Tracking of Blood Lipids and Blood Pressures in School Age Children: The Muscatine Study

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SUMMARY  In four cross sectional school screens, the Muscatine Study has sampled 8,909 school children; 820 have been studied repeatedly over a six-year period. Tracking of measurements described by the relationship between repeated observations and the relationship between peer rank orderings over the six-year period has been studied. For height and weight, correlations between observations six years apart were approximately 0.74 and about 60% of children initially in the upper quintile were there again six years later. Six-year correlations were 0.65 for skinfold and 0.61 for cholesterol. Four-year correlation for fasting triglyceride was 0.40. Six-year correlations were 0.30 for casual systolic blood pressure and 0.18 for diastolic blood pressure. Peer rank orderings for both blood pressures were highly variable.

Height and weight track well, and thus routine measurement of these variables are useful in identifying children with growth perturbing disorders. Cholesterol and, to a lesser degree, triglycerides also track, and a significant proportion of children with initially high values demonstrated consistently high values throughout the study period. Blood pressures do not track as well; consistently high blood pressures are unusual, thus indicating the need for repeated blood pressure measurements to identify children with persistent elevated levels. The future significance of transient blood pressure elevations has yet to be established.

PHYSICIANS ROUTINELY PLOT the heights and weights of children on charts similar to the Iowa, Harvard or National Center for Health Statistics Growth Curves.1-2 In using these figures it has been noted that children tend to maintain their percentile rank with increasing age. Children who have high percentiles tend to stay high as they mature, and children who begin low tend to stay low. A child who has marked deviation from his or her percentile rank for height or weight is usually examined for the presence of some chronic growth perturbing disease. The phenomenon of children maintaining their rank within their age-sex group is herein referred to as "tracking." Height and weight are said to "track with age."

Longitudinal studies of coronary risk factors beginning in subjects at adult age have shown that hypertension, hypercholesterolemia, and obesity are related to the risk of coronary artery disease and stroke.3-4 It is difficult to follow up on children until the time when clinical coronary artery disease occurs 40 or more years later, and no such study has been carried out. It is not known whether or not the adult coronary risk factors of elevated blood pressures, blood lipids, and obesity track from early childhood into the adult years. Thus, the prognostic significance of elevated blood lipids or blood pressures and obesity in children, as they relate to atherosclerotic and hypertensive disease complications, is not clear.

If children who have an elevated cholesterol or blood pressure level in relation to their peers in their school years maintained the relationship on a follow-up examination into young adulthood, it would argue in favor of early measurement of cholesterol and blood pressure levels as a method for the early identification of individuals at potential high risk for future coronary artery disease. This study describes and compares the degree of tracking that occurs for measures of height, weight, triceps skinfold thickness, blood pressures, cholesterol and triglyceride over the school age in order to examine the significance of some of the coronary risk measures in childhood.

Subjects and Methods

Population

The school children of Muscatine, Iowa have participated in a screening program for coronary risk factors since 1970. The great majority of children in the schools of Muscatine are white (96.4%). The children sampled were in kindergarten through twelfth grade and ranged in age from 5-18 years. Other data relating to this population have been published previously.7

To date, four cross sectional screenings at two-year intervals have examined 8,909 children. Of these, 3,848 have been seen only once, 2,409 twice, 1,368 three times and 1,284 have been examined in all four school screens. Since the initial school screen took two school years, there are observations six years apart on only 820 children. Of the 1,284 children sampled in all four school screens, 662 have been followed six years and 622 for five years. The participation rate was approximately 70% for all ages. Participation rates were approximately the same in males and females but were somewhat age-dependent. After age 12, participation
decreased, with the lowest rates observed in 17- and 18-year-old students, where only 50% of those eligible participated.

Table 1 shows the realized sample sizes for the pairs of observations analysed in this study. Age is given as age at last birthdate and refers to age when first sample in the pair was obtained. First, second, and third grade students were not sampled until the 1971-72 school year and kindergarteners were not sampled until 1974; thus, there are no four-year correlations for age 5, and no six-year correlations before age 8. No students were sampled after they left high school, so there are no two-year correlations after age 16, no four-year correlations after age 14 and no six-year correlations after age 12. Fasting lipids were not obtained before 1973. Only fasting triglycerides were used in the analyses, so no six-year correlations are reported for triglyceride.

Many of the results reported in this study were based on the 820 children for whom six years of follow-up were available. The distributions of measurements for this group within each of the school screens were examined to determine if in any way the group was atypical. All observations for this group were reduced to age, sex and survey year standard deviation units (SDUs) and compared to the expected zero mean and unit variance. Children in this group were slightly but significantly taller than their peers, averaging about 0.1 standard deviations above the mean in each of the school screens. This difference amounted to approximately 0.7 cm. No other significant differences were observed.

Cholesterol and Triglyceride

Before 1974 the Autoanalyser I method was used and a quality control program in conjunction with the Iowa Clinical Research Clinic was maintained. In 1974 the lab was converted to an Autoanalyser II and since then Lipid Research Clinic protocols and quality control procedures have been followed. At the time of the conversion, a set of 165 samples were run in parallel and conversion formulae were developed. For the purposes of this study all values were converted to AAI standards using these conversion equations.

**Blood Pressure**

Casual blood pressures were measured using Baumanometer mercury sphygmomanometers. The subjects were seated. All pressures were measured in the right arm. Blood pressure cuffs, whose bladders covered at least two-thirds of the upper arm and at least half the circumference of the upper arm without overlapping, were used. Pressures at the first, fourth and fifth Korotkoff phase were recorded. The procedure was explained to the student and the cuff inflated and deflated once. The first blood pressure measurements following a second inflation were recorded. All observers were cautioned about digit preference and were asked to read pressures to the closest 2 mm Hg. The pressure at the fourth Korotkoff phase was used as the diastolic blood pressure in all analyses.

A comprehensive blood pressure training program was maintained throughout the study. Duplicate blood pressures recorded on video tape and film were used. The video tapes were changed periodically and different tapes were used for training and evaluation. Before each screening began all observers who were to participate in that year’s screen were evaluated. Good between-observer agreement was required before the screening began. In the evaluation preceding the 1975 screen, the four participating observers exhibited a between-observer standard deviation for systolic blood pressure of 0.6 mm Hg and for diastolic blood pressure, 2.9 mm Hg.

**Quality of Measurements**

One of several studies of the reproducibility of various measurements was carried out during the 1977 school screen. During each daily screening, a 10% random sample of children from that day was recycled through the screening process. Each child in the sample was measured again, usually within 15 minutes, by the same observer who had taken the first measurement. The observers did not know which children were to be rescreened, and on resample they did not know what the initial readings had been. Except for drawing bloods, the two screenings were conducted in the same manner. In all, 420 children had duplicate measurements taken during the 1977 survey.

Pearson correlation coefficients were calculated for each observer and were then pooled to get an overall estimate of within observer agreement. Overall cor-
relations were 0.99 for height and weight, 0.97 for skinfold thickness, 0.92 for systolic blood pressure and 0.83 for diastolic blood pressure. Pooled estimates of the variability of measurements on the same child (expressed as standard deviations) were 0.7 cm for height, 1.3 lb for weight, 0.9 mm for triceps skinfold thickness, 3.7 mm Hg for systolic blood pressure and 4 mm Hg for diastolic blood pressure.

The initials of the observer taking a measurement were recorded along with the measurement; thus, it was possible to compare distributions for individual observers in order to determine if there was any observer bias. Since there could have been systematic differences between the children examined by the different observers, SDUs were analysed. Data from the 1977 school screen showed no significant bias for height, weight or triceps skinfold. For the three observers taking blood pressures in this survey, the maximum difference between mean SDUs for systolic blood pressure was 0.07 or approximately 1 mm Hg. For diastolic blood pressure, the maximum difference was 0.5 SDUs, or approximately 5 mm Hg.

These studies and others carried out during the other school screens indicate that height, weight, and skinfold thickness measurements were very reliable. Systolic blood pressure was both precise and accurate. The observer bias for diastolic blood pressure reflected the difficulty in identifying the fourth Korotkoff sound. While within-observer agreement was good for diastolic blood pressure, the between-observer agreement was not as satisfactory.

### Analysis of Data

For purposes of comparison, the strength of the relationship between repeated measurements made on the same individual was estimated using age-sex specific Pearson correlations. Since fasting triglycerides and triceps skinfold thickness exhibited distributions which were skewed and heavy-tailed, these variables were transformed using natural logarithms before analysis.

Age and sex standardized scores were used to obtain overall estimates of correlations. For each variable an individual’s corrected score (age, sex, year of study correction) was expressed in standard deviation units $Z = (observed - mean)/(standard deviation)$, where means and standard deviations were age, sex, and survey year specific. Separate correlations were computed for all pairs of observations two, four and six.
To assess the variability in measures of lipids and blood pressure over time, data from the 1971 cohort were divided into four six-year periods. Children were stratified on the basis of sex and age and assigned percentiles, with the extremes of each distribution being the 1st and 99th. If in the same age-sex group, the highest possible rank was assigned. In the event of ties all the children in the tied group were assigned the same percentile rank. If in the above example children whose ranks would have been 197, 198, 199 and 200 all had the same cholesterol value, then all four would have been assigned the percentile rank 88.9.

Percentile ranks were divided into quintiles. The first quintile represented those children in the lowest 20% of their age-sex group, while the fifth quintile represented those children in the upper 20%, and the third quintile contained those in the middle 20%. Approximately 4,500 children were sampled on each school screen, thus there were approximately 900 children in each quintile. Initial and follow-up quintiles were cross-classified to describe changes in percentile ranks with time. Separate cross-classifications were generated for two-year, four-year and six-year pairs. There were 820 subjects who had been followed for six years and each quintile of the six-year follow-up represented approximately 164 children.

Estimates of the probabilities of remaining in the upper quintile on consecutive screenings were obtained using clinical life table methods. For each variable, estimates were based on experience with the cohort of children who were in the upper quintile for that variable in the 1971 school screen. By using conditional probabilities, this methodology allows for loss to follow-up, makes maximum use of the available data, and yields precise estimates.

**Results**

**Height and Weight**

Pearson correlations between measurements made on the same individuals two, four, and six years apart are displayed in table 1. For height, all correlations were strong but tended to be slightly lower for the older ages. Correlations for periods encompassing the

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### Table 1.

(Continued)

<table>
<thead>
<tr>
<th>Cholesterol</th>
<th>Fasting triglyceride</th>
<th>Systolic blood pressure</th>
<th>Diastolic blood pressure</th>
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<td>Male Female</td>
<td>Male Female</td>
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<td>0.18† 0.27</td>
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<td>0.42 0.36</td>
<td>0.28 0.17†</td>
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<tr>
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<td>0.26 0.35</td>
</tr>
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<td>0.65 0.68</td>
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<td>0.42 0.21</td>
</tr>
<tr>
<td>0.66 0.69</td>
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<td>0.53 0.42</td>
<td>0.41 0.28</td>
</tr>
<tr>
<td>0.72 0.71</td>
<td>0.57 0.40</td>
<td>0.42 0.42</td>
<td>0.39 0.36</td>
</tr>
<tr>
<td>0.73 0.71</td>
<td>0.54 0.48</td>
<td>0.57 0.59</td>
<td>0.28† 0.39</td>
</tr>
</tbody>
</table>

**Observations 2 Years Apart**

<table>
<thead>
<tr>
<th>Male Female</th>
<th>0.68 0.44 0.41 0.27</th>
</tr>
</thead>
<tbody>
<tr>
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<td>0.39† 0.44 0.39 0.32†</td>
</tr>
<tr>
<td>0.67 0.69</td>
<td>0.30† 0.52 0.47 0.27</td>
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<td>0.27† 0.26† 0.35 0.35</td>
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<tr>
<td>0.65 0.64</td>
<td>0.31 0.41 0.44 0.41</td>
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<tr>
<td>0.64 0.60</td>
<td>0.43 0.40 0.35 0.28</td>
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<tr>
<td>0.63 0.62</td>
<td>0.35 0.41 0.35 0.33</td>
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<tr>
<td>0.61 0.60</td>
<td>0.50 0.53 0.28 0.27</td>
</tr>
<tr>
<td>0.54 0.58</td>
<td>0.50 0.24* 0.42 0.38</td>
</tr>
<tr>
<td>0.64 0.60</td>
<td>0.40* 0.55 0.28† 0.36</td>
</tr>
</tbody>
</table>

**Observations 4 Years Apart**

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<th>Male Female</th>
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</thead>
<tbody>
<tr>
<td>0.69 0.48</td>
<td>— — 0.11(NS) 0.40</td>
</tr>
<tr>
<td>0.63 0.63</td>
<td>— — 0.41 0.22</td>
</tr>
<tr>
<td>0.65 0.61</td>
<td>— — 0.50 0.08(NS)</td>
</tr>
<tr>
<td>0.66 0.67</td>
<td>— — 0.34 0.29†</td>
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<tr>
<td>0.66 0.48†</td>
<td>— — 0.02(NS) 0.53†</td>
</tr>
</tbody>
</table>

**Observations 6 Years Apart**

<table>
<thead>
<tr>
<th>Male Female</th>
<th>0.61 0.30 0.18</th>
</tr>
</thead>
<tbody>
<tr>
<td>0.64 0.60†</td>
<td>— — 0.06(NS) 0.31†</td>
</tr>
<tr>
<td>0.66 0.48†</td>
<td>— — 0.02(NS) 0.53†</td>
</tr>
<tr>
<td>0.68 0.44</td>
<td>— — 0.06(NS) 0.31†</td>
</tr>
<tr>
<td>0.70 0.68</td>
<td>— — 0.21 (NS)</td>
</tr>
<tr>
<td>0.73 0.66</td>
<td>— — 0.22</td>
</tr>
<tr>
<td>0.71 0.65</td>
<td>— — 0.33(NS) 0.15(NS)</td>
</tr>
<tr>
<td>0.72 0.67</td>
<td>— — 0.02(NS) 0.53†</td>
</tr>
</tbody>
</table>

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onset of puberty were lower. The magnitudes of the
relations decreased slightly as the time between
observations increased. Similar results were observed
for weight.

Even though the correlations for height and weight
were high, some variation in percentile ranks with
time was observed. Figure 1 displays the distributions
of quintiles after a six-year period. The first block of
this display shows the distribution of follow-up quin-
tiles for those children who were initially in the lowest
20% (quintile one) of their age-sex groups. About 60%
of those children were again in the lowest quintile of
height six years later, while 26% had risen to the sec-
ond quintile and nearly 14% were above the third quin-
tile. Similarly, of those children who were initially in
the highest quintile (quintile five) for height, 60% were
again there six years later, 26% had dropped to the
fourth quintile and 14% had dropped below the fourth
quintile. Of those children initially in the middle quin-
tile for height, 33% were again there six years later,
while 10% were found in the lowest quintile and 12% were
found in the highest quintile. This symmetry of the
highs becoming lower and the lows becoming higher is
an example of the phenomenon called “regression toward
the mean.”

The magnitudes and frequency of changes were
smaller for shorter time periods. After two years, 71%
of the children initially in the lowest quintile of height,
74% of children initially in the highest quintile, and
44% of children initially in the middle quintile were
again in the same quintile. Very similar results were
observed for weight.

Correlations between repeated observations of
height and weight were high (approximately 0.88 for
two years, 0.80 for four years, and 0.74 for six years).
A high proportion of children in the extreme percent-
iles were still there on follow-up.

Triceps Skinfold Thickness

Triceps skinfold is used herein as an example of a
measure of obesity. Results for other measures of
obesity, including ponderal index (Ht/3√Wt) and
relative weight (weight corrected for age, sex and
height), were similar. Most two-year correlations were
between 0.7 and 0.8 for both males and females (Table
1). Four-year and six-year correlations ranged
between 0.46–0.71 with most values being greater than
0.6. These values are only slightly smaller than those
observed for height and weight.

Changes in percentile ranks of triceps skinfold
thickness measurements were also similar to those
observed for height and weight. Of all children who
were initially in the lowest quintile, 43% were again
there after six years, while 53% of those in the highest
quintile were found there six years later. Of those in
the middle quintile, one-fourth were there on six-year
follow-up, 14% were in the first quintile and 7% were
in the fifth quintile. Two-year and four-year values
exhibited similar patterns with slightly more children
remaining in the extremes and fewer children showing
large changes.

Cholesterol

Overall, two-, four-, and six-year correlations for
cholesterol were 0.68, 0.63, and 0.61, respectively, and
age-sex specific correlations ranged between 0.48 and
0.73. The differences between two-year and six-year
correlations were generally small. Greater variability
in percentile ranks with time was observed for
cholesterol than for height or weight. After a six year
interval, 57% of children initially in the lowest quintile
were again in the first quintile, 17% were in the sec-
ond quintile, 14% were in the third quintile, and 12% were
above the third quintile. Similarly, of those sub-
jects initially in the highest quintile, 50% were there
again, 26% were in the fourth quintile, 15% in the third
quintile and 9% below the third quintile. Two-year and
four-year quintile distributions were very similar. The
effect of time on the magnitudes of correlations
between repeated observations and changes in percent-
ile ranks was less pronounced than for height or
weight.

Triglyceride

Children were asked to fast overnight beginning
with the 1973 school survey. Approximately 97% of
students actually presented fasting. Only data from
children who were fasting were used in the analyses for
triglyceride. Correlations for triglyceride were smaller
than those observed for cholesterol. The overall cor-

\[ \text{FIGURE 1. Cross-classifications of quintiles for 820 children sampled in 1971 and again in 1977. Each horizontal section represents one of the seven variables studied. For each variable, the left-most display is for children who were initially in the lowest quintile for that variable while the right-most display is for those children initially in the highest quintile. The five bars in each set display the distributions of quintiles after six years. Percentages are estimates based on approximately 164 children in each initial quintile and their standard errors are less than 4%.} \]
relations for fasting triglyceride were 0.44 for observations separated by two years and 0.40 for observations separated by four years. Age- and sex-specific correlations ranged from 0.24–0.59. Two-year and four-year correlations were similar.

Large changes in percentile ranks with time were observed. One-third of those children initially in the lowest quintile were found four years later while 21% were above the 60th percentile. Of those children initially in the highest quintile, 40% were again there after four years and 19% had dropped below the 40th percentile. After a four-year interval, the distribution of quintiles of those children initially in the middle quintile was very nearly a random 20% in each of the five quintiles.

Blood Pressure

Overall correlations for systolic blood pressure were 0.41 for observations separated by two years, 0.35 for observations separated by four years and 0.30 for observations separated by six years. Overall correlations for diastolic blood pressure were 0.27, 0.21 and 0.18 for observations two, four and six years apart, respectively. Four-year and six-year correlations were usually smaller than two-year correlations. Although correlations for both systolic and diastolic blood pressure were generally significant (P < 0.001), all were relatively small and several of the age- and sex-specific correlations were not statistically significant (P > 0.05).

Changes in percentile ranks of systolic blood pressures were large. Although much weaker than observed for height and weight, there was still a tendency for children in the extreme percentiles of systolic blood pressure to maintain their rank orderings. The middle quintile distribution closely resembled a random 20% in each quintile. The distributions of follow-up diastolic blood pressure quintiles after six years was nearly a random scatter for all five initial quintiles.

Persistence of High Values

In clinical practice one is usually interested in patients who have consistently high levels of obesity, serum lipids or blood pressure. The cross-tabulations reported above described the distributions of quintiles after six years. In these tabulations, children found in the upper quintile on six-year follow-up need not have been there at the two-year or four-year examinations. Figure 2 displays estimated probabilities that a child who was initially found in the upper quintile would be there consistently on repeated measurement.

A child in the upper quintile of height or weight had a better than 0.75 probability of still being there after two years and about a 0.50 probability of being there for all four surveys. The probabilities were only slightly lower for skinfold and cholesterol. The estimated probability that a child initially in the upper quintile of cholesterol would be there on four consecutive screens was 0.27.

Elevated fasting triglyceride, systolic and diastolic blood pressures were less persistent. The probability of being in the upper quintile on two consecutive screens was approximately 0.43 for these three variables. For systolic blood pressure the probability of four consecutive readings in the upper quintile was 0.17 while for diastolic blood pressure this probability was only 0.09. Since the initial cohorts represented only 20% of the cross-sectional population, one would expect about 3% of children to be persistently above the 80th percentile for systolic blood pressure and 2% for diastolic blood pressure. Persistently high blood pressures were uncommon.

Discussion

Measurement of children's heights, weights and skinfold thicknesses is clearly a useful assessment tool for physicians. There is a high correlation of early measurements to future levels, and only a small percentage of children in the extremes of the distributions show large changes in percentile ranks. The practice of plotting a child's height and weight against percentile grids is useful in distinguishing a child who is growing well from one who has growth difficulties. Measures that are used as indices of obesity (skinfold thickness, relative weight and ponderal index) should also show similar tendencies because they also exhibit high correlations between measurements repeated over time.

Cholesterol measurements also track reasonably well. They showed slightly more variability than height or weight, but nearly 60% of subjects initially in the highest quintile were found there again six years later. The probability of remaining in the upper quintile for four consecutive screens was estimated to be 0.27.

Triglyceride and blood pressure showed a lower correlation between early and future levels. Triglyceride levels yielded correlations over two years approximately 0.4; 65% of upper quintile subjects stayed in the upper two quintiles, and 35% dropped to the lower three. Systolic blood pressure had an overall six-year correlation of 0.30 with 60% of upper quintile subjects staying in the upper two quintiles. Diastolic blood pressure tracked poorly. Over a six-year period, correlations were only 0.18 and, except for the upper quintile, distributions of percentile ranks were nearly random.

In adults, the Framingham study observed the following six-year correlations for males: 0.90 for weight, 0.87 for relative weight, 0.73 for cholesterol, 0.60 for systolic blood pressure and 0.54 for diastolic blood pressure. The adult values for blood pressures are somewhat larger than were observed in the Muscatine Study, but the other correlations are comparable. Similar tracking results for adult systolic blood pressure were noted by Oberman et al.

Beaglehole et al., in a study of Polynesian children aged 5–14 years, observed systolic blood pressure correlations between observations 1.5–3.7 years to be $r = 0.31$ for boys and $r = 0.24$ for girls. Their correla-
Figure 2. Persistence of values in the upper quintile. Entries in this figure are estimates of the probabilities that a child in the upper quintile for a variable will continue to be there on repeated examinations spaced at two year intervals. If a child fell below the 80th percentile at any stage then he was not considered in subsequent steps. Approximately 900 children were in the upper quintile of a variable, initially. Since the rate at which children dropped below the 80th percentile was different for each variable, the numbers of children eligible to continue at each stage also differed. For height, these numbers were 1,434 for the initial examination, 546 for the two-year examination and 212 for the 4-year examination. For diastolic blood pressure, the numbers considered at each stage were 1826, 388 and 80, respectively. Standard errors for the estimated probabilities were approximately 2% for two years, 2.3% for four years and 3% for six years.
tions for diastolic blood pressure were \( r = 0.12 \) for boys and \( r = 0.07 \) for girls, and were not statistically significant. Rosner et al. observed only slightly higher four-year correlations for systolic and diastolic blood pressure in children ages 5–19 years (approximately 0.45 for systolic and 0.33 for diastolic). They also showed that correlations for adults were significantly higher than for children. Zinner et al. reported four-year correlations in children of 0.25 for systolic blood pressure and 0.14 for diastolic blood pressure. Levine et al. studied the tracking of blood pressures in 60 infants from birth until 1 year of age. In this study, tracking correlations between observations obtained before 6 months of age were not significantly different from zero; correlations between observations obtained at 6 and 12 months were 0.38 for systolic blood pressure and 0.34 for diastolic blood pressure.

The Framingham Study showed that adult subjects whose initial cholesterol or blood pressures were high had an increased risk of future coronary heart disease. For example, of men 45–54 years of age when first examined, the smoothed incidence of coronary heart disease within 16 years was 2.4 times higher in men whose initial cholesterol was between 265–280 mg/dl than in men whose initial cholesterol was between 190–204 mg/dl. Similarly, the smoothed incidence of coronary heart disease was twice as high in men whose systolic blood pressure was between 160–169 mm Hg as in men with initial systolic blood pressure between 110–119 mm Hg. Weaker but still significant relationships were noted in females. A single elevated cholesterol or high blood pressure was significantly related to the future risk of developing coronary heart disease. The observation in adults that risk for coronary heart disease is related to a single elevated cholesterol or blood pressure, despite the fact that these measurements have considerable variability with time, raises the question of whether the same may also be true in children. The observation that nearly 20% of children with cholesterol levels in the upper quintile remain consistently elevated over a six-year period suggests the likelihood that a significant number of children with elevated cholesterol levels will enter adult life with an enhanced risk for coronary heart disease. Approximately 5% of children were estimated to be consistently in the upper quintile of cholesterol.

In both children and adults, blood pressures are highly variable in their measurement and require repetitive observation to identify those who have persistent pressure elevations. In adults, pressures are more variable in persons with higher levels, and there is no correlation between the degree of variability at one point in time to another time. Despite this variability, which does not allow a precise characterization for an individual, single casual blood pressure measurements are highly predictive of future cardiovascular disease.

There is no longitudinal study for children relating casual blood pressure measurements at an early age to the risk for future cardiovascular disease. Until such information is obtained, the significance of casual elevation of blood pressure in childhood will remain in doubt. Thus, there is a need for physicians to measure blood pressures in children repeatedly in order to identify not only those with fixed high levels of pressures, but also those with labile elevation which may prove to be predictive for future coronary heart disease. In the Muscavate Study, 13% of children were found to have systolic or diastolic pressures in excess of the 95th percentile for their age-sex group or greater than 140/90 on first measurement. The importance of the latter is underscored by the observation in college students and army officers that those with transient early elevations of blood pressure are more likely to develop sustained high blood pressure in later life.

Acknowledgments

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Type A Behavior Pattern and Coronary Atherosclerosis

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SUMMARY Previous research has demonstrated an increased rate of clinical coronary heart disease (CHD) events among people who exhibit a "coronary prone" (Type A) behavior pattern. This study was undertaken to determine whether the association between behavior pattern Type A and CHD might be extended beyond clinical CHD events to include also the coronary atherosclerotic process. In addition to usual clinical evaluation, 156 consecutive patients referred for diagnostic coronary angiography were independently assessed on the basis of a structured interview and assigned a rating of Type A, Type B, or Type X (indeterminate).

Traditional physiologic factors — age, sex, cholesterol and cigarette smoking — were found to correlate with atherosclerotic disease. Type A patients were found in increasing proportions among groups of patients with coronary occlusions of moderate to severe degree compared with patients with only mild occlusions. This increasing proportion of Type A patients with increasing disease severity remained significant, even when age, sex, blood pressure, serum cholesterol level and cigarette smoking history were all simultaneously covaried.

These findings suggest that, independently of traditional risk factors, behavior pattern Type A may contribute to the risk of clinical CHD events via effects on the atherosclerotic process.

MANY INVESTIGATORS HAVE SHOWN that increased levels of risk factors such as cholesterol, blood pressure and cigarette smoking are prospectively associated with increased subsequent expression of the clinical manifestations of coronary heart disease (CHD). Despite such findings among large groups of subjects, the best combination of these traditional risk factors fails to identify most new cases of CHD. Noting that traditional risk factors account for only about half of the CHD incidence in middle-aged American men, Keys et al., concluded that other variables may contribute significantly to CHD incidence.

In the search for other contributing causes of CHD, a large body of research has been undertaken to identify psychosocial factors that increase the risk of experiencing clinical CHD events. The most promising work in this area has been that of Rosenman, Friedman and coworkers with regard to the Type A (coronary prone) behavior pattern. The behavior of Type A individuals is characterized by excessive achievement striving, time urgency and hostility, while the Type B person shows a relative absence of these characteristics. Followup over an eight and one-half year period has shown Type A men to have about twice the rate of new CHD events as compared to their Type B counterparts. Furthermore, the significantly higher incidence of CHD events among Type A subjects was not found related to any differences in age, height or weight; and it was statistically independent of smoking, family history of CHD, blood pressure and various indices of lipid metabolism.