# The effects of a comprehensive community trial on cardiometabolic risk factors in adolescents: Isfahan Healthy Heart Program

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## Abstract

**BACKGROUND:** This study aimed to assess the effects of a 6-year-long community-participatory program including school-based interventions on mean values and prevalence of cardiometabolic risk factors among adolescents.

**METHODS:** The interventions of this community trial, conducted from 2000 to 2007 in Iran, targeted the whole population (of nearly two millions) living in two cities considered as the intervention area (IA) in comparison with a reference area (RA). Data from surveys conducted before and after interventions was used to compare the differences between the secondary school students of the IA and RA.

**RESULTS:** The prevalence of hypercholesterolemia and hypertriglyceridemia declined significantly in girls and boys in the IA (P < 0.01). The prevalence of high LDL-C decreased significantly in the girls in the RA (P = 0.002). Among both sexes in the IA, the prevalence of low HDL-C increased significantly (P < 0.001), whereas it decreased in the girls and boys in the RA (P = 0.04). Although in the IA, the prevalence of overweight and obesity decreased significantly in girls (P = 0.001), it increased in boys (P = 0.001) as well as in the girls of the RA (P = 0.01).

**CONCLUSION:** By performing school-based interventions, our study was successful, at least in part, in controlling some cardiometabolic risk factors in adolescents. Such modifications may have long-term impacts on non-communicable diseases prevention in adulthood.

## Introduction

Historically, infectious diseases and undernutrition have been the focus of global healthcare initiatives by international organizations. However, there has been a move in recent years towards the prevention and management of chronic non-communicable diseases (CNCDs).[1] Since the process of CNCDs is believed to begin early in life, interest in childhood precursors to CNCDs is increasing. Behavioral and biological risk factors persist from childhood into adulthood.

Several risk factors including overweight, dyslipidemia and high blood pressure are tracking from childhood to adult life, and are linked to adult diseases. Fortunately, many of these risk factors are modifiable.[2] Children and adolescents should achieve optimal physical and cognitive development, enjoy appropriate food and physical activity, attain normal growth, and reduce the risk of chronic disease through healthy lifestyle behaviors including appropriate eating habits, participation in regular physical activity, as well as tobacco control. Health

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promotion will help reduce lifestyle-related risks of CNCDS. Lifestyle behaviors, which contribute to the leading causes of morbidity and mortality among adults, are often established during childhood and adolescence and extend into adulthood. They are mostly interrelated and preventable. Moreover, cardiometabolic risk factors origin in early life, commonly persist in later life and are mostly strong predictors of chronic diseases in adulthood.[3,4]

Schools present opportunities for health education and lifestyle change, since no other institution has as much contact time with children and adolescents. Moreover, schools can implement environmental changes, which may affect available foods, physical education, curricula, and the acceptability of healthy behaviors.[5]

In industrialized countries, even from the 1990s, several multi-component school-based programs have been reported to be successful for health promotion among children and adolescents.[6-9] Thus, current school-based health promotion programs are conceptualized as including curriculum and related organizational factors supporting healthy behavior. Such experience on the efficacy of similar programs is scarce from low- and middle-income countries. Consequently, one of the ten interventional projects of a comprehensive community trial, entitled Isfahan Healthy Heart Program (IHHP), was considered for the pediatric age group, and focused on school-based activities.[10,11]

Here we report some findings on the 6-year-trend of changes in the mean values and prevalence of cardiometabolic risk factors in secondary school students evaluated in the project entitled Heart Health Promotion from Childhood (HHPC).

## Materials and Methods

This program was jointly conducted by Isfahan Cardiovascular Research Center (ICRC, a world health organization (WHO) collaborating center) and Isfahan Provincial Health Office, both affiliated to Isfahan University of Medical Sciences, Isfahan, Iran. Ethics committees of ICRC and other relevant national regulatory organizations approved the study. Written informed consents were obtained from parents or legal guardians of students.

This study was an interventional study embraced in the HHPC project of IHHP. The IHHP was a comprehensive community-based program for prevention and control of cardiovascular diseases (CVDs) and promotion of healthy lifestyle. Its impacts were evaluated in a quasi-experimental study design. This program was performed during 2000 to 2007 in three phases.[11]

*Participants*
In the 1st phase, the situation was assessed on 2000 students in secondary schools (1000 girls, 1000 boys) aged 11-18 years, selected from Isfahan and Najafabad (Iran) with populations of 1,895,856 and 275,084, respectively as the intervention area (IA) and Arak, Iran a city located 375 km northwest of Isfahan with a population of 668,531, was designated as the reference area (RA).[11,12] Both IA and RA are industrial areas in the center of Iran with similar socio-economic, demographics and health profiles. School-based approach and multistage random-cluster sampling method were conducted to choose 56 secondary schools of different urban and rural areas based on population distribution in urban/rural ratio of IA and RA which was 70/30 and 60/40, respectively. Complete information regarding sampling process has been presented elsewhere.[12] During the 2nd phase of the study, different interventions were performed in IA only on the basis of the results of the first study phase, whereas Arak remained as the RA. Lifestyle behaviors were assessed annually by questionnaire-based surveys in independent samples in both communities. After 7 years (2007), the post-intervention outcomes, consisting of physical and biochemical measurements, were evaluated by a cross-sectional survey similar to the 1st phase in independent random samples in both communities. Overall, 986 students of secondary schools in the two communities were studied at baseline, and 1037 in the post-intervention survey. Data was collected by a trained team of expert nurses, who were certified after a 1-week training program and evaluation of their inter- and intra-observer variability.[12] In both IA and RA, health-related lifestyle behaviors were determined through annual questionnaire-based surveys on independent samples, whereas physical examination and blood sampling were conducted in the first and final phases of the study. The study design and rationale for IHHP intervention and evaluation methods have been described elsewhere.[10,11]

*Physical examination*
The age and birth date were recorded. All measurements were conducted according to standard protocol by using calibrated instruments. Height and weight were measured to $\pm$ 0.2 cm and $\pm$ 0.2 kg, respectively with students being barefoot and lightly dressed. Body mass index (BMI) was calculated as weight (kg) divided by height squared (m²). Overweight and obesity were defined based on 85th $\leq$ BMI < 95th and $\geq$ 95th percentiles of BMI, respectively.[13]

For blood sampling, students were invited to the nearest health center to their school. They were instructed to fast for 12 hours before the screening, and compliance with fasting was determined by interview on

the morning of the examination. While one of the parents accompanied his/her child, blood samples were taken from the antecubital vein between 8:00 to 9:30 am. The blood samples were centrifuged for 10 minutes at 3000 rpm within 30 minutes of venipuncture. Standard laboratory kits (Pars Azmoun Co., Tehran, Iran) and standard laboratory methods were used to measure serum lipid profile. Blood samples were kept frozen at -20°C until assayed within 72 hours in the ICRC central laboratory, with adherence to the external national and international quality control. Total cholesterol (TC), high-density lipoprotein-cholesterol (HDL-C) and triglyceride (TG) were measured by an auto-analyzer (Elan, Germany in the baseline survey and Hitachi, Japan in the 2007 survey). In serum samples with TG $\leq$ 400 mg/dl, low-density lipoprotein-cholesterol (LDL-C) was calculated according to the Friedewald equation.[14] Hypercholesterolemia, hypertriglyceridemia and high LDL-C were defined based on $\geq$ 95th percentiles of TC, TG and LDL-C, respectively (i.e. TC $\geq$ 111 in boys and 120 mg/dl in girls, TG $\geq$ 220 in boys and 205 mg/dl in girls, LDL-C $\geq$ 132 in boys and 136 mg/dl in girls). Low HDL-C was determined based on $\leq$ 5th percentile (HDL-C $\leq$ 74 in boys and 70 mg/dl in girls) [15].

### Interventions

Based on data from the baseline survey and needs assessment, which delineated existing health and human resources, IHHP interventions were implemented in ten projects, each targeting different audience.[16] Meanwhile, routine national health activities were continuing in both intervention and reference communities. The target group was the general population in urban and rural areas of the intervention communities. The main fields of interventions in IHHP were healthy nutrition, increasing physical activity, tobacco control and coping with stress. Moreover, key strategies were educational, environmental and legislative interventions. They included public education through mass media, intersectoral collaboration, professional education and involvement, marketing and organizational development, legislation and coordination, policy development, as well as research and evaluation. The details of IHHP interventions were presented elsewhere.[10,16]

Out of 3934 schools in Isfahan and Najafabad 3654 have been involved in the activities carried out by HHPC. Overall, about 410,000 students were included in the IA. HHPC training elements on healthy lifestyle and CVD prevention from childhood had been integrated in regular mandatory education of school staff which was organized by the Provincial Training and Education Organization. In the beginning of the interventional phase, about 45% of schools were involved in the training and until 2004 the proportion of schools increased to 92%.[17]

Some of the interventions in the HHPC project were education with pamphlets, booklets and face-to-face meetings, designating role models among school children, organizing sports and painting competitions with heart health themes, serving healthy snacks, establishing healthy heart buffets, and reinforcing healthy eating habits and exercise hours in schools. All schools organized regular gatherings for parents 6 times during 2001-2006. The healthy messages of HHPC were trained in these sessions. In addition, health-related information from other projects of IHHP that could be beneficial for adolescents was also achieved by parents.[10,11]

### Evaluation

The quality of data collection was confirmed by strict training methods and strong quality assurance programs. Different levels of evaluation consisting of impact, outcome, process and external evaluations were taken into account as integrated components of the program.[10,17,18] The qualitative and quantitative questions of process evaluation were assumed in the intervention area only.

Due to the importance of IHHP, as the first community trial on CNCD prevention in Iran, the Isfahan University of Medical Sciences undertook an external evaluation of this program by international experts. Quality control was conducted for both the implementation of interventions and the research components. The report was submitted to the university officials and the WHO office in Iran.[17]

### Statistical analysis

Data from the baseline and final independent sample surveys was used to compare the differences in mean values of variables in IA and RA communities separately in boys and girls by using t-test. The relations between the year of the study with the intervention and reference areas were determined by univariate analysis. The frequency of cardiometabolic risk factors in the two areas under study was compared by chi-square test separately in each gender. The aforementioned interaction was determined by logistic regression analysis. Data was analyzed using the SPSS$_{15}$ for windows (SPSS Inc., Chicago, USA). The significance level was set at $P < 0.05$.

## Results

The baseline sample included 500 and 486 students in the IA and RA, respectively. In 2007 however, the sample included 522 and 515 adolescents in the IA and RA, respectively. The basic characteristics of participants in 2000-2001 and 2007 are presented in

table 1. The mean age of students was not significantly different across years.

Table 2 indicates mean values of cardiometabolic risk factors in secondary school students in the IA and RA based on gender during 2000-2001 and 2007. Although mean BMI had no significant differences in girls of the IA, it increased significantly among girls of the RA (P < 0.001). Therefore, mean BMI significantly increased in girls of RA vs. IA (P = 0.002). On the other hand, mean BMI among boys increased significantly in the IA (P < 0.001) and RA (P = 0.014). However, the interaction had no significant difference. Mean TC and TG values significantly declined in girls and boys of the IA vs. the RA across the years (P = 0.018 in girls and P = 0.002 in boys). Mean LDL-C values had no significant changes except for a significant reduction in girls of the RA (P < 0.001). While mean values of HDL-C declined significantly in both girls and boys of the IA, it increased significantly in the RA (P interaction < 0.001). The prevalence of cardiometabolic risk factors in secondary school students of the IA and RA based on gender are presented in table 3. Although the prevalence of hypercholesterolemia decreased significantly in girls and boys in the IA (P < 0.001 and P = 0.004, respectively), there was no changes among either sex in the RA. Likewise, the prevalence of hypertriglyceridemia significantly decreased in both sexes in the IA (P < 0.001) while no significant reductions were observed in girls or boys of the RA. The prevalence of high LDL-C decreased non-significantly in both sexes in the IA and boys in the RA. However, it had a significant reduction of 8.5% in girls of the RA (P < 0.002). Among both sexes in the IA, the prevalence of low HDL-C increased significantly (P < 0.001), whereas it decreased in girls (P = 0.001) and more slightly in the boys of the RA (P = 0.035).

Although there was a significant reduction in the prevalence of overweight and obesity in girls of the IA (P = 0.001), they increased significantly in girls of the RA (P = 0.014). The two complications also increased significantly in boys of the IA (P = 0.001) while no significant change was detected among boys of the RA.

## Discussion

The IHHP was the first community-based trial to assess the impact of a comprehensive, multi-component healthy lifestyle intervention program in a developing country. The findings revealed that the IHHP resulted in some complicated changes in mean values, as well as in the prevalence of cardiometabolic risk factors. Interestingly, the potential effects of school-based health intervention programs on lifestyle behaviors and CNCDs risk factors and surrogate markers are conflicting.

A study in India assessed the effectiveness of a multi-component intervention model of nutrition and lifestyle education on behavior modification, anthropometry and metabolic risk profile of urban Asian-Indian adolescents. At 6 months follow-up, significant improvements in several domains of knowledge and healthy lifestyle behaviors, as well as decreases in abdominal adiposity and blood glucose levels were observed in the intervention students in comparison with controls.[19] However, since this study was not conducted at a large scale, its results might not be generalizable.

A controlled study in the US evaluated health-related knowledge of CVD risk factors before and after a 16-week school-based intervention among children in rural areas. It found health-related knowledge of rural adolescents possible to be increased through partnership with schools and multidisciplinary teams of health care professionals.[20]

**Table 1.** Basic characteristics of secondary school students in the intervention and reference areas based on gender (IHHP-HHPC)

| | | Baseline | | Final | |
| --- | --- | --- | --- | --- | --- |
| | | Intervention n (%) | Reference n (%) | Intervention n (%) | Reference n (%) |
| Gender | Girls | 274 (54.80) | 269 (55.30) | 242 (46.40) | 256 (49.70) |
| | Boys | 226 (45.20) | 217 (44.70) | 280 (53.60) | 259 (50.30) |
| Residence | Urban | 309 (61.80) | 313 (64.40) | 457 (87.50) | 338 (65.60) |
| | Rural | 191 (38.20) | 173 (35.60) | 65 (12.50) | 177 (34.40) |
| Age (years) | | 12.92 ± 1.14 | 12.63 ± 1.11 | 13.17 ± 1.26 | 13.04 ± 1.15 |

Values are expressed as number (%) or mean ± standard deviation

**Table 2**. Cardiometabolic risk factors in secondary school students in the intervention and reference areas based on gender (IHHP-HHPC)

| | | Girls | | | | Boys | | | |
| --- | --- | --- | --- | --- | --- | --- | --- | --- | --- |
| | | **2001** | **2007** | **P** | **Interaction P** | **2001** | **2007** | **P** | **Interaction P** |
| Total cholesterol (mg/dl) | Intervention | 170.07 ± 34.85 | 155.34 ± 26.22 | < 0.001 | 0.018 | 163.99 ± 32.50 | 151.40 ± 26.25 | < 0.001 | 0.002 |
| | Reference | 169.35 ± 32.13 | 163.98 ± 28.74 | 0.055 | | 160.30 ± 32.84 | 159.78 ± 29.99 | 0.86 | |
| Triglycerides (mg/dl) | Intervention | 127.42 ± 49.61 | 109.99 ± 45.04 | < 0.001 | 0.025 | 129.55 ± 57.88 | 99.97 ± 40.69 | < 0.001 | < 0.001 |
| | Reference | 121.85 ± 50.56 | 118.39 ± 49.19 | 0.45 | | 114.47 ± 55.47 | 111.49 ± 50.16 | 0.55 | |
| LDL-cholesterol (mg/dl) | Intervention | 89.50 ± 31.22 | 88.91 ± 24.11 | 0.81 | 0.03 | 86.20 ± 29.66 | 84.16 ± 22.64 | 0.39 | 0.91 |
| | Reference | 100.66 ± 30.30 | 92.27 ± 24.25 | 0.001 | | 92.09 ± 29.03 | 89.69 ± 25.40 | 0.35 | |
| HDL-cholesterol (mg/dl) | Intervention | 55.87 ± 10.55 | 44.75 ± 10.41 | < 0.001 | < 0.001 | 52.29 ± 9.71 | 47.17 ± 10.30 | < 0.001 | < 0.001 |
| | Reference | 44.32 ± 10.57 | 48.42 ± 10.87 | < 0.001 | | 45.50 ± 11.92 | 47.99 ± 11.08 | 0.021 | |
| Body mass index (kg/m2) | Intervention | 19.79 ± 3.90 | 19.91 ± 3.72 | 0.73 | 0.002 | 17.75 ± 2.98 | 19.04 ± 3.95 | < 0.001 | 0.31 |
| | Reference | 17.76 ± 2.93 | 19.19 ± 3.34 | < 0.001 | | 18.56 ± 3.45 | 19.38 ± 3.67 | 0.014 | |

Values are expressed as mean ± standard deviation

**Table 3**. Prevalence of cardio-metabolic risk factors in middle school students in the intervention and reference areas based on gender: IHHP-HHPC

| | | Girls | | | | Boys | | | |
| --- | --- | --- | --- | --- | --- | --- | --- | --- | --- |
| | | **2001** | **2007** | **P** | **Interaction P** | **2001** | **2007** | **P** | **Interaction P** |
| Hypercholesterolemia[1] | Intervention | 44 (16.1) | 9 (3.8) | < 0.001 | 0.019 | 26 (11.6) | 13 (4.7) | 0.004 | 0.04 |
| | Reference | 39 (14.5) | 20 (9.6) | 0.10 | | 20 (9.2) | 22 (9.2) | 0.99 | |
| Hypertriglyceridemia[2] | Intervention | 139 (50.9) | 67 (27.9) | < 0.001 | 0.006 | 124 (54.9) | 72 (25.9) | < 0.001 | < 0.001 |
| | Reference | 120 (44.6) | 80 (38.3) | 0.16 | | 90 (41.5) | 93 (39.2) | 0.63 | |
| High LDL-C[3] | Intervention | 17 (6.3) | 11 (4.6) | 0.39 | 0.18 | 16 (7.1) | 10 (3.6) | 0.08 | 0.34 |
| | Reference | 37 (13.8) | 11 (5.3) | 0.002 | | 16 (7.6) | 15 (6.3) | 0.60 | |
| Low HDL-C[4] | Intervention | 2 (0.7) | 37 (15.4) | < 0.001 | < 0.001 | 8 (3.5) | 33 (11.9) | 0.001 | < 0.001 |
| | Reference | 52 (19.3) | 17 (8.1) | 0.001 | | 37 (17.3) | 25 (10.5) | 0.035 | |
| Overweight and Obesity[5] | Intervention | 65 (24.2) | 52 (21.4) | 0.46 | 0.016 | 19 (8.6) | 52 (18.6) | 0.001 | 0.11 |
| | Reference | 20 (7.4) | 36 (14.1) | 0.014 | | 35 (16.6) | 55 (21.2) | 0.20 | |

HDL-C: High density lipoprotein cholesterol; LDL-C: Low density lipoprotein cholesterol
[1] Total cholesterol ≥ 111 in boys and ≥ 120 mg/dl in girls[15]
[2] Triglyceride ≥ 220 in boys and ≥ 205 mg/dl in girls[15]
[3] LDL-C ≥ 132 in boys and ≥ 136 mg/dl in girls[15]
[4] HDL-C ≤ 74 in boys and ≤ 70 mg/dl in girls[15]
[5] Body mass index ≥ 85th percentiles in each age group and sex[13]

In the present study, the interventional program on overweight and obesity seemed to be effective only in girls. In fact, despite the increments in boys of the IA and all students in the RA, overweight and obesity were slightly reduced in girls of the IA. Although some school-based interventions have had effects on overweight,[21-23] most interventions, mainly those involving large cohorts, did not show promising effects.[24-26] Moreover, numerous school-based programs have been successful in improving glucose levels, insulin sensitivity and inflammatory markers.[27,28]

The beneficial effects of IHHP comprehensive community-based lifestyle interventions were shown in changing some lifestyle behaviors among adult population[16,29] and adolescents.[30] as the program has also been positively effective on cardiometabolic risk factors among adult population.[31,32] According to the present study however, it was less effective on adolescents. Our study combined a population-based approach with a school-based intervention aiming at children, teachers and parents.

As recommended by Berenson et al., the central thrust of health providers should be to help young generations grow up with healthful habits from the beginning, liberated from the harm of adverse lifestyles that were unwitting consequences of globalization and economic development.[33]

It is important to recognize that CNCD prevention from childhood requires a partnership. Although early researches in school health education, which focused on knowledge-based classroom programs, were able to make positive changes in students' knowledge and attitudes, they failed to improve health behaviors and related physiologic risk factors. Therefore, multiple factors should be considered in this regard. Governments, national and international organizations, consumers, industries and the media all play important roles in promoting healthy lifestyle from early life.

Lifestyle habits are influenced by the interaction between individuals and their social, cultural, and physical environments, not simply by knowledge about the healthfulness or harmfulness of different behaviors. Appropriate practice of evidence-based health promotion requires to consider the quality of available evidence, local values and prevailing resources. Each community must consider not only the development of scientific guideline strategies for its population but also strategies for effective and culturally-appropriate interventions to achieve the goals.

In conclusion, the IHHP interventions could to some extent have beneficial effects on cardiometabolic risk factors of adolescents. However, the efficacy of the program among adolescents was less than the adult population. It might reveal the youth to be more exposed to lifestyle changes. Therefore, more

considerations and time should be paid to achieve favorable results. Providing the appropriate interventions to achieve health goals can only be one component of a comprehensive policy which must be embraced through intersectoral collaboration, and appropriately applied to be effective.

## Conflict of Interests

Authors have no conflict of interests.

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