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Prevalence of Diabetes Mellitus in the Elderly of Namwon County, South Korea

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Background : *Ethnic and geographic differences exist in the prevalence of diabetes mellitus which has increased dramatically in South Korea. A few community-based epidemiologic studies with oral glucose tolerance test were performed in South Korea. The purpose of this study was to determine the prevalence of diabetes mellitus by the World Health Organization (WHO) and the American Diabetic Association (ADA) diagnostic criteria and to investigate their associated risk factors. Also, we compared and analyzed the characteristics of Koreans by WHO and ADA diagnostic criteria.*

Methods : *Between March 22, 1999 and July 14, 1999, a random sampling of 1,445 residents over 40 years of age in five villages (3 myons and 2 dongs) in Namwon City, Chollabuk-do Province, South Korea was carried out. WHO and ADA diagnostic criteria were used for the prevalence of DM, IGT and IFG. The associated factors of subjects were analyzed.*

Results : *After age adjustment for the population projection of Korea (1999), the prevalence of DM and IGT was 13.7% and 13.8%, respectively, by WHO criteria, while the prevalence of DM, IGT and IFG was 15.8%, 12.8% and 5.7%, respectively, by ADA criteria, and the previous diagnosed diabetics were 5.8% in 665 adults over 40 years of age in the Namwon area. The age-adjusted prevalence of previously diagnosed diabetics was 5.8%. When the subjects classified by both criteria were compared, the level of agreement between WHO and ADA diagnostic criteria, except IFG, was very high (κ=0.94; $p<0.001$). The ROC curve analysis determined FSG of 114.5 mg/dL (6.4 mmol/L) to yield optimal sensitivity and specificity corresponding to a PP2SG 200 mg/dL (11.1 mmol/L). The prevalence of DM and IGT with ADA diagnostic criteria rose with increasing age ($p<0.05$). The body mass index was mean 23.8±3.4 in all the subjects, 23.75±3.46 in NGT group and 23.67±3.16 in DM group, but the differences in the prevalence of DM, IGT and IFG by BMI were not significant. The prevalence of DM rose significantly with the increase in the waist-hip ratio ($p<0.05$). The prevalence of DM significantly increased in subjects by increases in blood pressure, and triglyceride and the relative risk in the prevalence of DM was significantly high with dyslipidemia (Odds ratio 2.29, 95% CI: 1.16-3.49).*

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Conclusion : *The prevalence of Diabetes Mellitus in the population over 40 years of age in Namwon City, South Korea remarkably increased compared with the 1970s and 1980s and was similar to that of the West. Ethnic differences in obesity of normal, DM and IGT subjects and in the effect on the prevalence of DM may exist in the Korean population, but they were not significant. As there is a limit in number, it is considered that a general population-based epidemiologic study on a large scale is required to investigate ethnic and geographic differences for the risk factors of DM in South Korea. The level of agreement, except IFG, by WHO and ADA diagnostic criteria was high, which indicates that these results may show that not only fasting serum glucose but also postprandial 2-h serum glucose are important for diagnosing diabetes in Korean.*

Key Words : *Diabetes Mellitus, Prevalence, Risk factor*

INTRODUCTION

Significant ethnic and geographic differences exist in the prevalence of diabetes mellitus, which recorded below 1% before the industrialization of the 1970s, based on a cross-sectional study, but has increased to 3% in the 1980s and dramatically to 7.1% in the 1990s[1, 2]. Death due to diabetes mellitus is increasing continuously and has become one of the main causes of death in Korea[1]. Diabetes mellitus is mainly attributed to obesity by economical and social developments and westernized life style, reduction of physical activities, increased lipid consumption, drug abuse, increased calorie intake and increased exposure to risk factors like stress, as well as the aging population structure.

Since the diagnostic criteria of diabetes mellitus have been suggested by the National Diabetes Data Group (NDDG) in 1979[3] and the World Health Organization (WHO) in 1985[4], most doctors and researchers have used them as a standard diagnosis. But, as they have been called in question, the American Diabetic Association (ADA) has come to recommend new diagnostic criteria for diabetes mellitus[5].

In spite of the importance of epidemiologic research and statistics of diabetes mellitus, only cross-sectional studies were carried out in general hospitals and relatively approachable medical insurance corporations in Korea. Epidemiologic studies by fasting serum glucose and postprandial 2-h serum glucose tests were performed only with local communities in Yeonchun, Kyunggi-do Province in 1993[6] and Jeongeup, Chollabuk-do Province in 1997[7]. This study tested people living in Namwon City, Chollabuk-do Province with WHO and ADA diagnostic criteria to calculate the prevalence of diabetes mellitus and to analyze the associated factors. Korean characteristics according to WHO and ADA diagnostic criteria were compared for analysis.

SUBJECTS and METHODS

This study was carried out in Namwon City, Chollabuk-do Province from March 22, 1999 to July 14, 1999. As Namwon City is a city and farming combined area, 3 farming areas and 2 urban areas were randomly selected and 1,445 adults aged over 40 were tested. Detailed questionnaires for past medical history, family history, life pattern, alcohol habit, amount of exercise, dietary habit and smoking experience were developed and performed for residents in each region and anthropometric data were collected. They were explained directly to health personnel of the public health center in Namwon to keep them well informed of the contents of questionnaires and to train them for measuring.

For oral glucose tolerance test, blood samples were collected after fasting at least for 8 hours and in 2 hours after glucose uptake. Collected samples were immediately centrifuged and serum specimens were kept in cold storage. Serum glucose level was measured by hexokinase method on the same day, and serum lipid level was measured by enzyme assay with Express 550 (Chiron Co., USA) for total cholesterol, triglyceride, HDL cholesterol.

For comparison of the prevalence nationwide, age was adjusted with the inductive population by age of Korea in 1999 (presented by Korea National Statistical Office) and the prevalence of diabetes mellitus (hereafter DM), impaired glucose tolerance (hereafter IGT) and impaired fasting glucose (hereafter IFG) was calculated by using WHO and ADA diagnostic criteria.

The level of agreement (κvalue) was obtained for comparing two diagnostic criteria. Reclassification and comparison were carried out based on fasting serum glucose (hereafter FSG) and postprandial 2-h serum glucose (hereafter PP2SG) only in order to identify the diagnostic values of FSG and PP2SG by ADA diagnostic criteria. Irrespectively of PP2SG, only FSG was divided into (hereafter ADA-FSG) FSG<110 mg/DL: normal (normal glucose tolerance, hereafter NGT), FSG≥110 mg/dL (6.1 mmol/L); IFG, FSG≥126 mg/dL (7.0 mmol/L); DM. Irrespectively of FSG, only PP2SG was divided into PP2SG<140 mg/dL (7.8 mmol/L); NGT, PP2SG 140~199 mg/dL (7.8~11.0 mmol/L); IGT, PP2SG≥200 mg/dL (11.1 mmol/L); DM. The relation between postprandial 2-h serum glucose of 200 mg/dL (11.1 mmol/L) and FSG standard value was confirmed with sensitivity and specificity of each FSG obtained through the receiver operating characteristics (ROC) curve (Epistat Statistics (USA)). Positive predictive values of each figure were compared.

Statistical Package for Social Sciences (SPSS) computer program was used for statistical procedures. The result was expressed in mean±standard deviation. Mantel-Haenszel Chi-Square test was used to confirm the comparison between IGT and DM according to the associated factors and the level of agreement to both diagnostic criteria, and to identify the association of some factors affecting the prevalence of DM. The associated factor analysis of subjects who are normal by WHO diagnostic criteria but abnormal by ADA criteria was calculated through oneway analysis of variance using *t*-test and general linear model, and Tukey method was used for post-hoc tests. Multivariate analysis for factors associated with diabetes mellitus adopted the logistic regression analysis. $p<0.05$ was judged significant.

RESULTS

1. Patients and participation

Of 1,445 adults aged over 40 who participated in the study, 1,128 residents answered and 665 (46.0%) completed all the tests of the questionnaires, body measurement and oral glucose tolerance test. They were 62.0±10.2 years old (mean±SD) and 60s were the most. Sex rate was

Table 1. Clinical charateristics of subjects according to age.

Age (year)	40-49	50-59	60-69	≥70	total
n	62	165	253	185	665
Age (year)	44.6±3.0	55.3±2.9	64.7±2.8	74.4±9.6	63.2±9.6
SBP (mmHg)	125.2±15.0	133.7±19.1	140.2±22.5	144.4±22.5	138.3±21.8
DBP (mmHg)	77.6±9.7	81.2±10.8	83.7±11.5	83.1±11.3	82.4±11.2
BMI (kg/m²)	25.0±2.8	24.7±3.3	23.7±3.4	22.5±3.4	23.8±3.4
WHR (cm/cm)	0.86±0.05	0.87±0.06	0.88±0.06	0.88±0.08	0.88±0.07
LDLC (mg/dL)	104.9±29.2	109.6±32.8	111.4±33.5	111.4±33.5	120.5±35.8
TC (mg/dL)	182.0±32.0	189.2±34.7	187.4±35.6	197.7±37.4	190.2±35.8
HDLC (mg/dL)	51.3±8.3	53.6±8.8	52.7±9.2	52.6±10.1	52.7±9.3
TG (mg/dL)	129.2±94.4	132.3±75.2	123.5±85.6	128.7±92.4	127.7±85.9

Mean±SD; N, numbers; SBP, systolic blood pressure; DBP, diastolic blood pressure; BMI, body mass index; WHR, waist-hip ratio; TC, total cholesterol; TG, triglyceride; HDLC, high density lipoprotein cholesterol; LDLC, low density lipoprotein cholesterol.

Table 2. Prevalence of and diabetes mellitus (DM) according to age groups by past-medical history.

	Prevalence: n (%)					Age-adjusted prevalence, %	95% CI
	40-49	50-59	60-69	>70	Total		
Past-DM							
M	2 (9.1)	3 (7.0)	5 (5.6)	8 (12.5)	18 (8.2)	8.5	1.2-15.1
F	1 (2.5)	6 (4.9)	7 (4.3)	13 (10.7)	27 (6.1)	4.7	1.5-8.0
M+F	3 (4.8)	9 (5.5)	12 (4.7)	21 (11.4)	45 (6.8)	5.8	2.6-8.9
Numbers	62	165	253	185	665		

Past-DM, Past Medical History of DM; M, male; F, female; M+F, male+female; n, numbers.

Table 3. Prevalence of impaired glucose tolerance (IGT), impaired fasting glucose (IFG) and diabetes mellitus (DM) according to age groups by WHO and ADA diagnostic criteria with past-medical history.

	Prevalence: n (%)					Age-adjusted prevalence, %	95% CI
	40-49	50-59	60-69	>70	Total		
WHO							
IGT							
M	2 (9.1)	5 (11.6)	16 (17.8)	14 (21.9)	37 (16.9)	12.5	4.6-20.5
F	3 (7.5)	20 (16.3)	32 (19.6)	27 (22.3)	82 (18.4)	14.5	9.1-19.8
M+F	5 (8.1)	25 (15.2)	48 (19.0)	41 (22.2)	119 (17.9)	13.8	9.3-18.3
DM							
M	5 (22.7)	7 (16.3)	11 (12.2)	15 (23.4)	38 (17.4)	19.0	9.1-29.0
F	3 (7.5)	13 (10.7)	18 (11.0)	29 (24.0)	63 (14.1)	11.5	6.5-16.5
M+F	8 (12.9)	20 (12.1)	29 (11.5)	44 (23.8)	101 (15.2)	13.7	9.0-18.5
ADA							
IFG							
M	1 (4.5)	4 (9.3)	11 (12.2)	6 (9.4)	22 (10.0)	7.7	1.5-14.0
F	1 (2.5)	8 (6.6)	11 (6.7)	5 (4.1)	25 (5.6)	4.7	1.4- 7.9
M+F	2 (3.2)	12 (7.3)	22 (8.7)	11 (5.9)	47 (7.1)	5.7	2.7- 8.7
IGT							
M	2 (9.1)	5 (11.6)	14 (15.6)	13 (20.3)	34 (15.5)	12.0	4.1-19.8
F	3 (7.5)	18 (14.8)	30 (18.4)	23 (19.0)	74 (16.6)	13.3	8.1-18.5
M+F	5 (8.1)	23 (13.9)	44 (17.4)	36 (19.5)	108 (16.2)	12.8	8.5-17.2
DM							
M	5 (22.7)	7 (16.3)	15 (16.7)	17 (26.6)	44 (20.1)	20.1	10.1-30.2
F	4 (10.0)	16 (13.1)	20 (12.3)	34 (28.1)	74 (16.6)	14.0	8.4-19.4
M+F	9 (14.5)	23 (13.9)	35 (13.8)	51 (27.6)	118 (17.7)	15.8	10.8-20.8
Numbers	62	165	253	185	665		

M, male; F, female; M+F, male+female; n, numbers.

1:1.86 with more females. Clinical characteristics of weight, body mass index (BMI), waist-hip ratio (WHR) and blood pressure by age are shown in Table 1.

2. Prevalence of DM, IGT, IFG

With 665 adults aged over 40 in the Namwon area, the prevalence of DM and IGT by WHO criteria was 15.2% and 17.9%, respectively. The prevalence of DM, IGT and IFG by ADA criteria was 17.7%, 16.2%, 7.1%, respectively. The previously diagnosed diabetics under therapy were 6.8% (n=45), which was 38.1% of the total diabetes mellitus patients (Table 2, 3). The age-adjusted prevalence with the inductive population (by age) of Korea in 1999 was 13.7% of DM and 13.8% of IGT by WHO criteria, whereas DM, IGT and IFG were 15.8%, 12.8% and 5.7%, respectively, by ADA criteria. The patients already diagnosed as diabetes mellitus were 5.8%.

3. Comparison of WHO and ADA diagnostic criteria

The prevalence of DM by ADA criteria increased by 2.5% compared with WHO criteria. Subjects with consistent diagnosis of normal state, IGT, DM by WHO and ADA criteria were 601 (90.4%). Subjects with normal state by WHO, but IFG by ADA, were 47 (7.1%), whereas individuals with IGT by WHO and DM by ADA were 11 (1.7%). Diabetic patients already diagnosed were excepted and subjects classified by two diagnostic criteria were compared. The level of agreement of two criteria, except IFG group, was very high at κ=0.94 ($p<0.001$).

To evaluate the diagnostic value of FSG by ADA criteria, subjects were reclassified (ADA-FSG) and compared only by FSG before oral glucose tolerance test. The crude prevalence of IFG and DM by ADA-FSG criteria was 10.5% and 15.0%, respectively,

Table 4. Estimated prevalence of diabetes in individuals over 40 years old in the Namwon, Korea

Diabetes diagnostic criteria	Prevalence (%) of diabetes by glucose criteria without a medical history of diabetes A	Total diabetes prevalence (%) B
Past medical history of diabetes	-	6.8
WHO criteria for diabetes: FSG ≥140 mg/dL (7.8 mmol/L) or PP2hSG ≥200 mg/dL (11.1 mmol/L)	9.0	15.2
ADA criteria for diabetes : FSG ≥126 mg/dL (7.0 mmol/L) or PP2hSG ≥200 mg/dL (11.1 mmol/L)	11.8	17.7
ADA-FBG criteria for diabetes: FSG ≥ 126 mg/dL (7.0 mmol/L)	8.2	15.0
WHO-PP2h criteria for diabetes: PP2SG ≥200 gm/dL (11.1 mmol/L)	5.3	12.1

A Diabetes prevalence (by glucose criteria) in those without a past medical history of diabetes ×(100%-prevalence of diabetes by medical history).
B First column of data plus 6.8.
FSG, Fasting serum glucose; PP2hSG, postprandial 2h serum glucose.

which decreased compared with the criteria including postprandial serum glucose (Table 4). When compared by ADA-FSG and ADA criteria in 536 subjects without previously diagnosed diabetics and IGT, individuals in agreement were 512 (95.5%). Discrepant diagnosis was occurred in 24 subjects (4.4%), in which 20 individuals (3.7%) were diagnosed as DM by ADA criteria, even though normal by ADA-FSG criteria. On the other hand, individuals diagnosed as IFG by ADA-FSG, but DM by ADA criteria were 4 (0.7%), and the level of agreement between both criteria was relatively high at κ=0.89 (p<0.001). Of 620 subjects, except 45 previously diagnosed diabetics, 86 individuals displayed FBG of 110~139 mg/dL (7.7 mmol/L at 6.1). They were divided into 53 of normal state (61.6%), 26 of IGT (30.2%), 7 of DM (8.1%) by WHO criteria, whereas 15 of IGT (17.4%), 47 of IFG (54.7%) and 24 of DM (27.9%) by ADA criteria.

When the subjects were reclassified only by postprandial 2-hour serum glucose (WHO-PP2), the crude prevalence of IGT and DM was 20.3% and 12.1%, respectively. Based on 200 mg/dL (11.1 mmol/L) of postprandial 2-hour serum glucose as diagnostic criteria, the receiver operating characteristics (ROC) curve analysis was used to estimate the corresponding FSG. 114.5 mg/dL (6.4 mmol/L) was estimated as maximum accurate FSG value (sensitivity; 0.615, 1-specificity; 0.131).

4. Associated factors

The prevalence of DM and IGT by ADA criteria for all the subjects rose with increasing age. When classified by sex, a significant increase was displayed in females (p<0.05). The prevalence and the relative risk of DM in individuals over 70 years of age were significantly high (Table 5). BMI (body mass index) was mean 23.8±3.4 kg/m^2 in all the subjects, 23.75±3.46 kg/m^2 in NGT group and 23.67±3.16 kg/m^2 in DM group. The differences of prevalence of DM, IGT, IFG according to the increase of BMI were not observed. The prevalence of DM by WHR increase significantly rose (p<0.05). However, the increase in the prevalence of DM by increasing waist was not observed. The prevalence of DM showed a significant increase according to blood pressure and triglyceride increases. Females had a significant increase when classified by sex (p<0.05). The crude prevalence of hypertension occupied 44.4% in all the subjects and 33.6% (95% CI: 27.5~39.7) when adjusted with age. The crude prevalence of hypertension in diabetic patients was 19.2% and the age-adjusted prevalence was 39.4% (95% CI: 22.6~56.3). There was no significant difference in the prevalence of DM according to total cholesterol, high density lipoprotein cholesterol and low density lipoprotein cholesterol. But, when it was defined as dyslipidemia in case of total cholesterol≥240 mg/dL or HDL cholesterol≥160 mg/dL or LDL cholesterol<35 mg/dL, the relative risk in the

Table 5. Associated factors of diabetes

Associated factors	Range	People with diabetes	Total in group	Prevalence Odds ratio	95% CI
Age (years)					
Quartile 1	≥40, ≤57	24	174	1	
Quartile 2	>57, ≤64	29	172	1.27	0.70~2.28
Quartile 3	>64, ≤71	25	181	1.02	0.92~1.09
Quartile 4	>71	40	138	2.55	1.45~4.50
Sex					
Male		44	175	1	
Female		74	372	0.79	0.52~1.20
BMI (kg/m^2)					
Quartile 1	≤21.3076	28	164	1	
Quartile 2	>21.3076 ≤23.4845	31	165	1.12	0.64~1.98
Quartile 3	>23.4845, ≤25.9190	26	164	.0.91	0.51~1.63
Quartile 4	>25.9190	31	164	1.13	0.64~2.00
WHR (cm/cm)					
Quartile 1	≤0.8293	24	164	1	
Quartile 2	>0.8293, ≤0.8750	22	166	0.89	0.48~1.66
Quartile 3	>0.8750, ≤0.9167	33	161	1.50	0.84~2.68
Quartile 4	>0.9167	37	165	1.69	0.96~2.97
Waist (cm)					
Quartile 1	≤77	27	174	1	
Quartile 2	>77, ≤83	28	168	1.09	0.61~1.94
Quartile 3	>83, ≤90	29	183	1.03	0.58~1.81
Quartile 4	>90	32	131	1.76	0.99~3.12
Mean BP (mmHg)					
Quartile 1	≤98.5	25	169	1	
Quartile 2	>98.5, ≤108.75	22	169	0.86	0.47~1.60
Quartile 3	>108.75, ≤120.625	28	161	1.21	0.67~2.18
Quartile 4	>120.625	43	166	2.01	1.16~3.49
Dyslipidemia					
No		89	566	1	
Yes		29	97	2.29	1.40~3.73
TG (mg/dL)					
Quartile 1	≤73.0	25	169	1	
Quartile 2	>73.0, ≤103.0	22	169	0.86	0.47~1.60
Quartile 3	>103.0, ≤157.5	28	161	1.21	0.67~2.18
Quartile 4	>157.5	43	166	2.01	1.16~3.49
FH of diabetes					
No		99	482	1	
Yes		16	27	2.89	1.50~5.56
Smoking					
No		76	382	1	
Yes		32	101	1.59	1.00~2.54

prevalence of DM was significantly high with dyslipidemia (Odds ratio 2.29, 95% CI:1.16-3.49). Of multivariate analysis including age, mean BP, body mass index, waist and the presence of dyslipidemia from the associated factors of DM, significant correlations appeared in age (RR = 1.025, p = 0.043), waist (RR = 1.034, 0.035) and the presence of dyslipidemia (RR = 2.219, p = 0.003).

Smoking was checked with 631 individuals of all the subjects. They were divided into no-smoking (72.6%), having been smoking over 6 months (21.1%, n=133, 107

Table 6. Associated factors by diagnostic criteria.

Factors \ WHO/ADA	NGT/NGT	NGT/IFG	NGT/DM	IGT/IGT	IGT/DM	DM/DM
N	407	47	6	114	12	79
Age (years)	61.9±9.7	63.0±7.7	62.7±12.9	65.7±9.2*	67.3±8.4	65.9±9.5*
FSG (mg/dL)	88.9±11.1	115.4±4.6*	132.3±3.4*	94.9±14.0	130.2±4.4*	151.4±51.4*
PP2SG (mm/dL)	104.9±19.2	112.9±14.9	118.8±18.9	161.9±17.6*	175.5±14.4*	214.0±76.6*
SBP (mmHg)	136.0±20.8	137.7±23.4	134.3±21.3	141.9±22.4	136.8±20.4	146.0±23.3*
DBP (mmHg)	81.3±10.9	83.2±12.17	80.3±10.1	83.5±11.5	83.6±11.2	85.7±11.6*
BMI (kg/m²)	23.75±3.46	23.33±3.23	22.58±2.82	24.02±3.64	24.59±3.74	23.67±3.16
WHR (cm/cm)	0.87±0.07	0.88±0.05	0.90±0.08	0.88±0.06	0.90±0.06	0.88±0.08
Waist (cm)	83.0±9.1	84.1±7.7	83.8±9.3	83.9±9.4	86.6±11.4	84.7±8.6
T-chol (mg/dL)	188.2±33.8	192.3±35.0	187.2±43.0	191.1±37.6	198.8±35.1	196.7±42.8
HDL (mg/dL)	52.2±8.5	54.6±9.6	60.0±11.8	53.0±9.9	55.7±7.1	53.0±11.8
TG (mg/dL)	120.4±82.5	140.3±82.3	123.8±149.4	128.1±84.4	133.2±52.8	156.2±99.9*
LDL (mg/dL)	113.1±32.6	112.5±34.2	107.8±41.7	112.8±33.8	116.5±37.6	111.9±40.1

NGT, normal glucose tolerance; DM, diabetes mellitus; IFG, impaired fasting glucose; IGT, impaired glucose tolerance; N, numbers; FSG, fasting serum glucose; SBP, systolic blood pressure; DBP, diastolic blood pressure; T-chol, total cholesterol; HDL, high density lipoprotein cholesterol; TG, triglycerides; LDL, low density lipoprotein cholesterol.
*significant differences to NGT/NGT: $p<0.05$

males and 26 females) and smoking only in the past (7%, n=43). Smoking patients with DM were 29.6% (n=32) and the different prevalence of D was not observed according to the smoking experience. The inquiry for practising habit (n=620) showed regularly practising twice or more per week (6.3%) and no experience or plan for practice (77.7%). The inquiry for practice time (n=8) displayed 48% of less 30 min. in average per week during the last month from the inquiry date, 37.3% of 30 min. to 2 hours and 16.9% of over 2 hours. 5.7% answered positively for family history of DM (n=33). The prevalence of DM increased according to the family history, but it was not statistically significant (Odds ratio 1.64, 95% CI:0.66-4.14).

The characteristics of associated factors like body mass index, waist-hip ratio, total cholesterol, LDL cholesterol, HDL cholesterol, systolic blood pressure, diastolic blood pressure, triglyceride, fasting serum glucose and age were compared by WHO and ADA diagnostic analysis (Table 6). According to both criteria, it was observed that age was significantly high ($p<0.05$) in DM group (54 subjects, hereafter DM/DM) and IGT group (114, hereafter IGT/IGT) compared with the normal group (412, hereafter NGT/NGT). SBP, DBP and TG were significantly high in DM/DM group compared with NGT/NGT group ($p<0.05$). But there were no statistically significant differences of BMI, WHR, T-chol, HDL and LDL cholesterol between each group.

DISCUSSION

This study was carried out as a cross-sectional research with a general population in the Namwon area of Chollabuk-do, Province. They were all adults over 40, regarded as relatively aged people with the average age of 62. According to WHO diagnostic criteria adjusted with age from the inductive population of 1999 in Korea, the prevalence of DM and IGT was 13.7% and 13.8%, respectively, whereas the prevalence of DM, IGT, IFG was 15.8%, 12.8%, 5.7%, respectively, based on ADA criteria. The prevalence of DM in Korea before the 1970s was reported as very low, less than 1% on a cross-sectional study[1], however, the recent study has showed increases like 10.1% (by WHO criteria) with adults over 40 years of age in the Yeonchun research[6] and 7.1/8.5% (by WHO/ADA criteria) in the Jeongeup research[7]. The prevalence of DM from our study was not significantly different from these, but increased more.

The prevalence of DM depends on geographic and ethnic differences but it has increased worldwide. The prevalence of DM in the age group over 40 has increased from 1~3% in the 1970s to 3~10% in the 1980s[8, 9] and 8.3~19.8% in the 1990s[10-13] in Caucasians in U.S. or Europe, which is similar to this study. The prevalence of DM has gradually increased also in Asia, including Korea. In case of a population over 40 years of age in Japan, the prevalence was 1.3~4.7% by Japan Diabetes Society (JDS) criteria in 1970, but it remarkably increased to 10~12% by WHO criteria from the late 1980s to the early 1990s[14-16]. A remarkable increase of prevalence is observed also in Taiwan and Singapore, which have relatively enhanced economic conditions like Japan. The current studies of Japan[17, 18], Taiwan[19] and Singapore[20, 21] have presented a similar or exceeding prevalence by 10% compared with the case of Korea. In Pakistan[22], India[23] and Bangladesh[24], a rapidly increasing prevalence has been reported in relation to urbanization. Low prevalence of 1~3% is still observed in rural areas of Bangladesh[25] and China[26], which implies that those countries remain backward in industrialization. King et al.[27] explained that the increasing prevalence of DM is associated with life-style, socioeconomic changes and industrialization. Especially, the high risk group of diabetes mellitus is explained in the population in developing countries or exposure to rapid industrialization and economic development.

King et al.[8] compared the prevalence of DM after the immigration of Asians, Africans and Pacific Islanders with the Chinese and rural Indians, and reported that it increased in immigrants. It is well known that the prevalence of DM, especially in Asians who immigrated to U.S., has remarkably increased and their 2nd and 3rd generations have an eminent increase by 20% in the prevalence of DM. The prevalence of diabetes mellitus has a prominent increasing trend in Koreans. According to the current studies, it is considered that the prevalence of diabetes mellitus in Korea is similar to that of the West. However, it may increase more depending on life-style or economic conditions. In addition, it is reported that there are some characteristics of Asians like an increasing prevalence of diabetes mellitus, a younger incidence and less obesity compared with the westerners[28]. The prevalence pattern of diabetes mellitus in Asians and immigrants from the East to the West attributes the increasing disease to industrialization and urbanization, like socioeconomic development, changed life-style and environmental contamination. It is mainly assumed that African and Asian populations are so weak to this change that the prevalence of diabetes mellitus increases when they are exposed to sudden industrialization by economic development and an urbanized environment.

The prevalence of diabetes mellitus rises with increasing age, which is more remarkable in a high prevalence population[8]. Most studies present that the peak prevalence of diabetes mellitus appears in the 50s and decreases after the 60s, whereas some populations shows a falling prevalence with increasing age. This study observed the increasing prevalence of diabetes mellitus and impaired glucose tolerance with increasing age and the peak prevalence in the population of the 70s. Kim et al.[7] also observed such a prevalent trend of diabetes mellitus in females of the population. It implies that the survival rate of Korean diabetics is relatively high or that the incidence of the disease appears in the more aged people, even though the average age of this study is higher with the population aged over 40. Therefore, it is considered that the aging population structure is one of the main reasons for diabetes mellitus being increased in Korea[8, 29].

Obesity is suggested as the most dangerous factor of type 2 diabetes mellitus, but this study could not observe the significant difference of prevalence depending on the increase of body mass index in DM, IGT and IFG. On the other hand, the prevalence by the increase of waist-hip ratio significantly rose in male and female individuals in case of diabetes mellitus. Body mass index was 24.5~28.0 kg/m² in the West and 21.6~23.1 kg/m² in the far East Asia, which indicated that population in the far East Asia does not have obesity compared with the westerners[30, 31]. Diabetic patients in the far East Asia have lower obesity than the westerners. Lee et al.[32] and Park et al.[33] reported that Korean diabetic patients with obesity in the past showed high obesity by 70~80%. However, their current weight did not show obesity at all. But their reports are limited as hospital data. In Kim et al.[7] study with normal population and our study, body mass index of subjects was 23.6±36 kg/m² and that of diabetic patients was 23.59±3.1 kg/m², which were similar to the previous results[18, 19]. It was reported that the 2nd Japanese-American generation showed a very high prevalence compared with Caucasians in U.S., but body mass index was not relatively high[34]. African-Americans did not show a high risk of diabetes mellitus by the increase in obesity compared with Caucasians[31], which implies that the degree of obesity and the effects of obesity on glucose tolerance are different according to the population group. Body fat amount and abnormal body fat distribution are important to the prevalence of diabetes mellitus and impaired glucose tolerance[35, 36]. Korean diabetic patients also showed a lower body mass index than the westerners[6, 7, 32, 33], whereas the prevalence of diabetes mellitus was similar to that of the West, by which the increase in visceral adiposity is considered more important[37]. This study also showed more relations between the prevalence of diabetes mellitus and waist-hip ratio reflecting an increase in abdominal obesity or visceral adiposity, instead of body mass index. This is proved because body mass index did not show any relation, but waist was significantly related in the multivariate analysis including age, average blood pressure, body mass index, waist and the presence of dyslipidemia among diabetic associated factors. Therefore, it is considered that the obesity standard or the measuring method should be adjusted in the East Asian population, including Koreans or Japanese.

The prevalence of diabetes mellitus increased according to BP increase, but no significant differences were observed in the prevalence of diabetes mellitus by total cholesterol, HDL cholesterol and LDL cholesterol. The prevalence of diabetes mellitus increased in case of less than 35 mg/dL of HDL and by triglyceride increase. When dyslipidemia was classified according to the values of total cholesterol, HDL cholesterol and LDL cholesterol and triglyceride, the relative risk of diabetes mellitus was remarkably high. Age and waist from the multivariate analysis were related to dyslipidemia.

Regardless of warning education for smoking, diabetic patients showed 29.6% in smoking. However, the difference in the prevalence of diabetes mellitus was not observed depending on smoking or non-smoking. In the inquiry for practising habit, a regular practising was rare and 77.7% answered no experience of practice or no plan for it, which indicates that a continuous education about improving life-style for diabetic patients is required. When classified by ADA and WHO diagnostic criteria, age, systolic blood pressure, diastolic blood pressure, serum triglyceride were significantly higher in DM/DM and group than NGT/NGT group. But there were no statistically significant differences of body mass index, waist-hip ratio, total cholesterol, HDL cholesterol and LDL cholesterol between each group. Unlike the previous reports38), a difference of the associated factors by different diagnostic criteria or a difference of associated factors in IGT and IFG groups was not observed.

In this study, the prevalence of diabetes mellitus by ADA criteria increased by 2.5% more than WHO criteria. Excepting the previously diagnosed diabetics, when classified subjects were compared by both criteria, the level of agreement was very high in both criteria without IFG group. Postprandial 2-h serum glucose and fasting serum glucose were calculated to get the maximum point of the curve by using the receiver operating characteristics curve with sensitivity and specificity. The adequate cut-off point was 114.5 mg/dL (6.4 mmol/L) to yield sensitivity and specificity in each continuous fasting serum glucose. The positive predictive value of the criteria was so relatively low that it is not good to adopt it, but this result is lower than the standard fasting glucose some foreign studies suggested[38-40], which corresponds with the results of other studies carried out before in Korea[41, 42].

Shaw et al.[43] reported that there was a difference in the prevalence of diabetes mellitus by fasting serum glucose vs. postprandial serum glucose between population groups, and that especially the diagnostic rate by fasting serum glucose increased in case of high obesity. They also reported that the aged over 64 showed an increased diagnostic rate by postprandial serum glucose, which implies that the postprandial serum glucose is important in the studies with the population groups of low obesity and of aging people. It indicates that obesity is not so high in case of Korea and that the postprandial serum glucose, as well as fasting serum glucose, should not go unheeded in diagnosing diabetes mellitus. It is considered that a lower cut-off point of fasting serum glucose than postprandial 2-hour serum glucose is attributed to the aging subject group as one of the reasons. The comparison between ADA diagnostic criteria and ADA only by fasting serum glucose showed a high agreement level, but the prevalence of diabetes mellitus became lower than that with postprandial serum glucose. Therefore, judging from facility, rapidity, convenience, reproduction and economical efficiency of the fasting serum glucose test, it is considered that it is better to be used as a screening test. But as a decrease in the prevalence is found only with the fasting serum glucose and the importance of postprandial serum glucose can not be passed by with Koreans, repeating measurement and adjustment thereby should be required.

Finally the prevalence of diabetes mellitus in the Korean population over 40 years of age is 15.8% similar to the that of the West, and remarkably increased in the 1970s and the 1980s, caused by industrialization, urbanization and the aging population structure. The obesity of Koreans with normal state, diabetes mellitus and impaired glucose tolerance was not high compared with that of the West and it did not much affect the prevalence of diabetes mellitus. However, there is a limit in number so that an epidemiologic research with the general population on a large scale is considered to be necessary to study the ethnic characteristics. WHO and ADA diagnostic criteria without fasting serum glucose showed a high agreement and the fasting serum glucose is important as a diagnostic standard, but the postprandial 2-h serum glucose can not be excepted in diagnosing diabetes mellitus in the Korean general population.

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