Achieving and Maintaining Cardiovascular Health Across the Lifespan

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Abstract The American Heart Association introduced the concept of cardiovascular health (CVH) in its 2020 Strategic Impact Goals. Defined by the presence of four health behaviors (smoking, weight, diet, and physical activity) and three health factors (glucose, blood pressure, and cholesterol), CVH reflects an expansion of preventive efforts to the entire population and a reframing of disease prevention to health promotion. Recent evidence has confirmed the relevance of the seven CVH metrics in cardiovascular outcomes, highlighting the critical role of a healthy lifestyle in achieving and maintaining CVH through the lifespan. Primordial prevention efforts geared towards health promotion and healthy behaviors, sustained over the life course, and fostered by public health and health policy will be the key to achieving and maintaining CVH and improving the cardiovascular health of the nation.

Keywords Cardiovascular health · Lifestyle · Primordial prevention · Cardiovascular disease · Risk factors

Introduction

In 2010, the American Heart Association (AHA) announced a new focus for its 2020 Strategic Impact Goals: “By 2020, to improve the cardiovascular health of all Americans by 20 % while reducing deaths from cardiovascular diseases and stroke by 20 %.” [1••] These goals reflected an expansion of

prevention efforts to the entire population and introduced the concept of cardiovascular health (CVH), a positive construct conceptualizing health and prevention as more than the absence of clinically evident disease. The AHA developed four health behavior metrics (smoking status, body mass index, dietary content, and participation in physical activity) and three health factor metrics (blood glucose, blood pressure, and total cholesterol) that, taken together, define CVH. Within each health metric, three clinically based strata of poor, intermediate, and ideal were set to capture the full spectrum of CVH. Since the AHA announced its 2020 Strategic Impact Goals, multiple studies have confirmed the importance of the CVH construct and its relevance to both cardiovascular and overall health outcomes. In this review, we describe the conceptual framework of CVH, highlight recent data demonstrating its relevance to health outcomes, and provide key strategies needed to achieve and maintain CVH over the lifespan.

Cardiovascular Health

The shift in focus from cardiovascular disease prevention to cardiovascular health promotion has been called a public health revolution [2]. Although origins can be traced back to the World Health Organization Constitution of 1946 and the Surgeon General’s *Healthy People* report in 1979, CVH as a construct defined by measureable health behavior and health factor metrics was first established by the AHA 2020 Strategic Impact Goals [1••, 2]. The goal was to reframe preventive efforts broadly to promote health and health behaviors in the population for greater societal and public health impact. Three central ideas underscore this new framework: 1) the balance between population- and individual-level interventions, 2) the significance of primordial prevention, and 3) the need to promote and maintain healthy behaviors and minimize risk factors throughout the lifespan.

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The first concept was popularized by Geoffrey Rose, who described the complementary relationship of preventive efforts directed towards unhealthy individuals (the high-risk strategy) and unhealthy populations (the population-based strategy) [3]. Because the majority of cardiovascular disease (CVD) events occur in the large segment of the population with average or only mildly elevated risk factors, Rose argued that population-level strategies could more effectively prevent CVD events by shifting the entire distribution of risk [3]. Small changes in mean population levels of risk would then result in large reductions in disease rates. The idea of “primordial prevention” was first introduced by Toma Strasser in 1978 [4]. This concept acknowledges that adverse risk factors carry graded and continuous cardiovascular risk and that pharmacologic and lifestyle interventions for secondary and primary prevention will not reduce event rates to rates seen in people who maintain optimal risk factor profiles throughout the lifespan. Therefore, prevention of risk factor development in the first place can hold immense societal and public health impact. The CVH construct attempts to integrate these two philosophies and incorporate them over the lifespan to reframe CVD prevention as lifelong health promotion.

The centerpiece of the AHA 2020 Strategic Impact Goals is ideal CVH, defined as the absence of clinically manifest CVD together with the simultaneous presence of optimal levels of all seven health metrics (four health behaviors and three health factors) [1•]. However, the CVH construct also recognizes that cardiovascular health can occur across a spectrum and therefore clinically based strata of “poor,” “intermediate,” and “ideal” levels for each health metric were defined (Table 1). For individuals with a history of clinical CVD, ideal CVH is not achievable, but controlling all health factors and health behaviors can move an individual from poor CVH to intermediate CVH. Among individuals without clinical CVD who have poor CVH, controlling all health factors and health behaviors with lifestyle or medications can help move one from poor to intermediate levels of CVH or from intermediate to ideal CVH if such control is achieved with lifestyle alone [1•].

Relevance of Cardiovascular Health

Although evidence had previously assessed clusters of ideal levels of risk factors with longevity [5], disease-free survival [6], quality of life [7], and healthcare costs [8, 9], only in the past few years have empirical data emerged to support the CVH construct. Analyses from the Atherosclerosis Risk in Communities study first demonstrated the link between CVH and outcomes. In the study, Folsom et al. analyzed 12,744 participants without CVD and demonstrated a step-wise

inverse association between the number of ideal health metrics and incident CVD events (including coronary heart disease death, nonfatal myocardial infarction, stroke, and heart failure) during 20 years of follow-up. Individuals with six or more ideal health metrics had approximately one tenth the rate of 20-year incident CVD compared with individuals with zero ideal health metrics, 3.9 events per 1,000 person-years vs. 32.1 events per 1,000 person-years (hazard ratio (HR) 0.11, 95 % confidence interval (CI) 0.07–0.17) [10]. In the 17 middle-aged participants with all seven metrics rated ideal, no CVD events were seen in the 20 years of follow-up. In contrast, CVD incidence rates were 7.5 per 1,000 person-years (95 % CI 6.4–8.4) for those with intermediate CVH and 14.6 per 1,000 person-years (95 % CI 14.0–15.2) for those with poor CVH. Similar analyses from the Northern Manhattan Study including a multi-ethnic cohort of whites, blacks, and Caribbean Hispanics from the New York area demonstrated an analogous dose response relationship between the number of ideal CVH metrics and individual CVD endpoints, confirming the relevance of CVH regardless of race-ethnic background.

Nationally representative data from the National Health and Nutrition Examination Surveys (NHANES) have also shown similar relationships. Using NHANES follow-up data from 1988 to 2006, Yang et al. reported a stepwise association between the number of ideal CVH metrics and the risk of all-cause mortality, CVD mortality, and ischemic heart disease mortality [11•]. In those who met six or more metrics, the adjusted HRs compared with individuals with one or fewer ideal health metrics was 0.49 (95 % CI 0.33–0.74) for all-cause mortality, 0.24 (95 % CI 0.13–0.47) for CVD mortality, and 0.30 (95 % CI 0.13–0.68) for ischemic heart disease mortality. Short-term data from more recent NHANES surveys (1999–2006) have demonstrated similar relationships [12].

The benefits of CVH metrics have also been linked to non-cardiovascular conditions. For example, Rasmussen-Torvik et al. demonstrated a graded inverse association between adherence to the AHA’s seven CVH metrics and cancer incidence over a 19-year follow-up with a 51 % lower risk of cancer among individuals with six or seven ideal CVH metrics compared with those with zero ideal metrics (HR 0.49, 95 % CI 0.35–0.69) [13]. This relationship remained significant even after excluding smoking status from the ideal health score. Similar prospective benefits in important non-cardiovascular outcomes have also been demonstrated for cognition [14], depressive symptoms [15], and health-related quality of life [16]. These data solidify the case that better CVH is associated with overall healthier longevity. Recent data support this notion by demonstrating greater long-term disease-free longevity and compression of morbidity in middle-aged men and women with better CVH [6].

Table 1 Definitions of cardiovascular health for adults and children in the American Heart Association's 2020 Strategic Impact Goals

Health metric	Level of cardiovascular health		
	Poor	Intermediate	Ideal
Smoking			
Adults aged ≥ 20 years	Current	Former ≤ 12 months	Never or quit > 12 months
Children aged 12–19 years	Tried in the prior 30 days		Never tried
Body weight (kg/m^2)			
Adults aged ≥ 20 years	≥ 30	25–29.9	< 25
Children aged 12–19 years	> 95 th percentile	85th–95th percentile	< 85 th percentile
Physical activity			
Adults aged ≥ 20 years	None	1–149 min/week moderate intensity, 1–74 min/week vigorous activity, or 1–149 min/week moderate + vigorous activity	≥ 150 min/week moderate intensity, ≥ 75 min/week vigorous intensity, or ≥ 150 min/week moderate + vigorous activity
Children aged 12–19 years	None	> 0 or < 60 min of moderate or vigorous activity/day	≥ 60 min of moderate or vigorous activity/day
Healthy diet score, no. of components			
Adults aged ≥ 20 years	0–1	2–3	4–5
Children aged 12–19 years	0–1	2–3	4–5
Total cholesterol (mg/dL)			
Adults aged ≥ 20 years	≥ 240	200–239 or treated to goal	< 200
Children aged 12–19 years	≥ 200	170–199	< 170
Blood pressure (systolic blood pressure/diastolic blood pressure, mmHg)			
Adults aged ≥ 20 years	$\geq 140/\geq 90$	120–139/80–89 or treated to goal	$< 120/< 80$
Children aged 12–19 years	> 95 th percentile	90th–95th percentile or $\geq 120/\geq 80$	< 90 th percentile
Fasting plasma glucose (mg/dL)			
Adults aged ≥ 20 years	≥ 126	100–125 or treated to goal	< 100
Children aged 12–19 years	≥ 126	100–125	< 100

Diet score is based on the Dietary Approaches to Stop Hypertension (DASH) diet and is scored on a 0–5 scale. There is one point for each component: ≥ 4.5 cups/day of fruits and vegetables, ≥ 2 servings/week of fish, < 1500 mg/day of sodium, ≤ 450 kcal (36 oz)/week of sweets/sugar-sweetened beverages, and ≥ 3 servings/day of whole grains. Data from Lloyd-Jones et al. [1•]

Prevalence of Cardiovascular Health in the USA

Although studies have convincingly demonstrated the health benefits of the ideal CVH construct, prevalence of ideal CVH metrics has consistently been low in community samples [17], longitudinal cohort studies [10, 18], and nationally representative surveys [11•, 12, 19]. Longitudinal analyses of multiple NHANES surveys demonstrated prevalence of ideal CVH of less than 2 % that remained similarly low over time [11•]. The most up-to-date survey data from the NHANES 2009–2010 cycle estimates that only 0.1 % of US adults aged ≥ 20 years meet all seven ideal CVH criteria [20]. Moreover, state-by-state assessments of CVH metrics reveal significant geographic variation, with prevalence of ideal CVH from 1.2 % in Oklahoma to 6.9 % in the District of Columbia, and poor CVH from 6.7 % in Colorado to 16.2 % in West Virginia [21].

These sobering prevalence estimates of CVH underscore the pervasiveness of unhealthy behaviors and risk factors and the enormous challenge we face to achieve CVH in the population. However, these same prevalence data hint at a pathway toward greater CVH in the population. The presence of ideal CVH is age related with younger adults more likely to meet greater numbers of ideal metrics than older adults (Fig. 1). For example, nearly half of US children (aged 12–19 years) meet five or more CVH criteria whereas only 17 % of US adults aged ≥ 20 years meet five or more criteria [20]. Thus, we are born with a stock of ideal CVH and this health is lost during adolescence and young adulthood through the adoption of unhealthy behaviors related to poor diet, sedentary lifestyle, obesity, and smoking. Achievement of ideal CVH into adulthood may thus be best reached by maintaining it over the lifespan, rather than attempting to restore it. With the inclusion of health behaviors in the definition of CVH, the primacy of lifestyle and health behaviors as the antecedents of risk factors is firmly acknowledged. Moreover, the critical role of societal factors as an enabler of unhealthy behaviors and a

barrier to healthy ones is also emphasized, thus justifying the role for public health and policy initiatives geared toward promoting health.

Adopting a Life-Course Approach to Cardiovascular Health

From early pathologic studies such as those in Korean War casualties [22] to studies in childhood cohorts [23, 24], there has been increasing evidence that atherosclerosis originates in childhood and is influenced by early risk factor levels and unhealthy behaviors. Pooled data from four prospective cohorts, the Bogalusa Heart Study, Cardiovascular Risk in Young Finns Study, Childhood Determinants of Adult Health study, and the Muscatine Study, have tracked these lifestyle and biologic factors into adulthood to demonstrate that higher risk-factor levels in youth are significantly associated with carotid intima-media thickness (IMT) in adulthood [25]. Similar analyses from the Coronary Artery Disease in Young Adults (CARDIA) cohort have shown an analogous relationship between young adulthood risk factor levels and coronary artery calcification in middle age [26].

These cohort analyses have been extended to demonstrate the importance of childhood achievement of ideal CVH on intermediate outcomes in adulthood. Using data from the Young Finns Study, Laitinen et al. examined the effects of the seven CVH metrics on cardiometabolic outcomes in adulthood in 856 Finnish participants aged 12–18 years [27••]. With up to 21 years of follow-up, each unit increase in ideal CVH metric in childhood was associated with a lower risk of hypertension (odds ratio (OR) 0.66, 95 % CI 0.54–0.80), metabolic syndrome (OR 0.63, 95 % CI 0.52–0.77), elevated low-density lipoprotein cholesterol (OR 0.66, 95 % CI 0.52–0.85), and high-risk IMT (OR 0.75, 95 % CI 0.60–0.94) in adulthood. Ideal childhood CVH was inversely associated

Fig. 1 Prevalence estimates of US individuals meeting different numbers of criteria for ideal cardiovascular health by age groups, National Health and Nutrition Examination Surveys 2009–2010. Prevalence of ideal levels of cardiovascular health metrics are higher in US children (aged 12–19 years) and young adults (aged 20–39 years) than in older adults. Data from Go et al. [20]

with adult carotid IMT with a 0.067-mm difference in adult carotid IMT between children with six criteria for CVH compared with one criterion. To put this in clinical context, a 0.1-mm increase in carotid IMT has been demonstrated to be predictive for myocardial infarction (HR 1.15, 95 % CI 1.12–1.18) and for stroke (HR 1.17, 95 % CI 1.15–1.21) [28]. Thus, these findings emphasize the role of childhood CVH for future outcomes in adults and highlight the importance of a life-course approach to CVH.

The Importance of Health Behaviors

Analyses from CARDIA and the Framingham Heart Study have provided key insights into the role of health behaviors in maintaining CVH from young adulthood to middle age. In an analysis of 3,154 black and white participants aged 18–30 years from the CARDIA study, Liu et al. tested the relationship between adopting healthy lifestyle factors during young adulthood and prevalence of low CVD risk in middle age [29•]. Healthy lifestyle behaviors consisted of the four health behaviors in the CVH metric (body mass index < 25 kg/m², healthy diet, physical activity, nonsmoking) with the addition of no or moderate alcohol intake. Participants had data collected at year 0 (baseline), year 7, and year 20. Among those who practiced all five healthy lifestyle behaviors in young adulthood, approximately 60 % had low CVD risk in middle age (Table 2). Furthermore, there was a dose–response relationship between the number of healthy lifestyle behaviors followed and the prevalence of low CVD risk 20 years later. Although individuals who maintained a healthy lifestyle throughout the 20 years had the lowest risk for CVD, there was still an important role for behavioral change. Among

those who had four or fewer healthy lifestyle behaviors at all time points, the prevalence of low CVD risk at year 20 was only 13.6 %. Conversely, for those who had four or fewer healthy lifestyle behaviors at baseline but then had four or more healthy behaviors at year 7, year 20, or both, the prevalence of low CVD risk was higher (29.8 %, 37.5 %, and 52.2 %, respectively). These results indicate that regardless of timing, adoption of healthy lifestyle has benefit for the primordial prevention of CVD risk factors and the preservation of CVH.

Analyses of the Framingham Heart Study provide further support to the critical role of health behaviors and lifestyle factors in achieving CVH. Among related members of the Original, Offspring, and Third Generation of the Framingham Heart Study cohorts who had risk factors measured at similar ages, the heritability of ideal CVH was modest, varying from 13 to 18 %. Similar analyses in a twin sample showed that the inverse association between CVH metrics and carotid IMT was independent of shared genetic and familial factors [30]. Thus, the majority of CVH was explained by the environment related to health behaviors and lifestyle factors rather than heritability and genetics [31].

The health behaviors that make up the CVH construct provide specific targets for behavior change. A recent AHA Scientific Statement identified several, effective, clinical interventions for achieving behavior change including goal setting, motivational interviewing, regular feedback, increasing self-efficacy, and multicomponent behavioral interventions [32]. Mobile technologies have also been used to facilitate weight loss and multi-behavioral interventions [33, 34•]. More research is still needed to examine which approaches lead to meaningful, long-term, behavior change that will impact clinical outcomes such as CVD, mortality, hospitalizations, and quality of life.

Table 2 Low-risk status at year 20 by number of healthy lifestyle factors, year 0 to year 20, among Coronary Artery Disease in Young Adults (CARDIA) study participants (*n*=3,154)

Healthy lifestyle factors	Prevalence of low cardiovascular risk profile (%)
0–1	3.0
2	14.6
3	29.5
4	39.2
5	60.7

Healthy lifestyle factors include: body mass index <25 kg/m², average alcohol intake of 0–15 g/day for women and 0–30 g/day for men; highest 40 % on a dietary score; highest 40 % of the sex-specific distribution of average physical activity; and never smoking. Estimates were based on the average values from the baseline exam, year 7, and year 20. Low cardiovascular risk profile was defined as the absence of pre-existing cardiovascular disease and the simultaneous presence of untreated cholesterol <200 mg/dL, untreated blood pressure <120/<80 mmHg, no diabetes mellitus, and never smoking. Data from Liu et al. [29•]

Public Policy

Although personal responsibility and individual-level clinical interventions are essential, population-based interventions will also be critical in achieving greater CVH in the nation. This population-based strategy is rooted in the social ecological theory that sees an individual's social and physical environment as a strong potential influence on health and its determinants [35]. The loss of CVH therefore reflects systemic deficiencies in the environment that: facilitate sedentary behaviors; promote consumption of high-calorie nutrient-poor foods; and impede healthy weight maintenance. As proposed by Geoffrey Rose, population-based strategies are essential to shift the population towards healthier behaviors [3]. Successful public health interventions promoting CVH include sodium reduction in processed foods, public smoking bans and tobacco excise taxes to limit smoking, and

modifications of the built environment to promote physical activity. These strategies help maintain optimal levels of CVH and shift the entire distribution of risk to lower levels. A recent AHA Scientific Statement systematically reviewed evidence for various population strategies across multiple domains including media, product labeling, taxation, school and workplace initiatives, local environment changes, and legal mandates [36]. New laws such as the passage of the 2010 Patient Protection and Affordable Care Act has provided the health community with multiple opportunities to improve access to clinical preventive services, bolster workplace wellness, and strengthen the role of communities in promoting prevention [37]. Moreover, the Department of Health and Human Services has partnered with state and local governments to launch the “Million Hearts” initiative to coordinate and enhance CVD prevention programs across all government health agencies to prevent 1 million heart attacks and strokes over the next 5 years [38]. Such policy initiatives attempt to enhance and restructure the environment where people live, making healthy behaviors and healthy choices the norm.

Conclusions

The AHA’s 2020 Strategic Impact Goals set out a bold new strategy to improve the cardiovascular health of the nation. The CVH construct was defined and quantified based on seven health behaviors and factors. A combination of clinical, public health, and health policy interventions will be critical to reduce the prevalence of poor CVH, and increase the control of risk factors and improve the prevalence of ideal and intermediate levels of CVH. For each metric, modest shifts in the population distribution towards improved health can produce large increases in the proportion of Americans in the ideal- and intermediate-health categories, producing substantial cardiovascular benefits. The strong correlations between health behaviors and ideal health factors suggest that individuals can achieve and maintain cardiovascular health through health behaviors rather than through genetic predisposition. Primordial prevention efforts geared toward health promotion, sustained over the life course, and fostered by public health and health policy will be the key to preserving and maintaining CVH from childhood throughout the lifespan and improve the cardiovascular health of the nation.

Compliance with Ethics Guidelines

Conflict of Interest KN Karmali declares no conflicts of interest. DM Lloyd-Jones declares no conflicts of interest.

Human and Animal Rights and Informed Consent This article does not contain any studies with human or animal subjects performed by any of the authors.

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