Original Article

Association between sodium and potassium intake levels and body compositions of Chinese college students

Zhenyu Liu[1†], Huixi Kong[1†], Yalin Wu BS[2], Hongrui Li MS[3], Dajun Li BS[3], Huini Ding BS[3], Rong Xiao PhD[3], Yuandi Xi PhD[3]

[1]*School of Basic Medical Sciences, Capital Medical University, Beijing, China*
[2]*Division of Students Affairs, Capital Medical University, Beijing, China*
[3]*Beijing Key Laboratory of Environmental Toxicology, School of Public Health, Capital Medical University, Beijing, China*
[†]*Both authors contributed to this manuscript equally*

Background and Objectives: To investigate the relationship between sodium (Na) and potassium (K) nutritional condition and body compositions in youth aiming to give target population reasonable diet recommendations. **Methods and Study Design:** The cross-sectional study was conducted involving 512 healthy youth aged 18 to 31 years from universities in Beijing. Food frequency questionnaire (FFQ) and bioelectrical impedance analyzer (BIA) were used to collect dietary intake information and body compositions. **Results:** There was an increasing tendency in fat-related indicators and muscle-related indicators of the dietary Na tertile group (p <0.05). Additionally, Weight, body mass index (BMI), waist circumference (WC), and muscle-related indicators increased with the dietary K tertile group (p <0.05). Across increasing tertiles of dietary Na intake, the odds ratio (OR) was increased significantly (p < 0.05) in fat-related indicators. On the contrary, with the increased dietary Na intake, the OR decreased (p < 0.05) in appendicular skeletal muscle mass index (ASMI) and body lean mass. As tertiles of dietary K intake increased, the OR in both skeletal muscle mass index (SMMI) and lean mass index (LMI) decreased. **Conclusions:** High dietary Na is a risk factor for abnormal lipid distribution in college students. High dietary K can maintain skeletal muscle mass and reduce the risk of obesity. Na in the diet has a greater impact on the body composition of young people than K. Low dietary Na and high dietary K still need to be strengthened in science popularization and practice among more college students.

Key Words: sodium, potassium, Na/K ratio, body compositions, cross-sectional study

INTRODUCTION

Sodium (Na) and potassium (K) are essential minerals for homeostasis in humans because they contribute to the maintenance of osmotic balance.[1] As we all know, dietary intakes of Na and K are an important daily source for the human body.[2] However, modern human diets are both high in salt (NaCl) and deficient in K-rich foods.

There is no doubt that higher dietary Na intake could be one of the main causes of increased blood pressure and increased risk of cardiovascular disease (CVD).[3-7] On the other hand, there is evidence that increased K intake has health benefits such as maintaining blood pressure and has no adverse effect on blood lipid concentrations, catecholamine concentrations, or kidney function in adults.[8] Furthermore, emerging data suggested that an increased dietary Na/K ratio was more strongly associated with an increased risk of hypertension and CVD than Na and K considered separately.[9-11]

Given the importance of dietary Na and K intakes for health, Institute of Medicine (IOM) and World Health Organization (WHO) proposed the Dietary Reference Intakes (DRIs) for adults. In China, the proposed Na intake for the prevention of chronic non-communicable diseases (PI-NCD) is 2000 mg/d and the AI is 1500mg/d. PI-NCD of K is 3600mg/d and the AI of the Chinese is 2000 mg/d.

Data from the 2010-2012 CNNHS demonstrated that the mean Na intake of Chinese was 5013 (95% Confidence Interval, CI: 4858, 5168) mg/d, and that 92.6 % of adults' Na intake was greater than that of PI-NCD.[12] K intake of Chinese was 1700 mg/d in 1991 and 1500 mg/d in 2015, far below the PI-NCD. The China Health and Nutrition Survey has shown that only 15.4 % of the participants consumed Na ≤2000 mg/d in 2015, PI-NCD recommended by China, and about 81 % of the population had K intake <2000 mg/d, AI of Chinese in 2015.[13] The dietary Na/K ratio was 4.1 in 1991 and 3.1 in 2015. China had the highest Na/K ratio among the four countries.

Corresponding Author: Prof. Yuandi Xi, Department of nutrition and food hygiene, School of public health, Capital Medical University, No.10 Xitoutiao, You An Men Wai, Beijing, 100069, China
Tel: +86-15810863506
Email: xiaoer711@163.com
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Exploring the reason for Na and K on chronic disease, not only the direct effect, it could also be through affecting body compositions. Obesity, overweight, and excessive amounts of visceral adipose tissue as well as ectopic adipose tissue largely increase the risk of chronic disease, particularly in hypertension and obesity.[14] Physical abnormalities induced by unreasonable diets could result in the long-term effects of chronic illnesses in middle and old age. We tried to find out the relationship between Na/K nutritional condition and body compositions in youth aiming to give young people reasonable dietary Na and K intakes recommendations.

METHODS

Study design and participants

This cross-sectional study was conducted. 512 healthy youth aged 18 to 31 years, including 114 men and 398 women, were recruited from universities in Beijing's urban and suburban areas. The sampling of college students was carried out randomly according to different grades. Subjects were excluded if they were diagnosed with any disease, were taking medications, or had any medical conditions that could affect growth, maturation, physical activity, nutritional status, or metabolism. Written informed consent was obtained from participants. The study was conducted in accordance with the Declaration of Helsinki and approved by the Ethics Committee of Capital Medical University (Approved number: Z2022SY008 and approval date: 9 March 2022).

Dietary intake assessment

The Food frequency questionnaire (FFQ) of the 2002 China National Nutrition and Health Survey (CNHS 2002),[15] was used to collect dietary energy, Na, and K intakes information (n = 488), which was calculated according to the Chinese Food Compositions Table.[16] All foods were classified into 28 groups (Supplementary Table 1) according to their nutritional profile. We calculated the total Na and K intake (tertiles) and the contribution (percentage of total Na or K intake) of each food group, and the ratio of Na/K intake (D[Na+]/[K+]).

Participants were classified into three groups according to the tertiles of Na intake from FFQ (≤3066, 3067-3912, ≥3913), K intake from FFQ (≤1301, 1302-1993, ≥1994) and D[Na+]/[K+] (≤1.78, 1.78-2.60, ≥2.60) separately. In addition, PI-NCD and AI of Chinese were also used as cut-points to classify the different Na and K conditions of subjects.[17] Moreover, it included questions on age, sex, smoking habits, alcohol consumption, and sugar-sweetened beverages in the questionnaire. Sugar-sweetened beverages contained soft drinks, sports drinks, industrialized juices, industrialized tea, concentrated syrup, industrialized fruit nectar, etc.

Anthropometric and body compositions measures

Trained personnel measured participants' weight, height, and waist circumference (WC). Body mass index (BMI) was classified according to the standards of slim (<18.5 kg/m^2), normal (18.5-24 kg/m^2), overweight (24-28 kg/m^2), obesity (≥28 kg/m^2).[18] Waist-to-hip ratio (WHR) was calculated as WC divided by hip circumference in meters. Abdominal obesity was defined as WC ≥85cm for men and ≥80cm for women,[18] or WHR >0.90 for men and >0.85 for women.[19]

Body composition measurements were taken according to the manufacturer's protocol of the bioelectrical impedance analyzer (BIA, Inbody 770 Co., Seoul, Korea).[20] Visceral fat area (VFA) ≥80 cm^2 was defined as abdominal obesity. Total-body percentage fat (TBPF) ≥25 % for men and ≥30 % for women was defined as obesity.[21] The fat mass index (FMI) cutoff value for overfat was 7.75 kg/m^2 for men and 8.16 kg/m^2 for women.[22] For men, the cutoff value for low body muscle was 14.15 kg/m^2 for fat-free mass index (FFMI), 7.0 kg/m^2 for appendicular skeletal muscle mass index (ASMI), 9.2 kg/m^2 for skeletal muscle mass index (SMMI), 15.33 kg/m^2 for lean mass index (LMI) and 45.58 kg for body lean mass, separately. For women, the corresponding cutoff value was 13.82 kg/m^2 (FFMI), 5.7 kg/m^2 (ASMI), 7.4 kg/m^2 (SMMI), 12.07 kg/m^2 (LMI), and 31.42 kg (body lean mass), separately.[22-25]

We defined fat-related indicators including TBPF, VFA and FMI, while muscle-related indicators included FFMI, ASMI, SMMI, LMI and body lean mass. Weight, BMI, WC and WHR were the physique indicators.

Serum lipids measurement

The subjects who measured (n = 61) serum lipids including total cholesterol, high-density lipoprotein cholesterol (HDL-c), low-density lipoprotein cholesterol (LDL-c), and triglyceride (TG) by an enzymatic method in automatic biochemistry analyzer (Olympus AU480, Japan).[26] Non-HDL-c was expressed as total cholesterol minus HDL-c.

Statistical analysis

Shapiro-Wilk or Kolmogorov-Smirnov (KS) and Levene tests confirmed normal distribution and homogeneity of variances. It compared categorical variables using the chi-square test and continuous variables using the Mann-Whitney U test. The food groups ranked according to their contribution to Na and K intake by BMI groups.

To compare differences in selected characteristics between groups, the Kruskal-Wallis test followed by Bonferroni post hoc comparison was used for continuous variables and the chi-square test was used for categorical variables. Robust linear regression, instead of ordinary linear regression, was chosen to assess the association of D[Na+]/[K+], dietary Na intake and dietary K intake as the independent variables with TBPF, because robust linear regression mitigated the potential effects of the right-skewed distribution of variables on the regression fit.[27] Furthermore, it adjusted the factors of age, energy intake, alcohol intake, and sugar-sweetened beverages intake in the robust linear regression.

Logistic regression analyses were used to do the association assessment. In multivariate models, model-a was adjusted for sex, age, and alcohol intake; model-b was adjusted for sex, age, alcohol intake, and energy intake; model-c was adjusted for sugar-sweetened beverages intake instead of energy intake; model-d was more adjusted for both energy intake and sugar-sweetened beverages intake based on model-a. p of the rows and columns lower than 0.07 were listed.

It conducted all statistical analyses using the software package IBM SPSS Statistics version 21® (IBM Corp., Armonk, NY, USA). All tests were two-sided, and a $p<0.05$ indicates statistical significance..

RESULTS

Baseline characteristics

Data from 512 participants were analyzed, composed of 114 men and 398 women aged 18 to 31 years, which were shown in Table 1. The median dietary intakes of Na and K and D[Na+]/[K+] were 3507 (2912, 4212) mg/d, 1595 (1146, 2207) mg/d and 2.19 (1.63, 2.90).

There was no difference between two genders in age, WHR, dietary intake of K and several serum lipids (total cholesterol, non-HDL-c, and LDL-c). The nutritional status of TBPF, VFA, FMI, and blood of HDL-c in women was reported higher than in men. However, weight, BMI, height, WC, FFMI, ASMI, SMMI, LMI, body lean mass, intake from FFQ (energy, Na, D[Na+]/[K+], and sugar-sweetened beverages), alcohol intake, and TG were higher in men than women.

Food subgroups contribute to Na and K intake

Top 10 foods and beverage categories that contributed Na and K to participants' dietary intake were listed according to four BMI groups (Table 2). In the slim group, the top three foods contributing to daily Na intake were added salt (1879 mg/d, 68.9 %), sauce (234 mg/d, 9.16 %) and milk (188.9 mg/d, 7.40 %); in the normal group, added salt also took the lead (2113 mg/d, 69.4 %), and sauce (289 mg/d, 9.48 %) and milk (189 mg/d, 6.21 %) were followed; in overweight, added salt took the highest contribution (2648 mg/d, 71.9 %), then next was sauce (342 mg/d, 9.29 %), followed by milk (214 mg/d, 5.81 %); in obesity, top three were added salt (3518 mg/d, 72.3 %), sauce (489 mg/d, 9.35 %) and milk (299 mg/d, 6.14 %). Besides, in the slim group, the top three foods contributing to daily K intake were milk (461 mg/d, 37.4 %), red meat (237 mg/d, 19.2 %) and dark vegetables (86.7 mg/d, 7.02%); in the normal group, milk also took the lead (461 mg/d, 37.1 %), and dark vegetables(137 mg/d, 11.0 %) and red meat (118 mg/d, 9.53 %) were followed; in overweight, milk took the highest contribution (522 mg/d, 39.3 %), then next was

Table 1. Baseline characteristics of participants

	Total sample	Man	Woman	p
n	512	114	398	
Age, y	20.0 (19.0, 22.0)	20.0 (19.0, 21.0)	20.0 (19.0, 22.0)	0.360
Weight, kg	58.7 (53.4, 66.1)	71.6±12.3	56.9 (52.5, 62.4)	<0.001*
BMI, kg/m²	21.7 (20.3, 23.8)	22.6 (20.9,25.2)	21.5 (20.1, 23.6)	<0.001*
Slim, n (%)	34 (6.8)	6 (5.3) ‡, §, ¶	28 (7.3) ‡, §, ¶	<0.001*
Normal, n (%)	352 (70.7)	66 (58.4) †, §, ¶	286 (74.3) †, §, ¶	
Overweight, n (%)	85 (17.1)	26 (23.0) †, ‡, ¶	59 (15.3) †, ‡, ¶	
Obesity, n (%)	27 (5.4)	15 (13.3) †, ‡, §	12 (3.1) †, ‡, §	
Height, m	164 (159, 170)	175±6.05	162±5.88	<0.001*
Waist circumference, cm	77.7 (73.2, 82.8)	80.0 (74.3, 88.2)	77.0 (72.6, 81.9)	<0.001*
total-body percentage fat, %	30.2 (24.4, 34.3)	20.23±6.56	32.1 (27.9, 35.4)	<0.001*
Waist-hip ratio	0.84 (0.81, 0.87)	0.83 (0.80, 0.87)	0.84 (0.81, 0.87)	0.314
VFA, cm²	73.2 (55.4, 101)	56.3 (39.6, 72.9)	81.2 (59.5, 105)	<0.001*
FMI, kg/m²	6.40 (5.00, 8.00)	4.30 (3.30, 5.85)	6.90 (5.60, 8.20)	<0.001*
FFMI, kg/m²	15.1 (14.3, 16.8)	18.4±1.76	14.7 (14.1, 15.5)	<0.001*
ASMI, kg/m²	6.15 (5.73, 6.97)	7.77±0.71	5.90 (5.63, 6.33)	<0.001*
SMMI, kg/m²	8.14 (7.60, 9.20)	10.29±1.07	7.90 (7.50, 8.36)	<0.001*
LMI, kg/m²	14.2 (13.4, 15.8)	17.3±1.64	13.8 (13.2, 14.5)	<0.001*
Body lean mass, kg	37.7 (34.5, 44.1)	53.2±6.77	32.4 (34.0, 38.9)	<0.001*
Sugar-sweetened beverages, mL/d	35.0 (7.5, 105)	52.5 (7.5,250.0)	35.0 (7.5, 105)	0.007*
Alcohol intake, n (%)	118 (24.2)	35 (32.7)	83 (21.8)	0.020*
Total cholesterol, mmol/L	4.22±0.60	4.10±0.62	4.37±0.56	0.083
HDL-c, mmol/L	1.21 (1.10, 1.39)	1.13±0.17	1.27 (1.20,1.63)	<0.001*
Non-HDL-c, mmol/L	2.98±0.51	2.97±0.61	2.98±0.39	0.922
LDL-c, mmol/L	2.05 (1.83, 2.45)	2.21±0.57	2.02 (1.89,2.39)	0.569
TG, mmol/L	0.94 (0.68, 1.33)	1.11 (0.76,1.66)	0.75 (0.65,1.01)	0.006*
Intake from FFQ				
Energy, kcal/d	1781 (1424, 2296)	1965 (1604, 2575)	1692 (1384, 2230)	<0.001*
Sodium, mg/d	3507 (2912, 4212)	4450 (3774, 5316)	3292 (2775, 3909)	<0.001*
Potassium, mg/d	1595 (1146, 2207)	1639 (1208, 2449)	1581 (1124, 2149)	0.323
D[Na+]/[K+]	2.19 (1.63, 2.90)	2.91±1.32	2.11 (1.57, 2.68)	<0.001*

BMI, body mass index; VFA, visceral fat area; FMI, fat mass index; FFMI, fat-free mass index; ASMI, appendicular skeletal muscle mass index; SMMI, skeletal muscle mass index; LMI, lean mass index; FFQ, food frequency questionnaires; HDL-c, high-density lipoprotein cholesterol; non-HDL-c, total cholesterol minus HDL-c; LDL-c, low-density lipoprotein cholesterol; TG, triglyceride.

Data are shown in the format of mean ± SD, median (P25, P75), n (%) unless otherwise specified.

† $p < 0.05$, statistically different with slim

‡ $p < 0.05$, statistically different with normal

§ $p < 0.05$, statistically different with overweight

¶ $p < 0.05$, statistically different with obesity

* $p < 0.05$

Table 2. Dietary top 10 food and beverage groups contributing to sodium and potassium intake in college students

BMI		Slim			Normal	
Ranking	Food groups	mg/day	% contribution	Food groups	mg/day	% contribution
Sodium		2995±581			3411 (2888, 3960)	
1	Added salt	1879±352	68.9	Added salt	2113 (1844, 2677)	69.4
2	Sauce	234 (217, 256)	9.16	Sauce	289 (248, 373)	9.48
3	Milk	189 (63.5, 300)	7.40	Milk	189 (79.4, 316)	6.21
4	Bean products	78.3 (37.3, 245)	3.07	Bean products	110 (42.1, 224)	3.63
5	Red meat	68.6 (30.7, 68.6)	2.69	Fried food	60.8 (20.3, 122)	2.00
6	Processed meat	46.3 (43.0, 208)	1.81	Processed meat	46.3 (19.8, 139)	1.52
7	Flour	25.8 (6.5, 61.5)	1.01	Flour	38.8 (12.9, 61.5)	1.27
8	Eggs	25.8 (10.9, 51.7)	1.01	Dark vegetables	38.6 (12.2, 48.9)	1.27
9	Dark vegetables	24.4 (12.2, 48.9)	0.96	Red meat	34.3 (17.1, 68.6)	1.13
10	Poultry	20.6 (9.5, 41.2)	0.81	Eggs	33.3 (10.9, 51.7)	1.09
Potassium		1423 (1093, 1807)			1605 (1093, 2195)	
1	Milk	461 (155, 733)	37.4	Milk	461 (194, 738)	37.1
2	Red meat	237 (106, 237)	19.2	Dark vegetables	137 (43.3, 173)	11.0
3	Dark vegetables	86.7 (43.3, 173)	7.02	Red meat	118 (59.2, 237)	9.53
4	Poultry	72.2 (33.2, 144)	5.85	Bean products	81.4 (31.1, 165)	6.55
5	Bean products	57.8 (27.5, 181)	4.68	Poultry	57.0 (30.3, 114)	4.59
6	Fruits	50.9 (25.4, 65.6)	4.12	Fruits	50.9 (25.4, 102)	4.09
7	Dumpling	32.4 (10.8, 64,7)	2.62	Coarse grains	44.9 (15.0, 107)	3.61
8	Coarse grains	32.3 (6.4, 66.3)	2.62	Eggs	40.5 (13.2, 62.9)	3.26
9	Eggs	31.4 (13.2, 62.7)	2.55	Flour	38.7 (12.9, 61.4)	3.11
10	Light vegetables	31.0 (19.5, 92.9)	2.51	Dumpling	32.4 (16.2, 77.0)	2.60

Table 2. Dietary top 10 food and beverage groups contributing to sodium and potassium intake in college students (cont.)

BMI	Overweight			Obesity		
Ranking	Food groups	mg/day	% contribution	Food groups	mg/day	% contribution
Sodium		4207±998			4865 (4368, 5485)	
1	Added salt	2648 (2258, 3296)	71.9	Added salt	3518 (2837.8, 3863.1)	72.3
2	Sauce	342 (298, 398)	9.29	Sauce	489±119	9.35
3	Milk	214 (109, 359)	5.81	Milk	299 (189, 378)	6.14
4	Bean products	105 (57.4, 228)	2.86	Bean products	133 (45.5, 232)	2.73
5	Processed meat	92.6 (24.8, 185)	2.51	Fried food	122 (40.5, 164)	2.50
6	Fried food	60.8 (20.3, 173)	1.65	Processed meat	92.6 (0.00, 278)	1.90
7	Dark vegetables	37.6 (19.3, 48.9)	1.02	Flour	61.5 (25.8, 94.8)	1.26
8	Red meat	34.3 (23.0, 68.6)	0.93	Dark vegetables	38.6 (15.8, 87.5)	0.79
9	Flour	30.8 (25.8, 61.5)	0.84	Red meat	34.3 (27.1, 68.6)	0.70
10	Eggs	30.1 (12.9, 51.7)	0.82	Eggs	25.8 (10.9, 51.7)	0.53
Potassium		1611 (1324, 2464)			1783 (1256, 2644)	
1	Milk	522 (267, 876)	39.3	Milk	729 (461, 923)	45.2
2	Dark vegetables	134 (68.5, 173)	10.1	Dark vegetables	137 (55.9, 310)	8.49
3	Red meat	118 (79.3, 237)	8.92	Red meat	118 (93.5, 237)	7.34
4	Bean products	77.6 (42.4, 168)	5.84	Bean products	97.9 (33.6, 171)	6.07
5	Fruits	76.3 (32.0, 116)	5.75	Fruits	76.3 (26.7, 152.6)	4.73
6	Poultry	72.2 (31.7, 114)	5.44	Poultry	72.2 (12.6, 144)	4.47
7	Coarse grains	44.9 (15.0, 155)	3.38	Flour	61.4 (25.8, 94.6)	3.81
8	Eggs	36.7 (15.7, 62.9)	2.76	Light vegetables	48.9 (13.0, 111)	3.04
9	Dumpling	32.4 (12.1, 122)	2.44	Fried food	35.0 (11.7, 47.0)	2.17
10	Light vegetables	31.0 (13.0, 62.0)	2.33	Dumpling	32.4 (21.6, 97.1)	2.01

dark vegetables (134 mg/d, 10.1 %), followed by red meat (118 mg/d, 8.92 %); in obesity, top three were milk (729 mg/d, 45.2 %), dark vegetables (137 mg/d, 8.49 %), and red meat (118 mg/d, 7.34 %). In addition, we found the total amounts of Na in different BMI groups were significantly different, which was verified by an additional Kruskal-Wallis test ($p < 0.001$), but the difference was not found in K ($p = 0.098$).

Association between Na and K and body compositions

As shown in Table 3, BMI exceeding 24.0 kg/m^2 was identified as obesity and overweight, and non-obesity was BMI lower than 23.9 kg/m^2. For the men of overweight and obesity, the adjusted robust linear regression β value related to the effect of D[Na+]/[K+] on TBPF was 2.349 ($p < 0.001$). Moreover, for the women of non-obesity, the β value was 0.979 ($p < 0.001$). Except for the women of obesity and overweight, TBPF was significantly associated with dietary Na ($p < 0.05$), but the β values were markedly attenuated. No relations were found between dietary K and TBPF. These data surfaced that D[Na+]/[K+] had a more considerable effect on TBPF for the men of overweight and obesity.

The results obtained from the preliminary analysis of body compositions based on the tertiles of dietary Na intake, dietary K intake and D[Na+]/[K+], were set out in Table 4. There was an increasing tendency in physique indicators (weight, BMI, WC and WHR), fat-related indicators (VFA and FMI) and muscle-related indicators (FFMI, ASMI, SMMI, LMI and body lean mass) of the dietary Na tertile group ($p < 0.05$). Additionally, physique indicators (BMI and WC) and muscle-related indicators (FFMI, ASMI, SMMI, LMI and body lean mass) were increased in the dietary K tertile group ($p < 0.05$). Moreover, there was an increasing tendency in physique indicators (weight, WC and WHR) and muscle-related indicators (FFMI, ASMI, ASMI, SMMI, LMI and body lean mass) of the D[Na+]/[K+] tertile group ($p < 0.05$). There was no difference of age among the tertiles of dietary Na intake, dietary K intake and D[Na+]/[K+], separately ($p < 0.05$). The deference of sex was significant in the tertiles of dietary Na intake and D[Na+]/[K+].

In Table 5, physique indicators (weight) and muscle-related indicators (FFMI, ASMI, SMMI, LMI and body lean mass) in ≥2000mg/d and ≥3600 mg/d K consuming groups were significantly higher compared with <2000 mg/d and <3600 mg/d ($p < 0.05$). Furthermore, participants with ≥2000 mg/d K consumption had higher physique indicators (BMI and WC) than those with <2000 mg/d ($p < 0.05$).

Table 6 used logistic regression to analyze the relationship between the tertiles of dietary Na intake and body compositions quantitatively. Across increasing tertiles of dietary Na intake in model d, the odds ratio (OR) was increased significantly ($p < 0.05$) in TBPF (1.00, 2.77 and 6.19, respectively), WHR (1.00, 2.59 and 6.35, respectively), VFA (1.00, 2.34 and 7.17, respectively) and FMI (1.00, 2.67 and 9.54, respectively). On the contrary, with the increased dietary Na intake in model d, the OR decreased ($p < 0.05$) in ASMI (1.00, 0.39 and 0.19, respectively) and body lean mass (1.00, 0.20 and 0.02, respectively). Model a, b, c and d were significant in all indicators except FFMI.

As tertiles of dietary K intake increased (Table 7), both the OR of model-a and model-c in SMMI (3.63, 2.53 and 1.00, respectively) and LMI (18.19, 11.28 and 1.00, respectively) decreased.

DISCUSSION

The nutritional levels of minerals of youth were closely related to their physical growth. Several studies have shown an association between Na and K and body compositions. It is undoubtedly that the body health of youth would affect the follow-up health in middle and old age. Given this, we investigated the association between Na and K intake conditions and body compositions in youth. From the slim group to the obesity group, dietary Na and K intakes increased progressively. High Na and low K were likely to contribute to low muscle mass and obesity.

Table 3. Association of dietary sodium to potassium intake ratio, dietary sodium intake and dietary potassium intake with total-body percentage fat

	β	*p*
D[Na+]/[K+]		
Men of obesity and overweight	2.349	<0.001*
Men of non-obesity	0.716	0.242
Women of obesity and overweight	0.217	0.740
Women of non-obesity	0.979	<0.001*
Dietary sodium		
Men of obesity and overweight	0.003	0.031*
Men of non-obesity	0.002	0.031*
Women of obesity and overweight	0.001	0.428
Women of non-obesity	0.002	<0.001*
Dietary potassium		
Men of obesity and overweight	0.002	0.565
Men of non-obesity	0.001	0.686
Women of obesity and overweight	-0.000	0.097
Women of non-obesity	-0.001	0.069

Robust linear regression analyses were conducted between D[Na+]/[K+], dietary sodium and potassium intakes and total-body percentage fat adjusted for age, energy intake, alcohol intake and sugar-sweetened beverages intake.
*$p < 0.05$.

Table 4. Selected characteristics of subjects according to the tertiles (T) of dietary sodium intake, dietary potassium intake and dietary sodium to potassium intake ratio

	Dietary sodium				Dietary potassium			
	T1: ≤3066 mg/d	T2: 3067-3912 mg/d	T3: ≥3913 mg/d	*p*	T1: ≤1301 mg/d	T2:1302-1993 mg/d	T3: ≥1994 mg/d	*p*
Male, n (%)	5 (3.10) †, ‡	34 (20.90) †, §	68 (42.00) ‡, §	<0.001*	33 (20.20)	37 (22.70)	37 (22.80)	0.817
Age, y	20.0 (19.0, 22.0)	20.0 (19.0, 22.0)	20.0 (19.0, 21.0)	0.682	20.0 (19.0, 22.0)	20.0 (19.0, 22.0)	20.0 (19.0, 21.0)	0.394
Weight, kg	53.8 (48.2, 57.5) †, ‡	58.7 (54.0, 63.7) †, §	66.0 (59.4, 75.9) ‡, §	<0.001*	57.0 (51.9, 64.1) ‡	58.5 (53.2, 66.0)	60.7 (55.2, 68.5) ‡	0.002*
BMI, kg/m^2	20.7±1.99 †, ‡	21.4 (20.4, 23.6) †, §	23.6 (21.7, 25.7) ‡, §	<0.001*	21.1 (19.8, 23.3) †, ‡	22.0 (20.6, 24.2) †	22.1 (20.6, 23.8) ‡	0.001*
Waist circumference, cm	74.4±5.38 †, ‡	78.00±6.16 †, §	82.0 (77.4, 89.1) ‡, §	<0.001*	76.4 (71.3, 81.4) ‡	77.6 (73.6, 83.5)	78.8 (74.3, 83.3) ‡	0.020*
Total-body percentage fat, %	29.2±5.56	31.10 (24.90, 34.50)	30.4 (22.3, 35.6)	0.691	28.6±7.20	30.4 (24.8, 34.5)	31.1 (24.4, 34.6)	0.397
Waist-hip ratio	0.82 (0.80, 0.85) †, ‡	0.84 (0.81, 0.86) †, §	0.86 (0.82, 0.90) ‡, §	<0.001*	0.83 (0.81, 0.87)	0.84 (0.81, 0.87)	0.84 (0.81, 0.88)	0.456
VFA, cm^2	63.4 (52.1, 85.1) †, ‡	75.1 (56.7, 99.3) †	86.2 (61.6, 115) ‡	<0.001*	66.9 (52.3, 97.3)	76.6 (58.2, 99.7)	78.1 (56.4, 108)	0.112
FMI, kg/m^2	6.00 (4.90, 7.20) ‡	6.50±2.09	7.08±2.83 ‡	0.006*	6.29±2.21	6.69±2.02	6.76±2.55	0.093
FFMI, kg/m^2	14.6 (13.9, 15.2) †, ‡	15.0 (14.3, 16.4) †, §	16.7 (14.9, 18.8) ‡, §	<0.001*	15.0 (14.1, 16.2) ‡	15.1 (14.1, 16.9)	15.3 (14.4, 17.5) ‡	0.024*
ASMI, kg/m^2	5.81±0.49 †, ‡	6.12 (5.77, 6.77) †, §	6.94 (6.14, 7.85) ‡, §	<0.001*	5.99 (5.67, 6.69) ‡	6.13 (5.65, 6.86)	6.23 (5.82, 7.20) ‡	0.022*
SMMI, kg/m^2	7.81±0.65 †, ‡	8.05 (7.61, 8.90) †, §	9.01 (7.97, 10.5) ‡, §	<0.001*	8.06 (7.50, 8.85) ‡	8.12 (7.57, 9.19)	8.23 (7.75, 9.54) ‡	0.027*
LMI, kg/m^2	13.7±0.99 †, ‡	14.1 (13.4, 15.4) †, §	15.6 (14.0, 17.7) ‡, §	<0.001*	14.1 (13.2, 15.2) ‡	14.2 (13.3, 15.8)	14.3 (13.5, 16.5) ‡	0.028*
Body lean mass, kg	35.4±3.81 †, ‡	37.9 (34.9, 42.7) †, §	43.2 (37.5, 54.8) ‡, §	<0.001*	37.1 (34.2, 42.6) ‡	37.6 (34.1, 43.2)	38.4 (35.6, 46.3) ‡	0.020*

BMI, body mass index; VFA, visceral fat area; FMI, fat mass index; FFMI, fat-free mass index; ASMI, appendicular skeletal muscle mass index; SMMI, skeletal muscle mass index; LMI, lean mass index.
†The difference between T1 and T2: $p < 0.05$ by post hoc comparison
‡The difference between T1 and T3: $p < 0.05$ by post hoc comparison
§The difference between T2 and T3: $p < 0.05$ by post hoc comparison
*$p < 0.05$

Table 4. Selected characteristics of subjects according to the tertiles (T) of dietary sodium intake, dietary potassium intake and dietary sodium to potassium intake ratio (cont.)

	D[Na+]/[K+]			
	T1: ≤1.78	T2: 1.78-2.60	T3: ≥2.60	p
Male, n (%)	21 (13.0) ‡	27 (16.6) §	59 (36.2) ‡, §	<0.001*
Age, y	20.0 (19.0, 21.0)	20.0 (19.0, 22.0)	20.0 (19.0, 22.0)	0.174
Weight, kg	57.8 (53.0, 63.7) ‡	57.7 (52.7, 66.1) §	61.4 (55.5, 72.4) ‡, §	<0.001*
BMI, kg/m^2	21.6 (20.2, 23.2)	21.5 (20.0, 23.7)	22.00 (20.4, 24.2)	0.141
Waist circumference, cm	76.7 (72.4, 80.8) ‡	77.6 (73.1, 82.1) §	79.9 (73.5, 84.3) ‡, §	0.003*
Total-body percentage fat, %	30.3 (25.1, 34.4)	31.3 (26.0, 34.8)	28.2±7.72	0.083
Waist-hip ratio	0.83 (0.80, 0.86) ‡	0.83 (0.81, 0.87)	0.85 (0.82, 0.88) ‡	0.028*
VFA, cm^2	72.8 (54.9, 101)	74.8 (56.7, 103)	73.5 (55.7, 101)	0.838
FMI, kg/m^2	6.57±2.17	6.68±2.27	6.49±2.37	0.744
FFMI, kg/m^2	15.0 (14.3, 15.9) ‡	14.9 (14.1, 16.3) §	15.7 (14.5, 17.5) ‡, §	0.001*
ASMI, kg/m^2	6.01 (5.72, 6.47) ‡	6.06 (5.60, 6.73) §	6.42 (5.85, 7.52) ‡, §	<0.001*
SMMI, kg/m^2	8.03 (7.60, 8.60) ‡	7.95 (7.53, 8.80) §	8.46 (7.79, 9.78) ‡, §	<0.001*
LMI, kg/m^2	14.0 (13.4, 14.9) ‡	14.0 (13.3, 15.3) §	14.7 (13.6, 16.5) ‡, §	0.001*
Body lean mass, kg	36.8 (34.4, 40.4) ‡	37.2 (33.9, 42.3) §	39.8 (35.8, 49.9) ‡, §	<0.001*

BMI, body mass index; VFA, visceral fat area; FMI, fat mass index; FFMI, fat-free mass index; ASMI, appendicular skeletal muscle mass index; SMMI, skeletal muscle mass index; LMI, lean mass index.
†The difference between T1 and T2: $p < 0.05$ by post hoc comparison
‡The difference between T1 and T3: $p < 0.05$ by post hoc comparison
§The difference between T2 and T3: $p < 0.05$ by post hoc comparison
*$p < 0.05$

Table 5. Selected characteristics of subjects according to the PI-NCD and AI of dietary potassium intake

Dietary potassium	Subjects consuming ≤2000 mg/d	Subjects consuming ≥2000 mg/d	p	Subjects consuming ≤3600 mg/d	Subjects consuming ≥3600 mg/d	p
Weight, kg	57.6 (52.6, 64.5)	60.8 (55.2, 68.8)	0.001*	58.6 (53.3, 65.5)	67.3±14.4	0.023*
BMI, kg/m^2	21.5 (20.1, 23.7)	22.1 (20.6, 23.8)	0.012*	21.7 (20.2, 23.7)	23.6±3.79	0.094
Waist circumference, cm	77.0 (72.6, 82.6)	78.9 (74.2, 83.3)	0.044*	77.7 (73.0, 82.8)	79.7 (75.7, 84.2)	0.168
total-body percentage fat, %	29.7 (24.5, 34.3)	31.1 (24.4, 34.7)	0.575	30.3 (24.5, 34.3)	27.3±8.82	0.308
Waist-hip ratio	0.84 (0.81, 0.87)	0.84 (0.81, 0.88)	0.555	0.84 (0.81 ,0.87)	0.84 (0.81, 0.87)	0.703
VFA, cm^2	72.8 (55.1, 99.8)	78.5 (56.1, 108)	0.194	73.5 (55.3, 102)	68.3 (56.1, 113)	0.968
FMI, kg/m^2	6.30 (5.10, 7.98)	6.76±2.57	0.354	6.40 (5.00, 8.00)	6.61±2.91	0.777
FFMI, kg/m^2	15.0 (14.1, 16.4)	15.3 (14.4, 17.6)	0.009*	15.1 (14.3, 16.6)	17.0±2.18	0.003*
ASMI, kg/m^2	6.06 (5.65, 6.83)	6.23 (5.83, 7.22)	0.006*	6.10 (5.72, 6.87)	6.89 (5.92, 7.84)	0.013*
SMMI, kg/m^2	8.08 (7.54, 8.93)	8.23 (7.76, 9.60)	0.011*	8.11 (7.59, 9.02)	9.32±1.39	0.004*
LMI, kg/m^2	14.1 (13.3, 15.4)	14.3 (13.5, 16.5)	0.011*	14.2 (13.4, 15.6)	15.9±2.07	0.004*
Body lean mass, kg	37.5 (34.1, 43.0)	38.4 (35.6, 46.5)	0.004*	37.6 (34.4, 43.1)	45.1 (36.2, 56.0)	0.014*

BMI, body mass index; VFA, visceral fat area; FMI, fat mass index; FFMI, fat-free mass index; ASMI, appendicular skeletal muscle mass index; SMMI, skeletal muscle mass index; LMI, lean mass index.
*$p < 0.05$

Table 6. Relationship between the tertiles (T) of dietary sodium intake and body compositions

	T1		T2		T3	
	OR (95% CI)	*p*	OR (95% CI)	*p*	OR (95% CI)	*p*
Dietary sodium intake						
Total-body percentage fat						
Obesity†	1		2.80 (1.72, 4.55)	<0.001*	6.28 (3.49, 11.32)	<0.001*
Obesity‡	1		2.79 (1.70, 4.57)	<0.001*	6.19 (3.17, 12.09)	<0.001*
Obesity§	1		2.72 (1.67, 4.43)	<0.001*	5.83 (3.23, 10.53)	<0.001*
Obesity¶	1		2.77 (1.69, 4.56)	<0.001*	6.19 (3.16, 12.10)	<0.001*
Waist-hip ratio						
Abdominal obesity†	1		2.52 (1.46, 4.32)	0.001*	5.97 (3.37, 10.57)	<0.001*
Abdominal obesity‡	1		2.57 (1.48, 4.46)	0.001*	6.34 (3.30, 12.15)	<0.001*
Abdominal obesity§	1		2.50 (1.45, 4.31)	0.001*	5.93 (3.34, 10.52)	<0.001*
Abdominal obesity¶	1		2.59 (1.47, 4.45)	0.001*	6.35 (3.31, 12.19)	<0.001*
VFA						
Abdominal obesity†	1		2.31 (1.29, 4.15)	0.005*	6.52 (3.59, 11.86)	<0.001*
Abdominal obesity‡	1		2.37 (1.31, 4.30)	0.004*	7.06 (3.59, 13.89)	<0.001*
Abdominal obesity§	1		2.25 (1.25, 4.04)	0.007*	6.32 (3.47, 11.52)	<0.001*
Abdominal obesity¶	1		2.34 (1.29, 4.25)	0.005*	7.17 (3.64, 14.14)	<0.001*
FMI						
Overfat†	1		2.60 (1.38, 4.91)	0.003*	8.14 (4.30, 15.42)	<0.001*
Overfat‡	1		2.72 (1.43, 5.19)	0.002*	9.26 (4.51, 19.01)	<0.001*
Overfat§	1		2.50 (1.32, 4.73)	0.005*	7.80 (4.11, 14.81)	<0.001*
Overfat¶	1		2.67 (1.39, 5.11)	0.003*	9.54 (4.62, 19.71)	<0.001*
FFMI						
Low muscle mass†	1		0.76 (0.41, 1.38)	0.360	0.28 (0.12, 0.67)	0.004*
Low muscle mass§	1		0.80 (0.44, 1.47)	0.477	0.30 (0.13, 0.71)	0.006*
ASMI						
Low muscle mass†	1		0.37 (0.23, 0.62)	<0.001*	0.17 (0.09, 0.31)	<0.001*
Low muscle mass‡	1		0.39 (0.23, 0.65)	<0.001*	0.19 (0.09, 0.39)	<0.001*
Low muscle mass§	1		0.38 (0.23, 0.63)	<0.001*	0.17 (0.09, 0.33)	<0.001*
Low muscle mass¶	1		0.39 (0.23, 0.66)	<0.001*	0.19 (0.09, 0.39)	<0.001*
SMMI						
Low muscle mass†	1		0.62 (0.36, 1.06)	0.080	0.13 (0.06, 0.30)	<0.001*
Low muscle mass‡	1		0.76 (0.43, 1.34)	0.340	0.24 (0.09, 0.59)	0.002*
Low muscle mass§	1		0.63 (0.37, 1.08)	0.090	0.14 (0.06, 0.31)	<0.001*
Low muscle mass¶	1		0.76 (0.43, 1.34)	0.337	0.24 (0.09, 0.59)	0.002*
LMI						
Low muscle mass†	1		0.24 (0.06, 0.96)	0.044*	0.02 (0.00, 0.15)	<0.001*
Low muscle mass‡	1		0.29 (0.07, 1.21)	0.089	0.05 (0.01, 0.36)	0.003*
Low muscle mass§	1		0.23 (0.06, 0.93)	0.039*	0.02 (0.00, 0.13)	<0.001*
Low muscle mass¶	1		0.30 (0.07, 1.24)	0.096	0.04 (0.01, 0.32)	0.002*
Body lean mass						
Low muscle mass†	1		0.18 (0.07, 0.51)	0.001*	0.02 (0.00, 0.09)	<0.001*
Low muscle mass‡	1		0.20 (0.07, 0.56)	0.002*	0.02 (0.00, 0.13)	<0.001*
Low muscle mass§	1		0.18 (0.07, 0.50)	0.001*	0.02 (0.00, 0.08)	<0.001*
Low muscle mass¶	1		0.20 (0.07, 0.59)	0.002*	0.02 (0.00, 0.13)	<0.001*

VFA, visceral fat area; FMI, fat mass index; FFMI, fat-free mass index; ASMI, appendicular skeletal muscle mass index; SMMI, skeletal muscle mass index; LMI, lean mass index; CI, confidence interval; OR, odds ratio.

† model-a adjusted for sex, age and alcohol intake.

‡ model-b adjusted for sex, age, alcohol intake and energy intake.

§ model-c adjusted for sex, age, alcohol intake and sugar-sweetened beverages intake.

¶ model-d adjusted for sex, age, alcohol intake, energy intake and sugar-sweetened beverages intake.

*$p < 0.05$.

There was significant difference in dietary Na intake between men and women. Men's median dietary Na intake of men was 4450 mg/d, while that of women was 3292 mg/d. The difference of dietary K intake between men and women was not statistically significant. D[Na+]/[K+] in men was also higher than in women. Moreover, this study has shown that all participants consumed excessive amounts of Na according to the PI-NCD and AI (2000 and 1500 mg/d).[17] On the contrary, only 4.7% and 32.6% of participants consumed sufficient amounts of K according to the PI-NCD and AI (3600 and 2000 mg/d) for dietary K. It illustrated that our subjects had typical problems of excessive Na intake and insufficient K intake of most people. The China Health and Nutrition Survey has shown that only 15.4% of the participants consumed Na ≤2000 mg/d in 2015, PI-NCD recommended by China, and about 81% of the population had K intake <2000 mg/d, AI of Chinese in 2015. It also has been reported that D[Na+]/[K+] decreased from 4.1 in 1991 to 3.1 in 2015.[13]

Moreover, we explored the sources of Na and K in different BMI groups. Results showed that the main food sources of dietary Na were added salt, sauce as well as milk, and the main food sources of dietary K were milk, dark vegetables and red meat. First, the data of the Mex-

Table 7. Relationship between the tertiles (T) of dietary potassium intake and insufficient K (according to the PI-NCD), and body compositions

	T1		T2		T3		Insufficient K ≤2000 mg/d	
	OR (95% CI)	*p*	OR (95% CI)	*p*	OR (95% CI)	*p*	OR (95% CI)	*p*
Dietary Potassium Intake								
Body mass index (kg/m^2)								
Slim†	3.30 (1.05,10.35)	0.041*	4.20 (1.35,13.09)	0.013*	1		3.62 (1.24,10.55)	0.019*
Slim§	3.36 (1.06,10.61)	0.039*	4.26 (1.36,13.34)	0.013*	1		3.68 (1.25,10.81)	0.018*
Overweight‡	0.95 (0.40,2.26)	0.900	2.02 (1.01,4.07)	0.048*	1		1.64 (0.81,3.31)	0.171
Overweight¶	0.93 (0.39,2.22)	0.867	2.01 (1.00,4.04)	0.051	1		1.62 (0.80,3.27)	0.181
Waist circumference								
Abdominal obesity†	0.51 (0.27,0.95)	0.035*	0.66 (0.37,1.19)	0.167	1		0.57 (0.34,0.96)	0.032*
Abdominal obesity§	0.54 (0.29,1.02)	0.058	0.70 (0.38,1.26)	0.231	1		0.61 (0.36,1.02)	0.059
total-body percentage fat								
Obesity†	0.60 (0.37,0.97)	0.035*	0.99 (0.61,1.59)	0.953	1		0.76 (0.50,1.15)	0.188
Waist-hip ratio								
Abdominal obesity†	0.62 (0.38,1.01)	0.057	0.70 (0.43,1.14)	0.149	1		0.67 (0.44,1.02)	0.060
Abdominal obesity§	0.63 (0.39,1.04)	0.069	0.71 (0.44,1.16)	0.169	1		0.68 (0.45,1.04)	0.073
VFA								
Abdominal obesity†	0.62 (0.37,1.03)	0.064	0.68 (0.41,1.11)	0.123	1		0.63 (0.41,0.96)	0.034*
FMI								
Overfat†	0.56 (0.33,0.95)	0.031*	0.76 (0.46,1.27)	0.298	1		0.64 (0.41,0.99)	0.046*
Overfat§	0.59 (0.35,1.02)	0.058	0.81 (0.48,1.35)	0.416	1		0.68 (0.43,1.06)	0.090
FFMI								
Low muscle mass†	2.29 (1.09,4.81)	0.029*	2.30 (1.09,4.80)	0.028*	1		2.23 (1.14,4.37)	0.020*
Low muscle mass§	2.20 (1.04,4.63)	0.038*	2.24 (1.07,4.72)	0.033*	1		2.15 (1.10,4.24)	0.026*
ASMI								
Low muscle mass†	2.81 (1.59,4.95)	<0.001*	2.82 (1.60,4.98)	<0.001*	1		2.94 (1.74,4.94)	<0.001*
Low muscle mass‡	1.89 (0.80,4.44)	0.145	2.19 (1.09,4.39)	0.027*	1		2.31 (1.15,4.67)	0.019*
Low muscle mass§	2.72 (1.54,4.80)	0.001*	2.76 (1.56,4.88)	<0.001*	1		2.86 (1.69,4.82)	<0.001*
Low muscle mass¶	2.01 (0.86,4.72)	0.108	2.28 (1.14,4.57)	0.020*	1		2.41 (1.20,4.86)	0.014*
SMMI								
Low muscle mass†	3.72 (1.93,7.17)	<0.001*	2.58 (1.32,5.06)	0.006*	1		3.04 (1.65,5.60)	<0.001*
Low muscle mass§	3.63 (1.88,7.00)	<0.001*	2.53 (1.29,4.97)	0.007*	1		2.97 (1.61,5.48)	<0.001*
LMI								
Low muscle mass†	16.79 (2.10,134.16)	0.008*	10.50 (1.29,85.59)	0.028*	1		13.26 (1.74,101.11)	0.013*
Low muscle mass§	18.19 (2.15,153.60)	0.008*	11.28 (1.32,96.56)	0.027*	1		14.23 (1.77,114.18)	0.012*
Body lean mass								
Low muscle mass†	6.10 (1.73,21.49)	0.005*	7.10 (2.04,24.71)	0.002*	1		6.50 (1.95,21.60)	0.002*
Low muscle mass§	5.94 (1.68,21.01)	0.006*	6.95 (1.99,24.23)	0.002*	1		6.35 (1.91,21.15)	0.003*

VFA, visceral fat area; FMI, fat mass index; FFMI, fat-free mass index; ASMI, appendicular skeletal muscle mass index; SMMI, skeletal muscle mass index; LMI, lean mass index; CI, confidence interval; OR, odds ratio.

†model-a adjusted for sex, age and alcohol intake.

‡model-b adjusted for sex, age, alcohol intake and energy intake.

§model-c adjusted for sex, age, alcohol intake and sugar-sweetened beverages intake.

¶model-d adjusted for sex, age, alcohol intake, energy intake and sugar-sweetened beverages intake.

*$p < 0.05$

ican National Health and Nutrition Survey 2016 has shown that the primary food groups contributing to a high Na intake in adults were added salt, cereals and red meat.[28] Regarding K intake, this population has shown that vegetables, fruits and corn tortillas contributed most of the intake of this nutrient. A cross-sectional analysis based on data from the China National Nutrition and Health Surveillance (CNNHS) reported that subjects from the north (7.1%) consumed a greater proportion of Na from flour products compared with subjects in the south (1.4%).[12] It also showed that urban adults aged 18 to 49 obtained a higher proportion of Na from processed food (8.1%) compared with rural adults aged 18 to 49 (4.4%). Hence, the sources of Na and K were mainly related to dietary habits and nutritional conditions. Second, in our study, the total amounts of Na in different BMI groups were significantly different, which was verified by an additional Kruskal-Wallis test (p <0.001), but the difference was not found in K (p = 0.098). And from the slim to obesity group, dietary Na intakes increased gradually. In addition, we found that muscle-related indexes were higher in the group exceeding PI-NCD and AI than in the group without. A study in China pointed out that a high-Na diet was one of the top four risk factors for both number of deaths and percentage of disability-adjusted life-years in 2017.[29] A research has noted that K deficiency was related to a decreased muscle mass.[30] Therefore, a diet low in Na and high in K was beneficial to weight control and muscle increase for people with overweight and obesity. We also found that weight, BMI and WC in ≥2000 mg/d K consumption were significantly higher than <2000 mg/d. People should also pay attention to controlling total dietary energy intake when increasing dietary K intake. And low Na diet because of its light taste might help this population control total food intake.

In this study, BMI of around 70% of participants was normal. Compared to men, the slim proportion of women was much higher, while more men tended to be obese than women because of higher weight, BMI and WC. Another research has also confirmed this result that men (BMI = 24.5 kg/m^2 and 25.1 kg/m^2) had higher BMI than women (BMI = 24.3 kg/m^2 and 23.9 kg/m^2) both in rural and urban areas.[31] However, BMI had certain limitations when used to evaluate obesity. For example, men with developed muscles were more likely to be wrongly considered obese because of their high weight. As discussed by others, BMI was not an optimal measure of obesity, in particular not in groups of patients with extraordinarily low or high lean body mass.[32] Therefore, it was more accurate to evaluate overweight and obesity objectively by measuring the body compositions of youth. In our research, FFMI, ASMI, SMMI, LMI and body lean mass were higher in men than women. However, women had higher TBPF, VFA and FMI than men. It could be explained that men had higher muscle mass than women.

More importantly, we further studied the influence of dietary Na and K intake on body compositions. In overweight/obesity men, D[Na+]/[K+] and dietary Na were positively correlated with TBPF. According to the comparison of tertiles, every index of body compositions except TBPF increased with dietary Na intake. As dietary K intake increased, FFMI, ASMI, SMMI, LMI and body lean mass in body compositions also increased. Logistic regression analyzed correlation furthermore. There were dose-response relationships between dietary Na intake and TBPF, WHR, VFA, FMI, ASMI and body lean mass, pointing out that increased dietary Na intake would increase the risk of obesity and overweight, while lower dietary Na intake was associated with the risk of low muscle mass. The above evidence could explain the importance of appropriate dietary Na intake. Too low and high sodium intake were both not recommended among youth. Moreover, low dietary K intake did not doubt to be a critical factor in the risk of low muscle mass, which might be affected by energy intake. After adjusting sex, age, alcohol intake, energy intake and sugar-sweetened beverages intake, different results showed that the influence of Na on body compositions was more significant than that of K. These results were also supported by the research that higher dietary K intake tended to be associated with decreased odds for low muscle mass.[33] The above result indicated that dietary Na intake was related to fat accumulation, and K intake was associated with muscle increase.

In a multiethnic, population-based cohort study, Jain et al. has reported that the dietary ratio of Na/K intake may be independently associated with TBPF.[34] Among our teenage subjects, the median D[Na+]/[K+] was 2.2, lower than the previous report. On the one hand, it implied that the youth's current dietary Na and K intakes were better than before. On the other hand, the national salt reduction initiative has been proven partially effective. There were a lot of evidence showing that high sodium intake increases hypertension and mortality from CVD.[35-37] A growing literature has shown that increased K intake has the potential to reduce cardiovascular risk factors and blood pressure.[38,39] Hence, youth still needed to control dietary Na intake and increase dietary K intake, especially for men.

Compared with other research, the strengths of our study include its stringent quality control procedures; use of different indices of obesity and sarcopenia; 4 models to adjust for confounders; exploration of the association between dietary Na and K intake and body composition; and offer feasible suggestions to prevent obesity from a dietary point of view.

Our study had several limitations. First of all, in conjunction with other evidence from experimental, cross-sectional as well as prospective cohort studies, our study indicated that high Na and low K were likely to be a contributing factor for low muscle mass and obesity, but we could not exclude the possibility that adiposity might predispose people to a higher Na and lower K consumption independent of other confounders. Secondly, FFQ might be subject to recall bias, despite being previously validated. Thirdly, our research objects were only college students and the sample size was relatively small. If we want to extend the results to the whole people, we should expand the target population to carry out large-scale surveys.

Conclusion

College students are a vital group with high dietary Na and abnormal body compositions. High dietary Na is a risk factor for abnormal lipid distribution in college students. High dietary K can maintain skeletal muscle mass and reduce the risk of obesity. Na in the diet has a greater impact on the body composition of young people than K. Low dietary

Na and high dietary K still need to be strengthened in science popularization and practice among more college students.

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CONFLICT OF INTEREST AND FUNDING DISCLOSURES

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