



Meta-Analysis

Spousal Concordance for Major Coronary Risk Factors: A Systematic Review and Meta-Analysis

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Spousal pairs permit assessment of determinants of diseases related to environment, because they share the same lifestyle and environment. The authors reviewed spouses' concordance for the major coronary risk factors. A search of the MEDLINE, PubMed, and EMBASE databases was performed. Seventy-one papers were selected for a total of 207 cohorts of pairs and 424,613 correlations in more than 100,000 couples. The most strongly correlated within-pairs factors were smoking and body mass index, with overall correlations of 0.23 (95% confidence interval: 0.12, 0.36) and 0.15 (95% confidence interval: 0.05, 0.25), respectively. Statistically significant positive correlations were also found for diastolic blood pressure, triglycerides, total and low density lipoprotein cholesterol, weight, and the waist/hip ratio. The overall odds ratios for concordance in hypertension, smoking, diabetes, and obesity were all statistically significant, ranging from 1.16 to 3.25. Assortative mating influenced concordance for blood pressure, smoking, glucose, low density lipoprotein cholesterol, weight, body mass index, and waist circumference. This systematic review shows a statistically significant positive spousal concordance for the majority of main coronary risk factors. However, the strength of the concordance was markedly different among factors and appeared to be quite modest for all of them. Interventions to reduce cardiovascular risk factors should be addressed jointly to both members of a marital couple.

concordance; coronary disease; environment and public health; meta-analysis; risk factors; spouses

Abbreviations: CI, confidence interval; HDL, high density lipoprotein; LDL, low density lipoprotein.

Both genetic and environmental factors predispose individuals to cardiovascular disease. An important contribution to assess the role of environmental factors in cardiovascular disease could arise from the study of similarity for cardiovascular risk factors between marital partners (1). Although the degree of consanguinity between spouses varies by country, spouses are in fact usually genetically unrelated but share a common environment. If spousal concordance for cardiovascular risk factors is found, then shared family environment might pose a threat for spouses of patients who have a high risk of developing a disease—a smart message for public health strategies. Indeed, interventions aimed at reducing cardiovascular risk

factors might be more effective if targeted to both marital partners, making prevention tailored for couples or families rather than individuals (2).

Many studies have investigated spousal concordance for coronary risk factors to date (1, 3–72). Some risk factors such as blood pressure have been investigated extensively, but others have not. Although the majority of these studies reported spousal concordance for the risk factors investigated, this is apparently the first systematic review performed to quantify and compare the degree and the consistency of spousal concordance with respect to each risk factor.

Spousal concordance may be due to shared environment, common behaviors, and also positive assortative mating, that

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is, the tendency of individuals to choose a spouse with similar characteristics (1). If concordance was mainly due to a cohabitation effect, then it should increase with increasing time shared by spouses. Differential effects of cohabitation and assortative mating are not mutually exclusive, and both should be considered for a correct interpretation of spousal resemblance.

We reviewed concordance between spouses for the principal environmental cardiovascular risk factors, and meta-analyses were performed for studies presenting correlation coefficients or odds ratios. When possible, distinct effects of cohabitation and assortative mating were also analyzed.

MATERIALS AND METHODS

A search of the MEDLINE, PubMed, and EMBASE databases was performed to find papers that investigated spousal concordance for the principal environmental coronary risk factors, published until March 2008. The keywords used in the search were “spouse (partner, couples, marital) concordance (aggregation, correlation, similarity).” They were used separately and in combination with each of the risk factors investigated (blood pressure, smoking, cholesterol, triglycerides, glucose, weight, body mass index, waist circumference, waist/hip ratio). Relevant citations in retrieved articles were also examined. When the same cohort of spousal pairs was studied in different scholarly papers, we selected the one with the highest number of pairs. Different parameters of spousal correlation were obtained from each study, with different statistical approaches, along with their respective statistical significance and 95% confidence intervals, type of population, number of pairs studied, and the variables used in multivariate analysis. The majority of the within-pair correlations have been reported as correlation coefficients (Pearson’s or Spearman’s product moment correlations) or odds ratios, whereas the remaining studies sparsely reported other measures of association (percentage of concordance, the observed/expected ratio expressed as both a percentage and a number, regression coefficients). Consequently, we performed 2 meta-analyses, restricted to the subgroup of studies for which effect sizes were retrieved in the form of correlation coefficients or odds ratios, respectively. Following the method of Hunter and Schmidt (73), we estimated for each set of study correlations the sample-size weighed average population correlation and the variance of population correlations. If the estimate for the error variance exceeded the variance of the observed correlations, the standard deviation of population correlations was set to the value of 0 (73). The standard error of the mean effect size was used to construct the 95% confidence intervals, which reflect the extent to which sampling errors remain in the estimate of a mean effect size (74). Heterogeneity was measured by both *residual standard deviation* (which should be smaller than 25% of the overall effect size to avoid heterogeneity) and *percentage of observed variance accounted for by sampling* (which should be at least 75% to avoid heterogeneity). The meta-analysis for correlation coefficients was conducted first by using all the studies available and then the subgroup for which correlation coefficients were calculated (in the original study) in multivariate analyses containing at least age of

partners as covariates. The percentage of explained variation was estimated as the square value of the correlation coefficient. Odds ratios were combined by using the general variance-based method (75). Confidence intervals were used to assess the variance of each study effect measure. Adjusted odds ratios and their confidence intervals, when available, were preferred; the χ^2 with $df = 1 - [\text{number of studies}]$ was used to assess the magnitude of heterogeneity among studies.

We identified papers that had investigated spousal concordance over time and classified them as finding or not finding increased concordance over time. This classification was made according to the variation of concordance over time and/or to authors’ statements in their original articles.

RESULTS

Altogether, 71 papers met the inclusion criteria, for a total of 207 cohorts and 424,613 correlations in more than 100,000 spousal pairs. Seventeen studies sparsely reported various measures of association, which was not suitable for a reliable quantitative meta-analysis (Web Tables 1–5). (This information is described in five supplementary tables; each is referred to as “Web table” in the text and is posted on the *Journal’s* website (<http://aje.oxfordjournals.org/>). Additional supplementary information is provided in Web Figures 1–12, each being referred to in the text as “Web figure” and available at the same Web location.) All other studies were combined in 2 separate meta-analyses, one for within-pairs correlations and one for odds ratios for concordance in dichotomous endpoints. A summary of the results for each cardiovascular risk factor investigated is shown in Table 1. The data reported for each risk factor include the number of populations in which the within-spousal correlation was investigated, the total number of pairs, and the percentage of studies that reported a positive, a negative, or a nonstatistically significant within-spousal correlation with their respective number of pairs involved. These types of summaries were based on all the studies reporting statistical significance for association, disregarding the statistics used for measuring the correlation. The number of studies for which an increase in the correlation over time was reported, divided by the total number of studies that investigated the correlations over time, is also shown.

Also in Table 1, a summary of the meta-analytical calculations is presented for both correlations and odds ratios. Meta-analytical calculations, indeed, were restricted to studies that reported effect sizes in the form of correlation coefficients or odds ratios. Figure 1 depicts meta-analytical overall estimations of the correlation coefficients together with the 95% confidence intervals, number of studies, and pairs used for the calculation for each risk factor; the overall estimate from all studies (black square) and the estimate from studies that provided correlation coefficients adjusted at least for age (white square) are presented.

Blood pressure

Thirty-nine studies on spousal concordance for blood pressure and 4 for hypertension were retrieved (Web Table 1). Among studies where the statistical significance of the within-pairs correlation was reported, 23 (64%) and 17 (52%)

Table 1. Summary of Results

| Risk Factors | All Studies That Reported a Test of Statistical Significance of Intrapairs Correlation | | | | | | | Studies for Which a Quantitative Meta-Analysis Was Performed | | | | | |
|--------------------------------------|--|--------------|-----------------------------|----------|-----------------|--|----|--|--------------|--------------------------|----------------------------------|--------------------------|--------------------------|
| | No. of Studies | No. of Pairs | % Correlations ^a | | | No. of Correlations Increasing Over Time/Total | % | No. of Studies | No. of Pairs | Effect Size ^b | 95% CI ^b | Residual SD ^c | Variance, % ^d |
| | | | Positive | Negative | Not Significant | | | | | | | | |
| <i>Meta-analyses of correlations</i> | | | | | | | | | | | | | |
| Systolic blood pressure | 36 | 51,753 | 64 | 0 | 36 | 3/18 | 17 | 30 | 50,362 | 0.10 | -0.03, 0.23 | 0.067 (>) | 12 |
| Diastolic blood pressure | 33 | 49,298 | 52 | 6 | 42 | 2/17 | 12 | 27 | 48,419 | 0.09 | 0.00, 0.19 | 0.050 (>) | 18 |
| Smoking | 13 | 16,075 | 94 | 0 | 6 | 0/4 | 0 | 7 | 4,763 | 0.23 | 0.12, 0.36 | 0.056 | 29 |
| Total cholesterol | 24 | 19,998 | 50 | 0 | 50 | 3/7 | 43 | 23 | 19,850 | 0.07 | 0.04, 0.10 | 0.017 | 80 |
| HDL cholesterol | 12 | 8,955 | 50 | 0 | 50 | 2/2 | 43 | 12 | 8,955 | 0.10 | -0.05, 0.24 | 0.072 (>) | 20 |
| LDL cholesterol | 7 | 5,313 | 43 | 0 | 57 | 0/1 | 0 | 7 | 5,313 | 0.06 | 0.03, 0.09 | 0.014 | 87 |
| Triglycerides | 13 | 9,933 | 38 | 8 | 54 | 2/3 | 67 | 12 | 9,785 | 0.08 | 0.08, 0.08 | 0.0 | 100 |
| Blood glucose | 7 | 8,801 | 86 | 0 | 14 | 0/3 | 0 | 7 | 8,801 | 0.15 | -0.03, 0.33 | 0.089 (>) | 9 |
| Weight | 9 | 6,765 | 67 | 0 | 33 | 1/4 | 25 | 9 | 6,765 | 0.11 | 0.02, 0.19 | 0.044 (>) | 40 |
| Body mass index | 23 | 40,235 | 57 | 0 | 43 | 1/5 | 20 | 19 | 34,582 | 0.15 | 0.05, 0.25 | 0.051 (>) | 17 |
| Waist circumference | 5 | 4,371 | 60 | 0 | 40 | 0/1 | 0 | 5 | 4,371 | 0.10 | -0.01, 0.21 | 0.059 (>) | 25 |
| Waist/hip circumference ratio | 4 | 4,536 | 50 | 0 | 50 | 0/0 | | 4 | 4,536 | 0.10 | 0.10, 0.10 | 0.0 | 100 |
| <i>Meta-analyses of odds ratios</i> | | | | | | | | | | | <i>P_{heterogeneity}</i> | | |
| Hypertension | | | | | | | | 4 | 75,434 | 1.21 | 1.16, 1.26 | 0.72 | |
| Smoking | | | | | | | | 3 | 74,881 | 3.25 | 2.94, 3.59 | <0.001 | |
| Diabetes | | | | | | | | 3 | 75,069 | 1.16 | 1.03, 1.31 | 0.66 | |
| Obesity | | | | | | | | 2 | 10,850 | 1.44 | 1.16, 1.78 | 0.70 | |

Abbreviations: CI, confidence interval; HDL, high density lipoprotein; LDL, low density lipoprotein, SD, standard deviation.

^a Percentage of studies reporting a statistically significant ($P < 0.05$) positive or negative or a nonstatistically significant within-pairs correlation.

^b Overall odds ratios, 95% confidence intervals, and test of heterogeneity for hypertension, smoking, diabetes, and obesity, with overall correlation and 95% confidence intervals for the other risk factors.

^c The residual standard deviation should be smaller than 25% of the overall effect size to avoid heterogeneity; when the symbol (>) is present, the residual standard deviation is greater than 25% of the overall effect size.

^d Percentage of observed variance accounted for by sampling; it should be at least 75% to avoid heterogeneity.

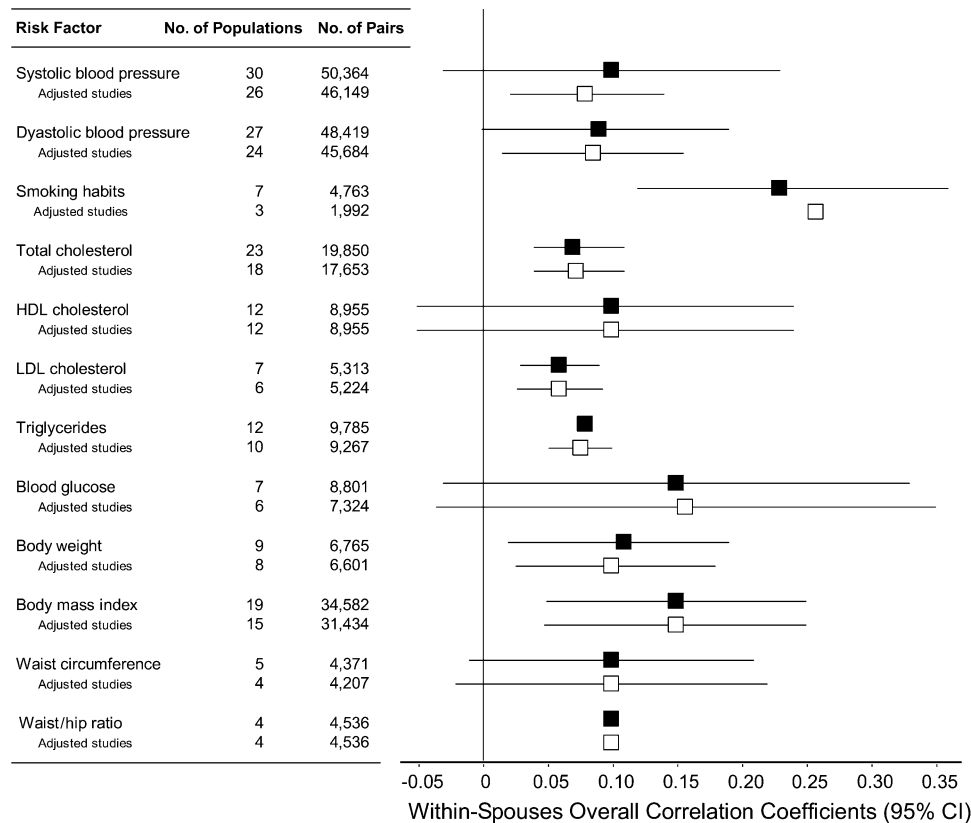


Figure 1. Meta-analytical overall estimations of the correlation coefficients together with 95% confidence intervals, number of studies, and number of pairs included. CI, confidence interval; HDL, high density lipoprotein; LDL, low density lipoprotein.

reported significant positive correlations for systolic and diastolic blood pressure, respectively (Table 1; Web Table 1). For systolic blood pressure, the overall correlation coefficient was 0.10 (95% confidence interval (CI): $-0.03, 0.23$) in all studies ($n = 30$) (Web Figure 1) and 0.08 (95% CI: $0.02, 0.14$) in adjusted studies ($n = 26$) (Table 1; Figure 1). For diastolic blood pressure, the overall correlation coefficient was 0.09 (95% CI: $0.00, 0.19$) in all studies ($n = 27$) (Web Figure 2) and 0.09 (95% CI: $0.02, 0.15$) in adjusted studies ($n = 24$) (Table 1; Figure 1). In both meta-analyses, a large heterogeneity is present, although in the subset of adjusted studies, 95% confidence intervals are narrower and heterogeneity is reduced (residual standard deviation = 0.030 and 0.035 for systolic and diastolic blood pressures, respectively). The overall odds ratio for concordance in hypertension was 1.21 (95% CI: $1.16, 1.26$) (Table 1; Web Table 1), without evidence of heterogeneity.

One study reported an increased concordance of systolic blood pressure in pairs married for a longer time, thus suggesting an effect of cohabitation on spousal concordance (Web Table 1) (3); however, the majority of studies found no increase in concordance according to marriage duration (1, 6, 8, 12, 14, 22, 24, 25, 32, 38). Two studies found higher correlations with increasing age of the partners (15, 33), while others failed in showing such an effect (7, 9, 14, 16, 26).

Smoking habits

Studies of spousal concordance for smoking habits are listed in Web Table 2. Seven studies provided correlation coefficients for smoking, 3 studies showed odds ratios for concordance in smoking, and 6 studies evaluated the intrapairs association with varied measures. All studies but 1 reported significant positive concordance (Table 1; Web Table 2). The overall correlation coefficient was 0.23 (95% CI: $0.12, 0.36$) (Web Figure 3), without evidence of heterogeneity (Table 1; Figure 1). The overall odds ratio for concordance in smoking was 3.25 (95% CI: $2.94, 3.59$) (Table 1; Web Table 2). In the study of Sutton (41), the correlations decreased from engagement to long-lasting cohabitation, suggesting that the intraspousal correlation for smoking habits might be mainly due to assortative mating. Moreover, 3 studies reported no increase in the correlation with partners' age (26, 44, 46).

Cholesterol and triglycerides

Twenty-nine studies measured the correlations between spouses at least for hyperlipidemia or triglycerides or total, high density lipoprotein (HDL), or low density lipoprotein (LDL) cholesterol (Web Table 3). Almost 50% of the studies showed a positive statistically significant correlation, 1 study

reported a negative statistically significant correlation (for triglycerides), and 1 study found positive concordance in hyperlipidemia (Table 1; Web Table 3). The overall correlation coefficients were statistically significant for total cholesterol (Web Figure 4), LDL cholesterol (Web Figure 5), and triglycerides (Web Figure 6) but not for HDL cholesterol (Web Figure 7) (Table 1; Figure 1). There was not evidence of heterogeneity, except for HDL cholesterol (Table 1), and the results were very similar in both all and adjusted studies (Figure 1). Three (26, 33, 50) of 7 studies (1, 24, 26, 33, 43, 48, 50) reported increased correlations for total cholesterol with partners' age. Two studies reported an increase in correlations for HDL cholesterol and triglycerides with partners' age (25, 26), suggesting an effect of cohabitation.

Blood glucose

Seven studies reported concordance between spouses for blood glucose levels, as did 3 for diabetes (Web Table 4). Despite the fact that 6 of 7 studies showed a positive statistically significant correlation (Table 1; Web Table 4), the overall estimate was not significant and was plagued by heterogeneity (Web Figure 8; Table 1; Figure 1). On the contrary, the overall odds ratio indicates a concordance in having diabetes, although with a low effect size (Table 1). All 3 studies that considered correlations over time reported no increase in correlations according to marriage duration (1, 25, 62).

Body weight, body mass index, waist circumference, and waist/hip circumference ratio

Twenty-seven studies measured the concordance between spouses for variables linked to weight and fat distribution, as did 2 for obesity (Web Table 5). More than 50% of the studies showed a positive statistically significant correlation (Table 1). The overall correlation coefficients were statistically significant for weight (Web Figure 9), body mass index (Web Figure 10), and waist/hip circumference ratio (Web Figure 11), but not for waist circumference (Web Figure 12) (Table 1; Figure 1). There was evidence of heterogeneity (Table 1), and the results were very similar in all and adjusted studies (Figure 1). Two studies indicate concordance in obesity (Table 1).

One study for weight (1) and 1 study for body mass index (33) evidenced an increased correlation with marriage duration or partner's age; however, 8 studies (8, 16, 24, 25, 32, 43, 64, 71) failed over time to observe modification in the extent of within-pair correlation for variables linked to weight and fat distribution.

Emerging risk factors

Some recent studies that reported spousal concordance for "new" risk factors were also considered. However, because of insufficient data, we do not present here any meta-analytical summary for such variables.

One study reported a significantly positive correlation for hemoglobin (Kendall's tau-A = 0.068, age and sex adjusted; 1,259 Framingham Study couples) (1), but another did not

($r = 0.08$, age and sex adjusted; 315 French couples living in Quebec, Canada) (60). One study reported a significant positive correlation for glycosylated hemoglobin ($r = 0.53$, age adjusted) between 3,141 Korean couples (39). Only 1 study analyzed spousal concordance for 3 new risk factors for cardiovascular disease: factor VII, homocysteine, and C-reactive protein. Pairs were significantly correlated for these risk factors ($r = 0.16$, 0.28, and 0.15 for factor VII activity, activated, and antigen, respectively; $r = 0.17$ for homocysteine; and $r = 0.13$ for C-reactive protein) (40).

One study reported a correlation for metabolic syndrome between 3,141 Korean couples (39). There was a significant spousal concordance for metabolic syndrome: Men whose wives had metabolic syndrome had 1.29 (95% CI: 1.07, 1.57) times higher risk of having metabolic syndrome, compared with those whose wives did not; similarly, women whose husbands had metabolic syndrome had 1.32 (95% CI: 1.09, 1.61) times higher risk of having metabolic syndrome.

DISCUSSION

There is a very large amount of data available on spousal concordance for cardiovascular risk factors. We reviewed 71 papers comprising 207 populations and over 100,000 spousal pairs, which reported quantitative measures of within-pairs concordance for the major coronary risk factors. The greatest majority of data indicate the existence of positive correlations between spouses for both traditional and emerging risk factors of ischemic cardiovascular disease. Blood pressure, smoking habits, cholesterol (total and LDL), triglycerides, and factors linked to body weight, on the 1 hand, and metabolic syndrome, C-reactive protein, homocysteine, and coagulation factor VII levels, on the other hand, were all positively—although at a variable and quite modest degree—correlated between spouses. In addition, a clear concordance for such dichotomous outcomes as hypertension, smoking, diabetes, and obesity was observed.

The factor most strongly correlated between spouses appeared to be smoking. Common metabolic risk factors, likely to be influenced by both genetic and environmental factors (76), were also positively correlated within pairs. However, the strength of all correlations was invariably slight. The values of overall correlation coefficients were in fact low, ranging from 0.06 to 0.23, which means that the percentage of explained variation of these factors attributable to spousal concordance is in the range of 0.4%–5.3%. The strength of correlation for the cardiovascular disease risk factors studied here is slightly inferior to that for correlation in mental health ($r = 0.25$) (77) or alcohol dependence ($r = 0.29$) (78).

The majority of overall correlation estimates showed a high degree of heterogeneity. We attempted to investigate such heterogeneity, comparing results from all studies with those from the subgroup of studies providing correlations calculated in multivariate analyses adjusted at least for age. In the latter studies, the heterogeneity was marginally reduced only for correlations in blood pressure. Further search for variables that may have caused systematic variations in the within-pairs correlations among studies is needed.

A variable number of studies and pairs was available for each different risk factor. Therefore, the relative weight of the results obtained and the strength of our conclusions were obviously different for any single factor. Interestingly, lipid metabolism factors were more influenced than blood pressure by shared environment, although they are known to have a stronger genetic component (79).

Very few studies investigated spousal concordance for new emerging risk factors, such as hemoglobin, coagulation factor VII, homocysteine, C-reactive protein, and metabolic syndrome; therefore, more data are needed to make any meaningful analysis.

Spousal concordance for coronary risk factors could be due to either shared environmental habits or assortative mating or to a synergic effect of both conditions. We tried to dissect the role of assortative mating and cohabitation, but we could rely upon only the possible variation of correlations over time reported in a minority of studies. Assortative mating appeared to mainly, though not fully, influence spousal resemblance for smoking habits, weight, body mass index, blood pressure, and LDL cholesterol, while assortative mating and cohabitation similarly affected spousal resemblance for total cholesterol and triglycerides. Altogether, our results seem to point out that spousal aggregation of most traditional cardiovascular risk factors is mainly due to assortative mating, while the contribution of shared marital environment is highly variable for each risk factor, possibly influencing mainly lipid metabolism. The prevalent importance of assortative mating on that of shared environment might partially justify the small impact of within-pairs correlation on the variability of metabolic risk factors. However, the variation of correlations over time was mainly evaluated cross-sectionally after stratifying couples according to either marriage duration or one/both partners' age (which was considered a surrogate of marriage duration). Only one study evaluated the variation of correlations both cross-sectionally and prospectively, obtaining contrasting results. Of 207 populations on whom spousal concordance for risk factors was investigated, only 65 populations (31%) analyzed possible variations of concordance over time, and this strongly limited the possibility to clearly distinguish between assortative mating and environmental effects.

Marital status may also affect total and cardiovascular mortality. Increased mortality risk was documented indeed for subjects who were unmarried (80), and physiologic pathways through which marital relationships influence health based on a stress/social support model have been proposed (81). Besides the fact that being married appears to have positive consequences on health, spouses could obtain additional benefit by controlling their respective risk factors. Because the components of a pair influence each other leading to the observed significant though modest concordance for the majority of coronary risk factors, it is reasonable to anticipate that interventions aimed at reducing the risk of cardiovascular disease could be more effective when jointly targeted to pairs rather than to individuals. This concept may bring an important public health message, because prevention policy for cardiovascular disease could also be targeted toward apparently healthy spousal partners of individuals with an obviously increased cardiovascular risk. There is

evidence already that spouses of men exposed to a continuous coronary heart disease risk factor intervention program made changes in their own risk status toward a healthier one in contrast to wives of men who did not receive any intervention program (82). In particular, Falba and Sindelar (83) found that, when 1 spouse improves his or her behavior (i.e., changes in smoking, drinking, exercising, or screening cholesterol), the other spouse is likely to do so as well.

In conclusion, evidence is clear about the concordance of major risk factors for cardiovascular risk within pairs. Rather than additional research showing correlations of cardiovascular risk factors between spouses, what is expected in the future is studies examining the effectiveness of couple-based interventions to reduce the cardiovascular risk of both partners.

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