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Age-Dependent Contributions of Neck Circumference to Indices of Obesity Among Female College Students Aged 18 to 20 Years

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ABSTRACT

Measurement of neck circumference (NC) is an easy method to assess obesity. Our investigation to estimate risks for metabolic disease in Japanese postmenopausal women indicated that NC is significantly associated with whole-body obesity indices and visceral fat accumulation. To clarify the early stage of metabolic changes and confirm NC validity as a predictor of metabolic syndrome, NC's association to the four obesity indices, namely, weight, body mass index (BMI), body fat, and waist circumference (WC), was examined in a college student group of 60 females aged 18.7±0.3 years. NC was mainly correlated with weight, followed by BMI, WC, and body fat. It was also significantly associated with weight and BMI, but not with body fat. The participants were divided into two subgroups: "sports-experienced" and "not-sports-experienced," who had moderate and strong correlation coefficients with NC and WC, respectively. WC value was possibly predicted by NC values using linear functions for the group and its subgroups. The correlation between NC and WC, NC's association to weight, and substitution of NC to WC were confirmed by the same analyses in another student group composed with 18 females aged 19.7±0.6 years. Our study showed that the distribution of body fat in college students is difficult to assess based on NC alone. Nevertheless, NC measurement is an easy, inexpensive, and reproducible method to assess obesity and a possible predictor to identify the risk for future metabolic diseases in Japanese college students with the four obesity indices, weight, BMI, body fat, and WC.

Key words: *Neck circumference, Body composition, young adult female, multiple regression analysis*

Measurement of neck circumference (NC) is a convenient method to assess thyroid- and obesity-related diseases. NC screening detected nutritional iodine deficiency, endocrinologic disorders, and thyroid tumours[8,11)]. Large NC was found to be associated with obstructive sleep apnoea in adults and children[5, 10, 12, 13, 18)] or with the prevalence of type 2 diabetes[4)]. We reported the possibility of NC as a predictor for metabolic syndrome in Japanese postmenopausal women[1)]. NC was associated with visceral fat accumulation and whole-body obesity indices as shown by the waist circumference (WC) and body mass index (BMI), respectively. It was also correlated with the three glucose metabolism indices, *i.e.*, glycated haemoglobin, homeostasis model assessment ratio, and leptin levels. Furthermore, NC was associated with the two fat metabolism indices, *i.e.*, increased triglyceride and decreased high-density lipoprotein cholesterol levels. Our recent study indicated the association of NC with brachial-ankle pulse wave velocity, one of cardiometabolic risk indicies[2)].

How old does abdominal obesity or advanced whole-body obesity start in Japanese women? How

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much does the NC index contribute to determine individual obesity? To answer these questions, this study aimed to predict the early stage of metabolic changes and to confirm the validity of NC as a predictor for metabolic syndrome[1, 2]. Among the four obesity indices, weight, BMI, and WC were recommended to evaluate obesity in school-age children[6], while the body fat index was for young women[17]. Because data on female NC aged 18–20 years have been limited, we measured NC in college students and assessed its association to the four obesity indices, *i.e.*, weight, BMI, body fat, and WC.

MATERIALS AND METHODS

(1) Study population

The participants were female college students, and all of them provided written informed consent. The study protocol was approved by the education and research committee of Suzugamine Women's College (# 2015-01).

Data of the 60 participants who had completed all the four tests, anthropometric, blood pressure, grip strength, and lifestyle assessments, were used for statistical analyses. The tests were conducted from April to July 2015. Data of the other 18 participants who had completed the same tests in April 2016 were used for further statistical analyses.

(2) Anthropometric measurements

Height, weight, BMI, body fat percentage, NC, WC, and arm, forearm, wrist, thigh, leg, and ankle circumferences were examined. Height was measured to the nearest 1 mm by a stadiometer. Body weight was assessed to the nearest 0.05 kg by a digital scale. BMI was calculated as weight divided by height squared (kg/m^2). Body fat percentage was measured by a body-fat-meter (EW-FA13, Panasonic Co. Ltd., Osaka, Japan). Positions of circumferences to be measured were shown to the individual participant by an anatomical picture (Fig. 1). Circumference measurements were performed to the nearest 1 mm using flexible tape measures. WC was measured at the level of umbilicus in a standing position. NC was measured at three levels above, on, and below the laryngeal prominence.

(3) Measurements of blood pressure

Every participant rested for 5 min in a sitting position before measuring the blood pressure. Systolic and diastolic blood pressure (SBP and DBP, respectively) were measured twice from each right and left brachial arteries using a sphygmomanometer.

(4) Measurements of grip strength

To measure the maximum isometric strength of the hand and forearm muscles, grip strength was assessed to the nearest 0.2 kg using a dynamometer (Camry Co. Ltd., Zhongshan, China). The participant held the dynamometer in his/her hand with the arm stretched down at the side of the body. The handle of the dynamometer was adjusted, so as the base should rest on metacarpus, while the handle should rest on the middle phalanx of four fingers. The participant squeezed the dynamometer with maximum effort for 5 s.

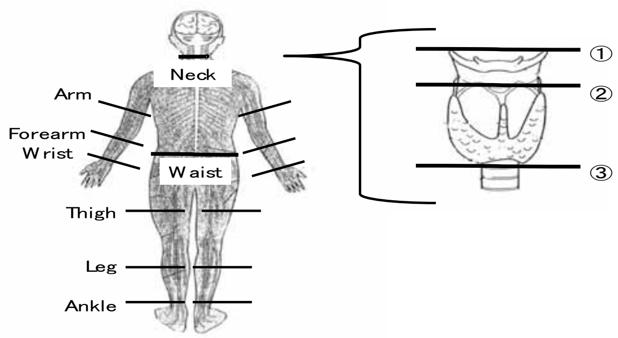

Fig. 1. Diagram of the body circumferences to be measured.
To measure neck circumferences (NC), three levels around the thyroid (above [Neck①)], on [Neck②)], and below [Neck③)] the laryngeal prominence) are measured and shown to the participants.

(5) Lifestyle assessments

Participants completed questionnaires regarding their dietary habits, sports experiences, and experienced diseases by a self-notation[7].

(6) Statistical analyses

Student's *t*-test was used to assess the reliability of data. Pearson's coefficient of correlation was used to assess the anthropometric data. Correlation coefficient of ≤0.4 with p-value of <0.05 was considered significant. Multiple regression analyses were used to compare the contribution rate of NC to the four indices, weight, BMI, body fat, and WC. Multiple logistic regression and factor analyses were performed to examine the effects of dietary habit, sports exercise experiences, and experienced diseases on the anthropometric variables. The software, EXCEL multiple regression analysis version 3 (ESUMI, Tokyo, Japan), was used for all statistical analyses.

RESULTS

(1) Univariate analyses

All 60 participants were Japanese young women living in a geographically local area at the western part of Japan (Table 1) with the mean age of 18.7±0.3 years and BMI of 20.5±2.7 kg/m^2, with 20.0% underweight (BMI<18.5) and 6.7% over-

Table 1. Anthropometric measurements of the participants.

		Group (n=60) a	Subgroups of the group (n=60) a, b: Sports-experienced (n=16)	Not-sports-experienced (n=34)	t-test nt-test n	F-test n	Group (n=18) a	School healthcare statistical survey, 2014
Age (years)		18.7 ± 0.3	18.7 ± 3.8	18.6 ± 3.2	n.s.	n.s.	19.7 ± 0.6	18, 19, 15-19 or 20-29 years old
Height (cm)		157.7 ± 5.9	161.6 ± 6.5 k	156.1 ± 5.0	$p<0.01$	n.s.	158.2 ± 4.7	159.0 and 157.7 cm for 18 and 19 years old, respectively
Weight (kg)		51.2 ± 8.5	56.6 ± 8.8 k	48.5 ± 6.2 k	$p<0.05$	n.s.	50.7 ± 6.6	50.9 and 47.7 kg for 18 and 19 years old, respectively
BMI (kg/m^2)		20.5 ± 2.7 g	21.6 ± 2.3 l	19.9 ± 2.5 l	n.s.	n.s.	20.1 ± 2.6	Not shown
Body fat (%)		23.6 ± 5.2	26.2 ± 4.6	22.6 ± 5.1	n.s.	n.s.	29.4 ± 6.9	Not shown
Circumference (cm)	Waist	66.6 ± 6.1	68.4 ± 6.8 m	65.9 ± 5.3 m	n.s.	n.s.	69.2 ± 6.3	Not shown
	Neck c	31.6 ± 2.0 h	32.5 ± 1.6	31.3 ± 1.8	n.s.	n.s.	31.4 ± 1.7	
	Arm d	23.7 ± 3.4	25.4 ± 4.2	23.1 ± 2.7	n.s.	n.s.	22.6 ± 4.9	
	Forearm c	21.2 ± 1.7	21.5 ± 1.7	21.0 ± 1.8	n.s.	n.s.	22.0 ± 1.6	
	Wrist d	14.7 ± 1.4	15.6 ± 2.0	14.4 ± 1.0	$p<0.05$	$p<0.000$	15.8 ± 4.0	
	Thigh d	45.6 ± 4.3	48.2 ± 4.2	44.5 ± 3.9	$p<0.01$	n.s.	38.9 ± 10.5	
	Leg d	33.0 ± 2.9	33.8 ± 2.6	32.7 ± 3.0	n.s.	n.s.	32.9 ± 2.5	
	Ankle d	20.5 ± 1.5	21.1 ± 1.4	20.1 ± 1.4	n.s.	n.s.	25.7 ± 11.7	
Blood pressure	SBP average (mmHg)	100.4 ± 9.4 i	99.6 ± 8.1	100.9 ± 10.1	n.s.	n.s.	103.7 ± 10.5	Not shown
	DBP average (mmHg)	60.4 ± 7.0 j	59.9 ± 7.1	60.5 ± 7.1	n.s.	n.s.	66.2 ± 8.1	
Grip strength (kg) d, f		23.3 ± 5.529	26.6 ± 3.3	22.1 ± 5.1	$p<0.01$	n.s.	25.6 ± 5.7	26.4 and 26.6 kg for 18 and 19 years old, respectively

BMI: body mass index; SBP: systolic blood pressure; DBP: diastolic blood pressure; n.s.: not specific.

a shown as Mean ±SD except BMI % and Blood pressure %.
b n=50. Ten students who did not answer the question about sports experiences were excluded.
c The average value of the 3 times or level measurement was used as representative of individual.
d The average value of the 6 times measurement was used as representative of individual.
e The average value of the 4 times measurement was used as representative of individual.
f 95% CI is 14.0 – 33.7 kg for right grip strength and 14.0–31.3 kg for left grip strength. Values of 59 participants are in the range of 95% CI.
g Value distribution was underweight (BMI<18.5) for 20.0%, standard weight (18.5≦BMI≦25.0) for 73.3%, and overweight (BMI>25.0) for 6.7%.
h Ratios of average NC/WC and average NC/height were 0.48±0.03 and 0.20±0.01, respectively.
i SBP correlated with height (R=0.300, $p<0.023$) weakly. Pearson's correlation analysis.
j DBP correlated with height (R=0.189, $p<0.152$) weakly. Pearson's correlation analysis.
k NC moderately correlated with height (R=0.600, $p<0.000$) and weight (R=0.582, $p<0.000$) in the sports-experienced subgroup, and strongly correlated with weight (R=0.741, $p<0.000$) strongly in the not-sports-experienced subgroup. Pearson's correlation analysis,
l WC strongly correlated with weight (R=0.784, $p<0.000$) and BMI (R=0.724, $p<0.000$) in the sports-experienced subgroup and strongly correlated with BMI (R=0.704, $p<0.000$) strongly in the not-sports-experienced subgroup. Pearson's correlation analysis,
m NC correlated with WC in the sports-experienced subgroup (R=0.544, $p<0.000$) and not-sports-experienced subgroup (R=0.467, $p<0.000$). Pearson's correlation analysis,
n Statistical significance between the two subgroups.
o Data from the Ministry of Education, Science and Sports, Japan.

weight (BMI>25.0) participants. Among the 60 participants, 57 had a 95% confidence interval (CI) of BMI (16.8–25.6). All participants showed normal SBP and DBP (≥119 mmHg for SBP and ≥79 mmHg for DBP). Hence, all participants were considered as a group with the standard normal distribution of BMI and blood pressures.

(2) Bivariate analysis

Table 2 shows the correlation coefficient values among the four obesity indices. The average NC value (average NC) was best correlated with weight (R=0.74, p<0.000), followed by BMI (R=0.67, p<0.000), WC (R=0.61, p<0.000), and body fat (R=0.46, p<0.000). Among the NC values at the three different levels, difference in the correlation coefficient to each index was statistically insignificant.

As the average NC moderately correlated with BMI (R=0.67, p<0.000), the distribution of body fat was examined using the two indices: neck-to-waist (NC/WC) and NC/height ratios. The average NC/WC ratio was 0.48±0.03 with the 95% CI of 0.41–0.54, and the average NC/height ratio was 0.20±0.01 with the 95% IC of 0.18–0.22 (Table 1).

Correlation coefficients between blood pressures and weight were low (R=0.30, p<0.023 for SBP and R=0.19, p<0.152 for DBP).

(3) Multivariate analyses

Outliers were not observed in anthropometric measurement data; hence, a brute force method of the multiple regression analysis was performed to obtain the standard partial regression coefficient (SRC) and variance inflation factor (VIF) values (Table 3). To explain the objective variable of weight, a combination of four explanatory variables, i.e., body fat, BMI, average NC, and WC, was best, where the average NC and WC highly contributed with the statistical significance (p<0.05 and p<0.01, respectively). However, to explain the objective variables of BMI and body fat, weight was excluded because of its high VIF score. To explain WC, the number of explanatory variables to each objective variable was two or three for the best-suited equations. WC was predictable from the average NC in the linear regression analysis (y=0.20 × + 18.2, p<0.000).

(4) Factor analyses

Sports exercise experiences during senior high school days influenced the wrist circumference values based on the logistic regression analyses (p<0.010) (Table 1). All participants could be divided into two subgroups: 'sports-experienced' and 'not-sports-experienced' using this index (p<0.01, based on multivariate logistic regression analysis). Weight, height, wrist circumference, and thigh circumference values were different from each other (p<0.05 for weight and wrist circumference, and p<0.01 for height and thigh circumference) based on *t*-test. The wrist circumference value of the sports-experienced subgroup was higher than that of not-sports-experienced (p<0.000) based on F-test. The grip strength value of the sports-experienced group was significantly higher than that of not-sports-experienced (p<0.010) based on *t*-test. Pearson's analyses indicated moderate and strong correlation coefficient between the average NC and WC (R=0.54, p<0.000 for the sports-experienced subgroup and R=0.74, p<0.000 for the not-sports-experienced subgroup).

To explain the objective weight variables, a combination of the four explanatory variables, i.e., body fat, BMI, average NC, and WC, was found, where BMI contribution was high (SRC=0.715, p<0.05) (Table 4). Regarding the objective variables of BMI and body fat, weight was not suitable as an explanatory variable because of its high VIF score. Regarding the objective WC variables, the number of explanatory variables was 2 or 3 for the best-suited equations, as the number of explanatory variables was 4, the VIF value of BMI exceeded 5. Linear regression analyses indicated the predict-

Table 2. Correlation coefficients between neck and waist circumferences and weight, BMI, body fat, and WC (n=60).

			NC			
			①	②	③	Average
	Size (Mean±SD, cm)		32.3±2.0	32.0±2.8	31.4±1.9	31.6±2.0
Indices	Weight	Correlation coefficient	0.60	0.62	0.60	0.74
		p-value	0.000	0.000	0.000	0.000
	BMI	Correlation coefficient	0.67	0.63	0.67	0.67
		p-value	0.000	0.000	0.000	0.000
	Body fat	Correlation coefficient	0.42	0.44	0.38	0.46
		p-value	0.018	0.013	0.036	0.010
	WC	Correlation coefficient	0.59	0.61	0.59	0.61
		p-value	0.000	0.000	0.000	0.000

BMI: body mass index; WC: waist circumference; NC: neck circumference.
①: above the laryngeal prominence; ②: on the laryngeal prominence; ③: below the laryngeal prominence; average: the average value of the NCs at three levels.

Table 3. Contribution of the waist and neck circumferences on the objective variables of body fat, weight, and BMI (n=60).

Objective variable	No. of explanatory variable	Explanatory variables										Constant	*p*-value
		Weight		BMI		Body fat		WC		Average NCAverage NC			
		SRC	VIF	SRC	VIF	SRC	VIF	SRC	VIF	SRC	VIF		
	4			0.102	1.15	0.262 **	1.84	0.316 **	2.66	0.102*	1.15	−133.90	0.000
	3			0.768	2.88	−	−	−0.086	2.51	0.281	0.19	−28.86	0.000
				−	−	0.366 *	1.76	0.49	1.76	0.146 **	2.44	−49.28	0.000
Weight	2			−	−	0.432 **	1.27	−	−	0.556 **	1.27	−47.22	0.000
				−	−	0.391 *	1.75	0.674 **	1.75	−	−	−9.15	0.000
				−	−	−	−	0.349 **	1.59	0.532 **	1.59	−53.84	0.000
	1			−	−	−	−	−	−	0.745	1.00	−50.08	0.000
				−	−	−	−	0.693	1.00	−	−	−12.19	0.000
	4	0.728	8.20			−0.026	2.45	−0.144	3.52	−0.514	2.64	100.33	0.000
	3	−	−			0.364	1.76	0.399	2.44	0.284	1.76	−9.22	0.000
		−	−			0.543 **	1.27	−	−	0.464	1.27	−7.43	0.000
BMI	2	−	−			0.278 **	1.75	0.576 **	1.75	−	−	−2.01	0.000
		−	−			−	−	0.566 **	1.59	0.327 **	1.59	−10.02	0.000
	1	−	−			−	−	−	−	0.670	1.00	−7.95	0.000
		−	−			−	−	0.765	1.00	−	−	−2.17	0.000
	4	0.949 **	6.65	−0.013	1.24			0.179	3.46	−0.246	2.81	47.63	0.000
	3	−	−	0.769 **	3.71			0.141	3.21	−0.182	2.1	2.41	0.000
		−	−	0.871 **	2.03			−	−	−0.162	2.03	4.72	0.000
Body fat	2	−	−	0.671 **	3.11			0.102	3.11	−	−	−6.28	0.000
		−	−	−	−			0.622 **	1.76	0.050	1.76	−13.73	0.000
	1	−	−	−	−			−	−	0.458	1.00	−12.49	0.000
		−	−	−	−			0.526	1.00	−	−	−11.55	0.000

BMI: body mass index; NC: neck circumference; WC: waist circumference; SRC: standard regression coefficient; VIF: variance inflation factor.

* :p<0.05 by multiple regression analysis. ** :p<0.01 by multiple regression analysis.

Table 4. Contribution of waist and neck circumferences on the objective variables of weight, BMI, and body fat in the sports-experienced and not-sports-experienced subgroups.

Subgroups of the group (n=60)	Objective variable	No. of explanatory variable	Explanatory variables										Constant	*p*-value
			Weight		BMI		Body fat		WC		Average NCAverage NCAverage NC			
			SRC	VIF	SRC	VIF	SRC	VIF	SRC	VIF	SRC	VIF		
		3			−	−	0.889	2.41	0.335	2.54	0.543	1.2	−22.24	0.050
		2			−	−	0.939	2.4	−0.155	2.4	−	−	−9.15	ns
	Weight				−	−	0.651 *	1.13	−	−	0.49	1.13	−27.70	0.010
					−	−			0.578 *	1.42	0.267	1.42	−41.83	0.010
		1			−	−	−	−	−	−	0.582 *	1.00	−46.55	0.050
					−	−	−	−	0.724 **	1.00	−	−	−7.29	0.010
		3	−	−			0.927 *	2.41	0.071	2.54	−0.068	1.2	11.05	0.050
		2	−	−			0.977 **	1.13	−	−	−0.057	1.13	11.40	0.010
Sports-experienced	BMI		−	−			0.921 *	2.4	0.049	2.4	−	−	9.10	0.010
			−	−			−	−	0.807 **	1.42	−0.043	1.42	4.84	ns
		1	−	−			−	−	−	−	0.397	1.00	3.10	ns
			−	−			−	−	0.784 **	1.00	−	−	3.39	0.010
		3	−	−	0.886	2.31			0.071	2.53	0.068	1.19	−20.21	0.050
		2	−	−	0.882 *	2.30			0.100	2.30	−	−	−16.34	0.010
	Body fat		−	−	0.935 **	1.08			−	−	0.083	1.08	−20.62	0.010
			−	−	−	−			0.746	1.19	0.044	1.19	−5.95	ns
		1	−	−	−	−			−	−	0.343	1.00	2.55	ns
			−	−	−	−			0.764 *	1.00	−	−	−3.46	0.050
		4			0.825 **	3.67	0.019	1.73	−0.254	2.3	0.306	1.62	−7.55	0.01
		3			10.44 **	2.84	−0.048	1.65	−0.247	2.3	−	−	18.69	0.01
					0.794 **	2.56	−	−	−0.192	1.99	0.333 **	1.65	−12.26	0.01
					−	−	0.289	1.33	0.155	1.57	0.566 **	1.25	−33.02	0.01
	Weight	2			−	−	0.301	1.33	0.363	1.33	−	−	13.41	0.05
					−	−	0.337	1.06	−	−	0.606 **	1.06	−30.05	0.01
					−	−	−	−	0.286	1.28	0.635 **	1.28	−37.38	0.01
		1			−	−	−	−	−	−	0.741 **	1.00	−31.47	0.01
					−	−	−	−	0.572 **	1.00	−	−	8.52	0.01
		3	−	−			0.328	1.31	0.446 *	1.57	0.315	1.25	−12.78	0.01
Not-sports-experienced		2	−	−			0.471 *	1.06	−	−	0.514 **	1.06	−8.00	0.01
	BMI		−	−			0.334	1.33	0.585 **	1.33	−	−	−2.09	0.01
			−	−			−	−	0.526 **	1.28	0.381 **	1.28	−12.66	0.01
		1	−	−			−	−	−	−	0.626 **	1.00	−7.14	0.01
			−	−			−	−	0.704 **	1.00	−	−	−1.66	0.01
		3	−	−	0.697	2.83			0.068	2.3	−0.205	1.54	9.05	0.050
		2	−	−	0.601	1.89			−	−	−0.174	1.89	14.26	ns
	Body fat		−	−	0.306	1.36			0.346	1.36	−	−	−13.81	0.050
			−	−	−	−			0.491	1.25	0.019	1.25	−12.95	ns
		1	−	−	−	−			−	−	0.239	1.00	−1.90	ns
			−	−	−	−			0.499 *	1.00	−	−	−11.26	0.050

BMI: body mass index; NC: neck circumference; WC: waist circumference; SRC: standard regression coefficient; VIF: variance inflation factor.

* : p<0.05 by multiple regression analysis. ** : p<0.01 by multiple regression analysis.

ability of WC values from the average NC values (y=0.15 x ×+ 22.0, p<0.008 for the sports-experienced group, and y=0.22 × + 16.7, p<0.000 for the not-sports-experienced group).

(5) Confirmation of NC validity in another young female population

In order to confirm the validity of NC index as a substitute for WC index in young adults, the same analyses were performed in another participant group, in which the number of participants was 18 aged 19.7±0.6 years (Table 1) with the mean BMI of 20.1±2.6 kg/m^2 including 5.6% underweight and 20.1% overweight participants. All participants had normal SBP and DBP values.

The difference among the NC values of the three levels was statistically insignificant. The average NC and WC (R=0.60, p<0.026) and blood pressures and weight were moderately and insignificantly correlated, respectively, based on Pearson's analyses. Weight, BMI, body fat, and WC were explained using the average NC with statistically significant contributions. WC values can possibly be predicted based on the average NC values using the equation of y=0.14 × + 21.5 (p<0.026). No objective variable coefficient to each anthropometric measurement was found in the self-reported dietary habit, sports experience, and experienced disease indices.

DISCUSSION

Our previous study revealed that NC was strongly correlated with BMI (R=0.75) and WC (R=0.72) in middle-aged women, 72.9% of whom had standard BMI ranges[1)]. However, in the present study of the young adult women, 73.3–74.3% had standard BMI ranges, revealing the following results: Firstly, NC was significantly correlated with weight. Secondly, the average NC/WC ratio, an indicator of visceral obesity, was much higher in the young adult than that in middle-aged women, while the average NC/height ratio for the young adult was as high as that for the middle aged[1, 10)]. Thirdly, WC was predicted by NC via linear functions. These age-dependent associations between the anthropometric measurement indices revealed that visceral fat deposit has not started at age <20 years. Along with our previous reports on NC measurements of middle-aged women[1)], the present data could indicate the age-dependent transition of fat deposition at the neck as well as abdomen and confirm the NC validity as a predictor of metabolic syndrome in Japanese women. The associations between NC and some metabolic factors were reported in the 40- to 65-year-old Hispanics[9)] and in the postmenopausal healthy Japanese women[2)]. A longitudinal or cross-sectional analysis revealed the contribution of lifestyles or physical activities to the personal fat deposition, respectively [14, 19)].

Definitions of NC values vary according to the levels of neck measured. Tumour size of the thyroid and the presence of lateral lymph node metastasis increased in the middle NC compared with those in the lower NC[11)]. Our analyses showed that the NC above the laryngeal prominence was best correlated with height (R=0.57, p<0.000)[3)]. However, NC was not significantly correlated with obesity indices[16)]. Therefore, assessing the distribution of body fat by NC alone is difficult.

We measured blood pressures accompanied with lifestyle assessments for young-adult Japanese women. All participants aged 18–20 years, showing normal SBP and DBP, which were not correlated with weight, although weight has been the most important determinant of blood pressures[3)]. Our data could be used to determine the onset of hypertension.

The grip strength has been measured to assess the ability of catching, throwing, or lifting, although the strength of the forearm muscles does not necessarily represent the strength of other muscles[15)]. In this report, the two indices, grip strength and wrist circumference, were contributed by the sports exercise experience during senior high school days. As these contributions were significant not only for the sports-experienced group but also for the not-sports-experienced group, questionnaires asking sports exercise experiences could be recommended and grip strength test should be performed by every participant.

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