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Alarming trends in ideal cardiovascular health among children and adolescents in Beijing, China, 2004 to 2014

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ABSTRACT

Background: The American Heart Association's 2020 Strategic Goals have defined a new concept of cardiovascular health for adults and children, emphasizing the importance of primordial prevention of cardiovascular diseases. However, detailed data on the trends of ideal cardiovascular health in Chinese children and adolescents are sparse.

Methods: A total of 5596 children and adolescents (aged 6–18 years) were selected from two cross-sectional surveys conducted in 2004 and 2014, respectively. Cardiovascular health behaviors (smoking, body mass index, physical activity, and diet) and factors (total cholesterol, blood pressure, and glucose) were evaluated, and only participants with information on all 7 metrics ($n = 4309$) were included for the cardiovascular score analysis.

Results: During 2004–2014, ideal levels of almost all the seven metrics decreased, except for a marked increase in physical activity (boys: 23.0% vs 52.8%; girls: 16.2% vs 41.0%). Overall, only 19.5% of boys and 22.0% of girls had ideal cardiovascular health (score ≥ 6) in 2004, which worsened in 2014 (boys: 9.8%; girls: 16.0%). The prevalence of ideal cardiovascular health factors also declined, but the prevalence of ideal cardiovascular health behaviors increased. Being a girl and having a younger age (aged 6–11 years) were associated with higher prevalence of ideal cardiovascular health. Higher family income and parental education were associated with a higher prevalence of ideal cardiovascular health behaviors.

Conclusion: Adverse trends in ideal cardiovascular health were observed among Chinese children and adolescents during 2004–2014. Effective intervention programs, in particular targeting children and adolescents, need to be developed to promote cardiovascular health in China.

1. Introduction

Worldwide, cardiovascular disease (CVD) is highly prevalent and remains the predominant cause of premature mortality [1]. Changes in social environments and unhealthy lifestyles are main culprits of the rising CVD events [2,3]. The rise of CVD risk factors has been found among children and adolescents in recent years [4,5] and likely will result in increases in CVDs in adulthood [6,7].

The American Heart Association (AHA) has defined a new concept of "ideal cardiovascular health (CVH)" for American adults and children in 2010 [8], which includes four health behaviors (non-smoking, physically active, normal BMI, healthy diet) and three health factors (normal blood pressure, total cholesterol, fasting glucose). Based on these seven health behaviors and factors, the construct of CVH comprehensively combines the traditional risk factors, as well as lifestyle behaviors, emphasizing the importance of overall strategies in achieving optimal cardiovascular health.

Several longitudinal studies have demonstrated that the number of ideal CVH metrics is associated with CVD incidence and all-cause mortality [9,10]. Additionally, the status of CVH during childhood has been shown to be a strong predictor of CVH and future subclinical CVD development in adulthood [11,12], suggesting that understanding the status and trends of CVH at young ages is a critical starting point for primordial prevention of CVD.

Promotion of CVH advocated by the AHA is also important for the Chinese population, especially for urbanized Beijing. Rapid economic

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growth and changes in diet and physical activity (PA) have led to an epidemic of CVD and other chronic diseases in recent decades [13]. Though several studies have examined the trends of specific CVD risk factors [14–16], as well as clustering of risk factors or metabolic syndrome [17,18], information on the overall trends of CVH among Chinese children and adolescents is sparse.

Using data collected in 2004 and 2014 in Beijing, the present study aims to estimate the trends and disparities of CVH among Chinese children and adolescents in the past 10 years.

2. Methods

2.1. Data source

The data under analysis are composed of two subsamples from the Beijing Child and Adolescent Metabolic Syndrome (BCAMS) study in 2004 and the China Child and Adolescent Cardiovascular Health (CCACH) in 2014, respectively. Both studies were cross-sectional surveys executed by the same investigator (JM) using similar procedures and data collection methods. For the present study, 5596 subjects (3528 in 2004, 2068 in 2014) were collected using a random cluster sampling method, targeting children and adolescents aged 6–18 years living in urban areas of central Beijing (Dongcheng Districts and Xicheng Districts). After excluding individuals with chronic diseases (diabetes mellitus, kidney disease, heart disease or thyroid), 5568 with available CVH metrics were included for trend analyses of each metric. However, only those with information of all seven metrics (3266 in 2004, 1043 in 2014) were included for calculating CVH scores. For the 2004 data, subjects who were excluded from CVH score analysis were generally similar to those included in the study in terms of household income and parental education, but with more adolescents and boys; for the 2014 data, parental education and household income were lower among subjects who were excluded from the study (Table A.1).

Signed informed consent was given by all participants (≥12 years) or their guardians (<12 years). Study protocols were approved by the Institutional Review Board and Ethics Committee of the Capital Institute of Pediatrics.

2.2. Data collection

Demographic (age, gender), socioeconomic information (parental education, annual household income), and lifestyle behaviors (smoking status, physical activity, diet) were obtained by questionnaires. Highest parental education level was categorized as below college versus college or above. Household income was classified into three categories based on a poverty-income ratio (PIR). PIR was derived by dividing household annual income by the established city's poverty level, accounting for household size and year of assessment. We defined PIR <1.0 as poor, 1.0–<3.0 as middle income, and ≥3.0 as high income.

Height was measured using wall-mounted stadiometers without shoes. Weight was measured using beam scales with light indoor clothing. Body mass index (BMI) was calculated as weight (in kg) divided by the square of height (in m^2). Similar data collection methods were employed in the 2004 and 2014 surveys.

Blood pressure (BP) was measured three times in the morning, using an appropriate cuff with a bladder covering at least 40% of arm circumference by trained research staff according to a standardized protocol. The average of the last two readings was used for statistical analysis. Different devices were used during the two surveys; a mercury sphygmomanometer in 2004 and an oscillometric device (OMRON HEM-7012) in 2014. Nevertheless, the device used in 2014 was validated in children and adolescents against a mercury sphygmomanometer. The results of validation test showed that the mean difference in readings of the electronic device and mercury device were between 0.3 and −4.7 mm Hg, which was less than the maximum offsets of 5.0 mm Hg set by the Association for the Advancement of Medical Instrument (AAMI) standards [19], indicating the 2004 and 2014 BP measures were comparable.

All blood samples were collected from participants after an overnight fast (>12 h). In 2004, fasting glucose (FG) and total cholesterol (TC) levels from finger capillary blood were determined by testing device (Accutrend GCT, Roche Diagnostics, Mannheim, Germany); while in 2014, FG and TC levels were from venous blood, and measured by an Olympus AU640 automatic chemistry analyzer (Olympus, Tokyo, Japan). Concentrations of FG and TC measured in 2004 were evaluated against those from simultaneously obtained venous blood samples, and both showed low mean difference (TC: 0.03 mmol/L; FG: 0.39 mmol/L) and imprecision (TC: 1.74%; FG: 10.96%). In addition, all measurements were performed using standard methods under national quality control in the Clinical Laboratory of the Capital Institute of Pediatrics, which provided accurate and comparable test results across surveys.

2.3. Definitions of CVH metrics

Due to changes or lack of information in the questionnaires for the 2004 versus 2014 surveys, modified definitions of CVH metrics, mainly for physical activity and diet, were used in this study, and detailed information is shown in Table A.2 in the appendix.

2.4. CVH behaviors

Smoking status was assessed for all subjects and was categorized as ideal (nonsmoker) versus non-ideal (current smoker or previous smoking attempts). We used BMI cutoffs for age and gender recommended by the Working Group on Obesity in China (WGOC) [20] to classify BMI as ideal (normal), intermediate (overweight), or poor (obesity). AHA recommended ≥60 min of moderate or vigorous PA (MVPA) daily in the statement, but ideal PA in our study was defined by daily frequencies of 30-min MVPA beyond school physical education. Dietary behaviors for the past 12 months were assessed by using a food frequency questionnaire, and we replaced whole grain and salt, two dietary components proposed by the AHA, with soybean product and salty snack consumption, respectively. A healthy diet was defined to include the following 5 components: 1) bean-curd or soybean products (≥1 time/day); 2) fruits and vegetables (≥1 time/day); 3) fish or fish products (≥1 time/week); 4) sugar-sweetened beverage (<1 time/week); and 5) salty snacks (<1 time/day). Subjects were classified as ideal (4–5 components), intermediate (2–3 components), or poor (0–1 component) based on the number of components they achieved.

2.5. CVH factors

BP level was classified as ideal (normal), intermediate (prehypertension) or poor (hypertension) according to the age-, gender-specific blood pressure reference standards for Chinese children and adolescents [21]. Total cholesterol status was defined as ideal (<4.4 mmol/L), intermediate (≥4.4– <5.2 mmol/L), or poor (≥5.2 mmol/L). For fasting glucose status, corresponding categories were: ideal (<5.6 mmol/L), intermediate (≥5.6– <7.1 mmol/L) or poor (≥7.1 mmol/L).

2.6. Calculation of CVH score

CVH score was calculated by the total number of ideal metrics, ranging from 0 to 7. The score for CVH behaviors and CVH factors were calculated similarly, and ranged from 0 to 4 and 0 to 3, respectively.

Individuals attained 6 or 7 in CVH score was defined as ideal CVH, 3 or 4 in CVH behavior score as ideal CVH behaviors, and 3 in CVH factor score as ideal CVH factors.

2.7. Statistical analysis

Differences in characteristics between surveys were compared using *t*-tests or chi-squared tests. Due to different age distributions for the two study periods, differences in BMI, blood pressure, total cholesterol and blood glucose across surveys were tested using a general linear model adjusted for age. Score distribution and ideal levels of overall CVH, CVH behaviors, and CVH factors were examined by gender. Due to the limited number of participants with lower or upper CVH scores, subjects scored 0–2 and 6–7 in CVH metrics, 0–1 in CVH behavior and factor metrics were combined to stabilize our estimates. Prevalence of each level of seven metrics was calculated by age and gender, and their time trends were tested by chi-squared test. For disparities analysis, logistic regression models were used to test for differences in prevalence of ideal CVH (score ≥ 6), ideal CVH behaviors (score ≥ 3) and ideal CVH factors (score = 3) by the selected characteristics. Data were analyzed using SPSS software version 19.0 (SPSS, Inc., Chicago, IL, USA). All tests were two-sided, and a value of $p < 0.05$ was used to denote statistical significance.

3. Results

Table 1 shows the characteristics of the study population. In both genders, age, parental education and household income increased between 2004 and 2014. Also, the mean value of age-adjusted BMI and almost all CVH risk factors (systolic blood pressure, total cholesterol, blood glucose) increased, except for a decline in diastolic blood pressure. Smoking and being physically active became prevalent in both boys and girls. For diet, the prevalence of daily intake of soybean products increased, but the prevalence of fish or fish products ≥1 time/week decreased. Moreover, fewer girls consumed fruits and vegetables ≥1 time/day, and sugar-sweetened beverage <1 time/week.

Trends in poor, intermediate, and ideal levels of all seven CVH metrics over time are presented in Fig. 1 and Table A.3. In both genders and age groups, downward trends were found in almost all ideal levels of CVH metrics, except for an increase in PA (boys: 23.0% vs 52.8%; girls: 16.2% vs 41.0%). Such reductions, like the ideal level of BMI, diet and blood pressure, were mostly found among boys and adolescents (children aged 12–18 years old). Among all of the metrics, the largest reduction was for ideal blood glucose, which dropped by 49.7% in adolescent boys (94.0% vs 47.3%) and by 35.6% in adolescent girls (98.3% vs 63.3%). For adolescent boys, although there was no increase in the prevalence of obesity or high blood pressure, proportions in the intermediate levels for each health factor increased.

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