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ORIGINAL ARTICLE

Life's Essential 8 and Life's Simple 7 in Relation to Coronary Atherosclerosis: Results From the Population-Based SCAPIS Project

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Abstract

Objective: To examine the associations between the American Heart Association scores ("Life's Essential 8" [LE8] and "Life's Simple 7" [LS7]) and 2 subclinical coronary atherosclerosis indicators: coronary computed tomographic angiography (CCTA)-stenosis and coronary artery calcium (CAC).

Patients and Methods: We included a population-based sample, aged 50 to 64 years, recruited between 2013 and 2018 from the Swedish Cardiopulmonary Bioimage Study (n=24,819, 50.3% women). CCTA-stenosis was graded as no stenosis, stenosis (1%-49%) or severe stenosis (≥50%), whereas CAC was graded as 0, 1 to 99, 100 to 399, or ≥400 Agatston units. Multinomial logistic regression and receiver operating characteristic (ROC) curves were used to study the associations between cardiovascular health scores and subclinical coronary atherosclerosis.

Results: Odds ratios (ORs) for CCTA-stenosis and severe CCTA-stenosis between the lowest (<50 points) vs the highest (≥80 points) LE8 group were 4.18 (95% CI, 3.56 to 4.91) and 11.17 (95% CI, 8.36 to 14.93), respectively. For corresponding CAC results, ORs were 3.36 (95% CI, 2.84 to 3.98), 7.72 (95% CI, 6.03 to 9.89), and 14.94 (95% CI, 10.47 to 21.31) for CAC scores of 1 to 99, 100 to 399, and ≥400, respectively. Area under ROC curves for predicting any stenosis were 0.642 (95% CI, 0.635 to 0.649) and 0.631 (95% CI, 0.624 to 0.638, $P<.001$) for LE8 and LS7, respectively.

Conclusion: Our data indicate that LE8 showed a strong, graded, and inverse association with CCTA-stenosis and CAC score. The capacity to predict CCTA-stenosis was comparable between LE8 and LS7, although LE8 had slightly higher prediction capacity of any stenosis. This study provides novel evidence that the LE8 score may be a useful tool for monitoring cardiovascular health.

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Cardiovascular disease continues to be the leading cause of mortality in the world.[1] Although the United States and Europe have experienced positive trends in age-adjusted cardiovascular disease mortality in the last decades, such positive trends are decelerating.[2,3] This highlights the importance of a reinforced global strategy for prevention of cardiovascular disease.

In 2010, the American Heart Association (AHA) defined the construct "ideal cardiovascular health" or "Life's Simple 7" (LS7), which implied a pivotal shift from management of cardiovascular disease to cardiovascular health (CVH) strategies, emphasizing primordial and primary prevention. Briefly, LS7 includes 4 lifestyle behaviors (nonsmoking status, ideal body mass index [BMI], ideal physical activity, and healthy diet) and 3 established risk factors (ideal profiles of blood total cholesterol, fasting blood glucose, and levels of blood pressure).[4] Previous research has demonstrated strong and inverse associations of LS7 with a range of health outcomes, including all-cause and cardiovascular disease mortality and morbidity.[5]

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Although LS7 has vastly improved the knowledge about CVH, it has shown some limitations, especially a limited sensitivity to measure interindividual variation and intraindividual or intrapopulation changes over time.[6] To overcome these limitations, in June 2022, the AHA defined a new construct called "Life's Essential 8" (LE8).[6] Compared with LS7, LE8 includes a new component (sleep health) and has considerably revised calculations for all components; therefore, the capacity of LE8 to predict coronary atherosclerosis is unknown at present. The AHA has requested that further research is needed to establish the utility of LE8, as it is currently uncertain whether this new construct performs equally well as a measure of CVH.

Early recognition of subclinical coronary atherosclerosis could offer an opportunity to prevent or delay cardiovascular disease at an early stage in individuals with the greatest cardiovascular disease risk, and it is therefore clinically useful to examine the extent to which LE8 predicts subclinical coronary atherosclerosis.[7] Coronary artery calcium (CAC) score is an indicator of subclinical coronary atherosclerosis that has been validated as a robust method to stratify the risk of future cardiovascular events in asymptomatic patients beyond traditional risk scores and risk factors.[8] In parallel, coronary computed tomographic angiography (CCTA) has emerged as an accurate noninvasive method that may increase prognostic capacity in the prediction of cardiovascular disease mortality not only in symptomatic patients but also in certain groups of asymptomatic individuals.[9-11]

To our knowledge, however, no previous study has examined the role of LE8 or LS7 scores in coronary plaque stenosis measured by gold-standard imaging techniques such as contrast-enhanced CCTA. This study aims to comprehensively examine the association of LE8 and LS7 scores with subclinical coronary atherosclerosis (CCTA-diagnosed plaque stenosis and CAC scores) in the general population.

METHODS

Study Design and Participants

The study design and methods of the Swedish Cardiopulmonary Bioimage Study (SCAPIS) have been previously described in detail.[12] Briefly, SCAPIS is a general population-based study that characterizes a large population (n=30,154) through state-of-the-art imaging technologies and comprehensive clinical examinations to improve prevention strategies for cardiovascular disease. During 2013 to 2018, men and women aged 50 to 64 years were randomly recruited (overall participation rate: 50.3%) from 6 university cities in Sweden: Gothenburg, Linköping, Malmö/Lund, Stockholm, Umeå, and Uppsala.

Figure 1 presents a flow chart for the study. Of the 30,154 participants available in SCAPIS, 24,819 (82.3%) and 24,443 (81.1%) participants were retained and used in the analysis of CCTA-stenosis and CAC, respectively. Ethical approval was obtained from the Swedish Ethical Review Authority (reference numbers 2021-06408-01, 2022-04375-02), and all participants provided written informed consent.

Cardiovascular Health Scores

Life's Essential 8. LE8 was defined according to the AHA criteria.[6] Details about measurements and calculation of the LE8 score are described in detail in Appendix S1 (available online at http://www.mayoclinicproceedings.org). Briefly, factors were measured using standardized methods for blood lipids, blood glucose, blood pressure, and BMI. Diet scores were calculated considering the Mediterranean Eating Pattern for Americans[13] through a web-based questionnaire (MiniMeal-Q), physical activity was measured through triaxial accelerometry, and nicotine exposure and sleep health were measured through questionnaires.

All 8 components within LE8 were scored from 0 to 100 (best CVH). As the AHA recommends,[6] LE8 was calculated as the unweighted average of all present components, and participants with data on $\geq$7

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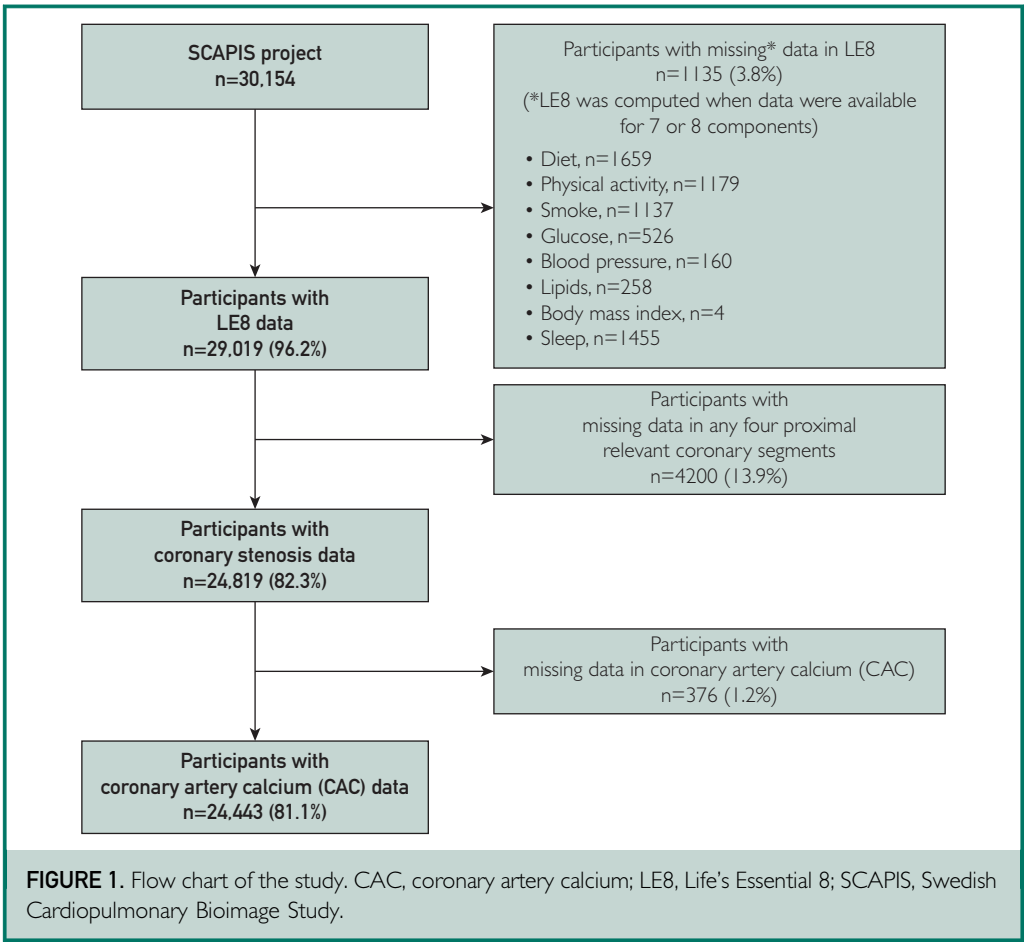

FIGURE 1. Flow chart of the study. CAC, coronary artery calcium; LE8, Life's Essential 8; SCAPIS, Swedish Cardiopulmonary Bioimage Study.

components were included. In addition, the total LE8 score was grouped in 5 groups as follows: <50, 50 to 59.9, 60 to 69.9, 70 to 79.9, and 80 to 100 points.

Life's Simple 7. LS7 was defined according to the AHA criteria.[4] Details about measurements and calculation of the LS7 score are outlined in Appendix S2 (available online at http://www.mayoclinicproceedings.org). Two scores of LS7 were created: in the LS7 (0-7) score, we calculated the number of LS7 components at ideal level, thus creating a score ranging from 0 to 7 (the highest CVH) points. In the LS7 (0-14) score, we calculated a combined score of the 7 components that were rated as 0 (poor CVH), 1 (intermediate CVH), or 2 (ideal CVH), leaving a total score from 0 to 14 (the highest CVH) points.

Subclinical Coronary Atherosclerosis Measurements

The imaging protocol for SCAPIS has been described in detail elsewhere and fulfills relevant guidelines and regulations.[12] In accordance with the Society of Cardiovascular Computed Tomography guidelines, an 18-segment coronary artery tree model was used to report coronary atherosclerosis from CCTA.[14] In the primary analysis, only the 11 clinically most relevant segments (segments 1 through 3, 5 through 7, 9, 11 through 13, and 17) were considered.[15] Each segment was categorized as follows: no stenosis, 1%-49% stenosis, ≥50% stenosis, not assessable because of calcium blooming (an artifact that prevents accurate evaluation of the coronary artery lumen), not assessable because of technical failure, and segment missing.

TABLE 1. Clinical Characteristics of the Study Sample by Sex

	Total n=24,819	Women n=12,477 (50.3%)	Men n=12,342 (49.7%)
Age and cardiovascular risk factors			
Age, y	57.4 (4.3)	57.4 (4.3)	57.4 (4.4)
BMI, kg/m^2	26.8 (4.3)	26.3 (4.6)	27.3 (3.8)
Obesity, n (%)	4955 (20.0)	2379 (19.1)	2576 (20.9)
Total cholesterol, mg/dL	212.6 (40.2)	218.4 (39.3)	206.7 (40.1)
HDL cholesterol, mg/dL	63.2 (19.1)	71.4 (19.1)	55.0 (15.3)
LDL cholesterol, mg/dL	133.3 (37.0)	133.2 (36.9)	133.3 (37.0)
Hypercholesterolemia, n (%)	2681 (11.0)	1038 (8.8)	1598 (13.2)
Systolic blood pressure, mm Hg	125.8 (16.8)	123.0 (17.6)	128.6 (15.5)
Diastolic blood pressure, mm Hg	77.5 (10.5)	76.6 (10.7)	78.4 (10.1)
Hypertension, n (%)	5250 (21.5)	2432 (19.8)	2818 (23.2)
Fasting glucose, mg/dL	102.7 (18.4)	99.5 (15.8)	106.0 (20.2)
HbA1c, %	5.48 (0.53)	5.46 (0.47)	5.50 (0.59)
Diabetes mellitus, n (%)	921 (3.8)	327 (2.7)	594 (4.9)
Moderate-vigorous physical activity, minutes per day	56.4 (29.6)	54.6 (27.9)	58.2 (31.1)
LE8 diet (0-100) score	40.9 (16.0)	44.5 (16.2)	37.2 (15.0)
Smoking, n (%)			
Current	3136 (12.8)	1594 (12.9)	1542 (12.6)
Ex-smoker	8865 (36.1)	4783 (38.8)	4082 (33.4)
Never	12,558 (51.1)	5951 (48.3)	6607 (54.0)
Alcohol intake, frequency, last year, n (%)			
Never	1983 (8.1)	1120 (9.1)	863 (7.0)
Monthly or less	3694 (15.0)	2145 (17.3)	1549 (12.7)
2-4 times a month	9468 (38.5)	4797 (38.8)	4671 (38.1)
2-3 times a week	7646 (31.1)	3671 (29.7)	3975 (32.5)
≥4 times a week	1826 (7.4)	640 (5.2)	1186 (9.7)
Social factors			
Education level, n (%)			
Unfinished primary school	135 (0.5)	60 (0.5)	75 (0.6)
Primary school	2037 (8.3)	891 (7.2)	1146 (9.3)
Secondary school	11,255 (45.6)	5279 (42.5)	5976 (48.7)
University degree	11,254 (46.6)	6182 (49.8)	5072 (41.3)
Current marital status, n (%)			
Single	3214 (13.1)	1663 (13.4)	1551 (12.7)
Divorced	2661 (10.8)	1664 (13.4)	997 (8.1)
Married	18,357 (74.6)	8766 (70.8)	9591 (78.4)
Widowed	386 (1.6)	286 (2.3)	100 (0.8)
Cardiovascular health scores			
Life's Essential 8 score, n (%)			
<50	933 (3.8)	367 (2.9)	566 (4.6)
50-59.9	3215 (13.0)	1301 (10.4)	1914 (15.5)
60-69.9	6854 (27.6)	2914 (23.4)	3940 (31.9)
70-79.9	7851 (31.6)	4020 (32.2)	3831 (31.0)
≥80	5966 (24.0)	3875 (31.1)	2091 (16.9)
LE8 (0-100) score	70.9 (11.4)	73.0 (11.5)	68.9 (11.0)
Life's Simple 7 score			
LS7 (0-7) score	3.3 (1.3)	3.5 (1.3)	3.1 (1.2)
LS7 (0-14) score	9.2 (2.0)	9.5 (2.0)	8.8 (1.9)

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TABLE 1. Continued

	Total n=24,819	Women n=12,477 (50.3%)	Men n=12,342 (49.7%)
Subclinical coronary atherosclerosis			
CCTA plaque, n (%)			
No stenosis	14,259 (57.5)	8806 (70.6)	5453 (44.2)
Any stenosis 1%-49%	9114 (36.7)	3378 (27.1)	5736 (46.5)
Any stenosis ≥50%	1446 (5.8)	293 (2.3)	1153 (9.3)
CAC score, Agatston units, n (%)			
0	14,614 (59.8)	8995 (72.7)	5619 (46.6)
1-99	6944 (28.4)	2686 (21.7)	4258 (35.3)
100-399	1976 (8.1)	534 (4.3)	1442 (11.9)
≥400	909 (3.7)	161 (1.3)	748 (6.2)

General and CCTA analysis: participants with available data in LE8 + 4 relevant proximal coronary segments are considered, n=24,819.

CAC score analysis: participants with available data in Life's Essential 8 + 4 relevant proximal coronary segments + CAC are considered, n=24,443.

Data refer to mean (standard deviation) and frequencies (percentage). Percentages are calculated without considering missing data in the denominator.

BMI, body mass index; CAC, coronary artery calcium; CCTA, coronary computed tomographic angiography; HbA1c, glycated hemoglobin; HDL, high-density lipoprotein; LDL, low-density lipoprotein; LE8, Life's Essential 8; LS7, Life's Simple 7.

In the primary analysis, as calcifications are known to generally overestimate the level of coronary stenosis,[16] calcium blooming in a coronary segment was rated as "1%-49% stenosis." Similarly, as percutaneous coronary intervention is usually a technical procedure for severe stenosis, the presence of a stent in a coronary segment was rated as "≥50% stenosis." Finally, a participant's grade of stenosis was classified as no stenosis, 1%-49% stenosis (any stenosis <50%), or severe stenosis (any stenosis ≥50%), based on the segment with the greatest amount of stenosis.

CAC images were analyzed according to an international standard protocol,[17] and the calcium content in each coronary artery was measured and summed to produce a total CAC score in Agatston units.[18,19] CAC scores were divided into the 4 categories commonly used in clinical practice as follows: 0, 1 to 99, 100 to 399, and ≥400 Agatston units.

Statistical Analysis

The associations between LE8 and LS7 scores and subclinical coronary atherosclerosis were analyzed through multinomial logistic regression models, with increasing level of covariate control: Model 1, unadjusted; Model 2, adjusted for age, sex, and study site; and Model 3, adjusted for age, sex, study site, alcohol intake, educational status, and current marital status. Model 2 was selected as the main analysis, considering its clinical utility. Multinomial (instead of ordinal) models were elected because of concerns about the parallel regression assumption of ordinal models.

To enhance clinical interpretation, we estimated the adjusted marginal probability of subclinical coronary atherosclerosis indicators across CVH scores in Model 2, which we hereafter refer to as the "adjusted prevalence." We also examined the adjusted prevalence of stenosis in specific segments, contrasting participants with high and low LE8 scores. The capacity to predict CCTA-stenosis for LE8 and LS7 were compared by receiver operating characteristic (ROC) curves trough DeLong tests.

We conducted a series of sensitivity analyses to examine the robustness of our main findings. First, as we excluded some participants because of missing data (17.7%) and we observed that those excluded had somewhat worse CVH and more coronary atherosclerosis, we performed an extreme scenario sensitivity analysis. In this analysis, participants with missing data on LE8 score or CCTA-stenosis were considered to have the worst possible score or the best possible score. Second, we also performed a secondary sensitivity analysis for the results within CCTA-stenosis as follows: considering all 18 coronary segments of the arterial tree,

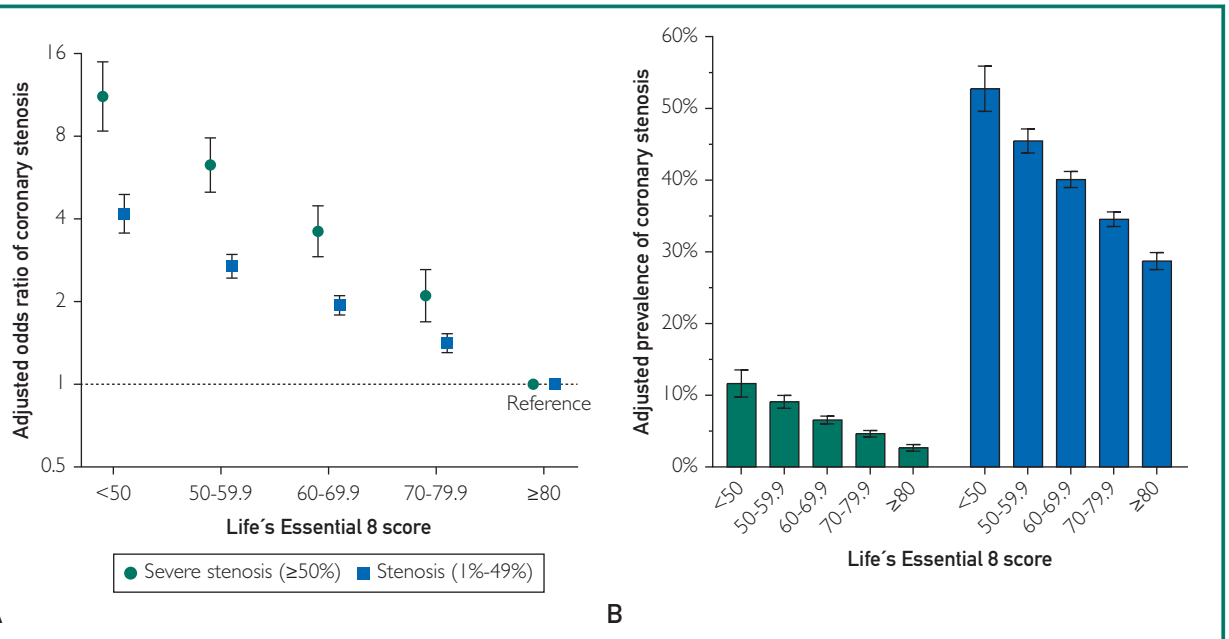

FIGURE 2. Life's Essential 8 and coronary plaque stenosis. (A) The multinomial regression model to estimate odds ratios of CCTA-stenosis (1%-49%) and severe CCTA-stenosis (≥50%) across Life's Essential 8 scores (adjusted for sex, age, and study site). (B) The adjusted prevalences of CCTA-stenosis (1%-49%) and severe CCTA-stenosis (≥50%) across Life's Essential 8 scores (adjusted for sex, age, and study site). CCTA, coronary computed tomography angiography.

analyzing calcium blooming as "≥50% stenosis," excluding coronary segments with a stent, excluding participants with self-reported cardiovascular disease, and considering only participants with valid data on all 8 components in LE8 instead of considering 7 or 8 components.

All statistical tests were 2-sided, and $P<.05$ was considered statistically significant. Analyses were conducted using IBM-SPSS-28 (IBM Corp, Armonk, New York, USA) and STATA 17 (StataCorp, College Station, Texas, USA).

RESULTS

Descriptive Statistics

The characteristics of the study population stratified by sex are presented in Table 1. Overall, the mean (standard deviation) for LE8 score was 70.9 (11.4) points, and 3.8% of participants had LE8 scores <50 points, 72.2% between 50 and 79.9 points, and 24.0% had LE8 scores ≥80 points. In general, women had better levels of LE8 than men (73.0 vs 68.9 points), and less coronary atherosclerosis defined by CCTA-stenosis (any stenosis 1%-49%, 27.1% vs 46.5%; any severe stenosis ≥50%, 2.3% vs 9.3%) and CAC score (CAC score = 0, 72.7% vs 46.6%). As shown in Appendix S3 and Supplemental Table 1 (available online at http://www.mayoclinicproceedings.org), participants who were excluded from the study had somewhat less favorable LE8 scores and more coronary atherosclerosis.

Life's Essential 8 and coronary plaque stenosis. Figure 2 presents the adjusted odds ratios (ORs) and adjusted prevalences of CCTA-stenosis by LE8 scores (detailed data in Supplemental Table 2 and Supplemental Table 3, available online at http://www.mayoclinicproceedings.org).

Overall, there was a strong, graded, and inverse association between LE8 scores and CCTA-stenosis that, in terms of ORs, was particularly high for severe stenosis. OR for CCTA-stenosis (1%-49%) was 4 times higher in the lowest LE8 (<50 points) group (OR, 4.18; 95% CI, 3.56 to 4.91; adjusted

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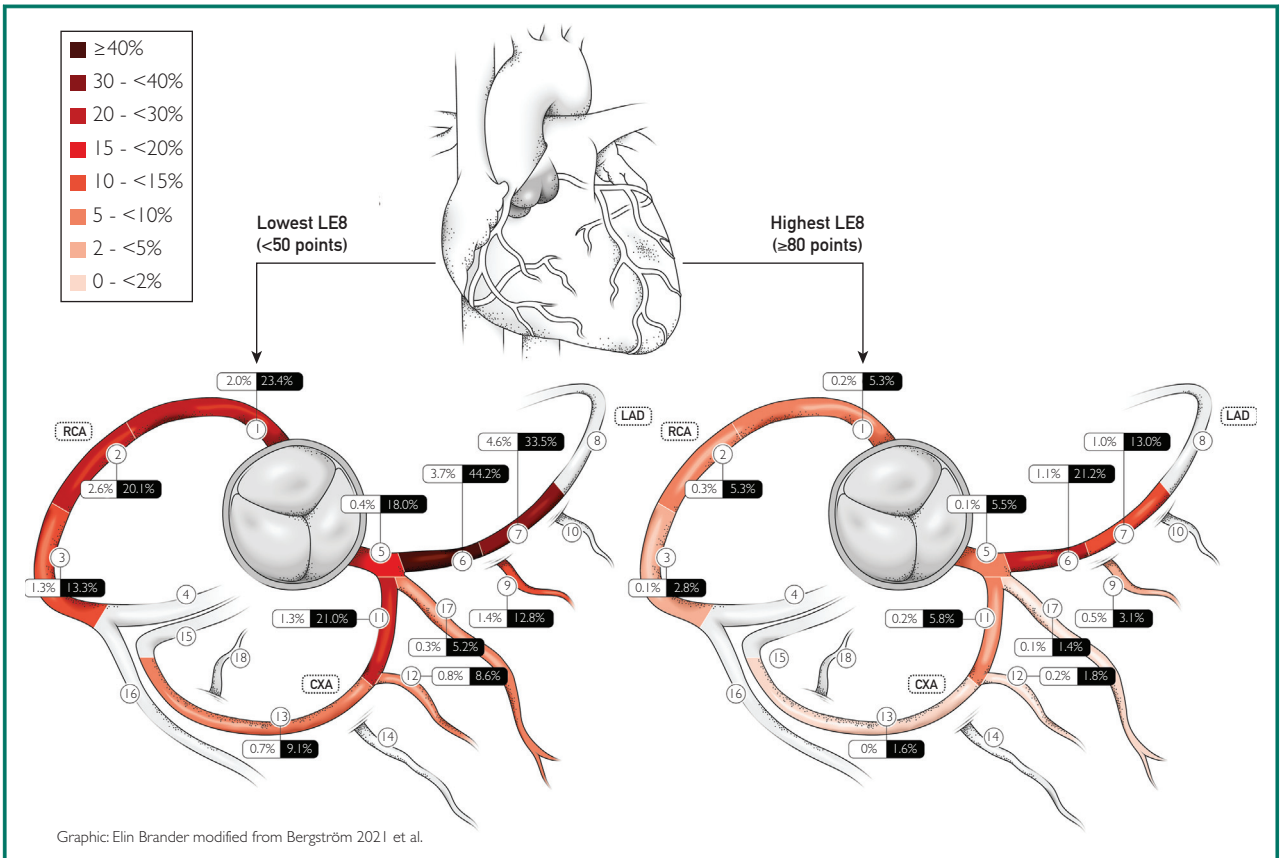

FIGURE 3. Life's Essential 8 and plaque stenosis in the 11 more relevant coronary segments. The image depicts the adjusted (by age, sex, and site study) prevalences for the association between CCTA-stenosis (1%-49%) and Life's Essential 8 score groups (black squares). White squares represent adjusted prevalences for severe CCTA-stenosis (≥50%). CCTA, coronary computed tomographic angiography; CXA, proximal circumflex artery; LAD, proximal left anterior descending artery; LE8, Life's Essential 8; RCA, proximal right coronary artery. Adapted from *J Cardiovasc Comput Tomogr*,[20] with permission.

prevalence 52.7%; 95% CI, 49.6 to 55.9) compared with the highest LE8 (≥80 points) group (adjusted prevalence 28.7%; 95% CI, 27.5 to 29.9). Similarly, OR for severe CCTA-stenosis (≥50%) was 11 times higher in the lowest LE8 group (OR, 11.17; 95% CI, 8.36 to 14.93; adjusted prevalence 11.6%; 95% CI, 9.8 to 13.5) compared with the highest LE8 group (adjusted prevalence 2.7%; 95% CI, 2.2 to 3.1).

Regarding the location of CCTA-stenosis, there were large differences in the prevalence of stenosis across different scores in LE8 for all the 11 segments of the arterial tree. In general, adjusted prevalences were higher for proximal segments (Figure 3 and Supplemental Table 4, available online at http://www.mayoclinicproceedings.org).

When analyzing the different contribution of health factors and health behaviors in the association of LE8 and coronary stenosis, both factors and behaviors showed a graded and statistically significant association, with factors exhibiting stronger associations (Supplemental Table 5, available online at http://www.mayoclinicproceedings.org).

Life's Essential 8 and coronary artery calcium. Figure 4 (detailed data in Supplemental Table 6 and Supplemental Table 7, available online at http://www.mayoclinicproceedings.org) depicts the associations between LE8 and CAC scores. Overall, there was a strong, graded, and inverse association between LE8 and CAC scores that, in terms of ORs, was particularly

strong for the highest CAC category (≥400 Agatston units). For example, OR for CAC = 1 to 99 was 3 times higher in the lowest LE8 (<50 points) group (OR, 3.36; 95% CI, 2.84 to 3.98; adjusted prevalence 37.3%; 95% CI, 34.2 to 40.4) compared with the highest LE8 (≥80 points) group (adjusted prevalence 23.5%; 95% CI, 22.3 to 24.6). Similarly, OR for CAC = 100 to 399 was almost 8 times higher in the lowest LE8 group (OR, 7.72; 95% CI, 6.03 to 9.89; adjusted prevalence 15.0%; 95% CI, 12.8 to 17.2) compared with the highest LE8 group (adjusted prevalence 4.6%; 95% CI, 4.0 to 5.2). Finally, OR for CAC ≥400 was almost 15 times higher in the lowest LE8 group (OR, 14.94; 95% CI, 10.47 to 21.31; adjusted prevalence 8.7%; 95% CI, 7.0 to 10.3) compared with the highest LE8 group (adjusted prevalence 1.5%; 95% CI, 1.1 to 1.9).

In consonance with the analysis of CCTA-stenosis, both health factors and health behaviors showed a graded and statistically significant association with CAC along all groups, with health factors exhibiting stronger associations (Supplemental Table 8, available online at http://www.mayoclinicproceedings.org).

Comparing the Associations of Life's Essential 8 and Life's Simple 7 With Subclinical Coronary Atherosclerosis

Associations of LS7 with CCTA-stenosis and CAC are presented in Supplemental Appendix S4 (available online at http://www.mayoclinicproceedings.org). Like LE8, LS7 scores were strongly and inversely associated with subclinical coronary atherosclerosis in all the analysis (Supplemental Figure 1 and Supplemental Figure 2, available online at http://www.mayoclinicproceedings.org). The area under ROC curves to predict any CCTA-stenosis was slightly higher for LE8 (0.642; 95% CI, 0.635 to 0.649) compared with LS7 0-7 points (0.631; 95% CI, 0.624 to 0.638; $P<.001$) and LS7 0-14 points (0.633; 95% CI, 0.625 to 0.640; $P<.001$), respectively (Supplemental Figure 3, available online at http://www.mayoclinicproceedings.org). Finally, the area under ROC curve to predict severe CCTA-stenosis (≥50%) was not statistically different for LE8 (0.672; 95% CI, 0.657 to 0.686) compared with LS7 0-7 points (0.672; 95% CI, 0.657 to 0.686; $P=.991$) and LS7 0-14 points (0.668; 95% CI, 0.653 to 0.682; $P=.339$), respectively (Supplemental Figure 4, available online at http://www.mayoclinicproceedings.org).

Sensitivity Analyses

In the extreme scenario sensitivity analysis, though the ORs were somewhat attenuated, the gradation, and the statistical significance of the associations along all subgroups remained (Supplemental Table 9, available online at http://www.mayoclinicproceedings.org). Similarly, in the secondary sensitivity analysis, the strong, dose-response, and inverse associations between LE8 and CCTA-stenosis remained, irrespective of the different consideration of coronary segments, calcium blooming, presence of stents, cardiovascular diseases, and number of components in the LE8 score (Supplemental Table 10, available online at http://www.mayoclinicproceedings.org).

DISCUSSION

This large (n=24,819) population-based study provides evidence of a strong, dose-response, and inverse association between the novel LE8 score and 2 subclinical coronary atherosclerosis indicators: CCTA-stenosis and CAC. These associations were stronger, in terms of ORs, for severe indicators (severe stenosis and CAC score ≥400). Importantly, those with poor LE8 had considerably higher atherosclerosis burden in all relevant coronary segments, especially proximal segments. Finally, the capacity to predict CCTA-stenosis was comparable in both scores, although LE8 slightly outperformed LS7 in predicting any CCTA-stenosis.

Little is known about LE8, as it was just launched in June 2022. Thus, we expand the literature[21,22] by reporting strong, graded, and inverse associations of LE8 scores with CCTA-stenosis and CAC. Specifically, ORs for CCTA-stenosis (1%-49%) and severe CCTA-stenosis (≥50%) were more than 4

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and 11 times higher in those with poor LE8 (<50 points) compared with those with ideal LE8 (≥80 points), respectively.

CCTA grants direct visualization of the arterial tree, which allows characterization of the severity, extent, and location of both calcified and noncalcified coronary plaques. Of note, those participants with poor LE8 scores had a considerably greater atherosclerosis burden of all relevant coronary segments, especially proximal segments, which may have prognostic implications in cardiovascular events, as proximal coronary plaques seem to be associated with more serious outcomes.[23] Monitoring LE8 scores may therefore detect participants with considerably higher coronary atherosclerosis burden before cardiovascular events occur, as has been previously suggested for LS7 scores.[5,24] In our work, in Figure 3, we provide a prevalence chart depicting the link between LE8 and coronary plaque. As suggested,[25] this kind of information could be useful to motivate patients to achieve better levels of LE8 scores.

We also provide novel results by comparing the capacity to predict CCTA-stenosis of the novel LE8 vs the older LS7 concept. Our results showed that both LE8 and LS7 were strongly associated with subclinical coronary atherosclerosis and that the predictive capacity was comparable, although the LE8 score was slightly better at classifying the presence of any CCTA-stenosis. Although the "Simple" LS7 score may still be of use given the ease of calculating this score, our results corroborate the usefulness of the LE8 score.

In a previous paper, the prevalence of any CCTA-stenosis in the SCAPIS cohort was as high as 42%, whereas 5% of the population exhibited severe CCTA-stenosis.[15] In our study, because of these high prevalences, the relative associations (expressed as ORs) between LE8 and coronary stenosis also translate to very important absolute risks. Specifically, in comparison with the group with ideal LE8, those with poor LE8 scored absolute prevalances that were 24.0% and 8.9% units higher for (1%-49%) CCTA-stenosis (28.7% vs 52.7%) and severe CCTA-stenosis (2.7% vs 11.6%), respectively. Such remarkable increments in the prevalence indicates the clinical utility of LE8 to monitor CVH.

Nevertheless, a cautionary note should be stated about disparities between CVH scores and subclinical coronary atherosclerosis; coronary stenosis and CAC >0 was still present in approximately one-fourth of the participants with ideal levels of LE8, which suggests that LE8 should not be used to rule out subclinical coronary atherosclerosis. However, despite the considerable residual risk for subclinical coronary atherosclerosis that LE8 did not detect, the clinical utility of CVH scores is pronounced when considering the large relative and absolute measures of association with coronary atherosclerosis. In addition, in our work, severe stenosis, which is the condition more usually linked to cardiovascular events,[23] was only detected in 1.9% of those with ideal LE8 (in comparison with 13.4% in the poor LE8 group). Although attainment of ideal LE8 is not expected to prevent subclinical coronary atherosclerosis completely, it may delay its onset compared with those attaining poor LE8.[26] Altogether, our results may motivate efforts to improve LE8 to reduce the burden of subclinical coronary atherosclerosis (and subsequent cardiovascular disease).

Strengths of the study include the large population-based and randomly selected sample of middle-aged men and women. Additional strengths are that subclinical coronary atherosclerosis was measured using high-quality images (CCTA) and that SCAPIS used comprehensive clinical examinations including all 8 LE8 components as the AHA recommends.

Limitations

This study also has limitations that should be acknowledged. First, our observational study had a cross-sectional design, not measuring either cumulative exposure in LE8 or incident subclinical coronary atherosclerosis. Thus, we cannot conclude the causal nature of the observed associations, and future longitudinal studies examining the cumulative

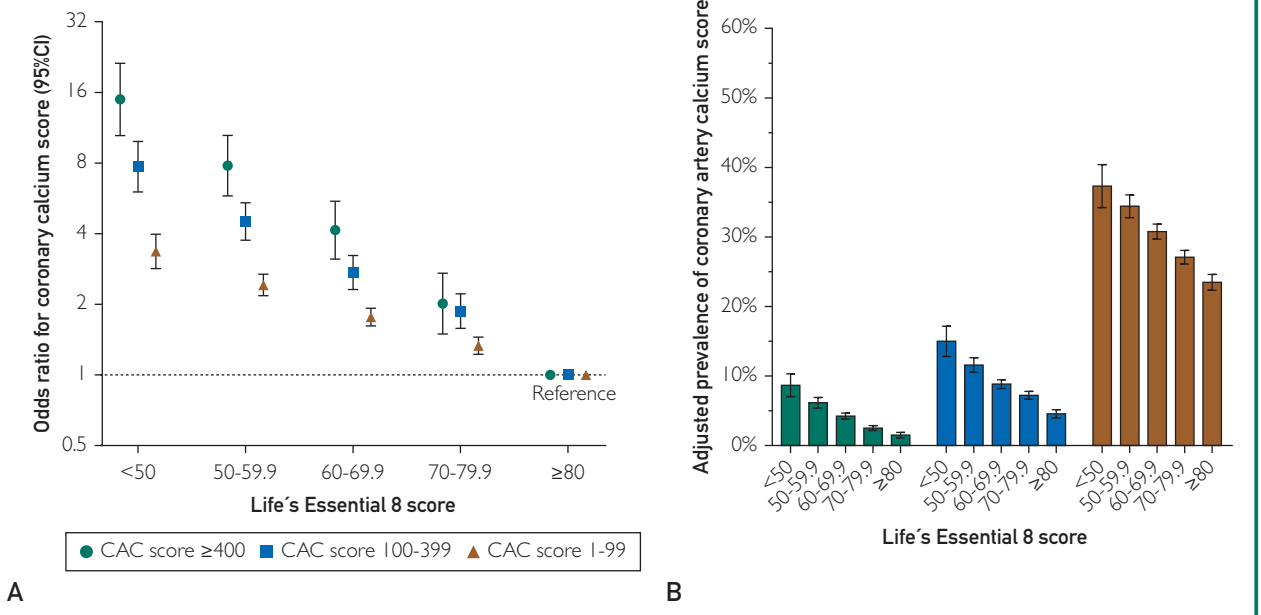

FIGURE 4. Life's Essential 8 and coronary artery calcium. (A) The multinomial regression model to estimate odds ratios of CAC score (1-99, 100-399, and ≥400 Agatston units) among different scores of Life's Essential 8 (adjusted for sex, age, and study site). (B) The adjusted prevalences of CAC score (1-99, 100-399, and ≥400 Agatston units) among different scores of Life's Essential 8 (adjusted for sex, age, and study site). CAC, coronary artery calcium.

association of LE8 and later atherosclerosis are needed. Nevertheless, LE8 may be useful as a monitoring or screening tool in public health work and clinical practice. Specifically, there are some aspects that should be noted: the remarkable strength of the associations, the existence of a dose-response effect, the biological relevance of the LE8 in CVH, and an ample body of evidence about the association between LS7 and other subclinical coronary atherosclerosis indicators. Second, the moderate rate of missingness in our study (17.7%) and the slightly different characteristics among those with missing information suggest that missingness could influence our estimates. Nevertheless, we performed a series of sensitivity analyses, and the associations remained largely consistent. Third, our population includes 2.8% participants with cardiovascular disease. Nonetheless, a sensitivity analysis excluding those participants showed similar associations. Fourth, in our work, we only considered 3 levels of stenosis: 0% (no stenosis), 1%-49% (comprising minimal and mild Coronary Artery Disease Reporting and Data System [CAD-RADS] categories[27]) and ≥50% (comprising moderate, severe, and occluded CAD-RADS categories). Nonetheless, the scientific evidence suggests that associations between cardiovascular health indicators and coronary atherosclerosis remain consistent irrespective of the elected cutoffs.[21,28] Finally, as the SCAPIS population consisted of subjects aged 50 to 64 years, it is unclear whether LE8 is associated with coronary atherosclerosis in other age groups of adulthood.

CONCLUSION

This large population-based study demonstrates strong, dose-response, and inverse associations between the newly developed LE8 score and subclinical coronary atherosclerosis. Although the capacity to predict CCTA-stenosis was comparable between LE8 and LS7 scores, LE8 had slightly higher capacity to predict the presence of any CCTA-stenosis. This provides evidence that the LE8 score may be a useful tool for

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monitoring CVH and screening subclinical coronary atherosclerosis in the population.

POTENTIAL COMPETING INTERESTS

Dr **Sundström** reports stock ownership in Anagram kommunikation AB and Symptoms Europe AB. The other authors report no competing interests.

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SUPPLEMENTAL ONLINE MATERIAL

Supplemental material can be found online at http://www.mayoclinicproceedings.org. Supplemental material attached to journal articles has not been edited, and the authors take responsibility for the accuracy of all data.

Abbreviations and Acronyms: **AHA,** American Heart Association; **CAC,** coronary artery calcium; **CCTA,** coronary computed tomographic angiography; **CVH,** cardiovascular health; **LE8,** Life's Essential 8; **LS7,** Life's Simple 7; **OR,** odds ratio; **ROC curve,** receiver operating characteristic curve; **SCAPIS,** Swedish Cardiopulmonary Bioimage Study

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