Improving Cardiovascular Health in a Pediatric Preventive Cardiology Practice

Holly C. Gooding, MD, MSc[1], Kimberlee Gauvreau, ScD[2], Jennifer Bachman, PNP[2], Annette Baker, RN, MSN, PNP[2], S. Skylar Griggs, MS, RD, LDN[2], Jacob Hartz, MD, MPH[2], Yisong Huang, DrPH[2], Michael M. Mendelson, MD, ScM[2,3], Hannah Palfrey, BS[2], and Sarah D. de Ferranti, MD, MPH[2]

Poor childhood cardiovascular health translates into poor adult cardiovascular health. We hypothesized care in a preventive cardiology clinic would improve cardiovascular health after lifestyle counseling. Over a median of 3.9 months, mean cardiovascular health score (range 0-11) improved from 5.8 ± 2.2 to 6.3 ± 2.1 ($P < .001$) in 767 children. *(J Pediatr 2021;232:282-6).*

The American Heart Association (AHA) defined the concept of ideal cardiovascular health in 2010, setting the bold goal of improving the cardiovascular health of all Americans by 20% in the next decade.[1] Cardiovascular health includes 4 ideal health behaviors (not smoking, normal body mass index [BMI], high physical activity levels, and healthy dietary patterns) and 3 ideal health factors (optimal untreated blood pressure, total cholesterol, and blood glucose levels). Cardiovascular health is associated with low risk of cardiovascular disease (CVD), healthy longevity, and decreased health care costs.[2-4]

Unfortunately, the prevalence of cardiovascular health remains low in both children and adults, with <1% of the population meeting optimal levels of all seven cardiovascular health metrics.[5] Only 7.2% of US children and 5.3% of US adults have ≥6 cardiovascular health metrics; more than one-half of US children (55%) and fully 4 in 5 US adults (82.6%) have <5 metrics. Lifestyle counseling has been shown to improve cardiovascular health in the Special Turku Coronary Risk Factor Intervention Project for Children (STRIP) study, a lifestyle counseling intervention in healthy children.[6] Few studies have been published on clinical practice-based interventions to improve cardiovascular health, with even fewer studies focused on children.[7,8] We aimed to describe the prevalence of cardiovascular health factors in a pediatric population referred to a preventive cardiology clinic and to describe changes in cardiovascular health after intensive lifestyle counseling in this setting.

Methods

The Boston Children's Hospital Pediatric Preventive Cardiology Program provides referral-based, subspecialty care to children and adolescents with dyslipidemia, elevated blood pressure, or a combination of CVD risk factors. In 2010, the clinic adopted a hospital-wide quality improvement initiative, known as the Standardized Clinical Assessment and Management Plans (SCAMPs), that aimed to improve patient outcomes, decrease practice variation, and minimize unnecessary health care use using an iterative approach to data analysis and incorporating the management decisions of practitioners.[9] Children referred for dyslipidemia were prospectively enrolled in the Lipid SCAMP and managed according to established algorithms based on the 2011 National Heart Lung Blood Institute Expert Panel on Integrated Guidelines for Cardiovascular Health and Risk Reduction in Children and Adolescents.[10] Patients and families met with a multidisciplinary team including physicians, nurse practitioners, and a registered dietician trained in motivational interviewing techniques.[11] Lifestyle counseling was developmentally appropriate (family based for children or focused on the patient for adolescents) and tailored to individual risk factors, for example, focused on increasing dietary fiber from fruits and vegetables and lowering glycemic load for those with high triglycerides, lowering saturated fat, and eliminating trans-fats for patients with high low-density lipoprotein cholesterol levels, and increasing physical activity for all. An analysis of the quality improvement data collected as a part of the Lipid SCAMP, together with supporting chart review, was approved by the Boston Children's Hospital Clinical Research Committee with a waiver of consent.

Providers recorded data for patients enrolled in the Lipid SCAMP on standardized forms, which were then entered into an analytic dataset. Trained clinical assistants measured height, weight, and blood pressure using standard clinical

AHA	American Heart Association
BMI	Body mass index
CVD	Cardiovascular disease
SCAMP	Standardized Clinical Assessment and Management Plan
STRIP	Special Turku Coronary Risk Factor Intervention Project for Children

From the [1]Department of Pediatrics, Emory University School of Medicine, Atlanta, GA; [2]Department of Cardiology, Boston Children's Hospital, Boston, MA; and the [3]Cardiovascular & Metabolism Translational Medicine, Novartis Institutes for Biomedical Research, Cambridge, MA

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procedures; elevated blood pressures were confirmed by the practitioner using a manual sphygmomanometer, ensuring appropriate cuff size. Total cholesterol and glucose were obtained from peripheral blood samples on the morning of the clinic visit or at an outside laboratory shortly before the visit, generally after an 8-hour fast. Lifestyle factors, including exposure to any cigarette smoke, inadequate physical activity, and nutritional concerns, were recorded by providers as a yes/no checkbox on the SCAMP form. Family history of early atherosclerotic CVD in a first- or second-degree relative before the age of 65 years if female or 55 years if male was recorded by the treating provider as present or absent. Additional conditions that put children at high or moderately elevated risk for CVD as defined by a 2006 AHA Statement were also recorded.[12] The SCAMP quality improvement dataset was interrogated for entry errors. All anthropometric and laboratory values that were outside of 3 SDs of the cohort mean were manually confirmed in the hospital electronic health record. Data points on anthropometrics and cholesterol measurements missing from the SCAMP dataset and available in the medical record were extracted.[11]

We used the AHA definitions for cardiovascular health, with slight modifications to the diet, physical activity, and smoking metrics due to limitations in our quality improvement dataset (**Table I**; available at www.jpeds.com). Given the high degree of missing data for glucose, we used a cardiovascular health score based only on the other 6 metrics. We assigned a score of 0 for all poor health metrics, 1 for all intermediate health metrics, and 2 for all ideal health metrics, for a possible cardiovascular health score range of 0-11 (because none had an ideal diet). We analyzed data on individual cardiovascular health metrics and the total cardiovascular health score for participants with complete data on the 6 metrics for ≥2 consecutive visits to the Preventive Cardiology clinic between September 2, 2010, and January 3, 2017.

We calculated the mean cardiovascular health score at the initial clinical visit, the second clinical visit, and the last recorded clinical visit for patients who had available data on >2 visits. We assessed for change in the mean cardiovascular health score between the initial and second clinical visit, and the initial and last recorded visit using paired *t* tests. Changes in ordinal variables were evaluated using the Wilcoxon signed-rank test, and changes in binary variables using the McNemar test. Mean cardiovascular health scores were compared between groups using the 2-sample *t* test or 1-way ANOVA. Categorical variables were compared between groups using the χ^2 test. We report results stratified by age (<14 vs ≥14 years of age), sex, moderate- or high-risk factor status, statin use, and the 3 time periods (September 2, 2010, to May 31, 2012; June 1, 2012, to February 28, 2014; and March 1, 2014, to January 6, 2017) of the quality improvement project.

Results

Of 1097 patients seen for 2 consecutive visits during the study period, 767 (69.9%) had complete data on all cardiovascular health metrics except glucose. The 767 patients included in the analytic sample were similar to the 330 who were not included on all demographic characteristics and most cardiometabolic measures; those included did have slightly lower median BMI percentile (89.6% vs 94.7%), higher median high-density lipoprotein cholesterol (48.2 mg/dL vs 43.4 mg/dL), lower median triglycerides (119 mg/dL vs 146 mg/dL), and lower mean diastolic blood pressure (62 mm Hgvs 64 mm Hg), and were more likely to have probable familial hypercholesterolemia (27.6% vs 19.1%) ($P < .01$ for all). Of the 767 patients seen twice, 449 (58.5%) had ≥1 additional visit recorded. Median age at the initial visit was 12.5 years (IQR, 10.2-15.9) and 414 (54.0%) were female. Only 32 (4.2%) had a moderate- or high-risk CVD condition. Additional demographic and clinical factors at first visit during the study period for the analytic sample are found in **Table II**. Participants attending a third visit were more likely to identify as White, to have higher mean total and low-density lipoprotein cholesterol levels, and to have probable familiar hypercholesterolemia (**Table II**).

The mean ± SD cardiovascular health score at the initial visit was 5.8 ± 2.2. Females had a higher mean cardiovascular health score (6.0 ± 2.1) than males (5.6 ± 2.2) ($P = .012$ for difference by sex), as did children <14 years compared with those 14 years of age and older (6.0 ± 2.2 vs 5.6 ± 2.0; $P = .005$ for difference by age). The mean cardiovascular health score did not differ significantly by presence or absence of a moderate-to-high CVD risk condition (5.5 vs 5.8; $P = .37$) or across the 3 time periods of the quality improvement project (5.6, 6.0, and 5.7; $P = .052$).

The **Figure** depicts the percentage of patients with ideal, intermediate, and poor status for each of the 6 metrics at the initial visit, first follow-up, and final follow-up visit. Females were more likely than males to have ideal BMI (52.2% vs 34.8%; $P < .001$), but less likely to have ideal total cholesterol (7.3% vs 12.1%; $P = .008$) at the initial visit. Younger patients were more likely than patients ≥14 years of age to have intermediate diet (24.0% vs 10.8%; $P < .001$), ideal physical activity (55.7% vs 35.3%; $P < .001$), and ideal BMI (47.7% vs 38.7%; $P = .004$), but also more likely to have poor blood pressure (26.6% vs 16.8.%; $P = .005$) at the initial visit.

Over a median of 3.9 months (IQR, 3.2-6.0 months) from the initial assessment to the first follow-up, the mean cardiovascular health score improved from 5.8 ± 2.2 to 6.3 ± 2.1 ($P < .001$). The mean cardiovascular health score improved further to 6.4 ± 2.2 for the 449 patients who had an additional visit recorded during a median of 11.5 months (IQR, 4.8-27.8 months) from the initial assessment ($P < .001$ for comparison with the initial visit). Improvement was seen in all cardiovascular health factors from the initial assessment to the first follow-up; differences in diet, smoking, blood pressure, and total cholesterol were statistically significant (**Figure**). Improvement was also seen in median BMI percentile from the initial to first follow-up (89.9th percentile vs 88.6th percentile; $P < .001$) but was not present at final follow-up (89.4th percentile; $P = .15$ for

Table II. Characteristics of 767 patients enrolled in a pediatric preventive cardiology Lipid SCAMP, from September 2, 2010, to January 3, 2017

Characteristics	Full sample (total = 767)	Has third visit (total = 449)	No third visit (total = 318)	*P* value
Demographics				
Age in years	12.5 [10.2-15.9]	12.2 [10.1-15.9]	12.6 [10.4-15.9]	.26
Female	414 (54.0)	250 (55.7)	164 (51.6)	.27
Race/ethnicity				
Asian	37 (4.8)	23 (5.1)	14 (4.4)	<.001
Black	35 (4.6)	23 (5.1)	12 (3.8)	
White	369 (48.1)	233 (51.9)	136 (42.8)	
Other	176 (23.0)	106 (23.6)	70 (22.0)	
Missing/declined to answer	150 (19.6)	64 (14.3)	86 (27.0)	
Cardiometabolic measures				
BMI, kg/m^2	23.1 [18.8-28.1]	23.0 [18.8-27.6]	23.5 [18.8-28.6]	.64
BMI percentile	89.6 [61.4-97.6]	89.9 [63.4-97.5]	88.9 [60.0-98.0]	.70
Total cholesterol, mg/dL	227.3 ± 51.7	232.2 ± 53.7	220.4 ± 48.0	.001
LDL cholesterol, mg/dL	150.7 ± 52.3	155.7 ± 54.1	143.7 ± 48.8	.001
HDL cholesterol, mg/dL	48.2 ± 14.1	47.7 ± 13.2	48.9 ± 15.2	.24
Triglycerides, mg/dL	119 [75-183]	119 [75-185]	117 [74-177]	.61
Fasting glucose, mg/dL	89 [84-94]	88 [83-93]	92 [86-97]	.003
Systolic blood pressure, mm Hg	112.9 ± 12.7	113.0 ± 12.5	112.8 ± 13.0	.87
Diastolic blood pressure, mm Hg	62.1 ± 9.3	62.6 ± 9.2	61.4 ± 9.4	.085
Conditions posing increased risk for CVD				
Probable familial hypercholesterolemia*	212 (27.6%)	138 (30.7)	74 (23.3)	.027
Diabetes, type 1	23 (3.0)	16 (3.6)	7 (2.2)	.39
Diabetes, type 2	10 (1.3)	8 (1.8)	2 (0.6)	.21
High-risk condition†	5 (0.7)	5 (1.1)	0 (0.0)	.080
Moderate-risk condition‡	27 (3.5)	18 (4.0)	9 (2.8)	.43

HDL, high-density lipoprotein cholesterol; *LDL*, low-density lipoprotein cholesterol
Values are median [IQR], number (%), or mean ± SD.
*Probable familial hypercholesterolemia defined as an LDL of ≥190 mg/dL, or an LDL of ≥160 mg/dL but <190 mg/dL, and a family history of a CVD event before age 55 (men) or 65 (women).
†High-risk conditions include Kawasaki disease with current aneurysms, postorthotopic heart transplant, chronic renal disease, diabetes mellitus type 1 or 2.
‡Moderate risk conditions include Kawasaki disease with regressed coronary aneurysms, HIV, congenital heart disease, and chronic inflammatory disease, such as juvenile rheumatoid arthritis and childhood cancer.

comparison with the initial visit). Males made greater gains in the total cardiovascular health score between the initial and the final visit compared with females (0.7 ± 2.3 vs 0.4 ± 2.0), as did patients with high/moderate CVD risk compared with those without (0.9 ± 2.8 vs 0.5 ± 2.1). Younger and older children made similar gains in cardiovascular health. Only 61 children (8%) were prescribed statin therapy, and the cardiovascular health score did not differ at the second or final visit based on whether or not statins were prescribed. Improvements were seen across the 3 time periods of the quality improvement project (data not shown).

Discussion

In this analysis of a quality improvement database collected in a pediatric preventive cardiology clinic, we were able to demonstrate an improvement in cardiovascular health in a referral-based clinical setting after just 1 visit, and further improvement for those patients who attended a third clinic visit. Females and younger patients had better cardiovascular health scores at baseline, but males showed more improvement. The greatest improvements were seen in the diet, smoking, blood pressure, and cholesterol metrics.

The cardiovascular health of children referred to a pediatric preventive cardiology clinic was understandably less than ideal at the start of this study, reflecting the referral nature of the sample. Compared with adolescents ages 12-19 years participating in the 2016 National Health and Nutrition Examination Survey, patients in this sample had a lower prevalence of ideal BMI (44% vs 60%), ideal blood pressure (64% vs 85%), and ideal total cholesterol (9% vs 78%).[5] Patients in this sample had a higher prevalence of intermediate diet (19% vs 11%) and ideal physical activity (48% vs 25%) compared with adolescents in National Health and Nutrition Examination Survey, although these metrics were based on provider assessment of patient and parent self-report and so are subject to desirability biases.

Most patients met with a registered dietician and almost all received counseling as a family unit. Both of these factors, along with the number of visits, have been associated with improvement in pediatric obesity as noted in a recent US Preventive Services Task Force review.[13] This is important, because obesity is a major contributor to poor cardiovascular health in both children and adults, and affected 37% of the patients referred to this subspecialty clinic. We did not see as much improvement in BMI categories as we saw in other cardiovascular health metrics, although we did see a slight improvement in the median BMI percentile. This result likely reflects the challenge of moving from obese or overweight into a lower BMI range in such a short time frame. Nevertheless, our findings suggest that lifestyle-based counseling can

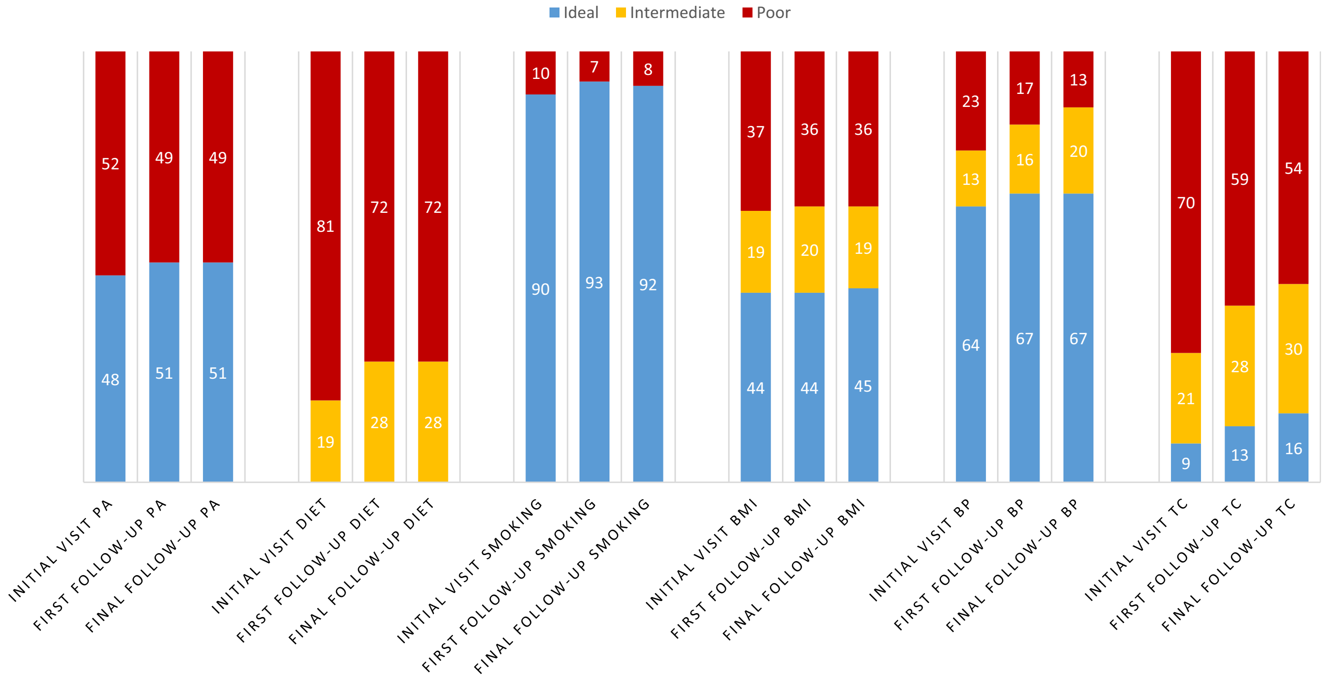

Figure. Proportion of patients enrolled in a pediatric preventive cardiology Lipid SCAMP meeting each of the AHA ideal cardiovascular health metrics at initial clinical visit first follow-up, and final follow-up. For 318 participants, the first follow-up and final follow-up are the same. *BP*, blood pressure; *PA*, physical activity; *TC*, total cholesterol.

be effective in improving cardiovascular health, even in the absence of weight change.

Our results in this clinic sample are similar to those reported by the STRIP study, a randomized controlled trial of individualized dietary and antismoking counseling delivered to healthy children biannually from infancy until 20 years of age in Finland.[6] The STRIP investigators measured carotid intima-media thickness as a part of their research protocol and also reported lower aortic intima-media thickness and greater elasticity with the increasing number of cardiovascular health metrics met, suggesting that even modest improvements in cardiovascular health in children may have long-term vascular benefits, especially if maintained over time. Longitudinal cohort data in adults demonstrate a clear dose-response relationship with cardiovascular health score and outcomes, with each 1-point improvement in cardiovascular health score corresponding with a 20% lower hazard of CVD events or all-cause mortality over time.[14]

Our patients demonstrated greater improvement than was shown in a trial of an electronic health record based intervention to improve the cardiovascular health of women ages ≥65 years in a primary care clinic, which showed a nonsignificant improvement in the overall cardiovascular health score of only 0.024, compared with the improvement of 0.4-0.6 seen in our pediatric sample.[7] Some of this difference may have been due to the fact that the adult study omitted physical activity and diet, which are arguably the easiest to improve quickly. Nevertheless, our data suggest that investing in pediatric cardiovascular prevention may yield great returns on investment.

Study limitations include the lack of long-term follow-up of participants; we are unable to comment on whether improvements seen in cardiovascular health were sustained over time. We had to make some alterations to the AHA definitions for cardiovascular health metrics, and some metrics in this real-world clinical sample relied on a provider's designation about the patient's adherence to exercise goals, nutritional recommendations, and smoking exposure; these factors are likely particularly susceptible to desirability bias and may have inflated the improvement seen in the overall cardiovascular health score. Patients were not randomized to the intervention, limiting our ability to ascribe improvements in cardiovascular health to the specific lifestyle counseling or other aspects associated with attending a pediatric preventive cardiology clinic. Improvements in the cholesterol and blood pressure metrics may also partially reflect regression to the mean. Finally, this quality improvement sample may not be representative of other clinical populations and we were unable to stratify our data by important factors such as race owing to the small number of participants with a race other than white identified in the patient record; tracking data by demographic factors to identify and address disparities in care is an important future initiative.

More studies are needed on the interventions within pediatric care settings to improve cardiovascular health. Primary care medical homes and pediatric obesity clinics are prime targets for future research because they are able to reach greater numbers of patients than preventive cardiology programs, and impact patients with better cardiovascular health at baseline. Expansion of the capacity of electronic health records to trigger screening, track cardiovascular health, and assist providers in delivering interventions is needed to improve quality improvement efforts and support scalability. To truly achieve primordial prevention and preservation of cardiovascular health, clinic-based interventions for higher risk patients must be combined with community and population-based efforts to improve the food and built environment, and systematic initiatives to screen and detect intermediate cardiovascular health metrics so targeted interventions can be delivered before poor health develops. ■

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Reprint requests: Sarah D. de Ferranti, MD, MPH, Department of Cardiology, Boston Children's Hospital, 300 Longwood Avenue, Boston, MA 02115. E-mail: sarah.deferranti@cardio.chboston.org

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Table I. Definitions of poor, intermediate, and ideal cardiovascular health metrics used in the original AHA 2020 Goals[1] and adapted for use in the Boston Children's Hospital Subspecialty Lipid SCAMP dataset

Cardiovascular health metrics	Poor		Intermediate		Ideal	
	AHA	SCAMP	AHA	SCAMP	AHA	SCAMP
Blood pressure	>95th percentile	>95th percentile	90-95th percentile or taking a blood pressure medication	90-95th percentile or taking a blood pressure medication	<90th percentile	<90th percentile
Total cholesterol	≥200 mg/dL	≥200 mg/dL	170-199 mg/dL or taking a lipid lowering medication	170-199 mg/dL or taking a lipid lowering medication	<170 mg/dL	<170 mg/dL
Plasma glucose	≥126 mg/dL or diabetes	≥126 mg/dL or diabetes	100-125 mg/dL	100-125 mg/dL	<100 mg/dL	<100 mg/dL
BMI	> 95th percentile	> 95th percentile	85th to 95th percentile	85th to 95th percentile	<85th percentile	<85th percentile
Smoking	Tried during the prior 30 days	Any cigarette smoke exposure*	…	…	Never smoked a whole cigarette	No cigarette smoke exposure*
Physical activity	None	Inadequate exercise (<5 hours per week)	>0 and <60 minutes of moderate or vigorous every day	…	≥60 minutes of moderate or vigorous every day	Not inadequate (≥5 h/wk)
Diet	<2 components of the AHA diet score	Nutritional concerns	2-3 components of the AHA diet score	No nutritional concerns	4-5 components of the AHA diet score	…

*Includes exposure to secondhand smoke.