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ORIGINAL ARTICLE

Gender differences in the relationship between blood pressure and body mass index during adolescence

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KEYWORDS
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Summary
Objective: In adults, gender and obesity play significant roles in the regulation of blood pressure (BP). This study investigated the effects of gender and body mass index (BMI) on BP during adolescence.
Design and setting: A cross-sectional and longitudinal study involving 6838 students under twenty years old (median, eighteen years old; male, 4624; female, 2214) at Osaka University visited the Healthcare Center for their matriculation health examination from April to May in the years 2008, 2009, and 2010, and re-visited the Healthcare Center for their student health examination from May to June in the years 2011, 2012, and 2013.
Methods: Height, body weight, and BP were measured in students both on and 3 years after admission to Osaka University.
Results: On admission, the slope of the regression line for BMI and systolic BP (SBP) in non-underweight students was significantly different between genders. SBP and diastolic BP (DBP) increased in both genders during the observation period. Among male students who had a normal BMI on admission, those who had an increase in BMI of over 4% during the observation period showed a greater increase in SBP than those who had a change in BMI of −4% to 4%. On the other hand, female students showed no change in BP with the increase in BMI.
Conclusions: The magnitude of BP elevation with increased BMI was associated with gender during adolescence. This may be a cause of the higher prevalence of hypertension in adult males.

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Introduction

Obesity plays a significant role as a risk factor for high blood pressure (BP) and cardiovascular diseases (CVD) in men and post-menopausal women [1]. In contrast, pre-menopausal women are resistant to developing cardiovascular disease and the underlying mechanisms of this protection are partly attributed to sex hormones, including estrogen and androgen [2,3].

Recent investigation has revealed that obesity in childhood increases BP by activating the sympathetic nervous system, increasing insulin resistance, and altering vascular function or structure [4]. Obesity during childhood is likely to persist through adulthood [5—7], and BP tracks from childhood to adulthood [8,9]. Although obesity-related complications in children are reversible, those whose obesity persists from childhood to adulthood are more likely to develop obesity-related complications and, in the end, develop CVD earlier than those whose weight was normal during childhood. In fact, the life expectancy of subjects who were obese during childhood is shorter than subjects who were normal weight [10,11]. Based on the fact that gender has little effect on physical condition during childhood, but has great impact on young adults, we speculated that during adolescence, BP and the relationship between obesity and BP may be influenced by gender. Presently, little information is available about the relationships among gender, body mass index (BMI), and BP during adolescence.

The aim of this study was to investigate the effects of gender and BMI on BP during adolescence using a longitudinal study design. Height, body weight, and BP were measured both on admission to Osaka University (median age, 18 years) and 3 years later. Data were obtained from Osaka University Healthcare Center student health examination program and were used to calculate BMI and the percent changes for each parameter of individual subjects.

Materials and methods

Subjects, setting, and measures

A total of 6838 students (male, 4624; female, 2214) at Osaka University visited the Healthcare Center for their matriculation health examination whose age under twenty from April to May in the years 2008, 2009, and 2010, and re-visited the Healthcare Center for their student health examination from May to June in the years 2011, 2012, and 2013. To exclude secondary hypertensive subjects, the students who has past history of hypertension have excluded from this analysis. Data examined included age, sex, height, body weight (BW), body mass index (BMI = BW (kg)/height^2 (m^2)), systolic blood pressure (SBP), diastolic blood pressure (DBP), sleep duration and physical activity.

BP measurements were performed at the sitting position after at least five minutes of waiting period. Full automatic manometer (TM-2655VP: A&D Co., Tokyo, Japan) was used for the BP measurement. This manometer equips automatic wrapping system for cuff by geared-motor and do not have to consider the risk of overestimation of BP due to the impaired fixation of cuff in obesity subjects.

Sleep was determined using the question ''How many hours do you usually sleep per day on the average (including sleep at night and during the day)?'' Sleep duration was categorised into three groups: <6 h/day; ≥6 to <7 h/day; and ≥7 h/day [12]. Physical activity was determined using the question how many hours they were physically active (including walking or cycling to and from school and during leisure time; and sports activities during physical education lessons and during leisure time). Physical activity was categorised into three groups: <1.0 h/week, 1.0—4.0 h/week, and ≥4.0 h/week [12].

The study protocol was approved by the ethics committee of the Osaka University Healthcare Center (approval No. 22).

Statistics

Using BMI level at admission and 3 years later allowed us to calculate percent changes in BMI. After categorising the participants into 3 groups (<18.5 kg/m^2 [underweight], 18.5—24.9 kg/m^2 [normal weight], and ≥25 kg/m^2 [overweight/obese]) according to baseline BMI level, the participants were further categorised into the following 7 categories: (Group 1) underweight with reduction or less than 4% increase in BMI after 3 years; (Group 2) underweight with over 4% increase in BMI after 3 years; (Group 3) normal weight with over 4% reduction in BMI after 3 years; (Group 4) normal weight with −4 to 4% change in BMI after 3 years; (Group 5) normal weight with over 4% increase in BMI after 3 years; (Group 6) overweight/obese with over 4% reduction in BMI after 3 years; (Group 7) overweight/obese with less than −4% reduction or increase in BMI after 3 years. The associations between these 7 categories and each parameters were compared using the Kruskal—Wallis test, followed by post hoc multiple comparisons. Group 4 was used as reference.