Secular trends of blood pressure in children and adolescents in Hong Kong: abridged secondary publication

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KEY MESSAGES

1. In children and adolescents in Hong Kong, a U-shaped trend in blood pressure and an increasing trend in body mass index were observed until recent years.
3. The recent levelling off in body mass index could be related to school-based health promotion campaign.
4. Such discordant trends suggest identifying unknown determinants of blood pressure besides body mass index is warranted.

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Introduction

Secular trends in blood pressure (BP) and body mass index (BMI) in children and adolescents foreshadow trends in cardiovascular disease in adults. They are useful sentinels for population cardiovascular health. Changes in BP do not mirror changes in BMI, as factors determining trends in BP and BMI may be less evident in different settings. Understanding the concomitant trends in BP and BMI and delineating their potential driving forces would provide aetiological insights for prevention. Specifically, the discordant trends in children and adolescents, which could not be explained by adult lifestyle risk factors or medication, suggest the importance of identifying factors in the early life course.[1] Age-period-cohort modelling decomposes temporal trends into the relative contribution of age, calendar period, and year of birth. This makes it possible to distinguish the impact of early life cohort-specific factors (cohort effect) and the impact of contemporaneous population-wide factors (period effect) from the physiological changes of BP and BMI with increasing age (age effect). We delineated the relative contribution of age, period, and birth cohort to the trends in BP in children and adolescents aged 9 to 18 years from 1999 to 2014 and BMI for those aged 6 to 18 years from 1996 to 2014 in Hong Kong.

Methods

The study was approved by the Institutional Review Board of The University of Hong Kong / Hospital Authority Hong Kong West Cluster. The Student Health Service of the Department of Health provides free annual health assessments for all primary and secondary school students in Hong Kong. The Student Health Service was introduced in 1995/96 for primary school students, and was extended to secondary school students in 1996/97, but was suspended for secondary school students in year 2 or above in 2009/10 because of the Human Swine Influenza Vaccination Programme.

BP for primary 5 (age 10-11 years) onwards was measured twice a year using an automated oscillometric device. If initial BP was over the 90th percentile for sex, age, and height local reference, re-checking would be performed. Weight and height for primary 1 (age 6-7 years) onwards was measured yearly using a digital scale and stadiometer, respectively. Coverage was incomplete in the early years; trends of BP from 1999 and BMI from 1996 were considered. We randomly selected one time point per participant so that there is no correlation between multiple measurements for the same participant.

We examined the overall secular trends in age-, sex- and height-standardised BP from 1999 to 2014 and age- and sex-standardised BMI from 1996 to 2014. We decomposed the trends of BP and BMI into the effects of three components, namely age, period, and birth cohort. Given age, period, and cohort are linearly dependent (ie, non-identifiability problem), age-period-cohort partial least squares regression imposes constraints that are exactly the inherent mathematical relations within the data of the age, period, and cohort variables (ie, age + cohort = period),[2] with no additional arbitrary constraints. We examined the curvilinear relationship of age-period-cohort on BP or BMI by including age, period, and cohort as categorical variables. We plotted the resultant regression coefficients with 95% confidence intervals. Statistical analyses were performed using Stata version 12.1 (Stata Corp, College station, Texas, USA) and R version 3.0.1 with the command plsr (R Development Core Team, Vienna, Austria).

Results

BP data of 402 040 students aged 9 to 18 years from 1999 to 2014 and BMI data of 1 898 816 students aged 6 to 18 years from 1996 to 2014 were included. Overall, systolic and diastolic BP trends declined from 1999 and bottomed in 2003-2005 but increased afterwards (Fig. 1). Systolic and diastolic BP was higher in earlier cohorts until about 1984. BMI trend gradually increased from 1996 before stabilised around 2009-2010 (Fig. 2). Those born in earlier years until about 1984 had higher BMI, whereas those born in 2003-2004 had lower BMI.

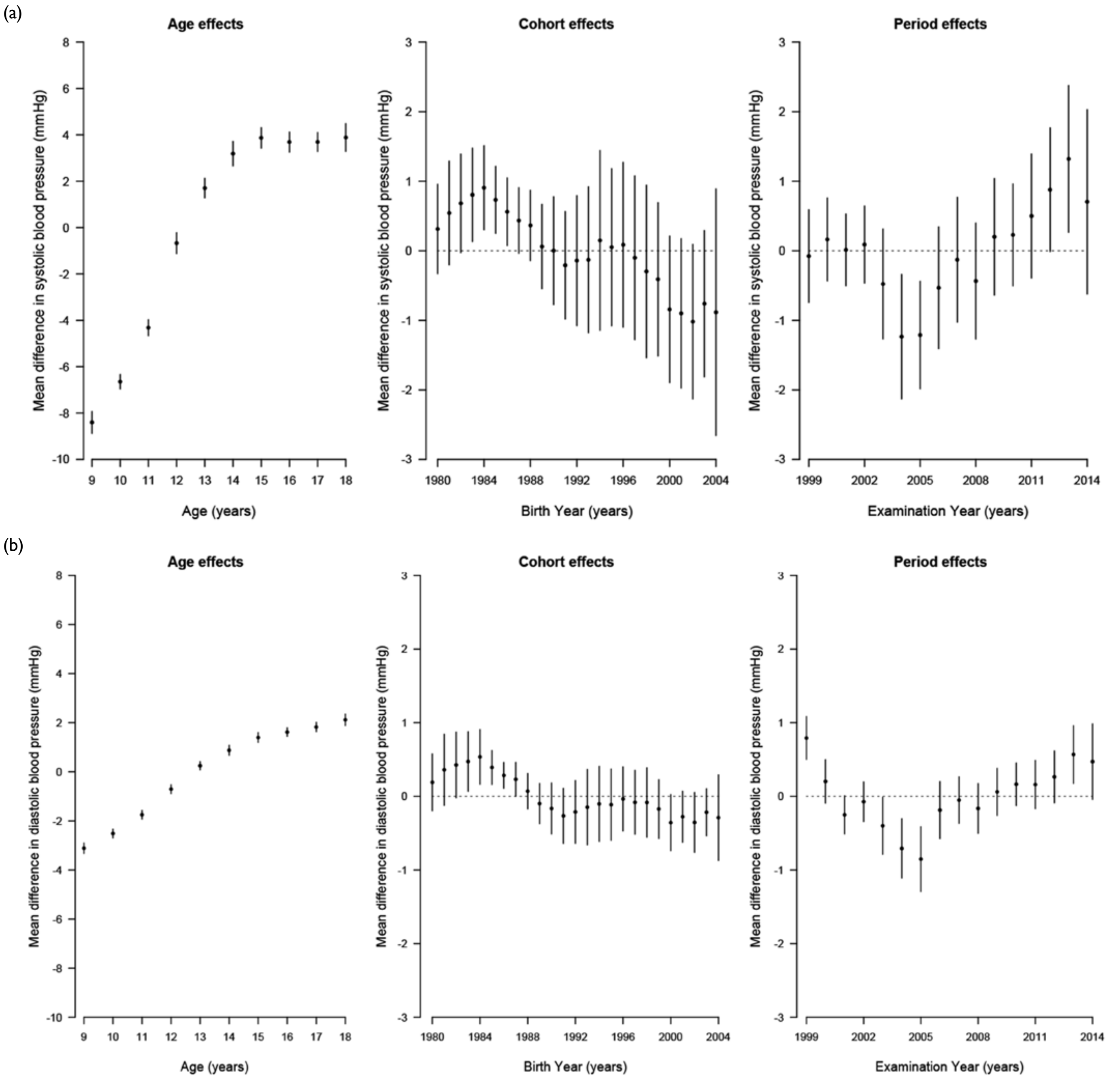

FIG 1. Parameter estimates of age, cohort, and period effects on (a) systolic and (b) diastolic blood pressure among children and adolescents aged 9 to 18 years from 1999 to 2014 (being born from 1980-1981 to 2004-2005) using partial least squares regression with two components and categorical variables

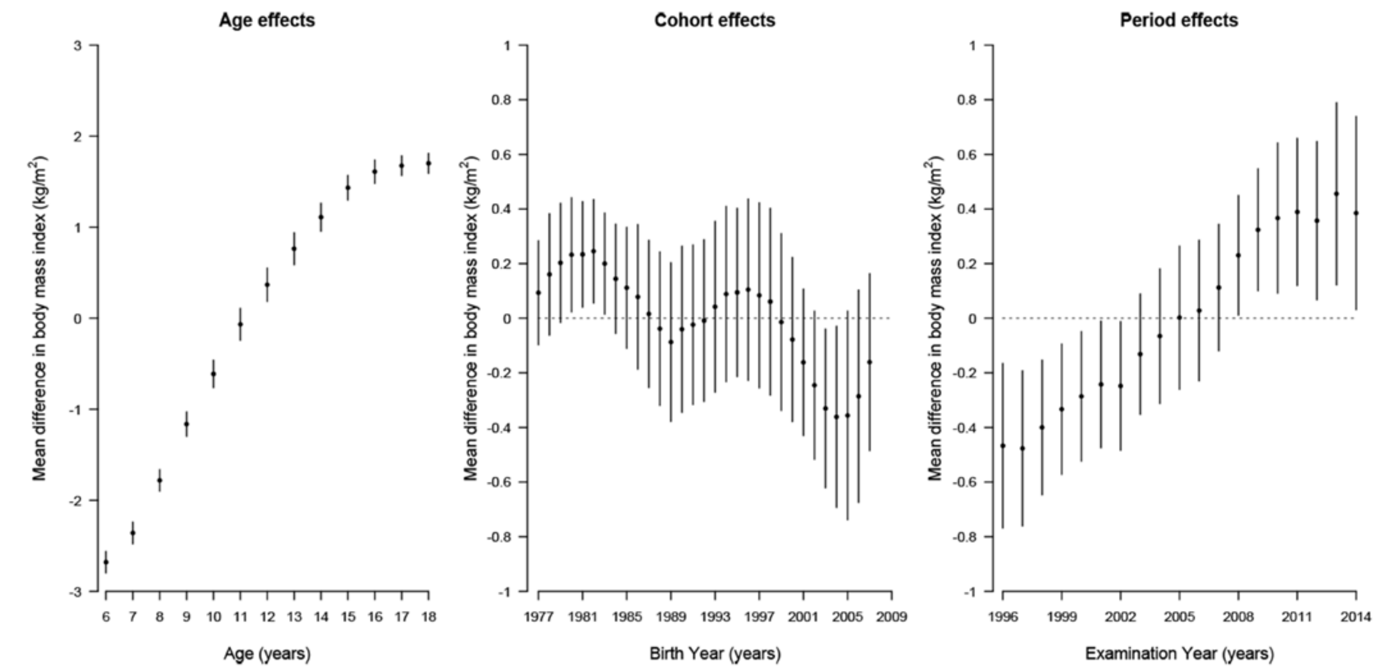

FIG 2. Parameter estimates of age, cohort, and period effects on body mass index among children and adolescents aged 6 to 18 years from 1996 to 2014 (being born from 1977-1978 to 2007-2008) using partial least squares regression with two components and categorical variables

Discussion

In Hong Kong, divergent secular trends in BP and BMI in children and adolescents were evident, with a U-shaped trend in BP but an increasing trend in BMI until levelling off in recent years. In addition to the physiological age effect, both period and cohort effects contributed to trends in BP and BMI.

Changes in BP do not necessarily occur with similar changes in BMI. Higher BMI is a major risk factor of BP. The modest BP downward trend before 2005 despite increasing BMI would have been more salient if BMI had not increased. Nonetheless, considering the trend in BP is not fully explained by the trend in BMI, and adjustment of BMI only accounts for a small proportion of trends in BP in elsewhere,[3] other factors may have contributed to changes in BP.

The positive period effect for BMI until recent years is consistent with westernisation of diet and lifestyle in a more obesogenic environment. As such, the recent levelling off in the BMI trend in Hong Kong may indicate introduction of effective interventions. In 2006, school-based health promotion campaign-EatSmart@school.hk-targeted primary schools with healthier lunch and snacks and modestly improved students' diet.[4]

The negative period effect for BP from about 1999 to 2003-2005 followed by a positive period effect suggests that contextually specific population-wide factors could be involved. In Hong Kong, high salt intake, low fruit and vegetables consumption, and physical inactivity was unlikely to have changed in similar U-shaped patterns as the trend in BP.[5] Moreover, in a South Korea study, changes in sodium or potassium intake, physical activity, smoking, stress, family size, and household income did not explain the declining trend in BP.

The cohort effects for BP are more synchronised with those for BMI. There may be common factors driving both BP and BMI.

Several limitations are noted. First, attending health assessment is voluntary. Differential selection by child health status or parental attributes or family socioeconomic position over time could bias the results, which is unlikely given health assessment at the Student Health Service is free and accessible to all public or private school students. Second, using a single BP measurement at a single visit may slightly overestimate average BP, but would not affect changes over time. Third, random measurement error is possible, but our large sample size minimises potential under- or over-estimation. Finally, the study is descriptive. We can only speculate about the aetiologies of the observed changes in BP and BMI. Nonetheless, these help generate hypotheses for further testing in different settings.

In Hong Kong, contemporaneous population-wide factors and cohort-specific factors may have contributed to the divergent trends in BP and BMI. Dual actions in tackling rising BMI and identifying other determinants of BP are imperative for improving future population cardiovascular health, as well as focusing on the poorer profile in boys.

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Disclosure

The results of this research have been previously published in:

1. Kwok MK, Tu YK, Kawachi I, Schooling CM. Age-period-cohort analysis of trends in blood pressure and body mass index in children and adolescents in Hong Kong. J Epidemiol Community Health 2017;71:1161-8.

2. Kwok MK, Wong IOL, Schooling CM. Age-period-cohort projection of trends in blood pressure and body mass index in children and adolescents in Hong Kong. BMC Pediatr 2020;20:43.

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