on BP
What is the Overall Effect of Dietary Intake of Sodium on BP? **ES1.** • In adults 25 to 80 years of age with BP 120–159/80–95 mm Hg, reducing sodium intake lowers BP.
Strength of Evidence: High

Comparison of Different Levels of Sodium Intake
What is the Effect of Different Levels of Dietary Sodium Intake on BP? **ES2.** • In adults 25 to 75 years of age with BP 120–159/80–95 mm Hg, reducing sodium intake that achieved a mean 24-hour urinary sodium excretion of approximately 2,400 mg/day, relative to approximately 3,300 mg/day, lowers BP by 2/1 mm Hg, and reducing sodium intake that achieved a mean 24-hour urinary sodium excretion of approximately 1,500 mg/day lowers BP by 7/3 mm Hg.
Strength of Evidence: Moderate
ES3. • In adults 30 to 80 years of age with or without HTN, counseling to reduce sodium intake by an average of 1,150 mg/day reduces BP by 3–4/1–2 mm Hg.
Strength of Evidence: High
Sodium and in Subpopulations
What is the Effect of Sodium on BP in Subgroups Defined by Sex, Race/Ethnicity, Age, and HTN Status? **ES4.** • In adults with pre-HTN or HTN, reducing sodium intake lowers BP in women and men; African American and nonAfrican American adults; and older and younger adults.
Strength of Evidence: High
ES5. • Reducing sodium intake lowers BP in adults with either pre-HTN or HTN when eating either the typical American diet or the DASH dietary pattern. The effect is greater in those with HTN.
Strength of Evidence: High
Sodium and Dietary Pattern Changes
What is the Effect of Sodium on BP in the Context of Dietary Pattern Changes? **ES6.** • In adults 22 to 80 years of age with BP 120-159/80-95 mm Hg, the combination of reduced sodium intake plus eating the DASH dietary pattern lowers BP more than reduced sodium intake alone.
Strength of Evidence: Moderate
Sodium in the Context of Other Minerals and BP
What is the Effect of Sodium on BP in the Context of Other Single Minerals? **ES7.** • There is insufficient evidence from RCTs to determine whether reducing sodium intake plus changing dietary intake of any other single mineral (for example, increasing potassium, calcium, or magnesium) lowers BP more than reducing sodium intake alone.
Strength of Evidence: Insufficient
Sodium and CHD/CVD Outcomes
What is the Effect of Dietary Intake of Sodium on CVD Outcomes? **ES8.** • A reduction in sodium intake of approximately 1,000 mg/day reduces CVD events by about 30%.
Strength of Evidence: Low
ES9. • Higher dietary sodium intake is associated with a greater risk of fatal and nonfatal stroke and CVD.
Strength of Evidence: Low
ES10. • There is insufficient evidence to determine the association between sodium intake and the development of HF.
Strength of Evidence: Insufficient
ES11. • There is insufficient evidence to assess the effect of reducing dietary sodium intake on cardiovascular outcomes in patients with existing HF.
Strength of Evidence: Insufficient
Potassium and BP and CHD/CVD Outcomes
What is the Effect of Dietary Intake of Potassium on BP and CVD Outcomes? **ES12.**

• There is insufficient evidence to determine whether increasing dietary potassium intake lowers BP.
Strength of Evidence: Insufficient
ES13. • In observational studies with appropriate adjustments (BP, sodium intake, etc.), higher dietary potassium intake is associated with lower stroke risk.
Strength of Evidence: Low
ES14. • There is insufficient evidence to determine whether there is an association between dietary potassium intake and CHD, HF, and cardiovascular mortality
Strength of Evidence: Insufficient

BP indicates blood pressure; CHD, congestive heart disease; CVD, cardiovascular disease; DASH, Dietary Approaches to Stop Hypertension; ES, evidence statement; and HF, heart failure; HTN, hypertension; and RCTs, randomized controlled trials.

4.5. Diet Recommendations for BP Lowering

1. **Advise adults who would benefit from BP lowering to:**
    a. **Consume a dietary pattern that emphasizes intake of vegetables, fruits, and whole grains; includes low-fat dairy products, poultry, fish, legumes, nontropical vegetable oils, and nuts; and limits intake of sweets, sugar-sweetened beverages, and red meats.**
        i. **Adapt this dietary pattern to appropriate calorie requirements, personal and cultural food preferences, and nutrition therapy for other medical conditions (including diabetes mellitus).**
        ii. **Achieve this pattern by following plans such as the DASH dietary pattern, the USDA Food Pattern, or the AHA Diet.**

NHLBI Grade: A (strong); ACC/AHA COR: I, LOE: A

Rationale: This recommendation is based largely on studies of the DASH dietary pattern (DASH and DASH-Sodium), which provided the highest quality evidence for this food-based dietary pattern causing improvements in lipid profiles and BP (Table 8 and 9, CQ1 ES3-ES9). This evidence was supplemented by studies of low quality in which various adaptations of the MED pattern were tested and also found to reduce BP (Table 7, CQ1 ES1). The evidence suggests that the effects of the recommended dietary pattern persist as long as the pattern is consumed. The BP lowering effect has been demonstrated in adults with HTN and pre-HTN, and is evident in men and women, African Americans and non-African Americans, and in older and younger adults (Table 8, ES5). The dietary pattern's effect on BP is independent of changes in weight and sodium intake. The magnitude of effect is sufficient to prevent progression from pre-HTN to HTN, promote nonpharmacological BP control in those with HTN, and supplement pharmacological BP lowering.

The caloric (energy) intake should be appropriate for the individual–e.g., restricted for those attempting weight loss. Patients should also be encouraged to adapt the recommended dietary pattern to their personal and cultural preferences. Materials are available to assist patients in achieving the recommended dietary pattern at different calorie levels (Table 9). The 2010 U.S. Department of Health and Human Services Dietary Guidelines for Americans recommend the USDA food pattern and the DASH eating plan (48). Overall, the recommended

dietary pattern is consistent with the AHA diet (49) and the USDA Food Pattern (48). The USDA Food Pattern offers lacto-ovo vegetarian and vegan adaptations. Therefore, this recommendation is consistent with other national guidelines. Clinicians should be familiar with the recommendations, advise their patients to adopt them, and provide easy access to information (Table 11). Dietary planning and nutritional counseling is often facilitated by referral to a nutrition professional.

2. **Advise adults who would benefit from BP lowering to:**
    a. **Lower sodium intake**

NHLBI Grade: A (strong); ACC/AHA COR: I, LOE: A

Rationale: There is strong and consistent clinical trial evidence that reducing sodium intake lowers BP. This BP-lowering effect has been demonstrated in adults with HTN and pre-HTN, in men and women, in African Americans and nonAfrican Americans, and in older and younger adults. Trials contributing to this evidence include well-controlled feeding studies as well as studies in which participants were counseled to lower sodium. The effect of reducing sodium intake on BP is independent of changes in weight. The magnitude of effect is sufficient to both prevent progression from pre-HTN to HTN, and to promote nonpharmacological BP control in those with HTN. Observational data also suggest that lower sodium intake is associated with lower risk of CV events in people with and without HTN, which is hypothesized to occur through reductions in BP.

3. **Advise adults who would benefit from BP lowering to:**
    a. **Consume no more than 2,400 mg/day of sodium;**
    b. **Further reduction of sodium intake to 1,500 mg/day is desirable since it is associated with an even greater reduction in BP; and**
    c. **Reduce sodium intake by at least 1,000 mg/day since that will lower BP, even if the desired daily sodium intake is not yet achieved.**

NHLBI Grade: B (moderate); ACC/AHA COR: IIa, LOE: B

Rationale: One well-conducted trial demonstrated clinically meaningful lowering of BP when sodium was reduced to 2,400 mg/day with lower BPs achieved when sodium intake was reduced to 1,500 mg/day. Reductions of 1,000 mg/day were shown to be beneficial in trials, and observational studies estimated significant reductions in relative risk associated with changes in sodium intake of about 1,000 mg/day. This recommendation is directed at the two-thirds of the U.S. adults who have pre-HTN or HTN, and for whom reducing sodium intake can prevent or improve control of HTN and potentially reduce CV events.

The Work Group acknowledges that the recommendation to reduce sodium intake <2,400 mg/day differs slightly from other current dietary recommendations, specifically the 2010 Dietary Guidelines for Americans and the Institute of Medicine Dietary Reference Intakes; both of these publications recommend 2,300 mg/day as the upper limit of intake for adults. Although the impact on behavior of a difference between intakes of 2,400 mg

versus 2,300 mg of sodium per day would be minimal, these recommendations are based on the strongest clinical trial evidence available: the achieved level of 2,400 mg/day from the DASH-Sodium trial (estimated from average urinary sodium excretion) (Table 11, CQ2 ES2).

The strength of this recommendation is graded "moderate" because there are fewer clinical trials used to devise the 2,400 and 1,500 goals compared to the large number of trials that are used to inform the overall recommendation on sodium (dietary recommendation #2 for BP lowering) that is graded "strong."

Reducing sodium intake can be challenging for an individual because of the ubiquitous nature of sodium in the American food supply. Educational materials with strategies to help patients lower sodium intake are provided by several Federal and private sources (48,94-97). Ultimately, however, significant changes in sodium intake among U.S. adults may require changes in both individual behavior and in food manufacturing and processing.

4. **Advise adults who would benefit from BP lowering to:**
    a. **Combine the DASH dietary pattern with lower sodium intake.**

NHLBI Grade: A (strong); ACC/AHA COR: I, LOE: A

Rationale: Both a healthy dietary pattern as exemplified by DASH and reduced sodium intake independently reduces BP. However, the BP-lowering effect is even greater when these dietary changes are combined. In the 60% of U.S. adults with pre-HTN or HTN, simultaneously implementing dietary recommendations #1 and #2 for BP lowering can prevent and control HTN more than either intervention alone.

5. CQ3—Physical Activity: Lipids and BP

See Table 14 for the CQ for physical activity and lipids and BP.

Table 14. CQ for Physical Activity: Lipids and BP

CQ3:
Among adults, what is the effect of physical activity on BP and lipids when compared to no treatment, or to other types of interventions?

BP indicates blood pressure and CQ, critical question.

5.1. Introduction/Rationale

Large bodies of observational data show an association between higher levels of physical activity and lower rates of many chronic diseases, including CVD, and enhanced longevity (98-100). Further, an inverse dose-response relation exists, with increasing higher levels of activity associated with commensurately lower rates of CVD in a curvilinear fashion (101,102). A recent analysis has estimated that by eliminating physical inactivity, 6% of CHD worldwide may be eliminated; further, life expectancy of the world may be increased by 0.68 years (103).

Among the mechanisms proposed to mediate the relationship between physical activity and decreased CVD rates are beneficial effects of exercise on lipid profile and BP (104). One study estimated that the effects of

physical activity on BP and development of HTN reduction explained some 27% of the activity-related reduction in CVD rates observed, while 19% of the reduction in CVD rates could be explained by the beneficial effects of physical activity on traditional lipids, and 16% on novel lipids.

Below, the Work Group elaborates on findings from meta-analyses of physical activity on changes in lipid profile and BP.

5.2. Selection of Inclusion/Exclusion Criteria

Due to resource limitations, the Work Group included only systematic reviews and meta-analyses of RCTs or controlled clinical trials published from 2001–2011. Detailed inclusion/exclusion criteria are available in the Lifestyle Full Work Group Report Supplement.

5.3. Literature Search Yield

A total of 26 systematic reviews and meta-analyses were identified that met inclusion/exclusion criteria and were rated good or fair (105-129).

The CQ3 subcommittee members next identified the included systematic reviews and meta-analyses that contained detailed data on BP outcomes. They identified 11 studies with data on BP outcomes. Ten meta-analyses and 1 systematic review examined the effects of aerobic exercise. One systematic review looked at the effects of resistance training.

The CQ3 subcommittee members next identified the included systematic reviews and meta-analyses that contained detailed data on lipid outcomes. They identified 14 studies with data on lipid outcomes, including 10 meta-analyses, and 4 systematic reviews.

The next step in the evidence review process for systematic reviews and meta-analyses was to develop ESs and recommendations from the included studies and present them to the full Work Group for consideration and voting. Because these systematic review and meta-analysis articles each summarize evidence from a number of studies, NHLBI staff and Work Group members determined that the development of formal evidence tables and summary tables of individual articles was unnecessary. CQ3 subcommittee members developed evidence tables that are available in the Lifestyle Full Work Group Report Supplement (CQ3 Summary Tables: Summary Table D–1: Aerobic Exercise and LDL–C, Summary Table D–2: Resistance Exercise and LDL–C, Summary Table D–3: Aerobic Exercise and HDL–C, and Summary Table D–4: Resistance Exercise and HDL–C) to summarize the evidence on physical activity and lipids.

5.4. CQ3 Evidence Statements

5.4.1. Physical Activity and Lipids

See Table 15 for the CQ3 ESs for physical activity and lipids.

This section examines evidence supporting the use of physical activity alone (i.e., not in combination with other interventions, such as dietary interventions or weight loss) versus no physical activity or other type of intervention for improvements in selected blood lipids (HDL–C, LDL–C, triglycerides, and non-HDL–C). The *2008 Physical Activity Guidelines Advisory Committee Report* was used as the starting point for evidence review (98). Additionally, a systematic search identified 8 meta-analyses from 2001 onwards and 5 systematic reviews rated fair to good that addressed this question and were included as the evidence base.

Table 15. ESs for Physical Activity and Lipids

Aerobic Exercise Training and Lipids
ES1. • Among adults, aerobic physical activity, as compared to control interventions, reduces LDL–C 3.0 to 6.0 mg/dL on average.
Strength of Evidence: Moderate
ES2. • Among adults, aerobic physical activity alone, as compared to control interventions, reduces non-HDL–C 6 mg/dL on average.
Strength of Evidence: Moderate
ES3. • Among adults, aerobic physical activity alone, as compared to control interventions, has no consistent effect on TG.
Strength of Evidence: Moderate
ES4. • Among adults, aerobic physical activity alone, as compared to control interventions, has no consistent effect on HDL–C.
Strength of Evidence: Moderate
Resistance Exercise Training and Lipids
ES5. • Among adults, resistance training, as compared to control interventions, reduces LDL–C, TG, and non-HDL–C by 6 mg/dL to 9 mg/dL on average and has no effect on HDL–C. Typical interventions shown to reduce LDL–C, TG, and non-HDL–C and have no effect on HDL–C include resistance physical activity programs that average 24 weeks in duration and include ≥3 days/week, 9 exercises performed for 3 sets and 11 repetitions at an average intensity of 70% of 1-maximal repetition.
Strength of Evidence: Low

ES indicates evidence statements: HDL–C, high-density lipoprotein- cholesterol; LDL–C, low-density lipoprotein-cholesterol; and TG, triglycerides.

5.4.2. Physical Activity and BP

This section examines evidence supporting the use of physical activity alone (i.e., not in combination with other interventions, such as dietary interventions or weight loss) versus no physical activity or other types of intervention for BP reduction. The *2008 Physical Activity Guidelines Advisory Committee Report* was used as the starting point for evidence review (98). Additionally, a systematic search identified 15 meta-analyses from 2001 onwards and reviews rated fair to good that addressed this question. Details of the search are provided in the Lifestyle Full Work Group Report Supplement.

5.4.2.1. Aerobic Exercise Training and BP

See Table 16 for the ES for aerobic exercise training and BP.

Table 16. ES for Aerobic Exercise Training and BP

ES1. • Among adult men and women at all BP levels, including individuals with HTN, aerobic physical activity decreases systolic and diastolic BP, on average by 2 to 5 mm Hg and 1 to 4 mm Hg, respectively. Typical interventions shown to be effective for lowering BP include aerobic physical activity of, on average, at least 12 weeks duration, 3 to 4 sessions per week, lasting on average 40 minutes/session, and involving moderate-to-vigorous intensity physical activity.
Strength of Evidence: High

BP indicates blood pressure and ES, evidence statement.

5.4.2.2. Resistance Exercise Training and BP

The *2008 Physical Activity Guidelines Advisory Committee* focused on data from a meta-analysis of 9 RCTs of resistance training that included 341 subjects (130). However, in the systematic search described above for CQ3 (Section 5.3), given the limited parameters of the search, only 1 review was identified. A qualitative review of clinical trials—randomized, nonrandomized, and uncontrolled studies—examined resistance exercise training in relation to metabolic health among patients with type 2 diabetes mellitus (126). Ten of these studies assessed BP. Investigators concluded that resistance exercise training resulted in beneficial changes in systolic BP, with benefits in diastolic BP less frequently observed. (The magnitude of reduction was not specified.)

Thus, the review of evidence did not provide consistent evidence on resistance exercise training for BP reduction.

5.4.2.3. Combination of Aerobic and Resistance Exercise Training and BP

There have been no published meta-analyses or reviews specifically examining the effect of a combined regimen of aerobic exercise and resistance training on BP. However, in some of the meta-analyses and reviews described above, studies with aerobic and resistance components were included in pooled data related to aerobic exercise training (112,113).

5.5. Physical Activity Recommendations

1. **In general, advise adults to engage in aerobic physical activity to reduce LDL–C and non-HDL–C: 3 to 4 sessions a week, lasting on average 40 minutes per session, and involving moderate-to-vigorous intensity physical activity.**

NHLBI Grade: B (moderate); ACC/AHA COR: IIa, LOE: A

Rationale: This recommendation was based on evidence from meta-analyses and reviews published from 2001 onwards and rated fair to good. This is also consistent with the findings of the literature review conducted for the *2008 Physical Activity Guidelines Advisory Committee Report*, in which it was found that it may require 12 metabolic equivalent task-hours per week of exercise to favorably influence LDL–C. The amount of physical activity recommended above for reducing LDL–C and non-HDL–C is congruent with the amount of physical activity recommended in 2008 by the Federal Government for overall health: “Most health benefits occur with at

least 150 minutes (2 hours and 30 minutes) a week of moderate intensity physical activity, such as brisk walking. Additional benefits occur with more physical activity" (131).

2. **In general, advise adults to engage in aerobic physical activity to lower BP: 3 to 4 sessions a week, lasting on average 40 minutes per session, and involving moderate-to-vigorous intensity physical activity.**

NHLBI Grade: B (moderate); ACC/AHA COR: IIa, LOE: A

Rationale: This recommendation was based on evidence from meta-analyses and reviews rated fair to good which were published from 2001 and later, as well as the *2008 Physical Activity Guidelines Advisory Committee Report*. The amount of physical activity recommended above for lowering BP is congruent with the amount of physical activity recommended in 2008 by the Federal Government for overall health: "Most health benefits occur with at least 150 minutes (2 hours and 30 minutes) a week of moderate intensity physical activity, such as brisk walking. Additional benefits occur with more physical activity" (132). It is worth noting that the present recommendation is congruent (i.e., expends approximately the same amount of energy), but not identical to the 2008 Federal guidelines. This is because the present recommendation is based on a review of meta-analyses of exercise in relation to BP only (hence, the specific regimens as used in the clinical trials), while the 2008 Federal guidelines targeted overall health (i.e., not just BP). Additionally, the 2008 Federal guidelines for overall health make it clear that any amount of physical activity is healthful ("Some physical activity is better than none"), and that there is a dose-response relationship ("For most health outcomes, additional benefits occur as the amount of physical activity increases through higher intensity, greater frequency, and/or longer duration").

5.6. Heart Healthy Nutrition and Physical Activity Behaviors

See Table 17 for information on heart healthy nutrition and physical activity behaviors.

Overall, the Work Group encourages heart healthy nutrition and physical activity behaviors for the entire U.S. adult population as stated in the *2010 Dietary Guidelines for Americans* and the *2008 Physical Activity Guidelines for Americans*. The recommendations in Table 17 are a consensus of the Work Group, not a guideline, and generally consistent with the *2010 Dietary Guidelines for Americans* and the *2008 Physical Activity Guidelines for Americans*.

Table 17. Heart Healthy Nutrition and Physical Activity Behaviors

Heart Healthy Nutrition and Physical Activity Behaviors
The adult population should be encouraged to practice heart healthy lifestyle behaviors including:
• Consume a dietary pattern that emphasizes intake of vegetables, fruits, and whole grains; includes low-fat dairy products, poultry, fish, legumes, nontropical vegetable oils and nuts; and limits intake of sodium, sweets, sugar-sweetened beverages and red meats.
▪ Adapt this dietary pattern to appropriate calorie requirements, personal and cultural food preferences, and nutrition therapy for other medical conditions (including diabetes mellitus).

▪ Achieve this pattern by following plans such as the DASH dietary pattern, the USDA Food Pattern, or the AHA Diet.
• Engage in 2 hours and 30 minutes a week of moderate-intensity, or 1 hour and 15 minutes (75 minutes) a week of vigorous-intensity aerobic physical activity, or an equivalent combination of moderate- and vigorous-intensity aerobic physical activity. Aerobic activity should be performed in episodes of at least 10 minutes, preferably spread throughout the week (132).
• Achieve and maintain a healthy weight. Refer to the 2013 Obesity Expert Panel Report for recommendations on weight loss and maintenance (133).

AHA indicates American Heart Association; DASH, Dietary Approaches to Stop Hypertension; and USDA, U.S. Department of Agriculture.

6. Gaps in Evidence and Future Research Needs

6.1. Diet

- Interaction between dietary modification and statin treatment.
- Relative effects of saturated fats, monounsaturated fatty acids, polyunsaturated fatty acids, *trans* fatty acids, omega–3 fatty acids, and the type of carbohydrates on lipids, inflammation, microbiome, and other newer, potential CVD risk factors.
- Relative effects of naturally occurring fiber (cereal [whole grains] and vegetable/fruit) and supplemental fiber on lipids, inflammation, microbiome, and other newer, potential CVD risk factors.
- Effects of dietary cholesterol on LDL–C and HDL–C over the current ranges of cholesterol and saturated fat intakes (5^{th} and 95^{th} percentiles).
- Effects of minerals in combination other than sodium on BP.
- Studies of high-density lipoprotein function in studies that modify HDL–C by changes in diet.
- Is the minimal effect of dietary carbohydrate on plasma triglycerides harmful?
- The effect of sodium reduction in patients with diabetes mellitus, heart failure, and chronic kidney disease.
- Effect of dietary pattern and sodium intake in adults taking BP and/or lipid-lowering medications (effects on BP/lipids; achieving BP/lipid goals; medication needs/costs; outcomes).
- Effect of dietary pattern and sodium intake in adults with CVD (e.g., postmyocardial infarction; poststroke; with coronary artery disease, heart failure, chronic kidney disease).
- Strategies for effectively (and cost-effectively) implementing these evidence-based recommendations. How can primary care providers, health systems, public health agencies, local and Federal Government, community organizations, and other stakeholders help patients adopt these diet and sodium intake recommendations?

Increased understanding of racial/ethnic/socioeconomic factors that may influence (a) effect of dietary pattern and sodium on BP and lipids; (b) adoption of diet/sodium recommendations; and (c) method of diet assessment.

6.2. Physical Activity

- The results from recent meta-analyses and systematic reviews demonstrate that exercise, when performed at a sufficient dose and intensity, will reduce LDL–C and non-HDL–C. However, additional research is needed to understand the pattern of exercise that may be associated with the reduction in LDL–C and non-HDL–C, which may lead to improved understanding of whether exercise performed at a lower intensity or dose, or whether different modes of exercise, can impact these outcomes. It is also important to further understand the characteristics of individuals for whom exercise of a certain dose and/or intensity can reduce LDL–C and non-HDL–C.

- The results from recent meta-analyses and systematic reviews show inconsistent effects of exercise on HDL–C and triglycerides. It is important to understand the source of these inconsistent findings to better understand under what conditions exercise can increase high-density lipoprotein or decrease triglycerides. This may include additional research to understand the optimal dose that will result in the desired changes in these outcomes, or whether exercise performed at a lower intensity or dose, or whether different modes of exercise, can impact these outcomes. It is also important to further understand the characteristics of individuals for whom exercise of a certain dose, intensity, or mode can increase HDL–C or reduce triglycerides.
- Although the data are clear in showing that physical activity lowers BP, most of the evidence comes from studies of Caucasian persons, with limited data on ethnic minorities. Additionally, it is unclear what specific aspects of an aerobic exercise program (i.e., length of program; frequency, duration, and intensity of physical activity) are related to greater reductions in BP; that is, it is unclear what the shape of the dose-response curve between physical activity and BP is. Further, there are limited data on whether resistance exercise training lowers BP, and whether a combination of aerobic and resistance exercise training offers any added BP lowering, compared to aerobic exercise only.
- Additional research is needed combining diet and physical activity regarding lipids and BP to determine how these behave synergistically.
- Effect of physical activity in adults taking BP and/or lipid-lowering medications (effects on BP/lipids; achieving BP/lipid goals; medication needs/costs; outcomes).
- Effect of physical activity in adults with CVD (e.g., postmyocardial infarction; poststroke; with CAD, heart failure, chronic kidney disease)
- Strategies for effectively (and cost-effectively) implementing these evidence-based recommendations. How can primary care providers, health systems, public health agencies, local and Federal Government, community organizations, and other stakeholders help patients adopt these physical activity recommendations?
- Increased understanding of racial/ethnic/socioeconomic factors that may influence (a) effect of physical activity on BP and lipids and (b) adoption of physical activity recommendations.

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Key Words: TBD

Appendix 1. Author Relationships With Industry and Other Entities (Relevant)—2013 AHA/ACC Guideline on Lifestyle Management to Reduce Cardiovascular Risk

Committee Member	Employment	Consultant	Speaker's Bureau	Ownership/ Partnership/ Principal	Personal Research	Expert Witness
Robert H. Eckel, *Co-Chair*	University of Colorado, Anschutz Medical Campus—Professor of Medicine, Professor of Physiology and Biophysics; and Charles A. Boettcher II Chair in Atherosclerosis	**2008-2012:** Foodminds	**2008-2012:** None	**2008-2012:** None	**2008-2012:** None	**2008-2012:** None
		2013: Foodminds	**2013:** None	**2013:** None	**2013:** None	**2013:** None
John M. Jakicic, *Co-Chair*	University of Pittsburg—Chair and Professor of Physical Activity and Weight Management Research Center	**2008-2012:** • Alere Wellbeing • JennyCraig • Nestle Nutrition	**2008-2012:** None	**2008-2012:** None	**2008-2012:** • Body Media—PI	**2008-2012:** None
		2013: • Calorie Control Council	**2013:** None	**2013:** None	**2013:** • Body Media—PI	**2013:** None
Jamy Ard	Wake Forest University—Assistant Professor of Epidemiology and Prevention; Weight Management Center—Co-Director	**2008-2012:** • Arena Pharmaceuticals • Nestle Healthcare Nutrition • OPTIFAST Division • Vivus	**2008-2012:** None	**2008-2012:** None	**2008-2012:** None	**2008-2012:** None
		2013: • Eisai • Nestle Healthcare Nutrition • OPTIFAST Division • Vivus	**2013:** None	**2013:** None	**2013:** None	**2013:** None
Van S. Hubbard, *Ex-Officio*	National Institute of Diabetes and Digestive and Kidney Diseases—Director, NIH Division of Nutrition Research Coordination	**2008-2012:** None	**2008-2012:** None	**2008-2012:** None	**2008-2012:** None	**2008-2012:** None
		2013: None	**2013:** None	**2013:** None	**2013:** None	**2013:** None

Janet M. de Jesus *Ex-Officio*	NHLBI— Nutritionist, Division for the Application of Research Discoveries	**2008-2012:** None	**2008-2012:** None	**2008-2012:** None	**2008-2012:** None	**2008-2012:** None
		2013: None	**2013:** None	**2013:** None	**2013:** None	**2013:** None
I-Min Lee	Harvard University—Professor of Medicine, Harvard Medical School	**2008-2012:** • Virgin Health Miles	**2008-2012:** None	**2008-2012:** None	**2008-2012:** None	**2008-2012:** None
		2013: None	**2013:** None	**2013:** None	**2013:** None	**2013:** None
Alice H. Lichtenstein	Tufts University, USDA Human Nutrition Research Center on Aging—Senior Scientist and Director, Cardiovascular Nutrition Laboratory Friedman School; Stanley N. Gershoff Professor of Nutrition Science and Policy	**2008-2012:** None	**2008-2012:** None	**2008-2012:** None	**2008-2012:** None	**2008-2012:** None
		2013: None	**2013:** None	**2013:** None	**2013:** None	**2013:** None
Catherine Loria, *Ex-Officio*	NHLBI—Nutritional Epidemiologist	**2008-2012:** None	**2008-2012:** None	**2008-2012:** None	**2008-2012:** None	**2008-2012:** None
		2013: None	**2013:** None	**2013:** None	**2013:** None	**2013:** None
Barbara Millen	Boston Nutrition Foundation—Chairman; Millennium Prevention—President	**2008-2012:** None	**2008-2012:** None	**2008-2012:** • Boston Nutrition Foundation* • Millennium Prevention*	**2008-2012:** None	**2008-2012:** None
		2013: None	**2013:** None	**2013:** • Boston Nutrition Foundation* • Millennium Prevention*	**2013:** None	**2013:** None
Nancy Houston Miller	Stanford University School of Medicine, Department of	**2008-2012:** None	**2008-2012:** None	**2008-2012:** None	**2008-2012:** None	**2008-2012:** None

	Cardiology—Associate Director, Stanford Cardiac Rehabilitation Program	**2013:** • California Walnut Board	**2013:** None	**2013:** None	**2013:** None	**2013:** None
Cathy A. Nonas	New York City Department of Health and Mental Hygiene—Senior Advisor, Bureau for Chronic Disease Prevention and Tobacco Control	**2008-2012** None	**2008-2012** None	**2008-2012** None	**2008-2012** None	**2008-2012** None
		2013 None	**2013** None	**2013** None	**2013** None	**2013** None
Frank M. Sacks	Harvard School of Public Health, Department of Nutrition—Professor of Cardiovascular Disease Prevention; Brigham and Women's Hospital—Senior Physician and Professor of Medicine	**2008-2012:** None	**2008-2012:** None	**2008-2012:** None	**2008-2012:** None	**2008-2012:** • Federal Trade Commission; Unilever, Keebler
		2013: None	**2013:** None	**2013:** None	**2013:** None	**2013:** None
Sidney C. Smith, Jr	University of North Carolina—Professor of Medicine; Director, Center for Cardiovascular Science and Medicine	**2008-2012:** None	**2008-2012:** None	**2008-2012:** None	**2008-2012:** None	**2008-2012:** None
		2013: None	**2013:** None	**2013:** None	**2013:** None	**2013:** None
Laura Svetkey	Duke University, Duke Hypertension Center—Professor; Director, Duke Hypertension Center; Director, Clinical Research, Sarah W. Stedman Nutrition and Metabolism Center	**2008-2012:** None	**2008-2012:** None	**2008-2012:** None	**2008-2012:** None	**2008-2012:** None
		2013: None	**2013:** None	**2013:** None	**2013:** None	**2013:** None
Thomas A. Wadden	University of Pennsylvania Perelman School of Medicine—Professor of Psychology, Psychiatry; Center for Weight and Eating Disorders—Director	**2008-2012** • Alere Wellbeing • BMIQ • Novo Nordisk • Orexigen • Vivus	**2008-2012** None	**2008-2012** None	**2008-2012** • Novo Nordisk • Nutrisystem • Weight Watchers	**2008-2012** None
		2013 • Novo Nordisk • Orexigen	**2013** None	**2013** None	**2013** None	**2013** None

Susan Yanovski, *Ex-Officio*	National Institute of Diabetes and Digestive and Kidney Diseases, Division of Digestive Diseases and Nutrition—Co-Director, Office of Obesity Research	**2008-2012:** None	**2008-2012:** None	**2008-2012:** None	**2008-2012:** None	**2008-2012:** None
		2013: None	**2013:** None	**2013:** None	**2013:** None	**2013:** None

This table reflects the relevant healthcare-related relationships of authors with industry and other entities (RWI) provided by the panels during the document development process (2008-2012). Both compensated and uncompensated relationships are reported. These relationships were reviewed and updated in conjunction with all meetings and/or conference calls of the expert panel during the document development process. Authors with relevant relationships during the document development process recused themselves from voting on recommendations relevant to their RWI. In the spirit of full transparency, the ACC and AHA asked expert panel members to provide updates and approve the final version of this table which includes current relevant relationships (2013).

To review the NHLBI and ACC/AHA's current comprehensive policies for managing RWI, please refer to http://www.nhlbi.nih.gov/guidelines/cvd_adult/coi-rwi_policy.htm and http://www.cardiosource.org/Science-And-Quality/Practice-Guidelines-and-Quality-Standards/Relationships-With-Industry-Policy.aspx.

Per ACC/AHA policy:
A person is deemed to have a significant interest in a business if the interest represents ownership of ≥5% of the voting stock or share of the business entity, or ownership of ≥$10,000 of the fair market value of the business entity; or if funds received by the person from the business entity exceed 5% of the person's gross income for the previous year. Relationships that exist with no financial benefit are also included for the purpose of transparency. Relationships in this table are modest unless otherwise noted.
*Significant relationship.
†No financial benefit.

ACC indicates American College of Cardiology; AHA, American Heart Association; IOM, Institute of Medicine; NHLBI, National Heart, Lung, and Blood Institute; NIH, National Institutes of Health; PI, primary investigator; and USDA, United States Department of Agriculture.

Appendix 2. Expert Reviewer Relationships With Industry and Other Entities—2013 AHA/ACC Guideline on Lifestyle Management to Reduce Cardiovascular Risk

Reviewer	Representation	Employment	Consultant	Speaker's Bureau	Ownership/ Partnership/ Principal	Personal Research	Institutional, Organizational, or Other Financial Benefit	Expert Witness
Nancy Albert	ACC/AHA Task Force on Practice Guidelines	Cleveland Clinic Foundation—Sr. Director of Nursing Research and CNS, Kaufman Center for Heart Failure	• Gambro • BG Medicine • Medtronic	None	None	None	None	None
Gerald Fletcher	ACC/AHA Expert Reviewer	Mayo Medical School Mayo Clinic Jacksonville—Professor of Medicine	None	None	None	None	None	None
Linda Van Horn	ACC/AHA Expert Reviewer	Northwestern University Feinberg School of Medicine—Professor, Preventive Medicine; Associate Dean, Faculty Development	None	None	None	None	None	None
Frederick Kushner	ACC/AHA Expert Reviewer	Heart Clinic of Louisiana—Medical Director; Tulane University Medical Center—Clinical Professor	• Federal Drug Administration Science Board†	None	None	None	None	None

†No financial benefit

Appendix 3. Abbreviations

ACC = American College of Cardiology
AHA = American Heart Association
BP = blood pressure
CHD = coronary heart disease
COR = Class of Recommendation
CQ = critical question
CV = cardiovascular
CVD = cardiovascular disease
DASH = Dietary Approaches to Stop Hypertension
ES = evidence statement
HDL–C = high-density lipoprotein cholesterol
HTN = hypertension
LDL–C = low-density lipoprotein cholesterol
LOE = Level of Evidence
MED = Mediterranean-style diet
NHLBI = National Heart, Lung, Blood Institute
NHLBAC = NHLBI Advisory Council
PICOTS = Population, Intervention, Comparator, Outcomes, Timing, and Setting
RCT = randomized controlled trial
Task Force = ACC/AHA Task Force on Practice Guidelines
U.S. = United States
USDA = United States Department of Agriculture

References

1. Clinical Practice Guidelines We Can Trust: The National Academies Press, 2011.
2. Gibbons GH, Harold JG, Jessup M, Robertson RM, Oetgen WJ. The Next Steps in Developing Clinical Practice Guidelines for Prevention. Journal of the American College of Cardiology 2013;62:1399-1400.
3. Gibbons GH, Shurin SB, Mensah GA, Lauer MS. Refocusing the Agenda on Cardiovascular Guidelines: An Announcement From the National Heart, Lung, and Blood Institute. Journal of the American College of Cardiology 2013;62:1396-1398.
4. Centers for Disease Control and Prevention (CDC). National Center for Health Statistics (NCHS). National Health and Nutrition Examination Survey Data. Hyattsville, MD: U.S. Department of Health and Human Services, Centers for Disease Control and Prevention, 2005–2008.
5. Stone NJ RJ, AH Lichtenstein, et al. 2013 ACC/AHA guideline on the treatment of blood cholesterol to reduce atherosclerotic cardiovascular risk in adults: a report of the American College of Cardiology /American Heart Association Task Force on Practice Guidelines. In Press. . 2013.
6. Micha R, Kalantarian S, Wirojratana P et al. Estimating the global and regional burden of suboptimal nutrition on chronic disease: methods and inputs to the analysis. European journal of clinical nutrition 2012;66:119-29.
7. Mehio Sibai A, Nasreddine L, Mokdad AH, Adra N, Tabet M, Hwalla N. Nutrition transition and cardiovascular disease risk factors in Middle East and North Africa countries: reviewing the evidence. Annals of nutrition & metabolism 2010;57:193-203.
8. Srinath Reddy K, Katan MB. Diet, nutrition and the prevention of hypertension and cardiovascular diseases. Public health nutrition 2004;7:167-86.
9. World Health Organization. Diet, nutrition, and the prevention of chronic diseases. Report of a WHO Study Group. World Health Organization technical report series 1990;797:1-204.
10. American Heart Association Nutrition Committee, Lichtenstein AH, Appel LJ et al. Diet and lifestyle recommendations revision 2006: a scientific statement from the American Heart Association Nutrition Committee. Circulation 2006;114:82-96.
11. Eilat-Adar S, Mete M, Fretts A et al. Dietary patterns and their association with cardiovascular risk factors in a population undergoing lifestyle changes: The Strong Heart Study. Nutrition, metabolism, and cardiovascular diseases : NMCD 2012.
12. Flock MR, Kris-Etherton PM. Dietary Guidelines for Americans 2010: implications for cardiovascular disease. Current atherosclerosis reports 2011;13:499-507.
13. Mozaffarian D, Appel LJ, Van Horn L. Components of a cardioprotective diet: new insights. Circulation 2011;123:2870-91.
14. Hercberg S, Castetbon K, Czernichow S et al. The Nutrinet-Sante Study: a web-based prospective study on the relationship between nutrition and health and determinants of dietary patterns and nutritional status. BMC public health 2010;10:242.
15. Kant AK. Dietary patterns: biomarkers and chronic disease risk. Applied physiology, nutrition, and metabolism = Physiologie appliquee, nutrition et metabolisme 2010;35:199-206.
16. Iqbal R, Anand S, Ounpuu S et al. Dietary patterns and the risk of acute myocardial infarction in 52 countries: results of the INTERHEART study. Circulation 2008;118:1929-37.
17. Nettleton JA, Schulze MB, Jiang R, Jenny NS, Burke GL, Jacobs DR, Jr. A priori-defined dietary patterns and markers of cardiovascular disease risk in the Multi-Ethnic Study of Atherosclerosis (MESA). The American journal of clinical nutrition 2008;88:185-94.
18. Mikkila V, Rasanen L, Raitakari OT et al. Major dietary patterns and cardiovascular risk factors from childhood to adulthood. The Cardiovascular Risk in Young Finns Study. The British journal of nutrition 2007;98:218-25.
19. Panagiotakos DB, Pitsavos C, Stefanadis C. Dietary patterns: a Mediterranean diet score and its relation to clinical and biological markers of cardiovascular disease risk. Nutrition, metabolism, and cardiovascular diseases : NMCD 2006;16:559-68.
20. Mensink RP, Katan MB. Effect of dietary fatty acids on serum lipids and lipoproteins. A meta-analysis of 27 trials. Arteriosclerosis and thrombosis : a journal of vascular biology / American Heart Association 1992;12:911-9.
21. Mensink RP, Zock PL, Kester AD, Katan MB. Effects of dietary fatty acids and carbohydrates on the ratio of serum total to HDL cholesterol and on serum lipids and apolipoproteins: a meta-analysis of 60 controlled trials. The American journal of clinical nutrition 2003;77:1146-55.
22. Mozaffarian D, Clarke R. Quantitative effects on cardiovascular risk factors and coronary heart disease risk of replacing partially hydrogenated vegetable oils with other fats and oils. European journal of clinical nutrition 2009;63 Suppl 2:S22-33.
23. Tang JL, Armitage JM, Lancaster T, Silagy CA, Fowler GH, Neil HA. Systematic review of dietary intervention trials to lower blood total cholesterol in free-living subjects. BMJ (Clinical research ed) 1998;316:1213-20.

24. Jula A, Marniemi J, Huupponen R, Virtanen A, Rastas M, Ronnemaa T. Effects of diet and simvastatin on serum lipids, insulin, and antioxidants in hypercholesterolemic men: a randomized controlled trial. JAMA : the journal of the American Medical Association 2002;287:598-605.
25. Michalsen A, Lehmann N, Pithan C et al. Mediterranean diet has no effect on markers of inflammation and metabolic risk factors in patients with coronary artery disease. European journal of clinical nutrition 2006;60:478-85.
26. Wolever TM, Gibbs AL, Mehling C et al. The Canadian Trial of Carbohydrates in Diabetes (CCD), a 1-y controlled trial of low-glycemic-index dietary carbohydrate in type 2 diabetes: no effect on glycated hemoglobin but reduction in C-reactive protein. The American journal of clinical nutrition 2008;87:114-25.
27. Appel LJ, Moore TJ, Obarzanek E et al. A clinical trial of the effects of dietary patterns on blood pressure. DASH Collaborative Research Group. The New England journal of medicine 1997;336:1117-24.
28. Sacks FM, Appel LJ, Moore TJ et al. A dietary approach to prevent hypertension: a review of the Dietary Approaches to Stop Hypertension (DASH) Study. Clinical cardiology 1999;22:III6-10.
29. Obarzanek E, Sacks FM, Vollmer WM et al. Effects on blood lipids of a blood pressure-lowering diet: the Dietary Approaches to Stop Hypertension (DASH) Trial. The American journal of clinical nutrition 2001;74:80-9.
30. Sacks FM, Svetkey LP, Vollmer WM et al. Effects on blood pressure of reduced dietary sodium and the Dietary Approaches to Stop Hypertension (DASH) diet. DASH-Sodium Collaborative Research Group. N Engl J Med 2001;344:3–10.
31. Harsha DW, Sacks FM, Obarzanek E et al. Effect of dietary sodium intake on blood lipids: results from the DASH-sodium trial. Hypertension 2004;43:393-8.
32. Erlinger TP, Miller ER, 3rd, Charleston J, Appel LJ. Inflammation modifies the effects of a reduced-fat low-cholesterol diet on lipids: results from the DASH-sodium trial. Circulation 2003;108:150-4.
33. Ginsberg HN, Kris-Etherton P, Dennis B et al. Effects of reducing dietary saturated fatty acids on plasma lipids and lipoproteins in healthy subjects: the DELTA Study, protocol 1. Arteriosclerosis, thrombosis, and vascular biology 1998;18:441-9.
34. Gardner CD, Coulston A, Chatterjee L, Rigby A, Spiller G, Farquhar JW. The effect of a plant-based diet on plasma lipids in hypercholesterolemic adults: a randomized trial. Annals of internal medicine 2005;142:725-33.
35. Jenkins DJ, Kendall CW, McKeown-Eyssen G et al. Effect of a low-glycemic index or a high-cereal fiber diet on type 2 diabetes: a randomized trial. JAMA : the journal of the American Medical Association 2008;300:2742-53.
36. Estruch R, Martinez-Gonzalez MA, Corella D et al. Effects of a Mediterranean-style diet on cardiovascular risk factors: a randomized trial. Annals of internal medicine 2006;145:1-11.
37. Appel LJ, Sacks FM, Carey VJ et al. Effects of protein, monounsaturated fat, and carbohydrate intake on blood pressure and serum lipids: results of the OmniHeart randomized trial. JAMA : the journal of the American Medical Association 2005;294:2455-64.
38. Nunez-Cordoba JM, Valencia-Serrano F, Toledo E, Alonso A, Martinez-Gonzalez MA. The Mediterranean diet and incidence of hypertension: the Seguimiento Universidad de Navarra (SUN) Study. American journal of epidemiology 2009;169:339-46.
39. Howard BV, Van Horn L, Hsia J et al. Low-fat dietary pattern and risk of cardiovascular disease: the Women's Health Initiative Randomized Controlled Dietary Modification Trial. JAMA : the journal of the American Medical Association 2006;295:655-66.
40. Tinker LF, Bonds DE, Margolis KL et al. Low-fat dietary pattern and risk of treated diabetes mellitus in postmenopausal women: the Women's Health Initiative randomized controlled dietary modification trial. Archives of internal medicine 2008;168:1500-11.
41. Yusof BN, Talib RA, Kamaruddin NA, Karim NA, Chinna K, Gilbertson H. A low-GI diet is associated with a short-term improvement of glycaemic control in Asian patients with type 2 diabetes. Diabetes, obesity & metabolism 2009;11:387-96.
42. Svetkey LP, Simons-Morton D, Vollmer WM et al. Effects of dietary patterns on blood pressure: subgroup analysis of the Dietary Approaches to Stop Hypertension (DASH) randomized clinical trial. Archives of internal medicine 1999;159:285-93.
43. Moore TJ, Vollmer WM, Appel LJ et al. Effect of dietary patterns on ambulatory blood pressure: results from the Dietary Approaches to Stop Hypertension (DASH) Trial. DASH Collaborative Research Group. Hypertension 1999;34:472-7.
44. Conlin PR, Chow D, Miller ER, 3rd et al. The effect of dietary patterns on blood pressure control in hypertensive patients: results from the Dietary Approaches to Stop Hypertension (DASH) trial. American journal of hypertension 2000;13:949-55.
45. Bray GA, Vollmer WM, Sacks FM, Obarzanek E, Svetkey LP, Appel LJ. A further subgroup analysis of the effects of the DASH diet and three dietary sodium levels on blood pressure: results of the DASH-Sodium Trial. The American journal of cardiology 2004;94:222-7.
46. Vollmer WM, Sacks FM, Ard J et al. Effects of diet and sodium intake on blood pressure: subgroup analysis of the DASH-sodium trial. Annals of internal medicine 2001;135:1019-28.

47. Tonstad S, Sundfor T, Seljeflot I. Effect of lifestyle changes on atherogenic lipids and endothelial cell adhesion molecules in young adults with familial premature coronary heart disease. The American journal of cardiology 2005;95:1187-91.
48. U.S. Department of Agriculture, U.S. Department of Health and Human Services. Dietary Guidelines for Americans, 2010. 7th ed. Washington, DC: U.S. Government Printing Office, 2010.
49. Lichtenstein AH, Appel LJ, Brands M et al. Summary of American Heart Association Diet and Lifestyle Recommendations revision 2006. Arteriosclerosis, thrombosis, and vascular biology 2006;26:2186-91.
50. Wright JD, Wang CY. Trends in intake of energy and macronutrients in adults from 1999-2000 through 2007-2008. NCHS data brief 2010:1-8.
51. Doell D, Folmer D, Lee H, Honigfort M, Carberry S. Updated estimate of trans fat intake by the US population. Food additives & contaminants Part A, Chemistry, analysis, control, exposure & risk assessment 2012;29:861-74.
52. Whelton PK, Appel LJ, Espeland MA et al. Sodium reduction and weight loss in the treatment of hypertension in older persons: a randomized controlled trial of nonpharmacologic interventions in the elderly (TONE). TONE Collaborative Research Group. JAMA : the journal of the American Medical Association 1998;279:839-46.
53. TOHP II Research Group 1997. Effects of weight loss and sodium reduction intervention on blood pressure and hypertension incidence in overweight people with high-normal blood pressure. The Trials of Hypertension Prevention, phase II. The Trials of Hypertension Prevention Collaborative Research Group. Archives of internal medicine 1997;157:657-67.
54. Appel LJ, Espeland MA, Easter L, Wilson AC, Folmar S, Lacy CR. Effects of reduced sodium intake on hypertension control in older individuals: results from the Trial of Nonpharmacologic Interventions in the Elderly (TONE). Archives of internal medicine 2001;161:685-93.
55. Espeland MA, Kumanyika S, Yunis C et al. Electrolyte intake and nonpharmacologic blood pressure control. Ann Epidemiol 2002;12:587-95.
56. Svetkey LP, Simons-Morton DG, Proschan MA et al. Effect of the dietary approaches to stop hypertension diet and reduced sodium intake on blood pressure control. J Clin Hypertens 2004;6:373-81.
57. Kumanyika SK, Cook NR, Cutler JA et al. Sodium reduction for hypertension prevention in overweight adults: further results from the Trials of Hypertension Prevention Phase II. J Hum Hypertens 2005;19:33-45.
58. Cook NR, Kumanyika SK, Cutler JA, Whelton PK. Dose-response of sodium excretion and blood pressure change among overweight, nonhypertensive adults in a 3-year dietary intervention study. J Hum Hypertens 2005;19:47-54.
59. Hu J, Jiang X, Li N et al. Effects of salt substitute on pulse wave analysis among individuals at high cardiovascular risk in rural China: a randomized controlled trial. Hypertens Res 2009;32:282-8.
60. China Salt Substitute Study Collaborative Group. Salt substitution: a low-cost strategy for blood pressure control among rural Chinese. A randomized, controlled trial. J Hypertens 2007;25:2011-8.
61. Charlton KE, Steyn K, Levitt NS et al. A food-based dietary strategy lowers blood pressure in a low socio-economic setting: a randomised study in South Africa. Public health nutrition 2008;11:1397-406.
62. Obarzanek E, Proschan MA, Vollmer WM et al. Individual blood pressure responses to changes in salt intake: results from the DASH-Sodium trial. Hypertension 2003;42:459-67.
63. Ard JD, Coffman CJ, Lin P-H, Svetkey LP. One-year follow-up study of blood pressure and dietary patterns in dietary approaches to stop hypertension (DASH)-sodium participants. American journal of hypertension 2004;17:1156-62.
64. Cappuccio FP, Kerry SM, Micah FB, Plange-Rhule J, Eastwood JB. A community programme to reduce salt intake and blood pressure in Ghana [ISRCTN88789643]. BMC public health 2006;6:13.
65. Cook NR, Cutler JA, Obarzanek E et al. Long term effects of dietary sodium reduction on cardiovascular disease outcomes: observational follow-up of the trials of hypertension prevention (TOHP). BMJ (Clinical research ed) 2007;334:885-8.
66. Chang H-Y, Hu Y-W, Yue C-SJ et al. Effect of potassium-enriched salt on cardiovascular mortality and medical expenses of elderly men. The American journal of clinical nutrition 2006;83:1289-96.
67. Cook NR, Obarzanek E, Cutler JA et al. Joint effects of sodium and potassium intake on subsequent cardiovascular disease: the Trials of Hypertension Prevention follow-up study. Archives of internal medicine 2009;169:32-40.
68. Nagata C, Takatsuka N, Shimizu N, Shimizu H. Sodium intake and risk of death from stroke in Japanese men and women. Stroke 2004;35:1543-7.
69. Tuomilehto J, Jousilahti P, Rastenyte D et al. Urinary sodium excretion and cardiovascular mortality in Finland: a prospective study. Lancet 2001;357:848-51.
70. Umesawa M, Iso H, Date C et al. Relations between dietary sodium and potassium intakes and mortality from cardiovascular disease: the Japan Collaborative Cohort Study for Evaluation of Cancer Risks. The American journal of clinical nutrition 2008;88:195-202.
71. Alderman MH, Cohen H, Madhavan S. Dietary sodium intake and mortality: the National Health and Nutrition Examination Survey (NHANES I). Lancet 1998;351:781-5.

72. Cohen HW, Hailpern SM, Fang J, Alderman MH. Sodium intake and mortality in the NHANES II follow-up study. Am J Med 2006;119:275.
73. Cohen HW, Hailpern SM, Alderman MH. Sodium intake and mortality follow-up in the Third National Health and Nutrition Examination Survey (NHANES III). J Gen Intern Med 2008;23:1297-302.
74. He J, Ogden LG, Vupputuri S, Bazzano LA, Loria C, Whelton PK. Dietary sodium intake and subsequent risk of cardiovascular disease in overweight adults. JAMA : the journal of the American Medical Association 1999;282:2027-34.
75. He J, Ogden LG, Bazzano LA, Vupputuri S, Loria C, Whelton PK. Dietary sodium intake and incidence of congestive heart failure in overweight US men and women: first National Health and Nutrition Examination Survey Epidemiologic Follow-up Study. Archives of internal medicine 2002;162:1619-24.
76. Yang Q, Liu T, Kuklina EV et al. Sodium and potassium intake and mortality among US adults: prospective data from the Third National Health and Nutrition Examination Survey. Archives of internal medicine 2011;171:1183-91.
77. O'Donnell MJ, Yusuf S, Mente A et al. Urinary sodium and potassium excretion and risk of cardiovascular events. JAMA : the journal of the American Medical Association 2011;306:2229-38.
78. Marniemi J, Alanen E, Impivaara O et al. Dietary and serum vitamins and minerals as predictors of myocardial infarction and stroke in elderly subjects. Nutrition, metabolism, and cardiovascular diseases : NMCD 2005;15:188-97.
79. Takachi R, Inoue M, Shimazu T et al. Consumption of sodium and salted foods in relation to cancer and cardiovascular disease: the Japan Public Health Center-based Prospective Study. The American journal of clinical nutrition 2010;91:456-64.
80. Liang W, Lee AH, Binns CW. Dietary intake of minerals and the risk of ischemic stroke in Guangdong Province, China, 2007-2008. Prev Chronic Dis 2011;8:A38.
81. Gardener H, Rundek T, Wright CB, Elkind MSV, Sacco RL. Dietary sodium and risk of stroke in the northern Manhattan study. Stroke 2012;43:1200-5.
82. Ekinci EI, Clarke S, Thomas MC et al. Dietary salt intake and mortality in patients with type 2 diabetes. Diabetes care 2011;34:703-9.
83. Stolarz-Skrzypek K, Kuznetsova T, Thijs L et al. Fatal and nonfatal outcomes, incidence of hypertension, and blood pressure changes in relation to urinary sodium excretion. JAMA : the journal of the American Medical Association 2011;305:1777-85.
84. Strazzullo P, D'Elia L, Kandala N-B, Cappuccio FP. Salt intake, stroke, and cardiovascular disease: meta-analysis of prospective studies. BMJ (Clinical research ed) 2009;339:b4567.
85. Walker J, MacKenzie AD, Dunning J. Does reducing your salt intake make you live longer? Interact Cardiovasc Thorac Surg 2007;6:793-8.
86. Fang J, Madhavan S, Alderman MH. Dietary potassium intake and stroke mortality. Stroke 2000;31:1532-7.
87. Bazzano LA, He J, Ogden LG et al. Dietary potassium intake and risk of stroke in US men and women: National Health and Nutrition Examination Survey I epidemiologic follow-up study. Stroke 2001;32:1473-80.
88. Al-Delaimy WK, Rimm EB, Willett WC, Stampfer MJ, Hu FB. Magnesium intake and risk of coronary heart disease among men. Journal of the American College of Nutrition 2004;23:63-70.
89. Ascherio A, Rimm EB, Hernán MA et al. Intake of potassium, magnesium, calcium, and fiber and risk of stroke among US men. Circulation 1998;98:1198-204.
90. Green DM, Ropper AH, Kronmal RA, Psaty BM, Burke GL. Serum potassium level and dietary potassium intake as risk factors for stroke. Neurology 2002;59:314-20.
91. Weng L-C, Yeh W-T, Bai C-H et al. Is ischemic stroke risk related to folate status or other nutrients correlated with folate intake? Stroke 2008;39:3152-8.
92. Geleijnse JM, Witteman JCM, Stijnen T, Kloos MW, Hofman A, Grobbee DE. Sodium and potassium intake and risk of cardiovascular events and all-cause mortality: the Rotterdam Study. Eur J Epidemiol 2007;22:763-70.
93. Iso H, Stampfer MJ, Manson JE et al. Prospective study of calcium, potassium, and magnesium intake and risk of stroke in women. Stroke 1999;30:1772-9.
94. National Heart, Lung, and Blood Institute (NHLBI). Your guide to lowering your blood pressure with DASH. NHLBI, 2013.
95. Centers for Disease Control and Prevention (CDC). Most Americans should consume less sodium. CDC, 2013.
96. U.S. Food and Drug Administration (FDA). Sodium reduction. FDA, 2013.
97. American Heart Association (AHA). Sodium (salt or sodium chloride). AHA, 2013.
98. Physical Activity Guidelines Advisory Committee. Physical Activity Guidelines Advisory Committee Report, 2008. Washington, DC: U.S. Department of Health and Human Services, 2008:1-683.
99. Warburton DE, Charlesworth S, Ivey A, Nettlefold L, Bredin SS. A systematic review of the evidence for Canada's Physical Activity Guidelines for Adults. The international journal of behavioral nutrition and physical activity 2010;7:39.

100. World Health Organization. Global Recommendations on Physical Activity for Health. Geneva, Switzerland: World Health Organization, 2010:1-60.
101. Shiroma EJ, Lee IM. Physical activity and cardiovascular health: lessons learned from epidemiological studies across age, gender, and race/ethnicity. Circulation 2010;122:743-52.
102. Sattelmair J, Pertman J, Ding EL, Kohl HW, 3rd, Haskell W, Lee IM. Dose response between physical activity and risk of coronary heart disease: a meta-analysis. Circulation 2011;124:789-95.
103. Lee IM, Shiroma EJ, Lobelo F et al. Effect of physical inactivity on major non-communicable diseases worldwide: an analysis of burden of disease and life expectancy. Lancet 2012;380:219-29.
104. Mora S, Cook N, Buring JE, Ridker PM, Lee IM. Physical activity and reduced risk of cardiovascular events: potential mediating mechanisms. Circulation 2007;116:2110-8.
105. Kelley GA, Kelley KS, Tran ZV. Walking and resting blood pressure in adults: a meta-analysis. Prev Med 2001;33:120-7.
106. Hamer M, Chida Y. Active commuting and cardiovascular risk: a meta-analytic review. Prev Med 2008;46:9-13.
107. Whelton SP, Chin A, Xin X, He J. Effect of aerobic exercise on blood pressure: a meta-analysis of randomized, controlled trials. Annals of internal medicine 2002;136:493-503.
108. Guo X, Zhou B, Nishimura T, Teramukai S, Fukushima M. Clinical effect of qigong practice on essential hypertension: a meta-analysis of randomized controlled trials. J Altern Complement Med 2008;14:27-37.
109. Lee MS, Pittler MH, Guo R, Ernst E. Qigong for hypertension: a systematic review of randomized clinical trials. J Hypertens 2007;25:1525-32.
110. Kelley GA, Sharpe Kelley K. Aerobic exercise and resting blood pressure in older adults: a meta-analytic review of randomized controlled trials. J Gerontol A Biol Sci Med Sci 2001;56:M298-303.
111. Jolly K, Taylor RS, Lip GYH, Stevens A. Home-based cardiac rehabilitation compared with centre-based rehabilitation and usual care: a systematic review and meta-analysis. Int J Cardiol 2006;111:343-51.
112. Thomas DE, Elliott EJ, Naughton GA. Exercise for type 2 diabetes mellitus. Cochrane Database Syst Rev 2006;3:CD002968.
113. Asikainen T-M, Kukkonen-Harjula K, Miilunpalo S. Exercise for health for early postmenopausal women: a systematic review of randomised controlled trials. Sports Med 2004;34:753-78.
114. Taylor RS, Brown A, Ebrahim S et al. Exercise-based rehabilitation for patients with coronary heart disease: systematic review and meta-analysis of randomized controlled trials. Am J Med 2004;116:682-92.
115. Kelley GA, Kelley KS, Tran ZV. Aerobic exercise and lipids and lipoproteins in women: a meta-analysis of randomized controlled trials. J Womens Health (Larchmt) 2004;13:1148-64.
116. Kelley GA, Kelley KS, Vu Tran Z. Aerobic exercise, lipids and lipoproteins in overweight and obese adults: a meta-analysis of randomized controlled trials. Int J Obes (Lond) 2005;29:881-93.
117. Kelley GA, Kelley KS, Tran ZV. Walking and Non-HDL-C in adults: a meta-analysis of randomized controlled trials. Prev Cardiol 2005;8:102-7.
118. Kelley GA, Kelley KS, Tran ZV. Exercise, lipids, and lipoproteins in older adults: a meta-analysis. Prev Cardiol 2005;8:206-14.
119. Kelley GA, Kelley KS, Tran ZV. Walking, lipids, and lipoproteins: a meta-analysis of randomized controlled trials. Prev Med 2004;38:651-61.
120. Kelley GA, Kelley KS. Aerobic exercise and HDL2-C: a meta-analysis of randomized controlled trials. Atherosclerosis 2006;184:207-15.
121. Kelley GA, Kelley KS. Effects of aerobic exercise on lipids and lipoproteins in adults with type 2 diabetes: a meta-analysis of randomized-controlled trials. Public Health 2007;121:643-55.
122. Kelley GA, Kelley KS. Impact of progressive resistance training on lipids and lipoproteins in adults: a meta-analysis of randomized controlled trials. Prev Med 2009;48:9-19.
123. Kelley GA, Kelley KS. Impact of progressive resistance training on lipids and lipoproteins in adults: another look at a meta-analysis using prediction intervals. Prev Med 2009;49:473-5.
124. Bravata DM, Smith-Spangler C, Sundaram V et al. Using pedometers to increase physical activity and improve health: a systematic review. JAMA : the journal of the American Medical Association 2007;298:2296-304.
125. Kodama S, Tanaka S, Saito K et al. Effect of aerobic exercise training on serum levels of high-density lipoprotein cholesterol: a meta-analysis. Archives of internal medicine 2007;167:999-1008.
126. Gordon BA, Benson AC, Bird SR, Fraser SF. Resistance training improves metabolic health in type 2 diabetes: a systematic review. Diabetes Res Clin Pract 2009;83:157-75.
127. Keogh JWL, Kilding A, Pidgeon P, Ashley L, Gillis D. Physical benefits of dancing for healthy older adults: a review. J Aging Phys Activ 2009;17:479-500.
128. Orozco LJ, Buchleitner AM, Gimenez-Perez G, Roqué I Figuls M, Richter B, Mauricio D. Exercise or exercise and diet for preventing type 2 diabetes mellitus. Cochrane Database Syst Rev 2008:CD003054.
129. Lin JS, O'Connor E, Whitlock EP, Beil TL. Behavioral counseling to promote physical activity and a healthful diet to prevent cardiovascular disease in adults: a systematic review for the U.S. Preventive Services Task Force. Annals of internal medicine 2010;153:736-50.

130. Cornelissen VA, Fagard RH. Effect of resistance training on resting blood pressure: a meta-analysis of randomized controlled trials. J Hypertens 2005;23:251-9.
131. Centers for Disease Control and Prevention. National Diabetes Fact Sheet: General Information and National Estimates on Diabetes in the United States, 2007. Atlanta, GA: U.S. Department of Health and Human Services, Centers for Disease Control and Prevention, 2008.
132. U.S. Department of Health and Human Services. 2008 Physical Activity Guidelines for Americans. Washington, DC: U.S. Department of Health and Human Services, 2008:1-76.
133. Jensen MD RD, Apovian CM, et al. 2013 ACC/AHA/TOS guideline for the management of overweight and obesity in adults: a report of the American College of Cardiology /American Heart Association Task Force on Practice Guidelines, and The Obesity Society. J Am Coll Cardiol 2013.

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