Age-Period-Cohort Analysis of Obesity and Overweight in Iranian Children and Adolescents

Mostafa Hosseini,1,2 Roya Kelishadi,3 Masoud Baikpour,4 Neamatollah Ataei,1,5 Mostafa Qorbani,6 Mahmoud Yousefifard,7 Ramin Heshmat,8 Mohammad-Esmail Motlagh,9 Behnaz Bazargani,1,5 Arash Abbasi,1,5 and Kazem Mohammad2,*

1Pediatric Chronic Kidney Disease Research Center, the Children’s Hospital Medical Center, Tehran University of Medical Sciences, Tehran, Iran
2Department of Epidemiology and Biostatistics, School of Public Health, Tehran University of Medical Sciences, Tehran, Iran
3Department of Pediatrics, Child Growth and Development Research Center, Research Institute for Primordial Prevention of Non-Communicable Disease, Isfahan University of Medical Sciences, Isfahan, Iran
4Department of Medicine, School of Medicine, Tehran University of Medical Sciences, Tehran, Iran
5Department of Pediatric Nephrology, The Children’s Hospital Medical Center, Faculty of Medicine, Tehran University of Medical Sciences, Tehran, Iran
6Department of Pediatrics, Alborz University of Medical Sciences, Karaj, Iran
7Physiology Research Center and Department of Physiology, Faculty of Medicine, Iran University of Medical Sciences, Tehran, Iran
8Chronic Diseases Research Center, Endocrinology and Metabolism Population Sciences Institute, Tehran University of Medical Sciences, Tehran, Iran
9Department of Pediatrics, Ahvaz Jundishapur University of Medical Sciences, Ahvaz, Iran

*Corresponding author: Kazem Mohammad, Professor, Department of Epidemiology and Biostatistics School of Public Health, Tehran University of Medical Sciences, Poursina Ave, Tehran, Iran. Tel: +98-2188989125, Fax: +98-2188989127, E-mail: mohamadk@tums.ac.ir

Received 2017 February 16; Revised 2017 June 21; Accepted 2017 July 01.

Abstract

Background: To date, few studies looked upon obesity and overweight in children and adolescents through the 3 different temporal dimensions of age, period, and cohort. The current study aimed at evaluating the trends of these health issues among children under 19 years old using the age-period-cohort (APC) analysis.

Methods: Data gathered through 5 cross sectional studies including 2 national health surveillance (1990 - 91 and 1999), and 3 CASPIAN surveys (2003, 2009, and 2011). Subjects were classified by their body mass index (BMI) into 3 groups of normal (BMI < 85th percentile), overweight-obese (85th percentile < BMI < 95th percentile), and obese (95th percentile < BMI). Intrinsic estimator method was used to analyze the effects of age, period, and birth cohort on obesity and overweight among the subjects.

Results: A total of 80,698 children and adolescents under 19 years old, including 40,419 (50.09%) males and 40,279 (49.91%) females, were evaluated. The prevalence of obesity decreased progressively by age in males and females with minor discrepancies. It increased from 1990 to 2009 in both genders, but from that point on remained quite constant in males and dropped significantly in females. The prevalence of obesity was steady in earlier birth cohorts, but increased significantly after the birth cohorts from 1986 to 1990.

Conclusions: Environmental factors and social stresses during neonatal and infantile periods (birth cohort effect) along with other variables influencing the children later in their lives (period effect) affect the prevalence of overweight and obesity substantially. Moreover, a decrease in the prevalence of obesity and overweight was observed by age increase (age effect).

Keywords: Obesity, Overweight, Prevalence, Age-Period-Cohort Analysis

1. Background

Nowadays, obesity and overweight are recognized as important health problems both in the developed and developing countries (1-6). Rapid growth occurs early in childhood; therefore, it is suggested to start taking preventive measures against obesity during this period to regulate the periodic changes of growth and metabolism according to the requirements of the body (7, 8). Another important issue about obesity in childhood is its correlation with adulthood obesity. Most obese children today will be the obese adults of the future (9, 10).

Various surveys from different parts of the world show that the trend of obesity varies according to the population (11-16). According to these surveys, it seems that the trend of obesity follows various patterns correlated with ethnicities and lifestyles of the subjects, confirming the importance of evaluating this matter among different populations.
To assess the changes of a variable in time, epidemiologic studies look upon the trends through 3 temporal dimensions; i.e., age, period, and cohort (APC) (17). Birth cohort effects refer to the changes of the variable in individuals who experience similar life events due to a common birth year. Age effects reflect the changes in the variable over one’s lifetime, and period effects refer to the changes in the environmental factors that affect an entire population at the same time with probably disparate effects on each individual. These 3 models generally act concurrently and present the changes of a variable in time (18).

To date, various surveys evaluated obesity, its incidence, prevalence, and changing trends worldwide; but most of them only assessed the age or period effects alone and few considered the simultaneous effects of all the 3 aspects. Moreover, the important effects of this health issue on cardiovascular diseases and diabetes call for continuous surveillance on obesity, especially among children and adolescents; therefore, the current study aimed at evaluating the changing trends of obesity in Iranian children and adolescents under 19 years old, considering the effects of APC.

2. Methods

2.1. Study Design and Setting

In the present study data gathered through 5 cross sectional studies including 2 national health surveillance (1990 - 91, 1999) (19) and 3 CASPIAN surveys (2003, 2009, and 2011) were used to analyze the effects of age, period, and birth cohort on obesity and overweight among Iranian population under 19 years old. The study designs were approved by the local ethics committee.

2.2. Data Collection

2.2.1. Nationwide Health Surveys 1990 - 91 and 1999

Data on demographic characteristics including weight, height, and body mass index (BMI) of the subjects were collected with collaboration of universities of medical sciences countrywide under the supervision of Iranian ministry of health and Medical education. The first survey was carried out from June 1990 to March 1992, gathering data from 18,194 subjects and the second one was conducted from April 1999 to February 2000 including 22,623 children and adolescents. Random cluster sampling method was used to collect data from elementary, guidance, and high schools of urban and rural areas.

2.3. Height, Weight, and Body Mass Index Measurements

In all the 5 nationwide surveys, height was measured via a stadiometer to the nearest 0.1 cm in upright standing, barefooted subjects with full extended knees. Weight was also measured in barefoot subjects without heavy clothing by a daily calibrated standard scale to the nearest 0.1 kg. BMI was calculated by dividing the body weight of the subjects in kilograms by their squared height in meters. Subjects were classified by their BMIs according to the growth charts presented by the world health organization (WHO) (22) into 3 groups of normal (BMI < 85th percentile), overweight-obese (85th percentile < BMI < 95th percentile) and obese (95th percentile < BMI).

2.4. Statistical Analysis

APC models are the means of interest in the statistical studies of human populations. To overcome the problem of collinearity between age, period, and birth cohort, Yang developed the intrinsic estimator (IE) method, which applies the principal component regression analysis of the APC models (23, 24). The current study aimed at evaluating the APC effect on the prevalence of overweight-obesity and obesity in Iranian children and adolescents using the IE model. The study also analyzed the effects based on gender. Analysis was performed using the “apc-ie” command statement in STATA software version 11.0 (Stata Corp., College Station, TX, USA). Since 5-year periods were required for the APC analysis, the overweight-obesity and obesity rates were estimated by regression analysis in 1995 and 2005.

3. Results

Data from 80,698 children and adolescents under 19 years old including 40,419 (50.09%) males and 40,279 (49.91%) females were examined in the present study. The largest proportion of the study sample came from the subjects that participated in 1999 (28.03%) and the smallest proportion was from the year 2009 (6.99%) (Table 1).
Table 1. Sample Sizes Based on Gender and the Study Year

| Study Year | Age Range, y | Male      | Female     | Total      | Total Percentage Based on Total |
|------------|--------------|-----------|------------|------------|---------------------------------|
| 1990       | 5 - 19       | 9001 (49.47) | 9193 (50.53) | 18194 (100) | 22.55                           |
| 1999       | 5 - 19       | 11063 (48.90) | 11560 (51.10) | 22623 (100) | 28.03                           |
| 2003       | 6 - 19       | 10775 (51.47) | 10161 (48.53) | 20936 (100) | 25.94                           |
| 2009       | 10 - 18      | 2829 (50.19)  | 2808 (49.81)  | 5637 (100)   | 6.99                            |
| 2011       | 7 - 19       | 6751 (50.73)  | 6557 (49.27)  | 13308 (100)  | 16.49                           |
| Total      |              | 40419 (50.09) | 40279 (49.91) | 80698 (100)  | 100.0                           |

Values are expressed as n (%).

3.1. Prevalence of Obesity

3.1.1. According to Age

Table 2 presents the prevalence of overweight-obesity and obesity in the study population based on age in the assessed periods. In the nationwide surveys of 1990, 1999, and 2003 the prevalence of obesity decreased with increasing age in both genders while the figures were quite steady up to the age of 19 from 2009 to 2011. A similar pattern was observed for overweight-obesity among males, but the trend was more fluctuating among females in such a way that the prevalence of overweight-obesity decreased with age up to the age of 12 in almost every period and after the age of 12 it increased and stayed quite constant up to the age of 19 (Table 2).

3.1.2. According to the Survey Period

The prevalence of obesity was mostly increasing among males in the 21-year assessment. It rose from 2.76% in 1990 to 4.79% in 1999, 7.98% in 2003, 6.72% in 2009, and 8.03% in 2011. On the other hand, the slope of the rising curve was lower among females, compared with males. The lowest prevalence was 3.12% in 1990, which reached its peak at 6.53% in 2003. A similar pattern was observed for the prevalence of overweight-obesity in both genders (Table 3).

3.1.4. According to Birth Cohort

According to the data presented in Table 3 based on the surveys of 1990, 1999, and 2003, the prevalence of obesity in males with earlier birth cohorts was lower than that of the male subjects of recent birth cohorts. According to the studies of 2009 and 2011, the prevalence was not affected by the birth cohort. The prevalence of obesity and overweight-obesity among females was also affected by the birth cohorts, but the changes were fluctuating. For instance, the prevalence of obesity among the females, evaluated in 2003, was higher in the subjects born in recent cohorts, compared with the females born in earlier cohorts. But, assessment of the females from 1990 revealed that the prevalence was quite similar in all the birth cohorts (Table 3).

3.2. Effects of Age, Period, and Cohort

According to the aforementioned results, the prevalence of obesity and overweight-obesity is affected by the 3 factors; therefore, the current study assessed the independent effect of each factor while controlling the other 2.

3.2.1. Age Effect

The coefficients of age effect on the prevalence of obesity and overweight-obesity in males and females are presented in Table 4 and Figure 1A and 1B separately. As it can be observed, the prevalence of obesity decreased among males progressively based on age. The coefficient decreased by 0.028 units when the age increased from 5 to 10 years and it decreased by 0.008 units when the age increased from 10 to 15. The same figures for females showed 0.019 and 0.009 decrease in the units of coefficients, respectively.

According to the effects of period and cohort, the prevalence of overweight-obesity also decreased under the effect of age among males. Coefficient of age effect decreased by 0.032 units when the age increased from 5 to 10 years and it decreased by 0.008 units when the age increased from 10 to 15. The same figures for females showed 0.019 and 0.009 decrease in the units of coefficients, respectively.

According to the effects of period and cohort, the prevalence of overweight-obesity also decreased under the effect of age among males. Coefficient of age effect decreased by 0.032 units when the age increased from 5 to 10, and by 0.015 units when the age increased from 10 to 15. As for the females, the prevalence of overweight-obesity was not affected by the age (Table 4 and Figure 2A and 2B).

3.2.2. Period Effect

The prevalence of obesity among males increased from 1990 to 2009. The highest coefficient of period effect on the prevalence of obesity in males was observed from 2003 to 2009 (coefficient difference = 0.019). The calculated coefficient decreased from 2009 to 2011 (coefficient difference = -0.002) while the prevalence of obesity remained quite constant during these years (Table 4 and Figure 1C). The prevalence of obesity also increased among females from 1990
Table 2. Prevalence of Overweight and Obesity Based on Age, Study Year, and Gender

| Age and Gender Period | 1990 | 1999 | 2003 | 2009 | 2011 |
|-----------------------|------|------|------|------|------|
| **Males**             |      |      |      |      |      |
| Obesity               | 5.74 | 7.74 | 15.24| 10.88| 19.79|
| Overweight and Obesity| 5.52 | 9.28 | 16.97| 10.10| 17.42|
| Obesity               | 7.87 | 10.60| 18.93| 9.49 | 19.73|
| Overweight and Obesity| 8.36 | 9.67 | 16.06| 7.96 | 18.04|
| Obesity               | 6.60 | 8.79 | 11.44| 8.33 | 18.28|
| Overweight and Obesity| 8.18 | 11.50| 16.15| 9.36 | 17.42|
| Obesity               | 5.07 | 5.51 | 10.60| 7.58 | 16.03|
| Overweight and Obesity| 9.49 | 9.15 | 19.73| 9.34 | 15.97|
| Obesity               | 3.06 | 5.07 | 7.84 | 5.67 | 15.06|
| Overweight and Obesity| 7.96 | 7.66 | 16.04| 7.96 | 18.04|
| Obesity               | 1.67 | 2.79 | 4.76 | 3.33 | 8.33 |
| Overweight and Obesity| 8.81 | 11.50| 16.15| 9.36 | 17.42|
| Obesity               | 1.99 | 4.18 | 9.27 | 5.33 | 12.35|
| Overweight and Obesity| 11.09| 9.09 | 15.58| 9.09 | 17.42|
| Obesity               | 2.04 | 3.95 | 7.89 | 4.09 | 11.53|
| Overweight and Obesity| 14.97| 9.96 | 19.30| 9.26 | 21.05|
| Obesity               | 0.74 | 6.08 | 2.10 | 6.00 | 16.53|
| Overweight and Obesity| 13.77| 9.71 | 21.75| 9.24 | 21.98|
| Obesity               | 2.12 | 2.98 | 4.04 | 3.35 | 8.05 |
| Overweight and Obesity| 18.97| 9.05 | 20.47| 8.38 | 20.22|
| Obesity               | 1.75 | 5.89 | 4.49 | 6.22 | 13.70|
| Overweight and Obesity| 15.37| 9.05 | 20.47| 8.38 | 20.22|
| Obesity               | 1.34 | 5.95 | 2.90 | 3.95 | 8.05 |
| Overweight and Obesity| 17.42| 9.05 | 20.47| 8.38 | 20.22|
| Obesity               | 0.74 | 6.08 | 2.10 | 6.00 | 16.53|
| Overweight and Obesity| 13.77| 9.71 | 21.75| 9.24 | 21.98|
| Obesity               | 2.83 | 5.95 | 1.97 | 15.20| 9.29 |
| Overweight and Obesity| 15.58| 9.05 | 20.47| 8.38 | 20.22|
| Obesity               | 1.37 | 5.95 | 2.90 | 3.95 | 8.05 |
| Overweight and Obesity| 17.42| 9.05 | 20.47| 8.38 | 20.22|
| Obesity               | 1.46 | 5.95 | 2.90 | 3.95 | 8.05 |
| Overweight and Obesity| 17.42| 9.05 | 20.47| 8.38 | 20.22|
| Obesity               | 1.25 | 5.95 | 2.90 | 3.95 | 8.05 |
| Overweight and Obesity| 17.42| 9.05 | 20.47| 8.38 | 20.22|

| Females               |      |      |      |      |      |
|-----------------------|------|------|------|------|------|
| Obesity               | 7.56 | 16.95| 10.04| 17.81| 18.18|
| Overweight and Obesity| 9.48 | 19.68| 19.68| 18.18| 27.27|
| Obesity               | 1.99 | 9.99 | 4.09 | 9.96 | 15.57|
| Overweight and Obesity| 13.46| 19.68| 19.68| 18.18| 27.27|
| Obesity               | 2.58 | 1.50 | 3.66 | 7.54 | 17.42|
| Overweight and Obesity| 9.01 | 15.57| 15.57| 14.27| 27.27|
| Obesity               | 1.70 | 5.60 | 4.20 | 9.00 | 19.77|
| Overweight and Obesity| 7.87 | 15.57| 15.57| 14.27| 27.27|
| Obesity               | 1.56 | 4.82 | 3.75 | 6.57 | 16.69|
| Overweight and Obesity| 14.92| 15.57| 15.57| 14.27| 27.27|
| Obesity               | 2.65 | 1.97 | 5.89 | 9.96 | 19.77|
| Overweight and Obesity| 14.92| 15.57| 15.57| 14.27| 27.27|
| Obesity               | 3.36 | 9.78 | 3.53 | 14.35| 10.04|
| Overweight and Obesity| 14.92| 15.57| 15.57| 14.27| 27.27|
| Obesity               | 2.46 | 6.09 | 2.56 | 14.93| 10.04|
| Overweight and Obesity| 14.92| 15.57| 15.57| 14.27| 27.27|
| Obesity               | 2.81 | 14.58| 2.70 | 14.35| 10.04|
| Overweight and Obesity| 14.92| 15.57| 15.57| 14.27| 27.27|
| Obesity               | 1.90 | 10.44| 1.90 | 11.34| 10.04|
| Overweight and Obesity| 14.92| 15.57| 15.57| 14.27| 27.27|
| Obesity               | 2.74 | 14.01| 3.35 | 14.35| 10.04|
| Overweight and Obesity| 14.92| 15.57| 15.57| 14.27| 27.27|
| Obesity               | 2.72 | 10.52| 2.72 | 12.56| 10.04|
| Overweight and Obesity| 14.92| 15.57| 15.57| 14.27| 27.27|
| Obesity               | 5.00 | 5.00 | 3.09 | 14.49| 2.78 |
| Overweight and Obesity| 9.72 | 9.72 | 9.72 | 9.72 | 9.72 |

to 2009, but it dropped significantly in 2011. According to the data presented in Table 4, the maximum difference between the coefficients of period effect on prevalence of obesity among females was observed from 2003 to 2009 (coefficient difference = 0.014). The decrease of this coefficient from 2009 to 2011 was 0.013 units (coefficient difference = -0.013) (Table 4 and Figure 1D). Tables 4 and Figures 1 and 2 present the changes in the coefficients of period effect on the prevalence of overweight-obesity for both genders. As depicted, the trends of changes were similar to the patterns of changes for the prevalence of obesity.

3.2.3. Birth Cohort Effect

The effects of birth cohorts on the prevalence of obesity and overweight-obesity are presented in Table 4 and Figures 1E and 1F and 2E and 2F. The coefficient of birth cohort effect on the prevalence of obesity among males with earlier birth cohorts was rather steady. The difference in coefficients of estimation between the males from birth cohorts of 1986 to 1995 was 0.019 units, but the prevalence decreased among the males born from 2000 to 2005. Different patterns were observed in females. The coefficient of birth cohort effect on the prevalence of obesity showed a significant drop among the females born from 1976 to 1980 and remained steady for the female subjects born from 1986 to 1990. The rise in coefficients of birth cohorts from 1991 to 1996, and this point on, indicated an increase in the prevalence of obesity in females born during this period. Table 4 presents the changes in coefficients of birth cohort effect on the prevalence of overweight-obesity in both genders. Accordingly, considerable similarities are observed between these data and the patterns of obesity.
Table 3. Prevalence of Overweight and Obesity Based on Birth Cohort, Period Year, and Gender

| Birth Cohort | 1990 | 1991 | 1992 | 1993 | 1994 | 1995 | 1996 | 1997 | 1998 | 1999 | 2000 | 2001 | 2002 | 2003 | 2004 | 2005 |
|--------------|------|------|------|------|------|------|------|------|------|------|------|------|------|------|------|------|
| **Male**     |      |      |      |      |      |      |      |      |      |      |      |      |      |      |      |      |
| 1971-1975    | 1.93 | 5.98 |      |      |      |      |      |      |      |      |      |      |      |      |      |      |
| 1976-1980    | 6.00 |      |      |      |      |      |      |      |      |      |      |      |      |      |      |      |
| 1981-1985    |      | 9.60 |      |      |      |      |      |      |      |      |      |      |      |      |      |      |
| 1986-1990    |      |      | 3.90 |      |      |      |      |      |      |      |      |      |      |      |      |      |
| 1991-1995    |      |      | 6.76 |      |      |      |      |      |      |      |      |      |      |      |      |      |
| 1996-2000    |      |      | 13.96|      |      |      |      |      |      |      |      |      |      |      |      |      |
| 2001-2005    |      |      | 18.73|      |      |      |      |      |      |      |      |      |      |      |      |      |
| **Female**   |      |      |      |      |      |      |      |      |      |      |      |      |      |      |      |      |
| 1971-1975    |      |      | 3.00 |      |      |      |      |      |      |      |      |      |      |      |      |      |
| 1976-1980    | 7.66 |      |      |      |      |      |      |      |      |      |      |      |      |      |      |      |
| 1981-1985    | 3.90 |      | 8.64 |      |      |      |      |      |      |      |      |      |      |      |      |      |
| 1986-1990    | 5.90 |      | 2.50 |      |      |      |      |      |      |      |      |      |      |      |      |      |
| 1991-1995    | 5.62 |      | 7.59 | 10.31|      |      |      |      |      |      |      |      |      |      |      |      |
| 1996-2000    | 10.75|      | 9.94 | 5.24 |      |      |      |      |      |      |      |      |      |      |      |      |
| 2001-2005    | 7.61 |      |      |      |      |      |      |      |      |      |      |      |      |      |      |      |
| **Total**    | 2.76 | 7.47 | 4.79 | 12.49| 5.98 | 17.83| 6.72 | 17.55| 8.03 | 18.74| 8.03 | 17.48| 6.53 | 16.52| 4.97 | 13.03|

4. Discussion

The results of the present study revealed a significant relationship between APC effects, and the prevalence of overweight-obesity and obesity. With increasing age, the prevalence of obesity decreased in both genders but the prevalence of overweight-obesity among females was not affected by age. Furthermore, the yielded results were indicative of a rise in the prevalence of obesity from 1990 to 2009 in both genders of the Iranian population. From 2009 onwards, the patterns of overweight-obesity and obesity differed between the 2 genders in such a way that the prevalence of obesity from 2009 to 2011 remained constant among males while a decline was observed among females.

Finally, it was shown that the prevalence of overweight-obesity and obesity was higher among the children born in recent birth cohorts compared to the subjects born in earlier cohorts.

Although many studies evaluated child obesity in different populations, few looked upon obesity and overweight in children and adolescents through the 3 different temporal dimensions of age, period, and cohort. Most surveys assessed only the effects of age and period on this health issue. In one of these studies, Thomsen et al. evaluated APC effects on obesity among males born from 1930 to 1975 and found a significant rise in weight of the children born from 1947 to 1949, which reached a plateau and remained unchanged until the 1970’s (25). Although the evaluated birth cohorts in the present study were much more recent than the survey conducted by Thomsen et al., similar patterns were observed between the 2. The current study also found a higher prevalence of obesity in children born in recent cohorts, compared to the earlier ones.

The increased prevalence of obesity in the recent cohorts could be attributed to the changes in the lifestyle of the Iranian population. Alterations in diet, preference for consuming high-fat foods and fast foods and limited physical activity are known as the risk factors of obesity, all of which increased significantly among the Iranian population in recent years (26-28).

It is noteworthy that the birth cohort effect represents the effects of environmental factors and life style related variables during pregnancy and the first years of the subject’s life such as maternal dietary habits and breastfeeding (23, 29). Moreover, the prevalence of obesity and overweight increased from 1990 to 2011, which can be due to the changes in contents of the regular diet in Iranian population. In this period, a transition occurred from dairy products, fruits, and vegetables towards fats, various oils, and sugars (30).

Ogden et al., assessed the trend of changes in the prevalence of obesity among American children from 1999 to 2010 (period effect) and found no significant changes in the prevalence of obesity in children aged 2 to19 years (13). On the other hand, Heude et al., found an increase in the prevalence of obesity in both genders in their 8-year survey conducted in France. The rise was more prominent among
males (14). Their results were similar to those of the current study, which showed considerable increasing trends in the prevalence of obesity in both genders (more eminent among males) from 1990 to 2011.

Despite the increasing application of APC analysis on various variables, the current study was the first study using this method on the prevalence of overweight and obesity among children and adolescents. The current study found a rise in the prevalence of these health issues from the period of 1986 to 1990 onwards, which coincided with the years leading to the end of the Iran-Iraq war. Such a disaster might affect the nutritional habits of a population through the changes it brings about in the lifestyle of the people. After the Iran-Iraq war, the nutritional status of Iranian people changed and consumption of high-fat foods and unhealthy nutritional patterns increased. Consequently, the
prevailed among the children born during this period.

Age is another factor that affects the prevalence of obesity in children and adolescents. A general evaluation of the rough figures of overweight and obesity prevalence (Table 1) indicates that the prevalence decreases with advancing age. This finding was in agreement with the results of the study conducted by Kelishadi et al., reporting a negative correlation between age and prevalence of overweight and obesity (28). It was also quite compatible with the reports from the United States indicating a decline in the prevalence of overweight and obesity with advancing age in healthy children (31). However, the exact reason for this correlation is not identified yet.
4.1. Conclusions

Overall, it can be concluded that changes in life styles and environmental factors and social stresses such as war and famine (birth cohort effect) during neonatal and infantile periods and the early years of life affect the prevalence of overweight and obesity substantially. On the other hand, there are other environmental and social factors which occur later in a child’s life that can affect obesity and overweight among children and adolescents in similar patterns such as the transition of dietary habits (period effect). Moreover, a decrease in the prevalence of obesity and overweight was observed by age increase (age effect).

Acknowledgments

Authors kindly appreciate the invaluable efforts of Mrs. Mehrnoosh Yazdanbakhsh for language editing.

Footnotes

Authors’ Contribution: Study design, Mostafa Hosseini; Mahmoud Yousefifard, Kazem Mohammad, Roya Kelishadi; data acquisition, Masoud Baikpour, Neamatollah Aataei, Mostafa Qorbani, Ramin Heshmat, Mohammad-Esmail Motlagh, Behnaz Bazargani, Arash Abbasi; analysis of data, Mostafa Hosseini; interpretation of data, Mostafa Hosseini, Mahmoud Yousefifard; Kazem Mohammad, Roya Kelishadi; drafting the manuscript, Mahmoud Yousefifard, Mostafa Hosseini; revising the draft critically for important intellectual content, All authors.

Financial Disclosure: The authors declared no conflict of interests.

Funding/Support: The research was financially supported by Tehran University of Medical Sciences and health services under the grant number 93-03-184-26561.

References

1. Hosseini M, Navidi I, Hesamifard B, Yousefifard M, Ifkawi A, Poorchaloo SR, et al. Weight, height and body mass index nomograms; early adiposity rebound in a sample of children in Tehran, Iran. Int J Prev Med. 2013;4(12):1414-20. [PubMed: 24498497].

2. Hosseini M, Baikpour M, Yousefifard M, Mansournia MA, Yaseri M, Aataei N, Poorchaloo SR, et al. Weight, height and body mass index nomograms; early adiposity rebound in a sample of children in Tehran, Iran. Int J Pediatr. 2016;4(6):926-34.

3. Hosseini M, Aataei N, Aghamohammadi A, Yousefifard M, Taslimi S, Aataei F. The relation of body mass index and blood pressure in Iranian children and adolescents aged 7-18 years old. Iran J Public Health. 2010;39(4):126-34. [PubMed: 23103046].

4. Hosseini M, Kelishadi R, Yousefifard M, Qorbani M, Bazargani B, Heshmat R, et al. Height-adjusted percentiles evaluated central obesity in children and adolescents more effectively than just waist circumference. Acta Paediatr. 2017;106(1):112-9. doi: 10.1111/apa.13622. [PubMed: 27727475].

5. Ogden CL, Carroll MD, Kit BK, Flegal KM. Prevalence of childhood and adult obesity in the United States, 2007-2008. JAMA. 2010;303(1):188-97. doi: 10.1001/jama.2009.1836. [PubMed: 20063436].

6. Karlson S, Kanekar A. Childhood obesity: a global public health crisis. Int J Prev Med. 2012;3(1):1-7. doi: 10.4103/0970-2089.88919. [PubMed: 22560994].

7. Goldschmidt AB, Willifey DE, Paluch RA, Roemmich JN, Epstein LH. Indicated prevention of adult obesity: how much weight change is necessary for normalization of weight status in children? JAMA Pediatr. 2011;165(1):21-6. doi: 10.1001/jamapediatrics.2010.416. [PubMed: 21290001].

8. Waters E, de Silva-Sanigorski A, Burford BJ, Brown T, Campbell KJ, Gao Y, et al. Interventions for preventing obesity in children. Cochrane Lib. 2011;2:12-21.

9. Centers for Disease C. CDC grand rounds: childhood obesity in the United States. MMWR Morb Mortal Wkly Rep. 2011;60(2):42-6. [PubMed: 21248685].

10. Olza J, Ruperez AI, Gil-Campos M, Leis R, Fernandez-Orth D, Tojo R, et al. Influence of FTO variants on obesity, inflammation and cardiovascular disease risk biomarkers in Spanish children: a case-control multicentre study. BMC Med Genet. 2013;14:121. doi: 10.1186/1471-2350-14-12. [PubMed: 24289790].

11. Hedley AA, Ogden CL, Johnson CL, Carroll MD, Curtin LR, Flegal KM. Prevalence of overweight and obesity among US children, adolescents, and adults, 1999-2002. JAMA. 2004;291(23):2847-50. doi: 10.1001/jama.291.23.2847. [PubMed: 15390355].

12. Magarey AM, Daniels LA, Boulton TJ. Prevalence of overweight and obesity in Australian children and adolescents: reassessment of 1985 and 1995 data against new standard international definitions. Med J Aust. 2001;174(1):564-6. [PubMed: 11453327].

13. Ogden CL, Carroll MD, Kit BK, Flegal KM. Prevalence of obesity and trends in body mass index among US children and adolescents, 1999-2010. JAMA. 2012;307(5):483-90. doi: 10.1001/jama.2012.40. [PubMed: 22253364].

14. Heude B, Lafay L, Borys JM, Thibault N, Lommez A, Romon M, et al. Time trend in height, weight, and obesity prevalence in school children from Northern France, 1992-2000. Diabetes Metabol. 2001;27(3):235-40. doi: 10.1016/S0246-6567(01)00026-8. [PubMed: 11453364].

15. Park YS, Lee DH, Choi JM, Kang YJ, Kim CH. Trend of obesity in school age children in Seoul over the past 23 years. Korean J Pediatr. 2004;47(3):247-57.

16. de Onis M, Blossner M, Borghi E. Global prevalence and trends of overweight and obesity among preschool children. Am J Clin Nutr. 2010;92(5):525-64. doi: 10.3945/ajcn.2010.297886. [PubMed: 20861773].

17. Hosseini M, Yousefifard M, Baikpour M, Raefi A, Fayaz M, Heshmat R, et al. Twenty-year dynamics of hypertension in Iranian adults: age, period, and cohort analysis. J Am Soc Hypertens. 2015;9(12):925-34. doi: 10.1016/j.jasht.2015.09.005. [PubMed: 26481406].

18. Szklm M, Nieto FJ. Epidemiology: beyond the basics.; 2007.

19. Massarrat MS, Tahaghoogh-Mehrizi S. Iranian national health survey: a brief report. Arch Iran Med. 2002;5(2):77-9.

20. Ahadi Z, Shaffiee G, Qorbani M, Sajedinnejad S, Kelishadi R, Arzaghi SM, et al. An overview on the successes, challenges and future perspective of a national school-based surveillance program: the CASPIAN study. J Diabetes Metab Disord. 2014;13(1):120. doi: 10.1186/s40200-014-0120-3. [PubMed: 25064853].

21. Kelishadi R, Ardalan G, Qorbani M, Ataei-Jafari A, Bahreynian M, Taslimi M, et al. Methodology and Early Findings of the Fourth Survey of Childhood and Adolescence Surveillance and Prevention of Adult Non-Communicable Disease in Iran: The CASPIAN-IV Study. Int J Prev Med. 2013;4(12):1463-70. doi: 10.4103/0972-0277.120958. [PubMed: 24495012].

22. Rosenthal N, Santini MP, Musaro A. Growth factor enhancement of cardiac regeneration. Cell Transplant. 2006;15 Suppl 1:S45-S51. doi: 10.3727/000000006783982287. [PubMed: 16582794].
23. Yang Y, Fu WJ, Land KC. A methodological comparison of age-period-cohort models: The intrinsic estimator and conventional generalized linear models. *Sociological methodology*. 2004;34(1):75–110.
24. Yang Y. Trends in U.S. adult chronic disease mortality, 1960-1999: age, period, and cohort variations. *Demography*. 2008;45(2):387–416. [PubMed: 18613487].
25. Thomsen BL, Ekstrom CT, Sorensen TI. Development of the obesity epidemic in Denmark: cohort, time and age effects among boys born 1930-1975. *Int J Obes Relat Metab Disord*. 1999;23(7):693–701. doi: 10.1038/sj.ijo.0800907. [PubMed: 10454102].
26. Bahadoran Z, Mirmiran P, Golzarand M, Hosseini-Esfahani F, Azizi F. Fast food consumption in Iranian adults; dietary intake and cardiovascular risk factors: Tehran Lipid and Glucose Study. *Arch Iran Med*. 2012;15(6):346–51. [PubMed: 22642243].
27. Esteghamati A, Khalilzadeh O, Mohammad K, Meysamie A, Rashidi A, Kamgar M, et al. Secular trends of obesity in Iran between 1999 and 2007: National Surveys of Risk Factors of Non-communicable Diseases. *Metab Syndr Relat Disord*. 2010;8(3):209–13. doi: 10.1089/met.2009.0064. [PubMed: 20085488].
28. Kelishadi R, Hovsepian S, Qorbani M, Jamshidi F, Fallah Z, Djalalinia S, et al. National and sub-national prevalence, trend, and burden of cardiometabolic risk factors in Iranian children and adolescents, 1990-2013. *Arch Iran Med*. 2014;17(1):71–80. [PubMed: 24444066].
29. Yang Y, Schulhofer-Wohl S, Fu WJ, Land KC. The intrinsic estimator for age-period-cohort analysis: What it is and how to use it. *Am J Sociol*. 2008;113(6):1697–736. doi: 10.1086/587954.
30. Ghassemi H, Harrison G, Mohammad K. An accelerated nutrition transition in Iran. *Public Health Nutr*. 2002;5(1A):149–55. doi: 10.1079/PHN2001287. [PubMed: 12027278].
31. Must A, Eliaziw M, Phillips SM, Curtin C, Kral TV, Segal M, et al. The Effect of Age on the Prevalence of Obesity among US Youth with Autism Spectrum Disorder. *Child Obes*. 2017;13(1):25–35. doi: 10.1089/chi.2016.0079. [PubMed: 27044874].
| Variables | Obesity | Overweight and Obesity |
|-----------|---------|------------------------|
|          | Coefficient | 95% CI  | P Value | Coefficient | 95% CI  | P Value |
| **Males** |           |         |         |             |         |         |
| Age, y    |           |         |         |             |         |         |
| 5 - 9     | 0.0217    | 0.0122 - 0.0312 | < 0.0001 | 0.0266    | 0.0127 - 0.0404 | 0.0000 |
| 10 - 14   | -0.0068   | -0.0162 - -0.0026 | 0.1570   | -0.0059   | -0.0196 - -0.0079 | 0.4030 |
| 15 - 19   | -0.0149   | -0.0240 - -0.0059 | 0.0010   | -0.0207   | -0.0339 - -0.0075 | 0.0020 |
| Period    |           |         |         |             |         |         |
| 1990      | -0.0222   | -0.0334 - -0.0111 | < 0.0001 | -0.0433   | -0.0597 - -0.0270 | < 0.0001 |
| 1995      | -0.0124   | -0.0265 - -0.0017 | 0.0840   | -0.0282   | -0.0488 - -0.0075 | 0.0070 |
| 2000      | -0.0008   | -0.0147 - -0.0011 | 0.9100   | -0.0042   | -0.0245 - 0.0016 | 0.6850 |
| 2005      | 0.0186    | 0.0060 - 0.0311 | 0.0040   | 0.0326    | 0.0042 - 0.0509 | < 0.0001 |
| 2010      | 0.0169    | 0.0010 - 0.0327 | 0.0370   | 0.0432    | 0.0200 - 0.0663 | < 0.0001 |
| Cohort    |           |         |         |             |         |         |
| 1971 - 1975 | 0.0019   | 0.0192 - 0.0154 | 0.8310   | -0.0082   | -0.0335 - 0.0170 | 0.5230 |
| 1976 - 1980 | -0.0125  | -0.0294 - -0.0043 | 0.1460   | -0.0098   | -0.0445 - 0.0048 | 0.350 |
| 1981 - 1985 | -0.0109  | -0.0262 - -0.0044 | 0.8640   | -0.0098   | -0.0322 - 0.0026 | 0.3900 |
| 1986 - 1990 | -0.0175  | -0.0336 - -0.0013 | 0.0340   | -0.0187   | -0.0403 - 0.0069 | 0.1660 |
| 1991 - 1995 | 0.0023   | 0.0813 - 0.0158 | 0.7420   | 0.0199    | 0.0001 - 0.0397 | 0.0480 |
| 1996 - 2000 | 0.0267   | 0.0127 - 0.0407 | < 0.0001 | 0.0399    | 0.0094 - 0.0604 | < 0.0001 |
| 2001 - 2005 | 0.0038   | -0.0130 - 0.0405 | 0.3130   | -0.0053   | -0.0444 - 0.0338 | 0.7980 |
| Constant  | 0.0574    | 0.0501 - 0.0647 | < 0.0001 | 0.1311    | 0.1207 - 0.1420 | < 0.0001 |
| **Females** |           |         |         |             |         |         |
| Age, y    |           |         |         |             |         |         |
| 5 - 9     | 0.0155    | 0.0093 - 0.0217 | < 0.0001 | 0.0049    | -0.0044 - 0.0042 | 0.2990 |
| 10 - 14   | -0.0032   | -0.0093 - -0.0030 | 0.3120   | 0.0021    | -0.0070 - 0.013 | 0.6460 |
| 15 - 19   | -0.0124   | -0.0182 - -0.0065 | < 0.0001 | -0.0070   | -0.0058 - 0.0017 | 0.1550 |
| Period    |           |         |         |             |         |         |
| 1990      | -0.0120   | -0.0193 - -0.0048 | 0.0010   | -0.0297   | -0.0406 - -0.0188 | < 0.0001 |
| 1995      | -0.0079   | -0.0271 - -0.0013 | 0.0940   | -0.0222   | -0.0349 - -0.0074 | 0.0030 |
| 2000      | 0.0015    | -0.0076 - 0.0016 | 0.7410   | 0.0031    | -0.0004 - 0.0266 | 0.580 |
| 2005      | 0.0057    | 0.0074 - 0.0219 | < 0.0001 | 0.0287    | 0.0165 - 0.0409 | < 0.0001 |
| 2010      | 0.0027    | -0.0076 - 0.0131 | 0.6040   | 0.0090    | -0.0064 - 0.0245 | 0.2510 |
| Cohort    |           |         |         |             |         |         |
| 1971 - 1975 | 0.0034   | -0.0079 - 0.0047 | 0.5680   | 0.0012    | -0.0067 - 0.0270 | 0.2370 |
| 1976 - 1980 | -0.0034  | -0.0245 - -0.0024 | 0.0070   | -0.0378   | -0.0542 - -0.0214 | < 0.0001 |
| 1981 - 1985 | -0.0132  | -0.0232 - -0.0032 | 0.0010   | -0.0189   | -0.0338 - -0.0040 | 0.0130 |
| 1986 - 1990 | -0.0181  | -0.0287 - -0.0076 | 0.0000   | -0.0251   | -0.0408 - -0.0094 | 0.0020 |
| 1991 - 1995 | -0.0048  | -0.0137 - 0.0040 | 0.2830   | 0.0028    | -0.0104 - 0.0060 | 0.6750 |
| 1996 - 2000 | 0.0090   | 0.0099 - 0.0282 | < 0.0001 | 0.0237    | 0.0010 - 0.0374 | 0.0000 |
| 2001 - 2005 | 0.0272   | 0.0097 - 0.0447 | 0.0020   | 0.0451    | 0.0091 - 0.0712 | 0.0010 |
| Constant  | 0.0510    | 0.0463 - 0.0558 | < 0.0001 | 0.1360    | 0.1290 - 0.1431 | < 0.0001 |