Association between obesity-related indicators and prevalence of chronic diseases: A cross-sectional study of 13,155 Korean adults

Sae-Kyun Jang[a], Jae-Hyun Kim[b,c,*]

[a] Department of Medical Science, Graduate School of Ajou University, South Korea
[b] Department of Health Administration, College of Health Science, Dankook University, Cheonan, South Korea
[c] Institute of Health Promotion and Policy, Dankook University, Cheonan, South Korea

ABSTRACT

Objective: The objective of this study was to evaluate the association between obesity-related indicators such as Body Mass Index (BMI) and A Body Shape Index (ABSI) and chronic diseases in Korean adults.
Methods: Data from the Sixth Korea National Health and Nutrition Examination Survey (KNHANES 6th) from 2013 to 2015 were analyzed. The total of 13,155 participants were selected for this analysis. The primary analysis was based on Chi-square test and multivariate logistic regression analysis to identify that BMI and ABSI were related to prevalence of diabetes, hypertension and dyslipidemia.
Results: After adjustment for covariates, the OR for hypertension of ABSI Q3 was significantly lower than the reference group (ABSI Q1), but there were not statistically significant in diabetes and dyslipidemia (Diabetes: OR 0.888, 95%CI 0.641–1.231; Hypertension: OR 0.723, 95% CI 0.555–0.942; Dyslipidemia: OR 0.959, 95%CI 0.717–1.282). According to BMI, adjusted OR of overweight group was significantly higher in diabetes (OR: 1.38, 95% CI: 1.08–1.78), hypertension (OR: 1.889, 95% CI:1.533–2.328) and dyslipidemia (OR: 1.330, 95% CI: 1.059–1.670) than that of reference group (Normal).
Conclusion: Despite the limitation of using BMI as a obesity-related indicator, due to the fact that muscle and fat accumulation is not considered, BMI is a better anthropometry investigator of diabetes, hypertension, and dyslipidemia for Koreans than ABSI.

1. Introduction

Obesity is a major public health problem worldwide. The prevalence of obesity has increased rapidly throughout the world over the last decades and has now reached epidemic proportions. For instance, the global prevalence of obesity has nearly doubled between 1980 and 2008. According to the World Health Organization (WHO), 35% of adults worldwide aged > 20 years were overweight (34% men and 35% women) in 2008, of which 10% men and 14% women being considered as obese (World Health Organization, 2018). Organization for Economic Cooperation and Development (OECD) health at a glance 2015 reported that global average rate of obesity as 19.0%, 35.3% in the United States and 4.7% in Korea (OECD, 2015). Although, the prevalence of overweight and obesity is relatively low in Korea compared to OECD average, it is consistently increasing (Ministry of Health and Welfare, 2012). Substantial study indicates that obesity is a well-known risk factor for mortality from all causes and for incidence of

chronic diseases such as hypertension, diabetes and dyslipidemia (Kearnset al., 2014; Egger and Dixon, 2014; AH et al., 2010; Ko et al., 2012). The Body Mass Index (BMI) is widely used as an overwhelming validity indicator of obesity. WHO defined overweight and obesity with BMI, calculated as weight divided by height squared. Overweight is defined as BMI greater than or equal to 25, and obesity is defined as BMI greater than or equal to 30 (World Health Organization, 2018). Although BMI is widely used as a measurement of obesity, it has potential weaknesses. For instance, BMI does not distinguish between muscle and fat deposition (Alan et al., 2006; AM et al., 2006; mez-Ambrosi et al., 2012). To overcome this limitation, a Body Shape Index (ABSI) has been proposed as a new anthropometric measurement, which can estimate both visceral abdominal and general overall adiposities. ABSI helps in understanding whether abdominal obesity has predictive ability that cannot be explained by BMI alone (Bouchi et al., 2016; Krakauer and Krakauer, 2012; Sowmya et al., 2014). Substantial studies demonstrated that ABSI is a robust predictor and a way to
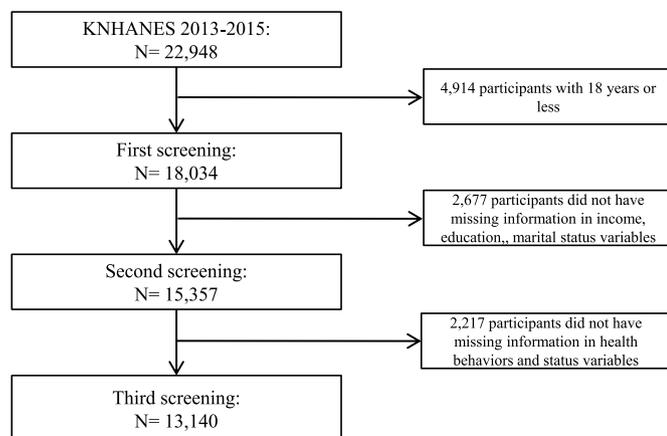
Fig. 1. Flow chart for sample selection.

quantify the risk associated with abdominal obesity, as indicated by a wide waist relative to BMI (Krakauer and Krakauer, 2014; Duncan et al., 2013; Kabat et al., 2015; Grant et al., 2017; Thomson et al., 2016). The aim of this study is to evaluate the association between ABSI with the prevalence of diabetes, hypertension, and dyslipidemia, compared to BMI by analyzing the Korea National Health and Nutrition Examination Survey (KNHANES). (see Fig. 1)

2. Methods

2.1. Data source and design

This study has used the Sixth Korea National Health and Nutrition Examination Survey (KNHANES VI, 2013–2015, Korea Centers for Disease Control and Prevention) (Korea Centers for Disease Control and Prevention, 2017). The survey was conducted by the Korea Ministry of Health and Welfare, and had three components: a health interview survey, a health examination survey, and a nutrition survey. The survey was approved by the Institutional Review Board of the Korea Centers for Disease Control and Prevention. The survey target population was all non-institutionalized South Korean civilian individuals aged 1 year or older. The sixth KNHANES was conducted for three years (2013–2015) and employed stratified, multistage probability sampling units that were based on geographic area, gender, and age. The total target population consisted of 22,948 people aged 1 year and older (8018 in 2013, 7550 in 2014, and 7380 in 2015), of which 29,321 people completed the survey. The average response rate was 78.3%. We excluded information from 4914 individuals aged 1–18 years and included information from 18,034 individuals aged 19 years and older. We further excluded 4894 individuals without information on education, income, marital status, alcohol use, residential region, body mass index, perceived body shape or self-rated health. Thus, a total of 13,140 individuals were selected for this analysis. As KNHANES data are released to the public for scientific use, ethical approval was not needed for this study.

3. Variables

3.1. Independent variables

BMI was calculated and classified into three groups following the KNHANES guideline (Centers for Disese Control and Prevention, 2018): Underweight ($< 18.5\,kg/m2$), Normal ($18.5\,kg/m2$-$24.9\,kg/m2$), and Overweight ($> 25\,kg/m2$). A Body Shape Index (ABSI) was specifically developed as a transformation of waist circumference (WC), statistically independent of BMI to better evaluate the relative contribution of WC to central obesity and clinical outcomes. Online calculators are

available to calculate an ABSI value and the z score. The provided information can then be used to compare between persons of the same sex and age, and further indicate individual mortality risk via tertiles (also see https://nirkrakauer.net/sw/absi-calculator.html that provides relative risk values for BMI and ABSI).

ABSI was calculated using the following formula (Thomson et al., 2016).

$$ABSI = \frac{WC}{BMI^{2/3} * Height^{1/2}}$$

3.2. Dependent variables

The dependent variables in this study were diabetes, hypertension, and dyslipidemia. Diabetes was defined by individuals' responses on whether they had ever been diagnosed with diabetes by a physician or have a fasting plasma glucose (FPG) $\geq 126\,mg/dL$. Hypertension was defined as the presence of one or more of the following criteria; diagnosed by a physician, using antihypertensive medication, as a systolic blood pressure (SBP) $\geq 140\,mmHg$ or diastolic blood pressure (DBP) $\geq 90\,mmHg$. Dyslipidemia was defined according to the criteria of the Korean Society of Lipid and Atherosclerosis: triglyceride (TC) level is normal when $\leq 200\,mg/dl$, prehyper-TC when 200–239 mg/dl, and hyper-TC when $\geq 240\,mg/dl$. TG level is normal when $\leq 200\,mg/dl$ and hyper-TG when $> 200\,mg/dl$. HDL-C level is normal when $> 40\,mg/dl$ ad hypo-HDL-C when $\leq 40\,mg/dl$.

3.3. Control variable

Age, gender, residential region, income, education, marital status, sleep duration, frequency of alcohol consumption in 1 year, stress perception level, and perceived body shape were included in the analysis as control variables. The age variable was divided into six groups: 19–29 years, 30–39 years, 40–49 years, 50–59 years 60–69 years and 70 years or older Residency regions were categorized into Urban (within city boundaries: Seoul, Daejeon, Daegu, Busan, Incheon, Kwangju, or Ulsan) and Rural (not within city boundaries). Household income was classified into four groups: low, middle low, middle high and high. Education level was categorized into four groups: elementary school or lower, middle school, high school, and college or higher. Marital status was categorized into married or single (including divorce, separation). Sleep duration was divided into five groups: 5 h or less, 6 h, 7 h, 8 h and 9 h or more. Questions about alcohol use were assessed by the health interview survey. Alcohol use was further assessed by questions about the average frequency (days per week or month) of alcohol consumption during the last year. Perceived body shape was assessed by asking, "In your opinion, how do you perceive your body shape?" Possible responses included thin, normal, or obese. Questions about perceived stress level was assessed by the health interview survey and divided into four groups: high, middle high, middle low and low.

3.4. Statistical methods

Chi-square tests and multivariate logistic regression analysis were conducted to analyze whether general characteristics, health status, and health risk behaviors as well as BMI and ABSI were related to self-rated health. Our models were adjusted for age, gender, residential region, income, education, marital status, sleep duration, frequency of alcohol use for 1 year, stress perception level for 1 year. We further performed subgroup analyses by perceived body shape. Odds ratios (OR) with a 95% confidence intervals (CI) were calculated. Statistical significance was set at $p < 0.05$. Statistical analyses were performed using SAS version 9.4 (SAS Institute Inc., Cary, NC, USA).

Table 1
General characteristics of subjects included for analysis.

	Total		Diabetes		P-value*	Hypertension		P-value*	Dyslipidemia		P-value*
	N	%*	Yes	%*		Yes	%*		Yes	%*	
A Body Shape Index (ABSI)					0.0045			< .0001			< .0001
Q1	4380	35.1	374	6.5		1062	18.5		503	8.9	
Q2	4380	33.1	333	5.4		844	13.8		480	7.9	
Q3	4380	31.8	288	5.0		671	10.9		362	6.2	
Body Mass Index (BMI)					< .0001			< .0001			< .0001
Underweight	580	4.9	12	1.1		25	2.4		17	2.1	
Normal	8341	63.3	532	4.7		1277	10.9		721	6.4	
Overweight	4219	31.8	451	8.3		1275	23.6		607	11.2	
Perceived Body Shape					0.0692			< .0001			< .0001
Thin	2212	17.1	154	4.8		360	11.1		152	4.8	
Normal	5383	40.5	401	5.5		997	13.1		507	7.0	
Obesity	5545	42.4	440	6.1		1220	17.3		686	9.6	
Age					< .0001			< .0001			< .0001
19-29	1801	20.5	4	0.2		6	0.4		9	0.4	
30-39	2335	20.3	21	0.9		38	1.7		46	2.0	
40-49	2565	21.7	78	3.2		198	8.5		120	5.0	
50-59	2621	19.5	179	7.1		523	20.0		341	12.1	
60-69	2150	10.6	388	17.9		896	40.6		507	22.3	
≥70	1668	7.5	325	19.8		916	54.4		322	18.4	
Gender					< .0001			0.0004			< .0001
Male	6084	52.3	567	6.6		1329	15.6		520	6.6	
Female	7056	47.7	428	4.6		1248	13.4		825	8.9	
Residential region					0.9566			0.1629			0.6890
Metropolitan	2711	21.6	201	5.7		507	13.5		301	7.7	
Urban	3372	25.8	272	5.5		662	13.9		370	8.0	
Rural	7057	52.6	522	5.7		1408	15.3		674	7.5	
Income					< .0001			< .0001			< .0001
Low	2171	13.3	330	12.8		846	31.6		350	12.8	
Middle Low	3308	24.5	306	6.8		694	14.9		356	7.6	
Middle high	3722	30.3	183	3.9		549	11.4		323	6.8	
High	3939	31.9	176	3.5		488	10.1		316	6.5	
Education					< .0001			< .0001			< .0001
≤ Elementary school	2583	13.8	423	15.7		1159	41.5		518	18.1	
Middle school	1375	8.9	164	10.9		389	24.1		214	14.0	
High school	4686	39.5	262	4.0		654	10.6		369	5.8	
≥ College	4496	37.9	146	2.6		375	6.6		244	4.4	
Marital status					< .0001			< .0001			< .0001
Married	10,882	75.6	960	7.1		2528	18.7		1303	9.7	
Single	2258	24.4	35	1.2		49	1.7		42	1.4	
Sleep duration (hr)					< .0001			< .0001			< .0001
≤5	2079	14.5	218	8.2		582	21.4		327	11.9	
6	3658	28.0	254	5.3		664	13.4		363	7.7	
7	3734	29.2	217	4.3		628	12.5		323	6.6	
8	2774	21.6	213	5.7		493	13.3		242	6.4	
≥9	895	6.7	93	7.5		210	17.2		90	7.4	
Frequency of alcohol use for 1 year					< .0001			< .0001			< .0001
Nothing	2441	15.6	305	9.9		668	21.9		364	11.7	
2–4 times per month	7534	58.9	458	4.4		1226	11.4		693	6.6	
2–3 times per week	2182	18.1	147	5.6		411	15.1		192	7.4	
≥4 times per week	983	7.4	85	6.9		272	22.8		96	8.4	
lifetime smoking status					< .0001			< .0001			0.0017
Less than 100	330	3.0	16	3.9		36	7.2		15	3.5	
More than 100	5318	43.3	515	7.1		1185	16.7		493	7.4	
Nothing	7492	53.6	464	4.6		1356	13.2		837	8.2	
Stress perception level					< .0001			< .0001			0.0003
High	563	4.6	54	7.3		110	15.0		75	10.0	
Middle high	2704	22.1	160	4.3		434	11.7		239	6.6	
Middle low	7717	58.8	515	5.1		1402	13.6		773	7.4	
Low	2156	14.5	266	9.7		631	22.6		258	9.7	
Self-rated health					< .0001			< .0001			< .0001
Good	4095	33.0	131	2.2		505	8.6		219	3.8	
Normal	6700	50.8	436	5.0		1289	14.6		656	7.6	
Bad	2345	16.2	428	14.7		783	26.6		470	15.8	
Walking days during a week (days)					< .0001			< .0001			0.0005
Nothing	2171	15.3	220	7.6		564	19.8		262	9.7	
1-2	2303	17.6	153	5.4		387	13.9		221	7.7	
3-4	2682	19.8	180	5.5		497	13.8		284	8.4	
5-6	2242	17.5	146	4.2		383	11.2		225	6.6	
Everyday	3742	29.6	296	5.8		746	14.6		353	6.9	
Total	13,140	100.0	995	5.7		2577	14.5		1345	7.7	

%*: Weighted %.

4. Results

4.1. General characteristics of participants

General characteristics of subjects are presented in Table 1. Of the 13,140 subjects included in this analysis, the prevalence of diabetes was 5.7% (n = 995), hypertension 14.5% (n = 2577), and dyslipidemia 7.7% (n = 1345). In the ABSI group, the prevalence of diabetes, hypertension, and hyperlipidemia decreased from Q1 to Q3. Likewise, the prevalence rate for the three diseases increased from the underweight group to the overweight group according to the BMI standard, and were statistically significant, respectively. Of those in the obesity group according to the perception of body shape, 6.1% (n = 440) had diabetes, 17.3% (n = 1220) had hypertension, and 9.6% (n = 686) had dyslipidemia and significantly higher in all three diseases compared with thin or normal group. In addition, there was a statistically significant difference in the prevalence of three diseases among the groups in age, gender, income, education, marital status, sleep duration, frequency of alcohol use, smoking status, stress perception, self-rate health and exercise level.

4.2. Association between obesity-related indicators and chronic diseases

The cross-sectional relationships of obesity-related indicators (BMI, ABSI, Perceived body shape) with chronic diseases (diabetes, hypertension, dyslipidemia) are shown in Table 2, which were conducted unadjusted (Model1) as well as adjusted for age, gender, residential region, income, education, marital status, sleep duration, frequency of alcohol, stress perception level and exercise level (Model2). In terms of ABSI, unadjusted ORs for diabetes, hypertension and dyslipidemia of Q3 (Diabetes: OR 2.405, 95%CI 1.771–3.265; Hypertension: OR 2.463,

95% CI 1.926–3.148; Dyslipidemia: OR 2.537, 95%CI 1.890–3.404) and Q2 (Diabetes: OR 2.005, 95%CI 1.570–1.771; Hypertension: OR 2.320, 95% CI 1.920–2.803; Dyslipidemia: OR 2.216, 95%CI 1.751–2.806) were significantly higher than Q1 (reference), respectively. On the other hand, unadjusted ORs of overweight group according to BMI were also significantly higher than normal group in all three diseases (Diabetes: OR 4.234, 95%CI 3.274–5.476; Hypertension: OR 6.037, 95% CI 4.932–7.390; Dyslipidemia: OR 3.200, 95%CI 2.524–4.057). However, unadjusted ORs of obesity group according to perceived body shape for diabetes and hypertension were significantly lower than normal group (Diabetes: OR 0.749, 95% CI 0.606–0.925; Hypertension: OR 0.796, 95% CI 0.693–0.915). Unadjusted OR for dyslipidemia was higher than normal but it was not statistically significant. (Dyslipidemia: OR 1.163, 95%CI 0.968–1.000).

After adjustment for age, gender, residential region, income, education, marital status, sleep duration, frequency of alcohol, stress perception level and exercise level, of those in ABSI group, the OR for hypertension of Q3 was significantly lower than the reference group (Q1), but were not statistically significant in diabetes and dyslipidemia (Diabetes: OR 0.888, 95%CI 0.641–1.231; Hypertension: OR 0.723, 95% CI 0.555–0.942; Dyslipidemia: OR 0.959, 95%CI 0.717–1.282). According to BMI, adjusted OR of overweight group was significantly higher in diabetes (OR: 1.38, 95% CI: 1.08–1.78), hypertension (OR: 1.889, 95% CI:1.533–2.328) and dyslipidemia (OR: 1.330, 95% CI: 1.059–1.670) than that of reference group (Normal). In terms of perception of body shape, the OR for hypertension (OR 1.272, 95% CI 1.089–1.487) and dyslipidemia (OR: 1.272, 95% CI: 1.052–1.539) of obesity group were significantly higher than reference group (Normal) and there was no difference in diabetes hypertension (OR 1.039, 95% CI 0.828–1.304).

Table 2
Association between obesity-related indicators and chronic diseases.

	Model 1								
	Diabetes			Hypertension			Dyslipidemia		
	Unadjusted OR	95% CI	P-value	Unadjusted OR	95% CI	P-value	Unadjusted OR	95% CI	P-value
A Body Shape Index (ABSI)									
Q1	1.000			1.000			1.000		
Q2	2.005	1.570 2.560	< .0001	2.320	1.920 2.803	< .0001	2.216	1.751 2.806	< .0001
Q3	2.405	1.771 3.265	< .0001	2.463	1.926 3.148	< .0001	2.537	1.890 3.404	< .0001
Body Mass Index (BMI)									
Underweight	0.172	0.093 0.319	< .0001	0.156	0.098 0.250	< .0001	0.343	0.190 0.621	0.000
Normal	1.000			1.000			1.000		
Overweight	4.234	3.274 5.476	< .0001	6.037	4.932 7.390	< .0001	3.200	2.524 4.057	< .0001
Perceived Body Shape									
Thin	1.106	0.883 1.387	0.380	1.158	0.982 1.365	0.080	0.780	0.616 0.987	0.038
Normal	1.000			1.000			1.000		
Obesity	0.749	0.606 0.925	0.007	0.796	0.693 0.915	0.001	1.163	0.968 1.000	0.106

	Model 2								
	Diabetes			Hypertension			Dyslipidemia		
	OR	95% CI	P-value	OR	95% CI	P-value	OR	95% CI	P-value
A Body Shape Index (ABSI)									
Q1	1.000			1.000			1.000		
Q2	0.846	0.656 1.092	0.199	0.818	0.666 1.005	0.055	0.982	0.782 1.233	0.875
Q3	0.888	0.641 1.231	0.477	0.723	0.555 0.942	0.017	0.959	0.717 1.282	0.775
Body Mass Index (BMI)									
Underweight	0.323	0.169 0.616	0.001	0.292	0.173 0.492	< .0001	0.672	0.357 1.263	0.216
Normal	1.000			1.000			1.000		
Overweight	1.374	1.064 1.774	0.015	1.889	1.533 2.328	< .0001	1.330	1.059 1.670	0.014
Perceived Body Shape									
Thin	0.828	0.639 1.073	0.154	0.935	0.763 1.146	0.517	0.713	0.551 0.922	0.010
Normal	1.000			1.000			1.000		
Obesity	1.039	0.828 1.304	0.743	1.272	1.089 1.487	0.003	1.272	1.052 1.539	0.013

Table 3
Adjusted effect between obesity-related indicators and chronic disease by gender and age.

	Diabetes			Hypertension			Dyslipidemia		
	OR	95% CI		OR	95% CI		OR	95% CI	
A Body Shape Index (ABSI)	Male								
Q1	1.000			1.000			1.000		
Q2	1.000	0.695	1.439	0.937	0.702	1.250	0.869	0.601	1.257
Q3	1.090	0.686	1.733	0.864	0.591	1.263	0.847	0.511	1.404
Body Mass Index (BMI)									
Underweight	0.373	0.172	0.811	0.263	0.123	0.562	0.731	0.286	1.869
Normal	1.000			1.000			1.000		
Overweight	1.309	0.909	1.884	1.860	1.402	2.468	0.918	0.622	1.356
Perceived Body Shape									
Thin	0.637	0.456	0.890	0.836	0.640	1.091	0.552	0.367	0.829
Normal	1.000			1.000			1.000		
Obesity	1.178	0.866	1.603	1.379	1.117	1.703	1.392	1.046	1.853
A Body Shape Index (ABSI)	**Female**								
Q1	1.000			1.000			1.000		
Q2	0.683	0.476	0.980	0.722	0.542	0.963	1.120	0.847	1.481
Q3	0.747	0.472	1.181	0.645	0.443	0.940	1.235	0.853	1.786
Body Mass Index (BMI)									
Underweight	0.281	0.091	0.874	0.411	0.212	0.800	0.755	0.312	1.827
Normal	1.000			1.000			1.000		
Overweight	1.439	0.980	2.114	1.780	1.306	2.426	1.638	1.242	2.160
Perceived Body Shape									
Thin	1.169	0.760	1.797	0.944	0.693	1.284	0.840	0.580	1.216
Normal	1.000			1.000			1.000		
Obesity	0.886	0.631	1.244	1.141	0.904	1.440	1.293	1.005	1.663
A Body Shape Index (ABSI)	< **60**								
Q1	1.000			1.000			1.000		
Q2	1.142	0.692	1.883	0.845	0.612	1.167	0.919	0.618	1.367
Q3	1.237	0.636	2.402	0.828	0.540	1.271	1.046	0.642	1.705
Body Mass Index (BMI)									
Underweight	0.399	0.122	1.305	0.201	0.063	0.644	0.836	0.336	2.080
Normal	1.000			1.000			1.000		
Overweight	1.767	1.106	2.823	2.161	1.567	2.979	1.431	0.962	2.130
Perceived Body Shape									
Thin	0.804	0.442	1.463	1.040	0.699	1.549	0.755	0.476	1.197
Normal	1.000			1.000			1.000		
Obesity	1.314	0.920	1.877	1.437	1.143	1.807	1.382	1.036	1.843
A Body Shape Index (ABSI)	≥**60**								
Q1	1.000			1.000			1.000		
Q2	0.778	0.581	1.041	0.812	0.630	1.046	1.160	0.873	1.542
Q3	0.779	0.534	1.137	0.645	0.463	0.900	0.980	0.682	1.410
Body Mass Index (BMI)									
Underweight	0.273	0.129	0.578	0.371	0.212	0.649	0.539	0.251	1.155
Normal	1.000			1.000			1.000		
Overweight	1.223	0.895	1.672	1.502	1.157	1.951	1.093	0.820	1.456
Perceived Body Shape									
Thin	0.856	0.638	1.147	0.882	0.709	1.097	0.654	0.491	0.870
Normal	1.000			1.000			1.000		
Obesity	0.861	0.643	1.153	1.146	0.931	1.412	1.241	0.972	1.585

*adjusted for age residential region, income, eduation, marital status, sleep duration, frequency of alcohol use for 1 year, lifetime smoking status, stress perception level, Self-rated health and walking days during a week (days).

4.3. Subgroup analysis by gender and age

Table 3 shows the result of subgroup analysis according to gender and age adjusted for covariates. In the comparison between the ABSI groups, Male did not show any differences between the groups in all three diseases, but in women, the ORs of Q2 and Q3 were significantly lower in hypertension than Q1 group (Q2: OR 0.722, 95%CI 0.542–0.963; Q3: OR 0.645, 95%CI 0.443–0.940). As a result of association between BMI and chronic diseases, the ORs for hypertension of overweight group was only significantly higher than that of normal group both in male and female (male: OR 1.860, 95% CI 1.402–2.468;

female: OR 1.780, 95%CI 1.306–2.426). The female group also showed significant results in dyslipidemia (OR 1.638, 95%CI 1.242–2.160). In terms of perceived body shape, the ORs for dyslipidemia of obesity group were significantly higher than normal group in male (OR 1.392, 95%CI 1.046–1.853) and female (OR 1.293, 95%CI 1.005–1.663). The male group also showed significant results in hypertension (OR 1.379, 95%CI 1.117–1.703).

In the results of subgroup analysis according to age which divided into two groups based on 60 years old adjusted for covariates, there were no significant differences between the ABSI groups at all age groups except that the OR for hypertension of ABSI Q3 group had a

significantly higher OR than Q1 groups in over 60 years of age. (OR 0.645, 95%CI 0.463–0.900). On the other hand, there were significant differences among the BMI groups by age. The OR for diabetes of overweight group was significantly higher than normal subjects in under 60 years of age. (OR 1.767, 95%CI 1.106–2.823) and the OR for hypertension was statically significant in both ages, respectively (< 60: OR 2.161, 95%CI 1.567–2.979; ≥60: OR 1.502, 95%CI 1.157–1.951). In terms of perceived body shape, the ORs for hypertension and dyslipidemia of obesity group were significantly higher than normal group only in under 60 years of age (Hypertension: OR 1.437, 95% CI 1.143–1.807; Dyslipidemia: OR 1.382, 95%CI 1.036–1.843).

5. Discussion

This study aimed to evaluate the association between obesity-related indicators such as Body Mass Index (BMI) and A Body Shape Index (ABSI), as well as chronic diseases (diabetes, hypertension, and dyslipidemia) in Korean adults. We found that BMI is more strongly associated with diabetes, hypertension, and dyslipidemia in Korean adults, compared with ABSI. ABSI and BMI showed similar results in model1, which was not adjusted for control variables. However, after adjustment for age, gender, residential region, income, education, marital status, sleep duration, frequency of alcohol, stress perception level and exercise level, the risk of each chronic disease was significantly increased in obese subjects compared to normal subjects only in terms of BMI.

Until now, public health studies have relied on BMI to screen for obesity-related disease risk and evaluated the risk of chronic disease, which can lead to further morbidity and mortality (Kearns et al., 2014; Jee et al., 2018). Some studies have recently addressed the validation of BMI, primarily owing to the fact that it may not sufficiently account for body composition, including visceral fat and its distribution (Thomson et al., 2016; Bertoli et al., 2017). As from 2012, ABSI has been newly suggested (Krakauer and Krakauer, 2012) and several studies have been conducted. ABSI in the United States Population Sample (National Health and Nutrition Examination Survey, NHANES, 1999–2004) was validated and further, a study for ABSI was applied in the context of mortality risk among 7011 adults enrolled in the British Health and Lifestyle Survey (Thomson et al., 2016), providing predictive power for mortality of ABSI (Bertoli et al., 2017). Another study reported that ABSI explained a greater amount of the association with high blood pressure in Portuguese adolescents (Duncan et al., 2013). By comparison with their Western population, in Japanese and Indonesia study, BMI was a better predictor of target chronic diseases compared with ABSI (Fujita, 2015; Cheung, 2014).

The contrast between the studies of Western and Eastern Asia illustrating two thematic oppositions could describe the following. One is the different outcome measures used: all-cause mortality versus specific disease conditions. The other is the ethnic difference: having relatively low obesity rate (OECD, 2015). According to the study of systematic review and meta-analysis, Asians are known to have limited innate capacity for insulin secretion, resulting in greater susceptibility to type 2 diabetes than Caucasians (Fujita, 2015; Kodama et al., 2013).

Despite these findings there are some limitations that should be taken into consideration in the present results. First, because this study used a cross-sectional design, the results prevent any causal inference about the relationship in the association between weight status and prevalence of diabetes, hypertension, and dyslipidemia. Studies that are longitudinal in design would clearly be advantageous in determining any causality and mechanisms that underline the association between body related index and these variables. Second, while national-level surveys hold considerable power, the data entails certain limitations as questions and diagnoses had to be kept relatively simple, and lacked validated questionnaires. More objective methods tend to yield more accurate results. Thus, this result should be cautiously interpreted, and prospective longitudinal studies are warranted. The follow-up study

will be conducted to demonstrate this causal relationship and elucidate the biological mechanisms that underlie this association.

Nevertheless, strengths of this study are that it investigated the association between Body Related Index and Prevalence of Chronic Disease through analysis of nationally representative data (KNHANES 6th) with a large sample size (n = 13,155 participants). Second, we used stratified, multistage probability sampling data and weighted for this analysis. Therefore, our findings are more generalizable to the Korean adult population. To conclude, we found statistically significant associations between chronic diseases (i.e., diabetes, hypertension, and dyslipidemia), and BMI, but not ABSI. Although our study did not find significant association between ABSI and the prevalence of diabetes, hypertension, or dyslipidemia; BMI is dependently related to chronic disease prevalence adjusting for residential region, income, education, marital status, sleep duration, frequency of alcohol consumption for 1 year, stress perception level, and self-rated health.

Despite the fact that BMI is a limited indicator due to the absence of a measure between muscle and fat accumulation, BMI is a better anthropometry investigator of diabetes, hypertension, and dyslipidemia in Koreans than ABSI.

Conflicts of interest

No author has any financial or other conflict of interest to declare.

References

AH, A., et al., 2010. *Obesity and overweight in Canada: an updated cost-of illness study* Obesity. Review (11), 10.

Alan, M., Nevill, A.D.S., Olds, Tim, Holder, Roger, 2006. Relationship between adiposity and body size reveals limitations of BMI. Am. J. Phys. Anthropol. 129, 6.

AM, N., et al., 2006. Relationship between adiposity and body size reveals limitation of BMI. Am. J. Phys. Anthropol. 129.

Bertoli, S., et al., 2017. Association of Body Shape Index (ABSI) with cardio-metabolic risk factors: a crosssectional study of 6081 Caucasian adults. PLoS One 12 (9), 15.

Bouchi, R., et al., 2016. Indirect measure of visceral adiposity 'A Body Shape Index' (ABSI) is associated with arterial stiffness in patients with type 2 diabetes. BMJ Open Diabetes Res. Care 4 (e000188), 7.

Centers for Disease Control and Prevention, 2018 June 28, 2017. [cited 2018; Available from: https://www.cdc.gov/chronicdisease/overview/index.htm.

Cheung, Y.B., 2014. A body shape index" in middle-age and older Indonesian population: scaling exponents and association with incident hypertension. PLoS One 9 (1), 5.

Duncan, M.J., et al., 2013. Association between body mass index, waist circumference and body shape index with resting blood pressure in Portuguese adolescents. Ann. Hum. Biol. 40 (2).

Egger, G., Dixon, J., 2014. *Beyond Obesity and Lifestyle: A Review of 21st Century Chronic Disease Determinants* BioMed Research International 2014. pp. 12.

Fujita, M., et al., 2015. Predictive power of a body shape index for development of diabetes, hypertension, and dyslipidemia in Japanese adults: a retrospecive cohort study. PLoS One 10 (6), e0128972.

Grant, J.F., et al., 2017. The association between A body shape index and mortality: results from an Australian cohort. PLoS One 12 (7).

Jee, S.H., Wull, J.W., Park, J., 2018. Body-mass index and mortality in Korean men and women. N. Engl. J. Med. 779–787.

Kabat, G.C., et al., 2015. Risk of breast, endometrial, colorectal, and renal cancers in postmenopausal women in association with a body shape index other anthropometric measures. Cancer Causes Control 26.

Kearns, Karen, et al., 2014. Chronic disease burden associated with overweight and obesity in Irelnd: the effects of a small BMI reduction at population level. BMC Public Health 14 (143), 10.

Ko, S.-H., et al., 2012. Long-term changes of the prevalence and control rate of hypertension among Korean adults with diagnosed diabetes: 1998-2008 Korean National and Nutrition Examination Survey. Diabetes Res. Clin. Pract. 97, 151–157.

Kodama, K., et al., 2013. Ethnic Differences in the relationship between insulin sensitivity and insulin respose. Diabetes Care 36, 1789–1796.

Korea Centers for Disease Control and Prevention, 2017. The Sixth Korea National Health and Nutrition Examination Survey (KNHANES VI).

Krakauer, N.Y., Krakauer, J.C., 2012. A new body shape index predicts mortality hazard independently of body mass index. PLoS One 7 (7), e39504.

Krakauer, N.Y., Krakauer, J.C., 2014. Dynamic associaiton of mortality hazard with body shape. PLoS One 9 (2), 7.

Ministry of Health and Welfare, 2012. National Health Statistics of 2011. Ministry of Health and welfare.

OECD, 2015. Health at a Glance 2015. OECD, pp. 217.

Sowmya, S., et al., 2014. A body shape index and heart rate variability in healthy Indians with low body mass index. J. Nutr. Metab. 2014, 6.

Thomson, C.A., et al., 2016. Body shape, adiposity index, and mortality in postmenopausal women: findings from the women's health initiative. Obesity 24 (5), 9.

World Health Organization, 2018. [cited 2018 4.18]; Available from: http://www.who.int/mediacentre/factsheets/fs311/en/.

mez-Ambrosi, J.G., et al., 2012. Body mass index classification misses subjects with increased crdiometabolic risk factors related to elevated adiposity. Int. J. Obes. 36, 286–294.