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Associations among health behaviors, body mass index, hypertension, and diabetes mellitus

A path analysis

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Abstract

Hypertension (HTN) and type 2 diabetes are common diseases; however, the effects of health behavior and body mass index (BMI) on their incidence and relationship are unclear. The purpose of this study was to investigate the associations among health behaviors, BMI, HTN, and type 2 diabetes.

This study was a secondary data analysis using Korean Longitudinal Study of Aging data between 2010 and 2014 (third and fifth). The sample consisted of 3481 people aged 45 years or older. Path analysis was conducted using the generalized structural equation modeling of STATA 13.1 that enabled analyzing the types of binary variables and logit links.

There were 129 underweight, 1714 normal, and 1638 overweight and obese individuals. In underweight and normal groups who had regular meals ($B=0.670$, $P<.001$), BMI was higher. However, for those who were older ($B=-0.041$, $P<.001$) and female ($B=-0.229$, $P=.021$), BMI was lower. The incidence of HTN increased with age ($B=0.038$, $P=.001$). In addition, the incidence of type 2 diabetes increased with age ($B=0.051$, $P=.005$) and smoking ($B=1.539$, $P=.001$). However, the incidence of type 2 diabetes was lower ($B=-1.077$, $P=.036$) for those who had regular meals. In the normal and overweight groups, BMI decreased with age ($B=-0.033$, $P<.001$). The incidence of HTN increased with age ($B=0.042$, $P<.001$) and BMI ($B=0.145$, $P<.001$). Moreover, the incidence of type 2 diabetes increased with age ($B=0.046$, $P<.001$), smoking ($B=0.682$, $P=.020$), and higher BMI ($B=0.151$, $P=.001$).

In the underweight and normal group, health behaviors were related to BMI. In the normal and overweight group, health behaviors were not related to BMI, but high BMI was related to the incidence of HTN and type 2 diabetes. Smoking has a direct effect on the incidence of type 2 diabetes. Thus, the importance of maintaining an ideal BMI and smoking cessation are highlighted.

Abbreviations: BMI = body mass index, DM = diabetes mellitus, GSEM = generalized structural equation modeling, HTN = hypertension, KLoSA = Korean Longitudinal Study of Aging, WHO = World Health Organization.

Keywords: diabetes milletus, health behavior, hypertension

1. Introduction

Hypertension (HTN) and type 2 diabetes are common lifestyle-related diseases not only in South Korea but also throughout the world. In 2012, the World Health Organization (WHO) dealt with high blood pressure and hyperglycemia as serious problems, and reported obesity as a major issue.[1] Furthermore, WHO emphasize the importance of blood pressure management as 17.5 million people have cardiovascular diseases worldwide, accounting for 31% of the world's population, of which 80% suffer from heart attack and stroke. The prevalence of diabetes is rapidly increasing from 4.7% in the 1980s to 8.5% in 2014, with a total of 422 million cases worldwide, and 1 in 10 adults having diabetes.[2] Type 2 diabetes is a major cause of cardiovascular disease and mortality, with a mortality rate 27% higher than that for the cohort without diabetes.[3] Moreover, among elderly people over 80 years of age, those with type 2 diabetes have a 4.3 times higher mortality rate than those with other diseases like congestive heart failure.[4] In South Korea, the prevalence rates of HTN and type 2 diabetes were estimated to be 29.0% and 9.0% in 2012; the rate of HTN decreased to 25.5% in 2014, whereas the rate of type 2 diabetes increased to 10.2%.[5]

Most previous studies have shown the main factors of HTN and type 2 diabetes to include age, sex, smoking, exercise, family history, dietary habits, body mass index (BMI), and waist circumference.[6–13] In particular, obesity in terms of BMI is the main cause of these diseases; thus, with an emphasis on continuous weight management, research is actively being conducted. However, some studies have suggested that type 2 diabetes may occur due to metabolic syndrome even with a normal BMI and waist circumference.[14,15] There are no studies about health behavior in the underweight and the incidence of

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HTN and type 2 diabetes. Previous studies have demonstrated that elderly people are at high risk for HTN and type 2 diabetes,[3,8,15,16] as age is recognized as a major factor. However, there are few studies on the relationship between age and other demographic characteristics, health behaviors, BMI, and the incidence of HTN and type 2 diabetes. For example, there are different views on smoking among health behaviors; some previous studies suggest that smoking is an important factor,[10,14] and that sometimes it is not related with incidence of type 2 diabetes.[16] Moreover, even though smoking is associated with mortality,[17] there are fewer studies that clearly show the relationship between incidence of illness and health behaviors such as physical activity, smoking, and drinking. In addition, BMI differ depending on ethnicity; according to the WHO, the distribution of body fat varies by ethnicity. This helps to explain the high incidence of type 2 diabetes in Asian countries, despite the population having low average BMI. Therefore, a BMI standard different from that in Western countries is needed to prevent diseases with high mortality in Asian countries, such as type 2 diabetes.[18] In Western countries, a BMI lower than 18.49 is generally classified as underweight, 18.5 to 24.9 as normal, and 25 or more as overweight. In Korean and other Asian countries, a BMI of 18.49 or lower is classified as underweight, 18.5 to 22.9 as normal, and higher than 23.0 as overweight or obese.[19]

The hypothesis of this study was that health behavior is related to demographic characteristics, which, in turn, influence changes in BMI, and, as a result, affect the incidence of chronic diseases such as hypertension and diabetes. To verify this hypothesis, we explored associations among health behaviors, BMI, HTN, and type 2 diabetes using path analysis methods from the Korean Longitudinal Study of Aging (KLoSA).[20] The path analysis uses regression equations to express the association among variables in a model by supplementing the mediator variable and its production with independent and mediator variables.[21] In addition, graphical representations of variables are very useful when considering causality.[22] Thus, this study will be meaningful in that it identifies health behaviors and the incidence of HTN and type 2 diabetes over time using longitudinal data.

2. Methods

2.1. Study design

This study was a secondary data analysis using KLoSA data between 2010 and 2014 (third and fifth) to explore the associations among health behaviors, HTN, type 2 diabetes, and BMI using path analysis methods. To clarify the relationships between the variables, we extracted demographic factors, health behaviours, and basal BMI from the third survey data in 2010. Changed BMI variables were extracted from the fourth survey data in 2012, and incidences of HTN and type 2 diabetes were extracted from the fifth survey data in 2014. Thus, this was a path analysis study that explored the influence of each variable on incidences of HTN and type 2 diabetes.

Korean Longitudinal Study of Aging was designed to enable comparative research with advanced countries already conducting aging panel surveys such as the United States (Health and Retirement Survey), England (English Longitudinal Survey of Aging), and Europe (Survey of Health, Aging and Retirement in Europe) in the process of transition to a super-aged society.[23] KLoSA included data of middle-aged and senior citizens aged 45 years and over at the time of data collection, for the purpose of producing basic data for establishing and implementing social and economic policies. Since 2006, basic surveys have been conducted using the same survey items in even-numbered years. Since 2007, surveys covering specific topics not included in the basic surveys such as family, health status, employment, income and consumption, assets, and quality of life have been conducted in odd-numbered years. Stratified sampling was done by area (residential type). KLoSA's survey method was computer-aided personal interview, where interviewers used notebooks, visited the households, and conducted interviews. Weighting was also used to compensate for changes over time.

2.2. Participants

The fifth KLoSA sample surveyed in 2014 included 9431 people, and the total number of surveyed panelists was 7467, including 438 who were deceased and 7029 survivors. BMI could be calculated for 6417 out of 7029 survivors using height and weight data from the third (2010) and fourth (2012) survival panel. The sample used in the current study consisted of 3481 people excluding 2936 who were already diagnosed with HTN and type 2 diabetes from the first to fourth survey. The KLoSA data were made publicly available from the Korea Employment Information Service website without any personal or identifying information. This study was performed after the approval of the research ethics review committee (2017–0024), ensuring anonymity and confidentiality without harm to the persons surveyed.

2.3. Dependent variables

Changed BMI (kg/m^2) was calculated using the 2012 KLoSA data regarding height and weight, and was a continuous variable. HTN incidence was assessed in response to the question "Have you ever been diagnosed with HTN from a doctor since the last survey?" of the 2014 KLoSA survey data; responses included "yes" or "no." Type 2 diabetes incidence was assessed in response to the question "Have you ever been diagnosed with type 2 diabetes or high blood sugar by your doctor since the last survey?" of the 2014 KLoSA survey data; responses included "yes" or "no."

2.4. Independent variables

The 2010 KLoSA survey data were used for the independent variables. The demographic characteristics were age, sex, education level, type of medical benefits, whether they lived alone, and 2010 BMI. Age was regarded as a continuous variable; sex was classified into male and female categories; and educational level was classified into 2 groups—lower than elementary school and higher. Type of medical benefits was divided into National Health Insurance and Medical Aid, and whether they lived alone was regarded in terms of binary responses of "yes" or "no." Basal BMI was regarded as a continuous variable.

Health behaviors included having regular meals, smoking, drinking, exercising regularly, and undergoing national health checkups. Respondents were classified as having regular meals when they indicated "yes" in response to the question, "In the last two days, did you eat breakfast, lunch, and dinner?" Individuals were categorized as smokers if they answered "yes" to the question, "Are you smoking now?" Individuals were categorized as drinkers if they answered "yes" to "Usually or occasionally drink alcohol (eg, Soju, beer, rice-wine, etc.)?" Exercising regularly was classified based on an answer of "yes" or "no"

Table 1

General characteristics according to body mass index groups in 2010 (n=3481).

Variables	Underweight (n=129) n (%)/M±SD	Normal (n=1714) n (%)/M±SD	Overweight (n=1638) n (%)/M±SD	*F* or χ^2 (*P*)
Demographic				
Age, y	69.14±10.59 (49–95)	61.89±9.94 (49–101)	60.72±8.57 (49–94)	50.06 (<.001)
Sex				
Male	55 (42.6)	769 (44.9)	753 (46.0)	0.78 (.671)
Female	74 (57.4)	945 (55.1)	885 (54.0)	
Education				
≤Elementary school	83 (64.3)	637 (37.2)	574 (35.0)	43.95 (<.001)
>Elementary school	46 (35.7)	1077 (62.8)	1064 (65.0)	
Type of medical benefits				
Medical aid (no)	123 (95.3)	1646 (96.0)	1579 (96.4)	0.56 (.757)
Medical aid (yes)	6 (4.7)	68 (4.0)	59 (3.6)	
Living alone (yes)	19 (14.7)	122 (7.1)	108 (6.6)	11.92 (.003)
Health-related behavior				
Regular diet (yes)	116 (87.6)	1588 (92.6)	1520 (92.8)	4.75 (.093)
Smoking (yes)	26 (20.2)	355 (20.7)	313 (19.1)	1.35 (.509)
Drinking (yes)	42 (32.6)	665 (38.8)	665 (40.6)	3.77 (.152)
Regular exercise (yes)	29 (22.5)	617 (36.0)	584 (35.7)	9.73 (.008)

to the question "Do you exercise regularly at least once a week?" "Undergoing national health checkups was classified according to responses of "yes" or "no" to the question "Have you ever received a primary health examination free of charge in the National Health Insurance and Medical Care System in the past two years?"

2.5. Statistical analysis

To analyze the BMI change, and incidence of HTN and type 2 diabetes according to health behaviors, PASW SPSS WIN 23.0 was used. Path analysis was conducted using generalized structural equation modeling (GSEM) of STATA 13.1 to analyze the types of binary variables and logit links.[24] However, despite its advantage, GSEM has the disadvantage of not being able to show indirect effects and goodness-of-fit indicators between variables.[24] To overcome this weakness, we used the "nlcom" command to directly calculate the indirect effect between health behavior and dependent variables. In the path analysis, confounding variables were controlled. For the major changes in BMI, we added the 2010 BMI (a continuous variable) as an independent variable. The 2012 BMI was also included as a continuous variable. After adding the 2010 BMI to the model, the correlation between the 2 independent variables (2010 BMI and health checkups) was high ($r=0.066$, $P<.001$). Thus, health checkups were excluded from the final model. There was no multicollinearity between other independent variables. The value of variation inflation factor was 1.07 to 1.60.

To analyze the influential factors according to BMI in 2010, BMI less than 18.5 was classified as underweight, 18.5 to 22.9 as normal, and 23 or over as overweight. Thus, 2 models were constructed to compare the underweight and normal groups; and the normal and overweight groups. We considered *P* value <.05 as statistically significant.

3. Results

3.1. General characteristics

As seen in Table 1, there were 129 underweight, 1714 normal, and 1638 overweight and obese individuals. The mean age was 69.14 years for the underweight group, 61.89 years for the normal group, and 60.72 years for the overweight group. There was a significant difference in age among the 3 groups ($F=50.06$, $P<.001$). The overweight group showed a higher educational level than the underweight group ($\chi^2=43.95$, $P<.001$), and lower frequency of living alone than the underweight group ($\chi^2=11.92$, $P=.003$). In the normal and overweight groups, 36.0% and 35.7% were regular exercisers, which was higher, compared with 22.5% of the underweight group ($\chi^2=9.73$, $P=.008$). However, type of medical benefits, regular diet, smoking, and drinking were not significantly different among the 3 groups (Table 1).

3.2. BMI and incidences of HTN, type 2 diabetes

There was a significant correlation between BMI for 2010 and 2012 (underweight group: $r=0.530$, $P<.001$; normal group: $r=0.722$, $P<.001$; overweight group: $r=0.795$, $P<.001$). The mean BMI in 2010 was 17.52±0.92 for the underweight group, 21.32±1.15 for the normal group, and 24.96±1.67 for the overweight group. In 2012, the mean BMI value increased by 0.29 in the underweight group and 0.12 in the normal group, and decreased by 0.19 in the overweight group. The incidence of HTN and type 2 diabetes was 5.7% and 2.4%, respectively (Table 2).

3.3. Results of the path analysis

We constructed 2 types of models for our research and included all variables in the 2 models. Figures 1 and 2 show only statistically significant findings.

3.3.1. Underweight and normal groups (model 1). In comparing the underweight and normal groups (model 1), higher BMI was related to more regular meals ($B=0.022$, $P<.001$). Age, sex, and education level were related to smoking. Smoking decreased with age ($B=-0.007$, $P<.001$). Moreover, females ($B=-0.435$, $P<.001$) and those with a higher education level ($B=-0.090$, $P<.001$) were less likely to be smokers. Similarly, age, sex, and education level affected drinking. Drinking decreased with age ($B=-0.009$, $P<.001$), females

Table 2

BMI and incidence of HTN and type 2 diabetes over a year (n=3481).

Variables		2010 Mean±SD	2012 Mean±SD	R (P)	2014 n (%)
BMI	Underweight group	17.52±0.92 (13.2–18.4)	17.81±1.37 (13.0–22.0)	0.530 (<.001)	—
	Normal group	21.32±1.15 (18.5–23.0)	21.44±1.52 (16.0–26.0)	0.722 (<.001)	—
	Overweight group	24.96±1.67 (23.0–33.4)	24.77±1.87 (20.0–34.0)	0.795 (<.001)	—
HTN (yes)		—	—		198 (5.7)
Type 2 diabetes (yes)		—	—		84 (2.4)

BMI=body mass index, HTN=hypertension.

($B=-0.439$, $P<.001$), and those with a higher education level ($B=-0.053$, $P=0.034$) were less likely to be drinkers. Those with a higher education level were more likely to be regular exercisers ($B=0.274$, $P<.001$).

Model 1 shows age, sex, and regular meals were found to have a direct effect on BMI. For those who had regular meals ($B=0.670$, $P<.001$), BMI was increased. However, BMI decreased with age ($B=-0.041$, $P<.001$), and females had lower BMI ($B=-0.229$, $P=.021$). In model 1, age had a direct effect on the incidence of HTN: the incidence of HTN increased with age ($B=0.038$, $P=.001$). In case of type 2 diabetes, age, regular meals, smoking, and BMI had a direct effect on the incidence of type 2 diabetes. In other words, the incidence of type 2 diabetes increased with age ($B=0.051$, $P=.005$), smoking ($B=1.539$, $P=.001$), and increased BMI ($B=0.239$, $P=.035$). Smoking had a total effect on the incidence of type 2 diabetes ($B=1.464$, $P=.002$). Regular meals had a direct effect on reducing diabetes ($B=-1.077$, $P=.036$), and there were no significant indirect effects (Fig. 1).

3.3.2. Normal and overweight groups (model 2). In comparing the normal and overweight groups (model 2), age, sex, and living alone influenced regular eating. Eating regularly increased with age ($B=0.001$, $P=.040$). However, females ($B=-0.020$, $P=.031$) and those living alone ($B=-0.052$, $P=.005$) ate less regularly. Smoking was influenced by age, sex, education level, and living alone. As in model 1, smoking decreased with age ($B=-0.006$, $P<.001$). In addition, females ($B=-0.411$, $P<.001$) and those with a higher education level ($B=-0.081$, $P<.001$) were less likely to be smokers. However, those who lived alone were more likely to be smokers ($B=0.067$, $P=.007$). Likelihood of being a drinker decreased with age ($B=-0.009$, $P<.001$), and females were less likely to be drinkers ($B=-0.436$, $P<.001$). Those with a higher education level were more likely to be regular exercisers ($B=0.256$, $P<.001$). Moreover, likelihood of being a regular exerciser increased with age ($B=0.002$, $P=.029$).

Model 2 shows age had a direct effect on BMI: BMI decreased with age ($B=-0.033$, $P<.001$). Age and BMI also had direct effects on the incidence of HTN. The incidence of HTN increased with age ($B=0.042$, $P<.001$) and BMI ($B=0.145$, $P<.001$). Age, smoking, and BMI had a direct effect on the incidence of type 2 diabetes. The incidence of type 2 diabetes increased with age ($B=0.046$, $P<.001$), smoking ($B=0.682$, $P=.020$), and higher BMI ($B=0.151$, $P=.001$). Smoking had a total effect on the incidence of type 2 diabetes ($B=0.648$, $P=.028$). There were no significant indirect effects (Fig. 2) (Table 3).

4. Discussion

The purpose of this study was to investigate the association between health behaviors, HTN, type 2 diabetes, and BMI using path analysis of Korean longitudinal studies of aging. The incidence of HTN and diabetes was found to be 5.7% and 2.4%,

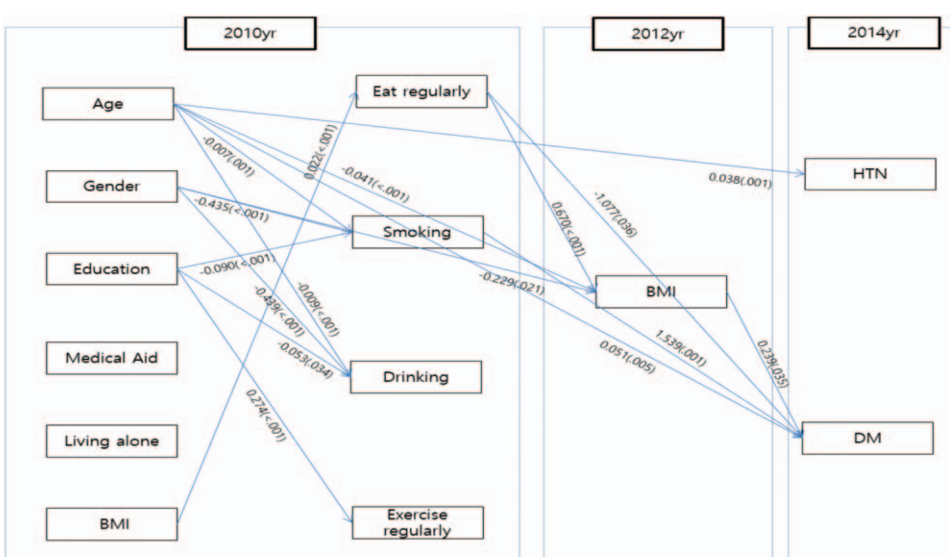

Figure 1. Significant path in underweight and normal weight group (model 1).

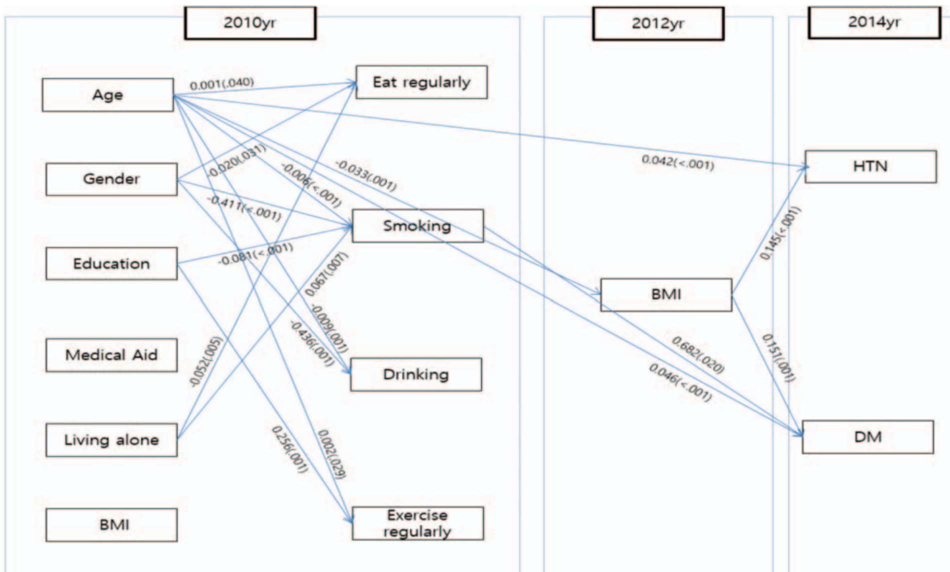

Figure 2. Significant path in normal weight and overweight group (model 2).

respectively, between 2012 and 2014, rates that are higher than the results of a survey conducted with those over the age of 30 years in the same period.[5] HTN was higher compared with findings of previous studies, which showed an incidence of HTN of 4.7% in Korea[25] and 4.4% in newly diagnosed patients in Canada.[26] In a previous study of middle-aged adults to predict the incidence of type 2 diabetes in the USA (Framingham Offspring study), over a period of 7 years (1995–2001), among 160 of 3140 patients diagnosed with type 2 diabetes, about 23 were diagnosed annually.[11] In another study of those 18 years or older that involved telephone surveys through the Behavioral Risk Factor Surveillance System in collaboration with the Centers

Table 3

Direct, indirect, and total effect between health behavior, BMI, hypertension, and type 2 diabetes in the 2 models.

Groups	Variables: Endogenous	Exogenous	Direct effect: Estimate (*P*)	Direct effect: 95% CI	Indirect effect: Estimate (*P*)	Indirect effect: 95% CI	Total effect: Estimate (*P*)	Total effect: 95% CI
Underweight and normal (n=1843)	BMI	Eat regularly	0.670 (<.001)			0.38, 0.96		
		Smoking	−0.145 (.214)	−0.37, 0.08				
		Drinking	0.073 (.436)	−0.11, 0.26				
		Exercise regularly	0.146 (.086)	−0.02, 0.31				
	HTN	BMI	0.050 (.455)	−0.08, 0.18				
		Eat regularly	−0.542 (.144)	−1.27, 0.18	0.033 (.461)	−0.06, 0.12	−0.500 (.181)	−1.23, 0.23
		Smoking	−0.239 (.462)	−0.88, 0.40	−0.007 (.522)	−0.03, 0.01	−0.252 (.439)	−0.89, 0.39
		Drinking	0.019 (.943)	−0.51, 0.54	0.004 (.590)	−0.01, 0.02	0.025 (.926)	−0.50, 0.55
		Exercise regularly	−0.109 (.665)	−0.61, 0.39	0.007 (.494)	−0.01, 0.03	−0.096 (.705)	−0.60, 0.40
	Type 2 DM	BMI	0.239 (.035)	0.002, 0.46				
		Eat regularly	−1.077 (.036)	−2.08, −0.07	0.160 (.057)	−0.01, 0.33	−0.832 (.107)	−1.84, 0.18
		Smoking	1.539 (.001)	0.59, 2.48	−0.035 (.285)	−0.10, 0.03	1.464 (.002)	0.52, 2.41
		Drinking	−0.274 (.539)	−1.15, 0.60	0.017 (.465)	−0.03, 0.06	−0.247 (.582)	−1.13, 0.63
		Exercise regularly	−0.174 (.684)	−1.01, 0.67	0.035 (.183)	−0.02, 0.09	−0.105 (.807)	−0.95, 0.74-
Normal and overweight (n=3352)	BMI	Eat regularly	0.245 (.119)	−0.06, 0.55				
		Smoking	−0.212 (.075)	−0.45, 0.02				
		Drinking	0.058 (.534)	−0.13, 0.24				
		Exercise regularly	0.006 (.943)	−0.16, 0.17				
	HTN	BMI	0.145 (<.001)	0.09, 0.20				
		Eat regularly	−0.177 (.530)	−0.73, 0.37	0.035 (.138)	−0.01, 0.08	−0.140 (.621)	−0.69, 0.41
		Smoking	−0.176 (.435)	−0.62, 0.27	−0.031 (.095)	−0.07, 0.01	−0.208 (.358)	−0.65, 0.24
		Drinking	0.281 (.108)	−0.06, 0.62	0.009 (.537)	−0.02, 0.04	0.290 (.098)	−0.05, 0.63
		Exercise regularly	0.053 (.740)	−0.26, 0.37	0.001 (.943)	−0.02, 0.03	0.055 (.735)	−0.26, 0.37
	Type 2 DM	BMI	0.151 (.001)	0.06, 0.24				
		Eat regularly	−0.086 (.843)	−0.93, 0.76	0.037 (.156)	−0.01, 0.09	−0.046 (.915)	−0.90, 0.81
		Smoking	0.682 (.020)	0.11, 1.26	−0.032 (.114)	−0.07, 0.01	0.648 (.028)	0.07, 1.23
		Drinking	0.121 (.646)	−0.39, 0.64	0.009 (.540)	−0.02, 0.04	0.130 (.621)	−0.39, 0.65
		Exercise regularly	−0.102 (.676)	−0.58, 0.38	0.001 (.943)	−0.02, 0.03	−0.100 (.682)	−0.58, 0.38

BMI=body mass index, HTN=hypertension, DM=diabetes mellitus.

for Disease Control and Prevention (CDC), over 8 years (1990–1998), about 1.6% were newly diagnosed[12]; thus, our result was higher than that in this study. This difference may have resulted because previous studies were conducted with younger participants. This study showed that age directly influences not only BMI but also HTN and type 2 diabetes.

To investigate the incidence of hypertension and type 2 diabetes according to BMI, the study population was divided into 3 groups, and 2 analytical models were created. Because of the nature of BMI, such that it is a comparison of higher or lower than normal, we could not explain it with 1 direction in 1 model. In general, studies examining the relationship between health-related behaviors, BMI, and the incidence of diabetes have classified BMI <25 as a same group.[15,26,27] However, both underweight and overweight are health problems, and researchers should carefully interpret their results. For the elderly, low body weight causes difficulty maintaining daily life due to decrease of muscle, and increases the mortality rate.[28,29] In another previous study analyzing the relationship between behaviors, BMI, and functional ability of the elderly, underweight was classified into the same group as normal weight because the number of underweight persons was low. The results showed better ability to function for those who were slightly overweight.[25] Therefore, when considering BMI and health behaviors, underweight should be separated from the normal weight group by age.

In this study, factors affecting BMI (2012) were age, sex, BMI (2010), and regular diet. We observed the incidence of HTN and diabetes according to BMI change in 2 models. In model 1, health behavior such as regular eating had an effect on BMI. However, when weight was above the normal level (in model 2), health behavior was not affected. In addition, high BMI directly affected the incidence of HTN and type 2 diabetes. Regular diet was related to increased BMI in the underweight and normal groups, and increased BMI was associated with incidence of type 2 diabetes. This may reflect the results of some people (237 out of 1714, 13.8%) who became overweight in 2012. However, regular eating served as a direct factor in lowering the incidence of type 2 diabetes. This supports a previous study that found regular meals to be a very important factor for prevention of type 2 diabetes.[30] In this study, exercise did not affect BMI significantly; however, changes in lifestyle such as diet and exercise are known to be related to the incidence of diabetes.[31,32] Therefore, it is necessary to repeat the study including type and amount of diet and exercise. Moreover, the results of this study are the same as those of previous studies showing that HTN and type 2 diabetes occur more frequently with a higher BMI, and being overweight and obese cause disease.[3,6,9,10,12,16,26] Therefore, it is important to maintain proper BMI, and above all, it is necessary to eat and exercise regularly so that BMI does not increase above normal.

Smoking was directly related to incidence of type 2 diabetes in all models. This is in line with the results of previous studies that showed smoking causes type 2 diabetes.[17,33,34] Smokers identified in this study were more likely to be younger, male, living alone, and with a low educational level. Therefore, smoking cessation and policy programs for people with these characteristics should be implemented.

Alcohol drinking was not associated with BMI in this study. The reason for this result could be that our study asked about usual drinking and did not consider the amount of alcohol. In addition, limitations of self-reported scales such as incorrect memory or under-reporting (social desirability bias) are possible. A study of the relationship between drinking patterns and the incidence of diabetes in Koreans over 30 years of age revealed that drinking more than 4 times per week was the cause of male diabetes.[35] Thus, further studies should be conducted to confirm the relationship between alcohol consumption, HTN, and type 2 diabetes.

The limitations of this study are as follows. First, it relies on reports by respondents regarding whether the diagnosis of HTN and type 2 diabetes were made by a doctor. Therefore, the incidence rate may be higher or lower than the results presented in this study. Second, this study was a secondary data analysis and did not include total intake (Kcal/d) and dietary type, amount of exercise and types of exercise, consumption of alcohol, and psychosocial factors such as stress or depression as factors affecting BMI. Third, this study examined the incidence of disease within a certain period. Future research will need to look at events over time. Despite these limitations, in this study, the path analyses were different from those that have been carried out so far, which were based on linear analysis of continuous variables. Our study is meaningful in that the influence of the variables was verified using nonlinear analysis with "yes" or "no" responses, which are commonly used in general questionnaire formats. In addition, with an aim to help prevent diseases, our study explains the relationship between variables by schematizing the process of health behaviors affecting HTN and type 2 diabetes. In future studies, it is necessary to complement the present study by directly measuring the disease-related data of the population and conducting research including psychological factors that may affect weight.

Author contributions

Conceptualization: Deulle Min, Eunhee Cho.
Writing – original draft: Deulle Min.
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