

Changes in Cardiovascular Health Knowledge Occurring from Childhood to Adulthood

A Cross-sectional Study

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SUMMARY A standardized test of cardiovascular health knowledge was administered to 1367 students, ages 12–18 years, and 562 adults, ages 20–60 years. Mean scores were: ages 12–14 years, $42.5 \pm 0.7\%$ (SEM); 15–18 years, $49.1 \pm 0.1\%$; 20–40 years, $68.7 \pm 0.7\%$; 40–60 years, $68.2 \pm 0.7\%$ correct. Cardiovascular health knowledge increased linearly in the student population, averaging 3.08% per year. Increases continued to occur in adults, but plateaued after age 40 years, despite an increasing incidence of cardiovascular disease in this age group. Health knowledge was highly correlated with the highest educational achievement. At all age levels, knowledge of diagnostic tests was highest and knowledge of pathophysiology lowest. A personal or family history of heart disease or history of an elevated serum cholesterol was not a stimulus for increases in health knowledge.

EFFORTS to reduce the cost of health care must ultimately focus on prevention rather than treatment of disease. Although our understanding of specific methods for the prevention of many cardiovascular diseases is limited, much is known of ways to minimize risk. The acquisition of health knowledge does not ensure healthier behavior, but may be a prerequisite for the success of other efforts aimed at changing behavior.¹⁻³ This study was designed to compare cardiovascular health knowledge in a cross section of children and adults in today's society. In addition, we wished to determine whether cardiovascular health knowledge in the adult population peaked when the incidence of cardiovascular disease was high and whether adults at greater risk of cardiovascular disease had a better understanding of this subject than did those at lesser risk. We used a standardized achievement test to assess health knowledge, based on specific objectives defined by medical educators. The same test was administered to all subjects, allowing comparisons between population groups.

Materials and Methods

Development of the Iowa Cardiovascular Health Knowledge Test

The investigators posed to a panel of cardiovascular medical educators the question, "What constitutes the minimum amount of knowledge of the cardiovascular system a person should possess in order to

make intelligent decisions regarding his/her health?" In response to this question, 44 concepts were identified and instructional objectives were written for each conceptual area. Experts in the field of cardiovascular disease and continuing medical education were then asked to rank from the list the 35 most relevant objectives. These objectives reflect the major content areas of anatomy, physiology, pathology, specific disease entities (including atherosclerotic, hypertensive, rheumatic and congenital heart disease), commonly used diagnostic procedures, and concepts of disease prevention. One multiple choice question based on each objective became the foundation for the Iowa Cardiovascular Health Knowledge Test (ICVHT).⁴ Five test forms were originally created. For subsequent uses, however, the one item most adequately reflecting the objective was selected for inclusion in the final test form. If two or more items equally reflected the objectives, psychometric criteria determined selection. All data in this report refer only to subjects given identical test items. A retrospective analysis showed that there were 14 questions on anatomy and physiology, 12 on pathophysiology, five on diagnostic tests and four on risk factors. All questions were written in the vocabulary of sixth grade students. A more complete discussion of the ICVHT and one of the original test forms have been published.⁴

Test Administration

The five original forms of the ICVHT were first administered experimentally in conjunction with the standardized Iowa Test of Basic Skills (ITBS) to a stratified sample of 2675 Iowa students. The ITBS is a nationwide standardized testing program sponsored by the College of Education of the University of Iowa.⁵ The test results from 518 of these students who were given the items used in the final form are described in this report. In cooperation with the Iowa Test of Educational Development, a similar nationwide standardized testing program for high school students, the ICVHT was later administered to 849 Iowa students in grades 9–12.

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Supported in part by a grant-in-aid from the Iowa Heart Association.

This work was done during Dr. White's tenure as a Teaching Scholar of the American Heart Association.

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Received January 18, 1980; revision accepted September 17, 1980.

Circulation 63, No. 5, 1981.

To ascertain the level of cardiovascular health knowledge in the adult population, the ICVHT was administered to 972 males, ages 20–60 years, randomly selected from among the employees of three large Iowa corporations. We attempted to sample both blue- and white-collar workers. For the adult population, the final 35-item test was expanded by adding five items to test knowledge of the relationship between nutrition and atherosclerosis. The new items were constructed by the authors and by staff members of the Iowa Lipid Research Clinic. Additional questions regarding the presence or absence of heart disease or the history of an elevated serum cholesterol level in the respondent, a history of heart disease in the immediate family, and the major source of health knowledge were included. Tests were delivered to the subjects at their place of employment, accompanied by a letter describing the purpose of the research. The tests were to be completed at home without the aid of references and returned to the investigators by mail. The response rate was 58%.

Data Analysis

The mean percentage of correctly answered questions and the variance were calculated for each population group using standard statistical techniques.⁶ Item difficulties and discriminations were also calculated. The overall mean scores in all age ranges were compared using a one-factor analysis of variance. For adults, a two-factor analysis of variance was computed to determine if age and education interacted to influence ICVHT test scores. In addition to an overall test score, scores on four subtopics were computed for each age group. The adult population was also scored on the subtopic of atherosclerosis, but these scores were not used for intergroup comparisons.

Results

General Cardiovascular Health Knowledge Levels

The general performance of students in grades 6–12 on the ICVHT is shown in figure 1. The percentage of

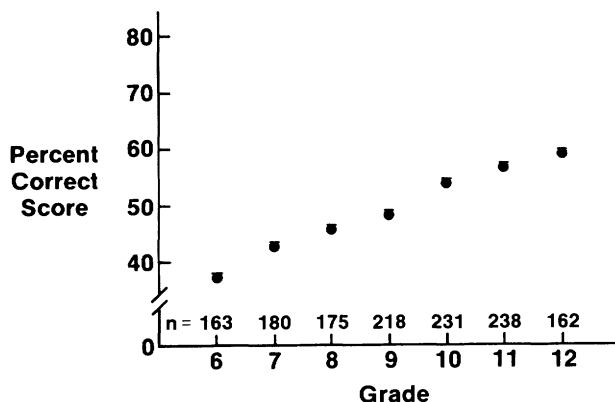


FIGURE 1. Relationship between grade level and percentage of correctly answered items on the Iowa Cardiovascular Health Knowledge Test in students in grades 6–12.

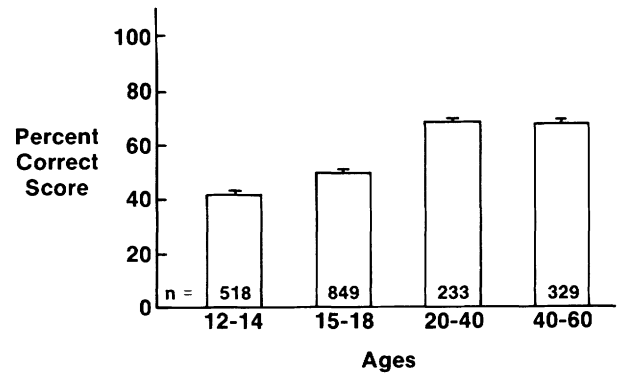


FIGURE 2. Progression of cardiovascular health knowledge in different age groups. All comparisons are significantly different from each other except for the scores of adults ages 20–40 years and adults 40–60 years.

correctly answered questions increased linearly by an average of 3.08% per year.

Changes in cardiovascular health knowledge in the population ages 12–60 years are shown in figure 2. There was a significant increase in knowledge for each group below age 40 years, but no increase was seen when older and younger adults were compared.

Table 1 shows mean ICVHT scores for adults as a function of the highest educational level achieved. Adults who had attended college or had greater educational achievements scored significantly higher than did adults with lesser educational achievements. This was true for both younger and older adults. However, there was no significant increase in the overall cardiovascular health knowledge of adults ages 40–60 years compared with adults ages 20–40 years who had equivalent educational achievements.

Table 2 shows mean ICVHT scores for adults who had special personal or family medical characteristics. Respondents who had a personal or family history of heart disease did not score higher than those who did not. The general level of cardiovascular health knowledge in respondents who had an elevated serum cholesterol level was not significantly higher. Table 3 shows the major sources of cardiovascular health

TABLE 1. General Cardiovascular Health Knowledge in Adults According to Age and Educational Status

	n	% correct		n	40–60 years
		20–40 years			
Less than high school	5	59.4 ± 3.7	33	65.4 ± 2.3	
High school	87	65.0 ± 1.3	165	65.2 ± 0.9	
Some college	92	68.2 ± 1.2	59	70.5 ± 1.4	
College graduate	30	74.8 ± 1.6	48	75.7 ± 1.5	
Graduate study	18	80.5 ± 2.1	23	73.0 ± 2.8	

Values are mean ± SEM.

Age × education interaction was not statistically significant ($F_{4, 550} = 1.79, p < 0.13$). The relationship between age and cardiovascular health knowledge was linear ($F_{1, 550} = 7.13, p < 0.0001$).

TABLE 2. General Cardiovascular Health Knowledge in Special Segments of the Adult Population

	n	% correct	p
Known heart disease	48	67.2 \pm 2.0	NS
No known heart disease	510	68.6 \pm 0.5	
Family member with heart disease	233	68.8 \pm 0.8	NS
No family member with heart disease	327	68.2 \pm 0.7	
Elevated serum cholesterol	57	68.2 \pm 1.4	NS
No elevated serum cholesterol	482	68.6 \pm 0.4	

Values are mean \pm SEM.

TABLE 3. Major Sources of Cardiovascular Health Knowledge

Source	% of pts
Television, newspapers, magazines	51.6
Schooling	18.6
American Heart Association	12.2
Friends and relatives	11.4
Physicians	6.2

knowledge as reported by the respondents. There was no significant difference in general knowledge scores when correlated with source of knowledge.

Subscales of Cardiovascular Health Knowledge

When the general level of cardiovascular health knowledge was divided into four major areas, interesting results were obtained. For all age levels, knowledge of diagnostic tests was highest and knowledge of pathophysiology lowest. Knowledge of risk factors and of normal anatomy and physiology ranked intermediate. Subscales of cardiovascular health knowledge for the population groups ages 15–60 years are shown in figure 3.

We were particularly interested in evaluating certain areas of knowledge for adults at higher risk. We wondered if knowledge of a personal cardiovascular health problem would serve as a stimulus to an increased level of knowledge of cardiovascular risk factors. Fifty-seven adults had been told they had an elevated serum cholesterol level; these adults answered correctly $83.6 \pm 2.6\%$ of the four test items on the risk factor subscale. This was not significantly greater than the $81.8 \pm 0.9\%$ scored by the 482 adults who did not have an elevated serum cholesterol level. Of the seven test items dealing with atherosclerosis, the average score of those with an elevated serum cholesterol level was $52.3 \pm 2.4\%$, which was not significantly different from the $51.6 \pm 0.9\%$ scored by the remainder of the population.

Discussion

Little is known about the changes in cardiovascular health knowledge that occur as children become adults

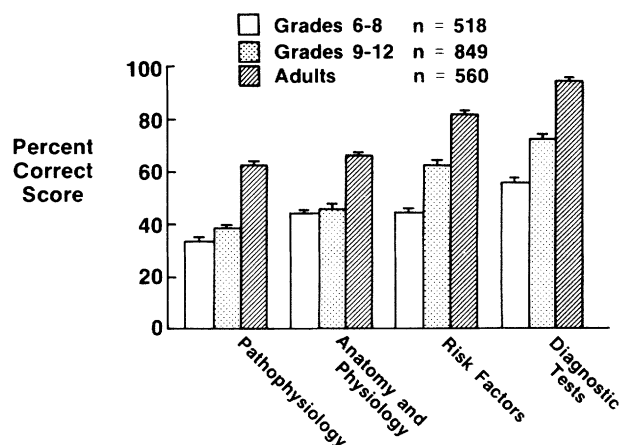


FIGURE 3. Percentage scores for students and adults in four major subscales on the Iowa Cardiovascular Health Knowledge Test. For each subscale, comparisons between groups show significant differences, with the exception of the anatomy and physiology scores for the two student groups.

in today's American culture. This study was designed to assess and compare this knowledge in children and adults of various ages using a standardized test of cardiovascular health knowledge. Because the same test was used to assess health knowledge in both adults and children, we could compare knowledge in different age groups. We postulated that the cultural and educational milieu would act to increase health knowledge even in the absence of formal instruction. We also presumed that various age groups might perform differently, according to the intensity of the stimulus for increasing health knowledge prevalent in the subgroup of the population at that time. Not all of these assumptions, however, were supported by our study.

We designed the ICVHT with the concept that a perfect score would reflect a minimally acceptable level of cardiovascular health knowledge. Because scores on any examination exhibit some variability due to errors of measurement and changing intrinsic factors affecting performance, a 90% score was considered acceptable. None of the population groups achieved this knowledge level. Although specific criteria for a minimally acceptable knowledge level might vary with different observers, this approach was useful for comparing different population groups.

To our knowledge, there are no comparable studies evaluating health knowledge on specific health topics using a standardized test given to a wide spectrum of ages. Evaluation of knowledge of specific health areas even among school children is also rare.⁷ Louria et al.⁸ described the results of a general health knowledge questionnaire given to students in grades 9–12 in a Newark high school; "poor results" were obtained in five of seven questions pertaining to cardiovascular disease. In a previous study of the efficacy of the cardiovascular unit of the School Health Curriculum (Berkeley) Project using the ICVHT, we found that sixth grade students receiving this specialized instruction scored only slightly better than matched control schools.⁷

Effects of Age and Education

General cardiovascular health knowledge progresses linearly from grades 6–12. Although children in Iowa's primary and secondary schools receive some formalized health education, specific instruction regarding cardiovascular health practices and disease problems is uncommon.⁷ The finding that students in grades 6–8 can correctly answer an average of only 41% of the items on a mastery level test is not reassuring, especially because Iowa has a relatively affluent population and few areas of low socioeconomic class and because lifelong behavior patterns develop at a young age.⁹ Although health knowledge increases gradually during the junior high and high school years, the observation that Iowa high school seniors can answer an average of 50% of the questions correctly is also disappointing.

Overall levels of cardiovascular health knowledge continue to increase in young adults after completion of formal schooling. The adults answered an average of 68% of the ICVHT questions correctly. At about age 40 years, however, the linear increase in knowledge that began at age 12 years appears to cease, even though the prevalence of cardiovascular disease increases rapidly in adults older than 40 years of age. In 1977, cardiovascular diseases were responsible for 16.6% of the deaths of Iowa adults ages 25–44 years. For adults ages 45–54 years, the prevalence of cardiovascular-related deaths had increased to 32.8%.¹⁰

The explanation for the plateau in the cardiovascular health knowledge of adults at a time of increasing cardiovascular disease mortality is unclear. It does not appear to be an artifact of test construction or administration, for no ceiling effect was observed and scores as high as 97% were obtained. Although the relationship of age to cognitive function is complex, tests of general knowledge reveal that the performance of adults is best in persons of middle age, while scores of older adults (70–79 years) differ little from those of younger adults (20–29 years).¹¹ These findings contrast with studies on "school-learned skills," in which a generally decreasing age-related performance occurs.¹¹ Changes in cognitive function in adults appear to be related primarily to interest or experience. Our findings show that the increasing prevalence of cardiovascular disease in the older adult population does not stimulate an increased knowledge of cardiovascular disease in this age group.

In both groups of adults, the level of education and performance on the ICVHT were clearly related. Even in the more highly educated adults, knowledge did not increase during middle age. The inverse relationship between the educational achievements of adults and levels of cardiovascular health knowledge, though perhaps intuitively expected, has highly significant implications. The educational status of adults has recently been found to be an independent cardiovascular risk factor. Weinblatt and co-workers¹² reported a threefold differential in the risk of sudden coronary death between patients of different educational levels who had complex ventricular premature

complexes during 1 hour of baseline monitoring. Dyer et al.¹³ noted an inverse relationship between education and high blood pressure in whites that could not be accounted for by differences in age, weight and heart rate. Thus, adults who have less education are at higher cardiovascular risk. This increased risk may, in part, be caused by ignorance of factors contributing to that risk, and poor understanding of disease and therapy.

What is the meaning of the poor examination performance in the general population? Although one might argue that it is merely a reflection of unrealistically high standards set by the test designers, the relatively high levels of achievement by the college graduates are evidence against this logic. Also, the continuing high death rate from cardiovascular disease supports the argument that current educational standards are too low.

Knowledge of Specific Cardiovascular Subtopics

When the ICVHT was subdivided into questions relating to four specific areas of cardiovascular health knowledge, interesting results were obtained. All age levels had greatest understanding of questions regarding cardiovascular diagnostic tests. This may reflect a greater exposure to this topic area through television and other popular mass media. Knowledge of pathophysiology and normal physiology was low. Although the absolute scores achieved on each subtopic varied, similar relative rankings were observed for all age groups.

The ICVHT, however, was not composed of four equally weighted subscales. Specific content objectives were determined and test items were then composed to assess each objective. Only retrospectively were general topical similarities observed and subtopic relationships assessed. The marked differences in numbers of test questions from each area probably reflect differences in complexity and scope among the areas as judged by the test's authors. Nonetheless, there is an interesting generally inverse relationship between the numbers of questions per topic area and the percentage of correct answers for all groups. This inverse relationship has two important implications. First, a disproportionate number of items from more difficult subscales may explain, in part, the generally poor test performance seen. Second, assuming that subjects are likely to know more about topics they consider important, this inverse relationship may reflect differences in the perception of the importance of knowledge of certain topic areas between the medical educators who constructed the test and all ages of the population. The test's authors assumed that a general understanding of normal cardiovascular functioning and how such functioning is altered by disease are important for establishing good preventive health behaviors. Whether knowledge of specific health-related "do's and don'ts" in the absence of an understanding of the reasons for such admonitions is a sufficient educational goal is an important question.

Effect of "At-risk" States

Are there specific segments of the general adult population that might be expected to have higher levels of cardiovascular health knowledge? One might assume that subjects known to be at higher risk of developing cardiovascular disease might be stimulated to increase their knowledge of this subject. The health-belief model, proposed to explain variations in health behavior, postulates that changes in health behavior are related to a person's perception of susceptibility to a disease and the severity of that disease.¹⁴ Adults with a personal or family history of heart disease, however, did not score significantly higher than those who did not. Likewise, there were no significant increases in the overall levels of cardiovascular health knowledge in that segment of the population who had been told they had an elevated serum cholesterol level.

Similar lack of educational stimulation from an "at-risk" behavior was also found when specific subtopic areas were analyzed. Baric¹⁵ regards the perceived state of health as a major factor in defining the effectiveness of health education efforts. In our study, however, adults at higher risk of developing heart disease had no greater knowledge of items related to atherosclerosis or to risk factors of cardiovascular disease than adults at lesser risk.

Sources of Health Knowledge

Most adults reported that their major source of health knowledge was from television and the popular press (table 3). This might be expected, given the popularity of medically related television programs. Although only 18.6% believed that most of their health knowledge had come from schooling, the correlation between educational achievement and ICVHT score suggests that schools and colleges could serve as a major source of health knowledge even for those in non-health-related occupations. The finding that only a small percentage of adults listed physicians or the American Heart Association as their major source of cardiovascular health knowledge is cause for concern. The ratings of physicians may reflect the fact that the educational activities of physicians have traditionally been directed at the sick rather than at preventive public health education. The American Heart Association, however, ranks public health education as a major goal.¹⁶ Although much of this activity may be occurring via the mass media, and the public's perception may unknowingly reflect the American Heart Association's effort, our findings suggest that the population does not credit the American Heart Association as a major source of cardiovascular health knowledge.

Implications

The results of this study show a need for improvement in cardiovascular health education for both children and adults. New approaches and new educational methods and materials are needed. Defining the

specific objectives of these educational efforts is not easy. Further research is needed to provide answers to questions regarding the amount of knowledge of anatomy, physiology and pathology necessary to provide an understanding of disease prevention strategies.

Special emphasis should be given to the design of cardiovascular educational programs for the adult population at age levels when cardiovascular disease is likely to become manifest. Educational efforts, however, should be accompanied by a thorough evaluation of their efficacy, including short- and long-range impact and relative effectiveness in populations of various ages. A well-designed standardized test can provide such an evaluation. An ideal test should assess, as accurately as possible, knowledge associated with behavior that minimizes risk factors. Studies have shown that knowledge of healthy behavior is not sufficient to modify unhealthy behaviors.^{17, 18} Therefore, the ICVHT was weighted toward assessing a more fundamental understanding of the underlying disease process. We postulated that an increased understanding of the reasons that underly recommendations for healthy behavior would be more likely to have a beneficial influence. This assumption should be studied further. Under any circumstances, however, the educational goals and the tests designed to assess health knowledge must evolve as our knowledge increases.

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Alterations in Carotid Arterial Velocity-Time Profile Produced by the Blalock-Taussig Shunt

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SUMMARY Because the presence of a systemic artery-to-pulmonary artery communication can alter blood flow patterns in both the systemic circulation distal to the communication as well as the pulmonary circulation, the effect of a Blalock-Taussig anastomosis on carotid arterial flow was investigated using noninvasive, continuous-wave Doppler ultrasonography. Thirty-seven patients without a Blalock-Taussig shunt (group 1) and 17 patients with a Blalock-Taussig shunt (group 2) were studied using an 8-MHz continuous-wave Doppler velocitometer. All group 1 patients had quantitatively similar carotid arterial velocity-time profiles and continuous antegrade flow throughout the entire cardiac cycle in both carotid arteries. Eight patients in group 1 subsequently underwent creation of a Blalock-Taussig shunt with an increase of systemic arterial oxygen pressure greater than 20 mm Hg. Immediately after operation, all showed marked alterations in the ipsilateral carotid arterial velocity-time profile from the preoperative pattern. Six showed the flow velocity diminishing to zero by late diastole. Two showed continuous retrograde diastolic flow, and developed congestive heart failure. The velocity-time profile of the contralateral carotid artery remained normal. Of the remaining nine patients in group 2 studied 6 months to 8 years postoperatively, six showed diminution of the ipsilateral carotid arterial velocity to zero by later diastole and at catheterization were shown to have an adequate-sized Blalock-Taussig shunt. The other three patients showed continuous forward flow in the ipsilateral carotid artery and at catheterization had a markedly stenotic Blalock-Taussig shunt. All nine patients showed continuous antegrade flow in the contralateral carotid artery. Features of the carotid arterial velocity profiles that separated groups 1 and 2 were unaffected by age or heart rate. Thus, a nonstenotic Blalock-Taussig shunt alters the ipsilateral carotid arterial velocity-time profile and induces characteristic changes that confirm the patency of the shunt. A shunt large enough to produce congestive heart failure produces additional distinctive alterations in the carotid arterial velocity-time profiles, e.g., diastolic retrograde flow.

THE PRESENCE of a systemic artery-to-pulmonary artery communication creates a situation in which the relatively low resistance pulmonary circuit is in parallel with the relatively higher resistance systemic circuit. Rudolph *et al.*¹ showed marked alterations in aortic and pulmonary artery flow patterns after creation of an aortic-to-pulmonary artery communication, with marked retrograde diastolic aortic flow distal to the communication and continuous diastolic antegrade aortic flow proximal to it. Naturally occurring

communications, such as a patent ductus arteriosus, also alter blood flow patterns significantly. Cassels,² Spencer and Denison³ and Serwer *et al.*⁴ showed alterations in the descending aortic flow velocity patterns in the presence of a patent ductus arteriosus similar to those shown by Rudolph *et al.*¹ that were eliminated after its ligation. Spach *et al.*⁵ demonstrated the same findings angiographically. All of these studies showed that in the aorta distal to the communication there was a diastolic "steal" present, with retrograde flow from the distal aorta to the pulmonary artery.

Anastomosis of the subclavian artery to the pulmonary artery may create the same physiologic situation present in animals when an artificial conduit is placed between the aorta and pulmonary artery and in patients with a patent ductus arteriosus. In this situation, the innominate artery is proximal to the shunt and, as such, is analogous to the ascending aorta, while the carotid artery arising from the innominate is distal to the shunt and is analogous to the descending

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Supported in part by USPHS grants HL-11307 and HL-20749. Dr. Anderson is the recipient of Research Career Development Award HL-00500.

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Received April 22, 1980; revision accepted September 15, 1980. *Circulation* **63**, No. 5, 1981.