

ORIGINAL

Contributions of Anthropometrics and Lifestyle to Blood Pressure in Japanese University Students : Investigation by Annual Health Screening

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Abstract : Background : High blood pressure (BP) is a healthcare problem in young persons. There are racial differences in anthropometrics, dietary habit and lifestyle relating to BP. Therefore, this study investigated the relationship between anthropometrics, lifestyle and BP obtained in the Japanese university students. **Materials and Methods :** Participants were recruited in annual health screening including questionnaire, measurements of BP and anthropometrics calculating body mass index (BMI). Totally, 14,280 students (10,273 males and 4,007 females) were eligible. Multiple regression analyses were applied to predict contributors to high BP. **Results :** BMI was the most powerful contributor to high BP in many subgroups divided by gender and graduation ($p < 0.001$). In lifestyle, contribution of lack of exercise to high BPs was observed in the undergraduates. Smoking, drinking and breakfast skipping had no significant impact on high BP. However, smoking and drinking permeated and exercise habit declined after graduation. Prevalence of obesity ($BMI \geq 25 \text{ kg/m}^2$) and hypertension ($\geq 140/90 \text{ mmHg}$) increased in subgroups with advanced age ($p < 0.001$). **Conclusion:** BMI was found to be the most powerful contributor to high BPs. Health literacy to modify lifestyle is important to prevent hypertension for university students who are exposed to social trends of unhealthy lifestyle. *J. Med. Invest.* 67:174-181, February, 2020

Keywords : blood pressure, body mass index, healthcare, lifestyle, university students

INTRODUCTION

Hypertension is the most prevalent risk factor of cardiovascular diseases. Current guideline published by The Japanese Society of Hypertension (JSH2019) emphasizes an importance of lifestyle modification including physical activity, food education and weight control (1). There are many factors accelerating hypertension such as obesity, salty food and social environment inducing emotional stress and short sleeping time. All these sociodemographic problems are important in the university students. Lifestyle of the university students becomes unhealthy after the entrance into the university, and such lifestyle generally continues thereafter. Many students are living alone and away from their families after graduation of senior high school. They have to behave at their own risk in classroom, extracurricular outdoor activity and part-time job. Outside of the university campus, they have to keep moderation in drinking, smoking, eating fast food and internet utilization (2,3). Therefore, comprehensive lifestyle modification should be promoted by educational health literacy performed in classroom or infirmary.

Racial difference in the prevalence of hypertension has been reported so far (4,5), and JSH defines the normal blood pressure (BP) as systolic BP (SBP) $< 120 \text{ mmHg}$ and diastolic BP (DBP) $< 80 \text{ mmHg}$. It has been reported that exceeding these ranges increases the risk of hypertensive complications (1). Therefore, it is important to clarify the prevalence and causal factors of juvenile hypertension in Japanese youth. Annual health screening is mandatory in Japan by the Japanese School Health and Safety

Act. Mega-data obtained by this mass screening is extremely useful for the healthcare promotion for the university students, because tracking phenomenon of high BP underlies transfer of juvenile into adult hypertension (6). However, there is limited data concerning nation-wide Japanese hypertensive youth. Therefore, this study investigated the relationship between the anthropometrics, lifestyle and BP obtained in an annual health screening program applied to the students of our university.

METHODS

Participants

This study was derived from the annual health screening of Kyushu University (Fukuoka, Japan) conducted on April 2015 in accordance with the Japanese School Health and Safety Act and the updated Declaration of Helsinki (2008). All procedures performed in this study were also in accordance with our institutional and/or national ethical standards. Because school-based health screening is legal annual event in all the Japanese universities, the study protocol was not argued in the institutional review board. Data extraction was informed to all the participants at the guidance of health screening and described in the self-administered questionnaire. All the students are strongly encouraged to participate the annual health screening program from the viewpoint of health maintenance, health education and health literacy. However, participants were allowed to opt out from the data extraction when they offered. Differentiation of postgraduates from graduates were performed automatically based on the self-identification cards when they underwent the health screening.

Annual health screening program includes taking histories and physical findings by physicians working at our university campus infirmary or at our university hospitals, the anthropometric measurements of body weight (BW : kg) and height

Received for publication November 19, 2019 ; accepted February 5, 2020.

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(BH : cm), BP (mmHg) measurements, urinalysis, chest X-ray and electrocardiogram (ECG) recordings. Resting BP and pulse rate (beats per minutes : bpm) were measured semi-automatically in sitting position after taking a few minutes' rest (Kentaro HBP-9021, Omron-Colin Healthcare, Tokyo, Japan). According to JSH 2019 defining hypertension as constant office BP of 140/90 mmHg or more (1), the second BP measurement was taken after 5 minutes of rest for the subjects showing the first SBP \geq 140 mmHg and/or the first DBP \geq 90 mmHg. If the difference in BP was more than 10 mmHg, a third measurement was performed, and the average of the last two measurements was used for analysis. BH and BW were measured simultaneously by validated automatic device (TANITA DC-250, Tokyo, Japan), and body mass index (BMI) was calculated automatically by dividing BW (kg) by square of BH (m). By taking personal history and physical finding, apparently healthy university students were eligible in this study.

Questionnaire for lifestyle

Lifestyles and habits of the participants were evaluated by our self-administered questionnaire package designed for quality of life (QOL) assessment in the university students (7). This package consists of 66 questions to assess 5 domains of global QOL, i.e., school life (4 items), physical health (16 items), past history (26 items), family history (15 items) and desire for health consultation domains (5 items). These domain scores demonstrated good internal consistency, content validity and test-retest reliability (7). Extraction of the questionnaire items was performed as it relates to BP and monitored by the Cronbach's alpha coefficient of the item measure. By this analysis, five questionnaire items of exercise, drinking, smoking, breakfast taking and sleeping hours were remained. We used a frequency-quantity approach as follows ; 1) exercise habit (1, exercising every day ; 2, exercising sometimes ; 3, not exercising), 2) drinking status (1, drinking every day ; 2, drinking socially ; 3, not drinking), 3) smoking status (1, current smoker ; 2, previous smoker ; 3, nonsmoker), 4) breakfast taking (1, taking every morning ; 2, taking a few days a week ; 3, skipping every morning) and 5) actual sleeping hours (hrs). These factors have been nominated in literature as health-related lifestyle components, which are related deeply not only to the physical health but also to the mental health of the university students (8-11).

Statistical analysis

Demographic variables of the enrolled participants were extracted from health screening personal cards. All continuous data were expressed as means \pm standard deviation (SD). Data sets were examined by Kolmogorov-Smirnov test and Shapiro-Wilks test for normality. Continuous data were analyzed by the unpaired Student's t test or the one-way analysis of variance (ANOVA) for normally distributed data, and by the Mann-Whitney analysis or the Kruskal-Wallis analysis for the data distributed not normally. Discrete variables were counted, expressed by percentage and analyzed by the chi-square test or the Fisher's exact test. Multiple regression analysis was performed first to predict contributors to high BP. Dependent variables were SBP and DBP, whereas independent variables were age, BMI and the components of lifestyle extracted from the questionnaire. The combination of the lifestyle components was decided by the best Cronbach's alpha. Thereafter, this analysis was applied to assess the contribution of lifestyle components to high BMI. For multivariate analyses, logarithmic transformation was performed for data which did not distributed normally. Coefficient of determination (R^2) was adjusted for the degree of freedom. None of the variables with missing data qualified. These analyses were performed using Bell Curve for Excels

version 2.12 (Social Survey Research Information Co., Ltd., Tokyo, Japan). Differences with two-sided $p < 0.05$ were considered to be significant.

RESULTS

Baseline characteristics and gender difference

Because annual health screening conducted at the beginning of fiscal year is legal in Japan, participation in this health screening program is encouraged strongly, yielding nearly 80% of participation rate. Baseline demographics of BP (mmHg), pulse rate (bpm), BMI (kg/m^2) and lifestyle in all the participants ($n = 14,280$) are detailed in Table 1. All the continuous data listed in Table 1 did not show normality at all. Mean age in all males did not differ from that in all females ($p = 0.113$). Gender difference was found in SBP, DBP and pulse rate in undergraduate ($p < 0.001$) and graduate ($p < 0.001$) students. SBP and DBP were significantly ($p < 0.001$) higher in the male students compared to the female counterparts, whereas pulse rate in the male students was less than that in the female students ($p < 0.001$). Small but significant ($p < 0.001$) gender difference was found in BMI which was greater in males relative to females in both graduates and undergraduates. These data indicate that Japanese youth are generally resistant to the social and environmental factors leading to the obesity as in literature (12).

Correlations of lifestyle, age and gender

With respect to the lifestyle components, smoking, drinking, exercise habit, breakfast taking and sleeping hours were skimmed from questionnaire due to the best Cronbach's alpha (0.43). The percentage of graduate smokers was greater than that of undergraduate smokers in both males and females ($p < 0.001$), and percentage of male smokers was greater than that in the female smokers both in graduates and undergraduates ($p < 0.001$). The same was true in the percentage of drinking, i.e., percentages of daily and social drinkers in the graduates were greater than those in the undergraduates in males ($p < 0.001$) and females ($p < 0.001$), and the percentage of male drinkers was greater than that of female drinkers in both graduates ($p < 0.001$) and undergraduates ($p < 0.001$). Smoking and drinking in teenagers are illegal in Japan, and the percentages of smoking and drinking in teenager male students were less than 1.1% and 1.2%, respectively.

With regards to exercise, male students were more likely ($p < 0.001$) to be engaged in exercise compared to the female counterparts, although such exercise habit in the male graduates was less than that in the male undergraduates ($p < 0.001$). With respect to breakfast, gender difference was found in the prevalence of breakfast skippers, i.e., breakfast skipping in females (59%) was significantly ($p < 0.001$) prevalent as compared with that in males (47%). Constant breakfast skippers were found in more than half of the male (55%) and female (65%) undergraduates. This trend was improved in the graduate students, although more than half of the female graduates were the constant breakfast skippers (52%). Therefore, just half (50%) of all the participants were found to be constant breakfast skippers. Finally, sleeping hours showed no gender difference and no difference between the graduate and undergraduate students (Table 1).

Correlations of BMI, BPs and age

In order to investigate the age-dependence of BP and BMI, all male participants were divided by age into the four groups of A (age < 20 yo), B ($20 \text{ yo} \leq \text{age} < 25$ yo), C ($25 \text{ yo} \leq \text{age} < 30$ yo) and D ($30 \text{ yo} \leq \text{age}$). Likewise, all female subjects were divided in the four groups by this criterion. The mode, median and mean

Table 1. Blood pressures, pulse rate and life style in our university students

| | Male undergraduates | Male graduates | Female undergraduates | Female graduates |
|---------------------------|---------------------|-------------------|-----------------------|------------------|
| n | 6405 | 3868 | 2680 | 1327 |
| Age (years)§ | 20 ± 2.0 | 25 ± 4.0 | 20 ± 1.6 | 26 ± 4.8 |
| SBP (mmHg)# | 126 ± 14 | 127 ± 15 | 112 ± 13 | 112 ± 12 |
| DBP (mmHg)* | 71 ± 10 | 74 ± 11 | 66 ± 9 | 67 ± 9 |
| Pulse rate (bpm)* | 79 ± 15 | 78 ± 14 | 82 ± 14 | 80 ± 13 |
| BMI (kg/m ²)* | 21.4 ± 2.8 | 22.2 ± 3.3 | 20.6 ± 2.4 | 20.8 ± 2.8 |
| Smoking (%)* | 389 / 134 / 5832 | 523 / 242 / 2853 | 26 / 14 / 2621 | 29 / 29 / 1126 |
| (current / previous / no) | (6 / 2 / 92) | (14 / 7 / 79) | (1 / 1 / 98) | (2 / 2 / 96) |
| Drinking (%)* | 72 / 1259 / 5027 | 132 / 1163 / 2338 | 13 / 380 / 2273 | 23 / 235 / 926 |
| (daily / social / no) | (1 / 20 / 79) | (4 / 32 / 64) | (1 / 14 / 85) | (2 / 20 / 78) |
| Exercise (%)* | 903 / 3476 / 1966 | 236 / 1956 / 1422 | 146 / 1088 / 1429 | 57 / 507 / 617 |
| (daily / casual / no) | (14 / 55 / 31) | (7 / 54 / 39) | (5 / 41 / 54) | (5 / 43 / 52) |
| Taking breakfast (%)* | 783 / 2090 / 3480 | 795 / 1465 / 1366 | 164 / 761 / 1738 | 144 / 420 / 619 |
| (daily / sometimes / no) | (12 / 33 / 55) | (22 / 40 / 38) | (6 / 29 / 65) | (12 / 36 / 52) |
| Sleeping hours (hrs) | 6.0 ± 1.0 | 6.0 ± 1.0 | 6.0 ± 0.9 | 6.0 ± 1.0 |

Symbols indicate significant ($p < 0.001$) difference in every paired comparison among the four groups (*), that in the limited paired comparison among the male and female students (#) and that in the limited paired comparison among the graduate and undergraduate students (§).

BMI : body mass index (kg/m²), DBP : diastolic blood pressure, SBP : systolic blood pressure.

of male BMI (kg/m²) in group A were 21.0, 20.8, 21.2 kg/m², respectively. These respective values in group B were 21.3, 21.2, 21.6 kg/m². These three values of group C were 21.6, 22.5, 23.0 kg/m², and these in group D were 22.4, 23.4, 24.2 kg/m², respectively (Figure 1). Similarly, these three values of female BMI were 20.1, 20.3, 20.5 kg/m² in group A, 20.3, 20.4, 20.6 kg/m² in group B, 19.9, 20.5, 20.9 kg/m² in group C and 19.6, 20.9, 21.9 kg/m² in group D (Figure 2). The mode of BMI increased gradually and significantly ($p < 0.001$) as age increases in males, whereas this mode remained in about 20 kg/m² in females irrespective of age.

With respect to BPs (SBP and DBP), the mode, median and mean of male BP in group A were 123/69, 125/70 and 126/70 mmHg, respectively. These values in group B were 123/71, 126/71, 127/72 mmHg, these values in group C were 119/78, 126/75, 128/75 mmHg, and these in group D were 121/78, 128/77 and 129/78 mmHg, respectively. Similarly, the paired female BPs were 105/66, 112/66, 113/66 mmHg in group A, 109/62, 111/66, 112/66 mmHg in group B, 114/71, 112/67, 112/67 mmHg in group C and 104/67, 113/68, 115/70 mmHg in group D, respectively. Small but significant ($p < 0.001$) rise in paired BPs was observed in male but not in female students. Cut-off BPs for screening hypertension are 140 mmHg for SBP and/or 90 mmHg for DBP. Elevated BP was defined as SBP = 130-139 mmHg and/or DBP = 80-89 mmHg, and high normal BP as SBP = 120-129 mmHg and/or DBP < 80 mmHg according to the Guideline of JSH 2019 (1). The prevalence of hypertension as related to the different age groups was shown in Figure 3. Totally, it was 17.3% in males and 2.3% in females. However, the prevalence of elevated BP was 21.1% in males and 6.5% in females, and that of high normal BP was 29.9% in males and 16.2% in females.

Obesity is defined as BMI ≥ 25.0 kg/m² according to the criteria of the Japan Society for the Study of Obesity (13), because the prevalence of obesity-related complications increases rapidly in subjects showing BMI ≥ 25.0 kg/m² (14). The prevalence of obesity among the four age groups was also shown in Figure 3. As in literature reporting gender difference in cardiovascular

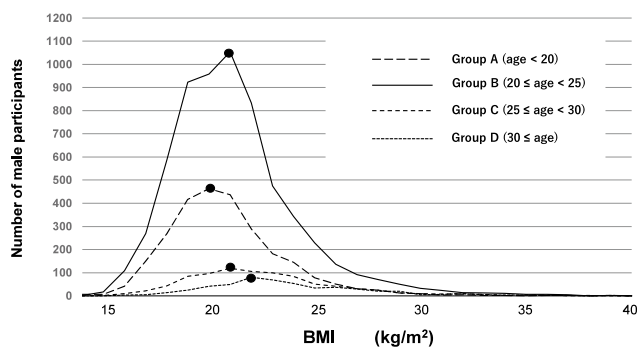


Figure 1. Histogram images of BMI (kg/m²) distribution demonstrated by dividing male participants by age (years old ; y.o.) into the four groups of A (age < 20 y.o.), B (20 y.o. ≤ age < 25 y.o.), C (25 y.o. ≤ age < 30 y.o.) and D (30 y.o. ≤ age). Points on the distribution curves indicate mode, which increased significantly ($p < 0.001$) according to aging.

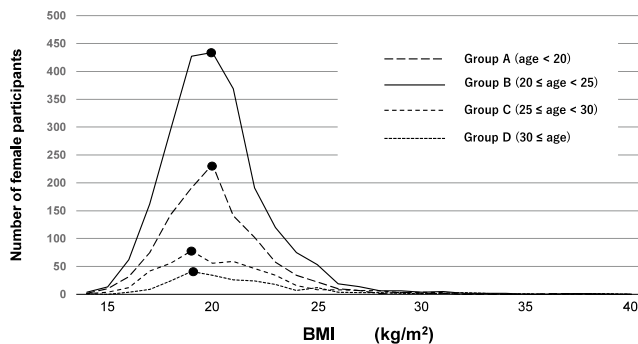


Figure 2. Histogram images of BMI (kg/m²) distribution demonstrated by dividing female participants by age into the four groups as shown in Figure 1. Points on the distribution curves indicate mode, which remains in about 20 kg/m² irrespective of aging.

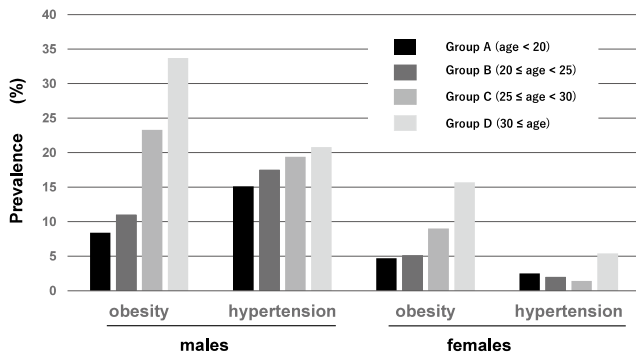


Figure 3. Prevalence of obesity and hypertension in different four age groups. Marked increase in the prevalence of obesity as increasing age was observed in both males and females ($p < 0.001$), whereas steady increase in the prevalence of hypertension was noted not in the females but in the males ($p < 0.001$).

risk accumulation (15), the prevalence of obesity and hypertension was evident in males relative to females. Moreover, marked increase in the prevalence of obesity as increasing age was observed in both males and females ($p < 0.001$), whereas steady increase in the prevalence of hypertension was noted in males ($p < 0.001$) but not in females.

Correlations of BMI, BPs and lifestyle

Lifestyle is deeply related to the BPs in the university students' reports (9,10,11,16). In the multivariate analyses, BMI, age and lack of exercise were the variables significantly ($p < 0.001$) contributing to high BPs in the male undergraduates (Table 2). On the other hand, both BMI and lack of exercise had significantly ($p < 0.001$) positive impact on high BPs in the female undergraduates (Table 3). In the male graduate students, BMI was the most significant ($p < 0.001$) contributor to high BPs (Table 4). In the female graduates, BMI and age were the significant ($p < 0.001$) contributors to high BPs (Table 5). As a

Table 2. Determinants of blood pressures in the male undergraduates

| SBP | β (95%CI) | standardized β | partial r | p value |
|---|---------------------------|----------------------|-----------|-------------|
| BMI | 1.5666 (1.4464 – 1.6868) | 0.3091 | 0.3059 | $P < 0.001$ |
| Exercise | 1.2134 (0.6981 – 1.7286) | 0.0553 | 0.0580 | $P < 0.001$ |
| Age | 0.3264 (0.1465 – 0.5064) | 0.0451 | 0.0447 | $P < 0.001$ |
| Drinking | 0.8918 (0.0774 – 1.7062) | 0.0276 | 0.0270 | 0.0319 |
| Smoking | 0.5159 (-0.1901 – 1.2219) | 0.0179 | 0.0180 | 0.1520 |
| Sleeping hours | 0.2410 (-0.1185 – 0.6005) | 0.0157 | 0.0165 | 0.1888 |
| $(R^2 = 0.1002, F = 117.3460, P < 0.001)$ | | | | |
| DBP | β (95%CI) | standardized β | partial r | p value |
| BMI | 0.6248 (0.5350 – 0.7145) | 0.1697 | 0.1691 | $P < 0.001$ |
| Age | 0.5745 (0.4401 – 0.7089) | 0.1093 | 0.1048 | $P < 0.001$ |
| Exercise | 1.5466 (1.1588 – 1.9345) | 0.0971 | 0.0978 | $P < 0.001$ |
| Drinking | 0.6418 (0.0439 – 1.2397) | 0.0273 | 0.0265 | 0.0354 |
| Sleeping hours | 0.3032 (0.0351 – 0.5713) | 0.0272 | 0.0279 | 0.0267 |
| Taking breakfast | 0.2808 (-0.0893 – 0.6509) | 0.0190 | 0.0187 | 0.1369 |
| $(R^2 = 0.0526, F = 58.4930, P < 0.001)$ | | | | |

β : partial regression coefficient, CI: confidence interval, r: correlation coefficient.

Table 3. Determinants of blood pressures in the female undergraduates

| SBP | β (95%CI) | standardized β | partial r | p value |
|--|---------------------------|----------------------|-----------|-------------|
| BMI | 1.3406 (1.1518 – 1.5294) | 0.2612 | 0.2612 | $P < 0.001$ |
| Drinking | 2.6187 (1.3822 – 3.8552) | 0.0777 | 0.0804 | $P < 0.001$ |
| Exercise | 1.4526 (0.6805 – 2.2246) | 0.0693 | 0.0715 | $P < 0.001$ |
| Sleeping hours | 0.6019 (0.0973 – 1.1065) | 0.0437 | 0.0454 | 0.0194 |
| $(R^2 = 0.0769, F = 55.1615, P < 0.001)$ | | | | |
| DBP | β (95%CI) | standardized β | partial r | p value |
| BMI | 0.5287 (0.3885 – 0.6689) | 0.1425 | 0.1422 | $P < 0.001$ |
| Exercise | 1.1165 (0.5444 – 1.6887) | 0.0737 | 0.0741 | $P < 0.001$ |
| Sleeping hours | 0.3690 (-0.0058 – 0.7437) | 0.0371 | 0.0375 | 0.0536 |
| $(R^2 = 0.0249, F = 22.5377, P < 0.001)$ | | | | |

Abbreviations are as follows in Tables 1 and 2.

Table 4. Determinants of blood pressures in the male graduates

| SBP | β (95%CI) | standardized β | partial r | p value |
|---|-----------------------------|----------------------|-----------|-----------|
| BMI | 1.6021 (1.4623 – 1.7419) | 0.3525 | 0.3515 | P < 0.001 |
| Sleeping hours | 0.5552 (0.1022 – 1.0082) | 0.0377 | 0.0401 | 0.0163 |
| Taking breakfast | -0.6674 (-1.2719 - -0.0628) | -0.0339 | -0.0361 | 0.0305 |
| ($R^2 = 0.1261$, $F = 172.3482$, $P < 0.001$) | | | | |
| DBP | β (95%CI) | standardized β | partial r | p value |
| BMI | 0.8898 (0.7876 – 0.9919) | 0.2749 | 0.2744 | P < 0.001 |
| Age | 0.4016 (0.3129 – 0.4903) | 0.1454 | 0.1468 | P < 0.001 |
| Taking breakfast | 0.4783 (0.0331 – 0.9235) | 0.0341 | 0.0352 | 0.0352 |
| Smoking | 0.3926 (-0.0679 – 0.8531) | 0.0268 | 0.0279 | 0.0947 |
| ($R^2 = 0.1101$, $F = 110.7668$, $P < 0.001$) | | | | |

Abbreviations are as follows in Tables 1 and 2.

Table 5. Determinants of blood pressures in the female graduates

| SBP | β (95%CI) | standardized β | partial r | p value |
|--|--------------------------|----------------------|-----------|-----------|
| BMI | 1.3567 (1.1211 – 1.5924) | 0.3113 | 0.3130 | P < 0.001 |
| Age | 0.2784 (0.1389 – 0.4179) | 0.1079 | 0.1135 | P < 0.001 |
| ($R^2 = 0.1143$, $F = 75.8403$, $P < 0.001$) | | | | |
| DBP | β (95%CI) | standardized β | partial r | p value |
| BMI | 0.7391 (0.5559 – 0.9224) | 0.2216 | 0.2250 | P < 0.001 |
| Age | 0.3452 (0.2368 – 0.4537) | 0.1748 | 0.1792 | P < 0.001 |
| ($R^2 = 0.0863$, $F = 55.5044$, $P < 0.001$) | | | | |

Abbreviations are as follows in Tables 1 and 2.

whole, BMI showed the greatest standardized partial regression coefficient (β) in each regression model, indicating the most powerful impact on high BPs.

Multiple regression analysis was applied to the BMI as a dependent variable and lifestyle components as independent variables, because BMI was the most powerful contributor to high BPs. In the undergraduates, all the unhealthy life style components (drinking, smoking, lack of exercise, skipping breakfast, shortage of sleeping time) were significantly proportional to BMI in males, but lack of exercise alone was a contributor to high BMI in females. In the graduates, smoking, short sleeping hour and skipping breakfast were the contributors to high BMI in males, whereas significant multiple regression model was not obtained in females. Generally, males appeared sensitive to various unhealthy life style components increasing BW relative to females (not shown).

DISCUSSION

In this cross-sectional survey of the Japanese students in our university, the prevalence of obesity and hypertension increased with age, because BMI was the most powerful contributor to high BPs irrespective of gender and graduation. In the questionnaire of this study, their general lifestyle was not necessarily healthy in that 1) a steady part of students started smoking and drinking after graduation, 2) more than half of female students showed lack of exercise, and male students tended to cease exercise after graduation, and 3) just half of the participants (50%) were the constant breakfast skippers. These indicate

that lifestyle modification should be promoted to prevent future development of the BMI-dependent hypertension by educational health literacy (17).

Legal annual health screening conducted in every school of Japan has healthcare benefit. This is particularly important for university students being in a transitional stage of life, getting unhealthy habits through the lifespan leading to substantial anthropometric changes in this life stage. Anthropometrics are important health and fitness indicators. Especially, BMI has a strong impact on BPs as well as on the ECG findings (16,18), i.e., consensus is acquired in many updated guidelines with respect to that systemic obesity is associated with hypertension (1,19,20). Cut-off point of BMI defining obesity differs internationally. BMI ≥ 25.0 kg/m² discriminating obesity by the criterion of the Japan Society for the Study of Obesity yields age-dependent increase in the prevalence of obesity as in Figure 3 (13), i.e., this criterion yields 5.0% obese female and 9.5% obese male undergraduates, whereas it yields 8.1% obese female and 17.5% obese male graduates. These results indicate that such cut-off criteria for BMI are appropriate in the university student healthcare.

Although age-dependent increase in obese university students was confirmed, Japanese adolescents have demonstrated no evidence of a major rise in the prevalence of obesity for the last half century in spite of the global trend toward an increase in adolescents BMI (12,21). This trend is supported by low BMI in all the participants with mean BMI ranging from 20.6 to 22.2 kg/m² (Table 1). Moreover, the distribution of male BMI showed positive skewness of 1.18 in group A, 1.31 in group B, 1.05 in group C, 0.95 in group D (Figures 1). Likewise, the skewness

of female BMI distribution was 1.27 in group A, 1.38 in group B, 1.08 in group C, and 1.73 in group D, respectively (Figure 2). This is caused by unhealthy social trend toward inaccurate weight perception, i.e., overweight is considered as anthropometric minority in Japanese youth (22), which influences greatly the lifestyle of the university students and is a matter of health literacy for the university students (23).

Age is another important factor contributing to high BPs. In the male students, age-dependent rise in BPs was confirmed in both undergraduates and graduates (Tables 2, 4). On the other hand, this trend was confirmed in the female graduates (Table 5) but not in the female undergraduates (Table 3). This survey could not provide accurate explanation for these results. Although it is possible to hypothesize that the delayed effects of aging on an elevation of BPs in females is related to the estrogen, large cohort with long-term prospective study is required to test this hypothesis. Another gender difference was obtained in the habit of exercise. Exercise has a strong impact for prevention of hypertension in general population (24). Relatively, such evidence is poor in the university students. In this study, lack of exercise has significantly positive impact on high BPs in undergraduate students alone (Tables 2, 3). Generally, lifestyle becomes busier after graduation for laboratory work and writing dissertation, and graduate students have less time to take exercise. Actually, half (53.2%) of the graduate students showed no habit of exercise in this study (Table 1). This should be followed up to examine whether lack of exercise in youth underlies future hypertension and to validate the exercise promotion in health literacy (16).

Although the other lifestyle factors of smoking, drinking and taking breakfast have limited influence on BPs in our study, the causality of these factors is a matter of future study. Just half of participants (50%) were the constant breakfast skippers, which had no impact on BP. However, this finding does not deny the possible effects of breakfast skipping on future development of cardiovascular disease (25). It is unknown whether breakfast skipping is associated with unhealthy food and snack consumption in the participants. The main reasons for skipping breakfast are busy life and desire for weight reduction. One of the reasons for smoking is also the weight reduction, and smoking and drinking are interdependent in the university lifestyle. Since modifiable lifestyle components are clustering in adolescents, interdependency should be investigated in the longitudinal or multivariate study (26). Because obesity is associated with systemic vascular and cardiac damage (27-30), lifestyle modification is important for the unhealthy university students. One month after the primary health screening, secondary screening is performed in our infirmary for the students showing high BPs (SBP \geq 140 and/or DBP \geq 90 mmHg) constantly in the primary screening. The repetitive BPs measurement is educational to learn natural BPs fluctuation, relationship of BMI and BPs, and self-control of BMI (15).

Strengths and limitations

The strengths of this study are sufficient sample size to analyze appropriately the gender- and age-dependent prevalence of obesity, hypertension and lifestyle components under legal school-based survey of annual health screening program showing nearly 80% of participation rate. However, the findings of this study should be interpreted carefully due to some limitations. First of all, this is a cross-sectional study, and hence the comparison of graduates with undergraduates was not longitudinal. Prevalence of white-coat and masked hypertension was reported to be 7.5% and 2.2% in adolescents, respectively (31), but was not confirmed in this study without home BP monitoring. Second limitation is the unknown causality among smoking,

drinking, breakfast skipping and sedentary lifestyle because of the cross-sectional screening associated with questionnaire study. Third, the relatively low coefficients of determination (R^2) ranging from 0.025 to 0.126 indicate unknown causes or confounders associated with juvenile hypertension, and 20% of non-participants may have a chance to improve R^2 in multiple regression analyses. The relationship between future development of hypertension and the university lifestyle should wait for future study using large cohort with lifestyle intervention.

CONCLUSIONS

Hypertension is a major healthcare problem in the university students considering tracking phenomenon of casual high BPs leading to the future hypertension (6). Although some limitations permit, BMI was found to be the most powerful contributor to high BPs irrespective of gender and graduation in this study. Contribution of sedentary lifestyle to high BPs was observed in the undergraduates. Smoking, drinking and breakfast skipping had no major impact on high BPs in our university students. However, such unhealthy lifestyle may have long-term effects on the development of hypertension. In this sense, lifestyle counseling and health literacy focusing on weight control are required for the university students (32), who are exposed to social trends of unhealthy habits.

ACKNOWLEDGEMENTS

The authors wish to thank Ms. Yoshiko Yoshimura for secretarial assistance and all the public health nurses in the Center for Health Sciences and Counseling for assistance in the annual health screening of the Kyushu University. The authors thank also Dr. Atsushi Ichimiya (Professor Emeritus, Center for Health Sciences and Counseling, Kyushu University) for development and validity assessment of our self-administered health-supporting questionnaire package (7) and Dr. Keiko Uezono (Professor Emeritus, Institute of Health Science, Kyushu University) for her prior study which provided us motif of the present study (6).

CONFLICT OF INTEREST

The authors have no conflicts of interest to declare.

FUNDING SOURCES

This work was supported in part by academic support from TANITA Healthy Weight Community Trust (TANITA Co, Ltd., Tokyo, Japan), ASTELLAS Research Support (ASTELLAS Co, Ltd., Tokyo, Japan) and SOUSEIKAI Global Clinical Research Center (LTA Medical Corporation, Fukuoka, Japan).

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