# Effect of lifestyle changes after percutaneous coronary intervention on revascularization

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**Short title:**

Life's simple 7 in secondary prevention

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## Abstract

***Objective***: Whether optimal cardiovascular health metrics may reduce the risk of cardiovascular events in secondary prevention is uncertain. The study was conducted to evaluate the influence of lifestyle changes on clinical outcomes among the subjects underwent percutaneous coronary intervention (PCI).

***Methods****:* The study group consists of 17,099 consecutive PCI patients. We recorded data on subject lifestyle behavior changes after their procedure. Patients were categorized as ideal, intermediate or poor CV health according to a modified Life's Simple 7 score (on body mass, smoking, physical activity, diet, cholesterol, blood pressure and glucose). Multi-variable COX regression was used to evaluate the association between CV health and revascularization event. We also tested the impact of cumulative cardiovascular health score on re-occurrence of cardiovascular event.

***Results***: During a 3-years median follow-up, 1,583 revascularization events were identified. The observed revascularization rate was 8.0%, 9.3% and 10.6% in the group of patients with optimal (modified-Life's Simple 7 score of 11-14), average (score=9 or 10) or inadequate (less or equal than 8) CV health, respectively. After multivariable analysis, the adjusted hazard ratios were 0.83 (95%CI: 0.73-0.94) and 0.89 (95%CI: 0.79-0.99) for patients with optimal and average lifestyle changes comparing with the inadequate tertile (P for trend=0.003). In addition, each unit increase in above metrics was associated with a decrease risk of revascularization (HR, 0.96; 95% confidence interval,

0.93-0.98; P<0.001).

***Conclusion:*** Ideal CV health related to lower incidence of cardiovascular events, even after the percutaneous coronary intervention. Revascularization can be reduced by lifestyle changes. The cardiovascular health metrics could be extrapolated to secondary prevention and need for further validation.

**Key Words:** Cardiovascular health metrics, Secondary prevention, Revascularization

## Introduction

Ideal cardiovascular health (CVH) has been proposed by the American Heart Association (AHA) and used to measure population health.[1] The seven risk factors (Life's Simple 7) that people can improve through lifestyle changes included four health behaviors (stop smoking, eat better, get active and lose weight) and three health factors (manage blood pressure, control cholesterol and reduce blood sugar). Cumulative evidence already demonstrated the AHA ideal CVH metrics could be used for cardiovascular health factors assessment, health promotion and a tool to predict mortality and cardiovascular diseases (CVD) risk.[2,3] The steep gradient relationship between ideal CVH metrics and CVD was similar across different region and diverse race-ethnic groups.[4-8]

The concept of ideal CVH metrics was originally defined and intended to use for primordial prevention among general population.[1,9] Although the inverse relationship between ideal CVH and CVD incidence was also well documented for primary prevention,[10-15] the evidence in secondary prevention is limited.[16,17] It should be noticed that most of the individual components in ideal CVH metrics associated with reduced clinical event risk for the subject with established CVD.[18,19] However, few data are available on the relationship between having ideal risk factor profile using a composite measure and the recurrence of cardiovascular events.

Therefore, our aim in this study is to investigate the influence of ideal CVH as risk factor of cardiovascular outcomes for secondary prevention. The study

was based on a cohort of patients who underwent percutaneous coronary intervention. We hypothesized that the subjects with optimal CVH would be less likely to develop cardiovascular events during their follow-up period.

## Methods

The data that support the findings of this study are available from the corresponding author upon reasonable request.

### *Study design and population*

The current analysis was based on an established cohort from Fuwai hospital. A total of 19,506 consecutive patients with successful percutaneous coronary intervention were recruited. Further inclusion criteria for analysis were: subject should have at least one stent implantation, one year or longer post procedure follow up, alive, complete the questionnaire during follow-up visit. Finally, there were 17,099 (87.7%) patients fulfill the above requirements. The study protocol was approved by ethical committee and formal inform consent was obtained from every study participants. Details of the study design have been previously described.[20]

### *Follow up*

Follow-up was conduct by a group of trained investigators. Standard operation procedure was fixed after a small scale pilot study. Non-responder

was the subject who can not be reached after 3 contacts on different days within one week. Both lifestyle changes related information and clinical outcomes were collected in a standardized questionnaire. A 5% random re-sampling process was carried out to validate the reliability of the data collected by the above interview procedure (kappa coefficients were from 0.91 to 0.97 for different items in the questionnaire).

***Exposure and outcome***

Pre-specified options (exp. greater, no change or less) had been used to reflect the lifestyle behavior changes after PCI procedure compare with the situation before procedure. A modified Life's Simple 7 score (on body mass, smoking, physical activity, diet, cholesterol, blood pressure and glucose) had been developed according to AHA recommendation (giving 2 points for ideal, 1 point for intermediate and 0 point for poor). For physical activity, 2=longer, 1=no change and 0=shorter. The blood pressure, cholesterol and glucose were used the same rule, 2=better controlled than before, 1=no change and 0=worsen. Healthy diet covered fresh vegetables/fruits, salt and meat. If patient reported more fresh vegetables/fruits, less salt and meat consumption, the score for healthy diet was 2. On the opposite, if a patient had less vegetables/fruits, more salt or meat compare with before procedure status, the healthy diet score was 0. The remained situations were assigned 1 for diet score. For weight changes, 2=no change, 1=loss weight and 0=weight

increase. If patient was a non-smoker or they quit smoking at least 1 year before their procedure, the non-smoking score was 2. For smokers and other former smokers, the non-smoking score were 0 and 1 respectively. After obtain of the modified Life's Simple 7 score, both cumulative score (ranged from 0 to 14) and its tertiles ($1^{st}$ tertile: inadequate CVH, $2^{nd}$ tertile: average CVH, $3^{rd}$ tertile: optimal CVH) were used to estimate the impact on re-occurrence of cardiovascular event. The key clinical outcome in current analysis was any revascularization during the follow-up period.

***Statistical analysis***

Means and standard deviations were used as descriptive analysis for continuous variables. Categorical variables used frequencies and proportions. The patients were divided into 3 groups according to their tertiles of modified-Life's Simple 7 score. One-way ANOVA or Chi-square test was used for between groups comparison where appropriate. To evaluate the potential association between modified-Life's Simple 7 score and revascularization, the uni-variable and multi-variable COX regression model had been used. The covariates were fixed according to published literature (included demographic, health status, family health history and procedure related characteristics etc.). Firstly, the trend between each ideal CVH group had been tested. After that, dummy variables were used to represent the patient with optimal (11-14) and average (score=9 or 10) modified-Life's Simple 7 score and the lowest tertile

(inadequate: socre less or equal than 8) group was used as reference. In addition, the risk of revascularization for each unit increase in ideal CVH metrics was estimated under the same confounding variables adjustment model. The analysis software was SAS®9.4 and significant level in this study was 2-sided 0.05.

## Results

### *Characteristics of study population*

A total of 17,099 percutaneous coronary intervention patients (78.7% male) with a mean age of years 57.5±10.4 were enrolled in this analysis. Two-thirds of the patients were diagnosed as unstable ungina. The proportion of hypertension, dyslipidemia and diabetes among the overall population was 50.0%, 32.0% and 18.5%, respectively. A total of 1,583 revascularization events during the follow-up period had been identified. The participants were grouped by the occurrence of revascularization (Yes/No). Detail demographic characteristics are listed in Table 1.

### *Lifestyle behavior (ideal cardiovascular health metrics) changes*

Table 2 shows the prevalence of each component of cardiovascular health metrics. Most subjects (72.8%) could manage and maintain weight at appropriate range after their PCI procedure. More than half of the patients were non-smoker or permanent quit smoking. Over forty percent subjects

moved to a healthy diet behavior after their discharge from hospital. The control of blood pressure, cholesterol and blood glucose was achieved in 59.5%, 55.7% and 22.1% among the overall participants, respectively. The proportions of each individual ideal CVH component among the tertile groups (determined by the cumulative score: inadequate, average and optimal) had also been described.

### *Uni- and multi-variable logistic regression analysis*

Firstly, we simply counted the cumulative score of ideal Life's Simple 7 components. The hazard ratio of 1 unit change on the ideal CVH metrics was 0.96 (95% CI, 0.93 to 0.98) after the adjustment of potential confounding variables. The multivariable COX regression model shows, comparing with the inadequate category (the lowest tertile on lifestyle behavior modification), the hazard ratios on revascularization for patients in average and optimal ideal CVH group were 0.89 (95% CI, 0.79 to 0.99) and 0.83 (95% CI, 0.73 to 0.94), respectively. The P for trend was 0.003. The relationships between each individual ideal CVH components and repeated revascularization event were ranged from 0.79 to 1.05 (hazard ratios by multivariable adjusted model). Detail results are described in Table 3.

## Discussion

### *Key findings and study strengths*

Our study suggested subjects in optimal ranges of Life's Simple 7 (LS7) had a lower risk of revascularization compared with people in poor ranges during a 3 years follow-up period after percutaneous coronary intervention. Each additional ideal cardiovascular health metrics was associated with 4% lower risks of repeated revascularization event. To the best of our knowledge, this study is the first to investigate the association of ideal cardiovascular health metrics with clinical outcome among participants underwent percutaneous coronary intervention.

***Comparisons with published literature***

Current percutaneous coronary intervention studies are more focused on examining the efficacy of different treatment strategies, of emerging or existing devices and of the value of coronary physiology or intravascular imaging in PCI planning.[21] Evidence regarding the links between healthy lifestyle and cardiometabolic consequences in people who had coronary interventions is fairly sparse. Potential benefit of Life's Simple 7 had been investigated among myocardial infarction patients. The findings suggested ideal CV health at middle age was associated with better prognosis after MI in later life.[22] However, the impact of ideal cardiovascular health metrics among subjects with different risk strata has not been well established. In a recent large scale nationwide prospective cohort study, participants with prediabetes or diabetes who had five or more ICVHMs (ideal cardiovascular health metrics) exhibited

lower or no significant excess risk of CVD events compare with those with normal glucose regulation. Compared with 1 ideal CVH metric or none, 5 or more ideal metrics were associated with 58% and 61% lower CVD risks among participants with prediabetes and diabetes, respectively.[23] The attenuated effect size observed in our study may attribute to the heterogeneity between different populations. Our study extends previous findings by comprehensively assessing 7 lifestyle risk factors in secondary prevention for revascularization in relation to lifestyle factors individually and in combination.

Baseline measurement of ideal CVH and the longitudinal maintenance of CVH were both significant associated with CVD progression in general population.[24,25] However, it should be noticed the prevalence of ideal cardiovascular health metrics was systematic different in secondary prevention.[26] For example, the prevalence of smoking in general population has been reported to be 52.9%.[27] But the proportion for quit smoking was only 8%.[28] In contrast, the smoking cessation rate was 40% to 94% at 1 year and 37% at 5 years after the ischemic event.[29,30] Further, a pooled cohorts consisted of 661,137 participants indicate a benefit threshold at approximately 3 to 5 times the recommended leisure time physical activity.[31] Around one fifth participants could meet the above intensity of physical activity for general population. Compare with our study, the observed proportion of patient had increased level of physical activities after the PCI procedure was around thirty percent (27.7%). Cardiovascular intervention is an opportunity to reassess the

risk factor control and an optimal time when patients and family members are more likely to be receptive to lifestyle modification.[32] Healthcare professionals should encourage PCI patient to perform more ideal CVH metrics.

Although cardiac rehabilitation is strongly recommended following myocardial infarction, which components of rehabilitation are most beneficial is unclear.[33] As one key component of cardiovascular health metrics, smoking increases the risk of virtually all cardiovascular disease subtypes.[34] Smoking cessation had been demonstrated as a modifiable risk factor both for primary and secondary prevention of stroke.[35-37] However, the effect of single ideal CVH metrics maybe partly attributable to other lifestyle behavior changes (eg. subject has more exercise and healthier diet at the same time with smoking cessation).[36,38] The combination of cardiovascular health metrics may had joint impact on the endothelialization and inflammatory process. This proposed phenomenon was corresponding to the underling mechanism of restenosis of the coronary arteries.[39,40] Further basic researches are required to validate the above hypothesis.

***Study limitations***

Our study has several limitations. First, we could not fully rule out all the residual and unmeasured confounders, such as genetic predisposition, medications, and psychological status and possible reverse causation. Nevertheless, the sensitivity analysis taking into account this potential bias

showed similar results. Second, the cardiovascular health metrics were modified according to the feature of follow-up process in this study. The changes in the metrics over time (health check-up periods) could not be accounted for in this study. Further, participants were excluded if their cardiovascular health metrics missing, so the selection bias may also exist. Third, measurement errors in self-reported assessments of lifestyle changes were inevitable, although the accuracy of self-reports information had been demonstrated through a 5% re-sampling validation process. The use of prospectively collected, cumulatively averaged values based repeated assessments would be reduced the effect of random measurement error. By the above reasons our results should be interpreted cautiously.

***Conclusions***

In this observational study, patients underwent percutaneous coronary intervention who achieved a greater number of ideal CVH metrics exhibited lower risk of repeated revascularization event. Our findings emphasize the importance of promoting the adherence to ideal CVH metrics in the population with established cardiovascular disease. We believe further researches addressing this hypothesis are warranted.

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## Disclosures

None.

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**Table 1 Baseline Characteristics of Participant with or without Revascularization**

| Variables | Revas. (N=1583) | No Revas. (N=15516) | P value |
|---|---|---|---|
| Age, y, mean±SD | 58.1±10.4 | 57.4±10.4 | 0.023 |
| Male, n (%) | 1259 (79.5) | 12201 (78.6) | 0.406 |
| Unstable angina, n (%) | 1028 (64.9) | 10228 (65.9) | <0.001 |
| Prior myocardial Infarction, n (%) | 570 (36.0) | 4755 (30.7) | <0.001 |
| Family history of CHD, n (%) | 88 (5.6) | 611 (3.9) | 0.002 |
| Hypertension, n (%) | 911 (57.6) | 7636 (49.2) | <0.001 |
| Dyslipidemia, n (%) | 574 (36.3) | 4905 (31.6) | <0.001 |
| Diabetes, n (%) | 349 (22.1) | 2821 (18.2) | <0.001 |
| LVEF<40%, n (%) | 683 (43.2) | 8516 (54.9) | <0.001 |
| Reference Vessel Diameter, mm, mean±SD | 3.1±0.6 | 3.2±1.9 | <0.001 |
| Lesion length, mm, mean±SD | 26.1±15.7 | 25.4±14.6 | 0.078 |
| Diameter Stenosis, %, mean±SD | 89.7±7.7 | 88.4±8.0 | <0.001 |
| Calcification, n (%) | 72 (4.6) | 534 (3.4) | 0.023 |
| Total occlusion, n (%) | 469 (29.6) | 3231 (20.8) | <0.001 |
| Trans-radial access, n (%) | 1140 (72.0) | 12495 (80.5) | <0.001 |
| TIMI classification, n (%) | | | <0.001 |
| 0 | 421 (26.6) | 3232 (20.8) | |
| 1 | 75 (4.7) | 648 (4.2) | |
| 2 | 202 (12.8) | 1945 (12.5) | |
| 3 | 885 (55.9) | 9691 (62.5) | |

**Table 2 Prevalence of Ideal Cardiovascular Health Metrics**

| | Overall (N=17099) | Inadequate (N=5267) | Average (N=6029) | Optimal (N=5803) |
|---|---|---|---|---|
| Physical activity | | | | |
| -Poor | 2785 (16.3) | 1521 (28.9) | 907 (15.0) | 3572.8) |
| -Intermediate | 9674 (56.0) | 3254 (61.8) | 3775 (62.6) | 2545 (26.6) |
| -Ideal | 4740 (27.7) | 492 (9.3) | 1347 (22.3) | 2901 (61.2) |
| Blood pressure | | | | |
| -Poor | 1290 (7.5) | 1000 (19.0) | 250 (4.2) | 40 (0.7) |
| -Intermediate | 5642 (33.0) | 3150 (59.8) | 2179 (36.1) | 313 (5.4) |
| -Ideal | 10167 (59.5) | 1117 (21.2) | 3600 (59.7) | 5450 (93.9) |
| Blood cholesterol | | | | |
| -Poor | 1371 (8.0) | 1003 (19.0) | 315 (5.2) | 53 (0.9) |
| -Intermediate | 6205 (36.3) | 3348 (63.6) | 2446 (40.6) | 411 (7.1) |
| -Ideal | 9523 (55.7) | 916 (17.4) | 3268 (54.2) | 5339 (92.0) |
| Blood glucose | | | | |
| -Poor | 1977 (11.6) | 1179 (22.4) | 621 (10.3) | 177 (3.1) |
| -Intermediate | 11337 (66.3) | 3751 (71.2) | 4525 (75.1) | 3061 (52.8) |
| -Ideal | 3785 (22.1) | 337 (6.4) | 883 (14.7) | 2565 (44.2) |
| Ideal BMI | | | | |
| -Poor | 2046 (12.0) | 1098 (20.9) | 700 (11.6) | 248 (4.3) |
| -Intermediate | 2599 (15.2) | 1027 (19.5) | 877 (14.6) | 695 (12.0) |
| -Ideal | 12454 (72.8) | 3142 (58.7) | 4452 (73.8) | 4860 (83.6) |
| Healthy diet | | | | |
| -Poor | 818 (4.8) | 543 (10.3) | 207 (3.4) | 68 (1.2) |
| -Intermediate | 9035 (52.8) | 3720 (70.6) | 3592 (59.6) | 1723 (29.7) |
| -Ideal | 7246 (42.4) | 1004 (19.1) | 2230 (37.0) | 4012 (69.1) |
| Ideal smoking status | | | | |
| -Poor | 3683 (21.5) | 2003 (38.0) | 1190 (19.7) | 490 (8.4) |
| -Intermediate | 4156 (24.3) | 1557 (29.6) | 1420 (23.6) | 1179 (20.3) |
| -Ideal | 9260 (54.2) | 1707 (32.4) | 3419 (56.7) | 4134 (71.2) |

**Table 3 Hazard Ration (95% CI) of Revascularization According to Combined and Individual Ideal CVH Metrics**

| | Univariable analysis | Multivariable analysis |
|---|---|---|
| Combined ideal CVH metrics | | |
| - 1 unit change (Each 1-number increment in ICVHMs) | 0.95 (0.93, 0.98) | 0.96 (0.93, 0.98) |
| - Trend (P for trend instead) | 0.90 (0.85, 0.96)<br><0.001 | 0.91 (0.85, 0.97)<br>0.003 |
| - Average vs. Inadequate | 0.88 (0.79, 0.99) | 0.89 (0.79, 0.99) |
| - Optimal vs. Inadequate | 0.81 (0.72, 0.92) | 0.83 (0.73, 0.94) |
| Individual component of ideal CVH metrics – Physical activity | | |
| - 1 unit change | 0.92 (0.85, 0.99) | 0.92 (0.85, 0.99) |
| - P for trend | 0.038 | 0.037 |
| Individual component of ideal CVH metrics - Blood pressure | | |
| - 1 unit change | 0.89 (0.82, 0.96) | 0.90 (0.84, 0.97) |
| - P for trend | 0.002 | 0.008 |
| Individual component of ideal CVH metrics - Blood cholesterol | | |
| - 1 unit change | 0.88 (0.82, 0.95) | 0.89 (0.83, 0.96) |
| - P for trend | 0.001 | 0.004 |
| Individual component of ideal CVH metrics - Blood glucose | | |
| - 1 unit change | 0.79 (0.72, 0.86) | 0.79 (0.72, 0.86) |
| - P for trend | <0.001 | <0.001 |
| Individual component of ideal CVH metrics - Ideal BMI | | |
| - 1 unit change | 0.95 (0.89, 1.02) | 0.94 (0.88, 1.01) |
| - P for trend | 0.192 | 0.110 |
| Individual component of ideal CVH metrics - Healthy diet | | |
| - 1 unit change | 0.98 (0.90, 1.06) | 1.01 (0.92, 1.10) |
| - P for trend | 0.586 | 0.885 |
| Individual component of ideal CVH metrics - Ideal smoking status | | |
| - 1 unit change | 1.05 (0.98, 1.11) | 1.05 (0.98, 1.12) |
| - P for trend | 0.153 | 0.150 |