Spouse Correlations in Cardiovascular Risk Factors and the Effect of Marriage Duration

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Spouse correlations in cardiovascular risk factors were investigated using data on 2,836 spouse pairs collected in the Busselton Population Health Surveys over the period 1966-1981. The risk factors considered were systolic blood pressure, diastolic blood pressure, body mass index, triceps fatfold, cholesterol, and forced expiratory volume (1 second). Statistically significant positive correlations (p < 0.01) were found for all (age-adjusted) variables. There was a statistically significant decreasing trend in the correlations for systolic blood pressure with marriage duration (trend p < 0.01). Although no other variables showed statistically significant trends, the correlations for diastolic blood pressure (p = 0.29), body mass index (p = 0.14), and forced expiratory volume (p = 0.16) also decreased with marriage duration, and correlations for cholesterol (p = 0.61) and triceps fatfold (p = 0.99) increased with marriage duration. These results suggest that there is spousal concordance in cardiovascular risk factors. The lack of consistent increasing trends in the correlations with marriage duration suggests that assortative mating may be a more likely explanation than the sharing of a common environment. Am J Epidemiol 1996; 143:48-53.

There is considerable interest in identifying environmental factors that contribute to cardiovascular risk. Cohabitation, or the sharing of the same or a similar household environment, usually implies the sharing of many aspects of lifestyle. Thus, individuals who cohabit should show concordance in cardiovascular risk factors that have associations with lifestyle, and such concordance should increase with duration of cohabitation. Husband and wife are not genetically related, and therefore any concordance in cardiovascular risk factors must be due to either assortative mating—the tendency for individuals to choose a marital partner with a similar lifestyle—or the effects of cohabitation. Studies which include spouse pairs and genetically related individuals can be used to identify the genetic and environmental contributions to risk factors, provided that assortative mating is taken into account.

Several studies have investigated correlations between spouses in cardiovascular risk factors (1-14). The majority have found positive correlations, although the findings for cholesterol have been equivocal (3, 5, 8, 10). However, very few studies have investigated the effect of marriage duration (or length of cohabitation) on the correlations, even though this is essential in distinguishing assortative mating from cohabitation effects.

An early study based on Framingham data found no trend with marriage duration for systolic blood pressure but increasing trends for diastolic blood pressure and cholesterol in cross-sectional analyses, and no trends for any of the three variables in longitudinal analyses (1). A recent Norwegian study involving 23,936 spouse pairs found no trend with marriage duration in systolic blood pressure, diastolic blood pressure, or body mass index (12, 13). Another study found decreasing trends for systolic and diastolic blood pressure (4), and a further study, which used age of the wife as a surrogate for marriage duration, found an increasing trend for systolic and diastolic blood pressure (6). Thus, there are conflicting findings.

This article reports correlations between spouses for systolic blood pressure, diastolic blood pressure, body mass index, cholesterol, triceps fatfold, and forced expiratory volume and investigates the effects of marriage duration, using data on 2,836 spouse pairs from the Busselton Study.

MATERIALS AND METHODS

The Busselton Population Health Studies are a series of cross-sectional health surveys undertaken in the
town of Busselton in the state of Western Australia. Surveys of adults were undertaken every 3 years from 1966 to 1981. Approximately 3,500 adults attended each survey, and a total of 8,310 persons attended at least one survey. The conduct of the surveys, including a detailed description of the study population, the examinations of subjects, and laboratory methods, have been fully described elsewhere (15–17).

Participants were asked to complete a comprehensive health and lifestyle questionnaire; to undergo various measurements and tests, including measurement of height, weight, and midtriceps fatfold (mm), respiratory function tests (forced expiratory volume (liters) in 1 second), and blood pressure measurements (mmHg); and to provide a blood sample from which total cholesterol (mmol/liter) and other biochemical measurements were made. Body mass index was derived as weight (kg) divided by the square of height (m).

In 1966, subjects were seated only briefly before blood pressure was measured by mercury sphygmomanometer, whereas in later surveys it was measured after 5 minutes' rest in a sitting position. This had a considerable effect on systolic blood pressure but only a small effect on diastolic blood pressure (18). Using longitudinal data on individuals who attended several of the earlier surveys, we estimated that the effect on systolic blood pressure of not resting for 5 minutes was 12.7 mmHg and that the effect on diastolic blood pressure was −1.9 mmHg. The 1966 blood pressure measurements used in this analysis have been adjusted by these amounts.

Although cholesterol was measured in different units in different surveys, all data were converted to mmol/liter for analysis. The 1969 and 1972 cholesterol determinations were carried out interstate, whereas all others were carried out locally. Longitudinal analyses of individuals attending several surveys revealed consistent discrepancies in cholesterol measures for 1969 and 1972; the estimated adjustments were −0.05 for 1969 and 0.33 for 1972. These adjustments have been made to the 1969 and 1972 cholesterol measurements used here.

Midtriceps fatfold was measured by callipers in millimeters, and data were logarithmically transformed to remove the skewness in the data distribution.

Marital status was recorded in each survey, and for married participants the name and date of birth of the spouse and all children were recorded. A total of 2,836 spouse pairs attended at least one survey together. If a pair attended more than one survey together, the measurements used in the analysis were taken from the survey conducted when their average age was closest to 45 years. Because of missing values, the number of pairs analyzed was around 2,700 for all variables except body mass index. A total of 2,470 pairs of measurements were available for body mass index, since these measurements were not available from the 1981 survey.

Date of marriage was not recorded, but, as in the Framingham Study (1), it was estimated from the marital status records and dates of birth of the children from all of the surveys attended. A validation study of 52 pairs with years of marriage ranging from 1947 to 1981 (median, 1964) indicated that the estimated years of marriage were very accurate; the median absolute difference between estimated year and actual year was 2 years, and for 83 percent the difference was 3 years or less. Marriage duration was calculated as the time from year of marriage to year of the survey from which the measurements were taken. Since marriage durations ranged from 1 year to 63 years (median, 21 years), errors of 1–2 years would have had little effect on the results.

Multivariate normal models which allow trends in means, variances, and correlations have been recommended for spouse and family data for quantitative traits, and were used here (19–21). The spouse correlations in cardiovascular risk factors were estimated by maximum likelihood from a model which allowed the means to vary in a quadratic manner with age (separately for males and females), and the variance was allowed to vary with age (preliminary analysis showed that the variances tended to increase with age). Examination of the distribution, skewness, and kurtosis of residuals from these models indicated little departure from the normality assumption. Furthermore, maximum likelihood estimates of correlations are consistent and nearly unbiased even if the distributions are not normal (22).

In algebraic terms, the models for the mean and variance were:

\[
\text{Mean} = \beta_1 + \beta_2 \text{sex} + \beta_3 \text{age} + \beta_4 (\text{sex} \times \text{age}) + \beta_5 \text{age}^2 + \beta_6 (\text{sex} \times \text{age}^2).
\]

\[
\text{Var} = \gamma_1 + \gamma_2 \text{age}.
\]

The correlation model for estimating separate correlations for each marriage duration group was as follows. Correlation between spouses was held to be equal to \(\rho_1\) if marriage duration was 0–9 years, \(\rho_2\) if it was 10–19 years, \(\rho_3\) if it was 20–29 years, \(\rho_4\) if it was 30–39 years, and \(\rho_5\) if it was \(\geq 40\) years. In the correlation trend model, correlation between spouses was held to equal \(\rho_0 \exp (\lambda \text{duration})\).
TABLE 1. Mean values and regression coefficients for the relation of marriage duration (after age adjustment) to cardiovascular risk factors in 2,836 spouse pairs: The Busselton Study, 1966–1981

<table>
<thead>
<tr>
<th>Risk factor</th>
<th>Husbands</th>
<th>Wives</th>
<th></th>
<th></th>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Mean</td>
<td>SD*</td>
<td>Duration</td>
<td>Mean</td>
<td>SD</td>
<td>Duration</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>coefficient</td>
<td></td>
<td></td>
<td>coefficient</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>(SE)</td>
<td></td>
<td></td>
<td>(SE)</td>
</tr>
<tr>
<td>Age (years)</td>
<td>48.7</td>
<td>13.9</td>
<td>0.306 (0.085)†</td>
<td>45.2</td>
<td>13.6</td>
<td>0.378 (0.146)</td>
</tr>
<tr>
<td>Systolic blood pressure (mmHg)</td>
<td>133.6</td>
<td>21.3</td>
<td>0.126 (0.054)</td>
<td>130.6</td>
<td>24.5</td>
<td>0.405 (0.091)</td>
</tr>
<tr>
<td>Diastolic blood pressure (mmHg)</td>
<td>79.3</td>
<td>13.0</td>
<td>0.030 (0.014)</td>
<td>77.2</td>
<td>14.4</td>
<td>0.074 (0.030)</td>
</tr>
<tr>
<td>Body mass index$^\dagger$</td>
<td>25.4</td>
<td>3.2</td>
<td>0.000 (0.002)</td>
<td>24.6</td>
<td>4.1</td>
<td>0.009 (0.003)</td>
</tr>
<tr>
<td>Log triceps fatfold (mm)</td>
<td>2.29</td>
<td>0.43</td>
<td>0.007 (0.005)</td>
<td>3.00</td>
<td>0.44</td>
<td>0.009 (0.009)</td>
</tr>
<tr>
<td>Cholesterol (mmol/liter)</td>
<td>5.90</td>
<td>1.14</td>
<td>0.155 (0.003)</td>
<td>5.95</td>
<td>1.32</td>
<td>0.145 (0.003)</td>
</tr>
<tr>
<td>Forced expiratory volume in 1 second (liters)</td>
<td>3.43</td>
<td>0.90</td>
<td>-0.002 (0.003)</td>
<td>2.58</td>
<td>0.65</td>
<td>0.005 (0.003)</td>
</tr>
</tbody>
</table>

* SD, standard deviation.
† Numbers in parentheses, standard error.
$^\dagger$ Weight (kg)/height (m)$^2$.

The magnitude and sign of the $\lambda$ coefficient indicates the nature of the trend in the correlations with marriage duration.

The effects of using data from different survey years and of using the adjustment procedures for blood pressure and cholesterol (because of different measurement methods across survey years) were investigated by including a survey year effect in the mean. The results concerning the correlations were essentially unchanged.

The computer software FISHER was used to perform all analyses (21, 23).

RESULTS

Table 1 shows the cardiovascular risk factor characteristics of the spouse pairs used in the analysis, including the relation between the risk factor levels and marriage duration. Several risk factors showed increasing trends with marriage duration after age adjustment. Table 2 shows the estimated (age-adjusted) correlations between husband and wife. The overall correlations range from 0.105 for forced expiratory volume to 0.145 for triceps fatfold, and all are significantly different from zero at the 0.1 percent level of statistical significance. The correlations for the 0- to 9-year marriage duration group (recently married couples) range from 0.11 for diastolic blood pressure to 0.18 for systolic blood pressure, body mass index, and triceps fatfold, and all are significantly different from zero at the 1 percent level of significance.

The marriage duration group-specific correlations are also displayed in figure 1, together with the fitted trend model. All variables except triceps fatfold and cholesterol show a decreasing trend with marriage duration.


<table>
<thead>
<tr>
<th>Marriage duration (years)</th>
<th>No. of pairs</th>
<th>Systolic blood pressure</th>
<th>Diastolic blood pressure</th>
<th>Body mass index</th>
<th>Triceps fatfold</th>
<th>Cholesterol</th>
<th>Forced expiratory volume</th>
</tr>
</thead>
<tbody>
<tr>
<td>0–9</td>
<td>575</td>
<td>0.18</td>
<td>0.11</td>
<td>0.18</td>
<td>0.18</td>
<td>0.12</td>
<td>0.15</td>
</tr>
<tr>
<td>10–19</td>
<td>727</td>
<td>0.20</td>
<td>0.16</td>
<td>0.12</td>
<td>0.13</td>
<td>0.09</td>
<td>0.12</td>
</tr>
<tr>
<td>20–29</td>
<td>774</td>
<td>0.14</td>
<td>0.15</td>
<td>0.09</td>
<td>0.13</td>
<td>0.08</td>
<td>0.10</td>
</tr>
<tr>
<td>30–39</td>
<td>472</td>
<td>0.00</td>
<td>0.03</td>
<td>0.10</td>
<td>0.14</td>
<td>0.14</td>
<td>0.05</td>
</tr>
<tr>
<td>≥40</td>
<td>288</td>
<td>0.04</td>
<td>0.12</td>
<td>0.12</td>
<td>0.16</td>
<td>0.16</td>
<td>0.05</td>
</tr>
<tr>
<td>All</td>
<td>2,836</td>
<td>0.119</td>
<td>0.122</td>
<td>0.116</td>
<td>0.145</td>
<td>0.111</td>
<td>0.105</td>
</tr>
</tbody>
</table>

* Numbers in parentheses, standard error.
duration, but only the trend for systolic blood pressure reaches the 5 percent level of statistical significance.

**DISCUSSION**

The finding of positive correlations between spouses for cardiovascular risk factors is in agreement with the findings of most other studies (1–14). The correlations for recently married couples were generally larger than those for married couples who had been married for a longer time. This suggests that there has been considerable assortative mating in this population, in the sense that individuals in this population who were married during the years 1945–1964 tended to choose a marriage partner with a similar cardiovascular risk profile. This is probably an indirect effect of individuals’ choosing marital partners who have similar lifestyle habits such as smoking, exercise, and diet, as well as a similar religion, socioeconomic status, and possibly occupation.

None of the risk factors examined showed any significant increase in correlations between spouses with increasing marriage duration. These results are in general agreement with those of the large Norwegian study (12, 13) which found constant or slightly decreasing correlations with marriage duration for blood pressure and body mass index, and with those of a smaller study (4) which found that persons cohabiting for more than 4 years had lower correlations than those who lived together for less than 4 years. These findings are in direct contrast with the view that cohabitation is associated with a convergence of risk factor values.

Cross-sectional analyses from the Framingham Study found increasing correlations with marriage duration for diastolic blood pressure and cholesterol and possibly also for systolic blood pressure, but the longitudinal analyses showed constant correlations (1). The discrepancy between cross-sectional and longitudinal findings was explained by the tendency for initially discordant pairs to be more likely to have their marriages terminated through divorce or the death of one member. This theory could explain why increasing trends from cross-sectional analyses may vanish in longitudinal analyses, but it cannot explain the decreasing trends observed in our cross-sectional analysis. Although approximately 350 pairs in our study did attend several surveys, the length of longitudinal follow-up of each pair was generally less than 10 years, and thus a longitudinal analysis would be inconclusive.

The slightly different patterns observed in our study for systolic and diastolic blood pressure may be due to chance or could be due to real differences in the effects of lifestyle factors on systolic and diastolic blood pressure. Further analyses supported this conjecture, because the magnitude of the correlations and the rate of decline with marriage duration were greater for the difference in systolic and diastolic blood pressure than for the mean arterial pressure.

The opposite trends observed for body mass index and triceps fatfold are possibly due to chance. However, body mass index is a measure of total obesity, whereas triceps fatfold is a measure of peripheral obesity. Thus, different trends are feasible.

In summary, on the basis of our results and those of other studies, it can be concluded that cohabitation of spouses does not lead to a convergence of cardiovascular risk factors. Since cohabitation before marriage was uncommon among persons married during the period 1945–1964, the significant observed concordances between recently married spouses from this period cannot readily be attributed to the effects of cohabitation. Assortative mating would therefore appear to be the most plausible explanation. These points should be kept in mind when attempting to isolate genetic and environmental components in familial aggregation studies.

**ACKNOWLEDGMENTS**

This project was supported by the Public Health Research and Development Committee of the National Health and Medical Research Council of Australia.

The authors acknowledge the programming assistance of Dean Diepeveen in establishing the files relating to spouses.

**REFERENCES**