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The Degree of Atherosclerosis and the Metabolic Characteristics according
to the Abdominal Obesity in Type 2 Diabetic Patients

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- Abstract -

Background: Many of the maturity-onset type 2 diabetic patients with hypertension and dyslipidemia in Korea are not associated with obesity. However, these patients are at risk for developing macrovascular complications such as atherosclerosis due to hyperinsulinemia, insulin resistance and abdominal obesity. The aims of this study were to compare the clinical and biochemical differences between the type 2 diabetic patients that are with and without abdominal obesity, and we also wished to investigate the degree of insulin resistance and atherosclerosis in these patients.

Methods: Among 530 type 2 diabetes mellitus (DM) patients, the percentages of under-weight (UW), normal-weight (NW), over-weight (OW) and obese (OB) (BMI <20, 20-25, 25-29.9 and 30, respectively) subjects were 8.9%, 62.1%, 25.1% and 3.9%, respectively. To evaluate the severity of their atherosclerosis, the coronary artery calcification (CAC) score was measured by electron beam computed tomography, and the intima-media thickness (IMT) of the common carotid artery and the ankle-brachial pressure index (ABPI) were also measured. The Insulin sensitivity index (ISI) was measured by the plasma glucose disappearance rate (kitt: %/min).

Results: 1. There were no differences in age, duration of DM and the HbA_{1c} levels according to BMI for both the men and women, but the waist-hip ratio (WHR) and systolic blood pressure (SBP) were significantly different among each group.

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Serum triglyceride (TG), HDL-cholesterol (HDL-C), free fatty acid (FFA), fibrinogen, and fasting c-peptide levels, {excluding total cholesterol (TC)}, were also significantly different. The ISI, which is a marker for insulin resistance, as well correlated with the patients' BMI. Subjects having an with ISI above 2.5%/min were considered as having insulin resistance, and 28%, 60%, 68% and 75% of patients in the UW, NW, OW and OB groups, respectively, demonstrated insulin resistance. The visceral fat area/subcutaneous fat area ratio and visceral fat area/thigh muscle area ratio also increased with BMI.

2. The median values of the WHR were 0.95 for the men and 0.91 for the women. There were no significant differences for age, BMI, duration of DM and HbA_{1c} between patients with and without abdominal obesity, but the SBP, TG, HDL-C, FFA, fibrinogen and ISI were significantly different between those two groups.

3. For the OW group as well as the NW group, the carotid IMT, ABPI and CAC scores were significantly different between the patients with and without abdominal obesity. However, there were no differences between the NW group and the OW group.

Conclusion: In conclusion, those patients with abdominal obesity, regardless of their BMIs, have a higher prevalence for atherosclerosis, dyslipidemia, and hypertension, compared to those patients without abdominal obesity. Therefore, it is important to screen for atherosclerosis and to manage it accordingly, for the patients with insulin resistance or abdominal obesity in order to decrease their risk of developing atherosclerotic events (*J Kor Diabetes Assoc* 28:377 ~ 391, 2004).

Key Words: Abdominal obesity, Insulin resistance, Type 2 diabetes, Atherosclerosis

18).
 가
 가
 가
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 30 kg/m²
 가
 25 kg/m²
 가
 19).
 가
 1988 Reaven¹⁾
 가
 Ruderman²⁰⁾
 가
 2-17).
 가
 (metabolic obe-
 sity)
 fibrinogen plasminogen activator inhi-

tolerance test)³²⁾ 12
 20G
 3-way
 가
 가 20G
 가 21,22)
 20-30
 heating pad
 60~70 100
 (Humulin-R, Eli Lilly, USA)
 1 kg 0.1
 0, 3, 6, 9, 12, 15
 가 2 가 15
 가 20% 100 mL Beck-
 man glucose analyzer II (Beckman Instruments, Full-
 erton, CA, USA)
 1. 3
 15 regression line
 2
 530 (56 , : =319 : 211)
 (body mass index, BMI)
 가 ;
 (under-weight, UW): 18.5 kg/m² ,
 (normal-weight, NW): 18.5~24.9 kg/m² , (over-
 weight, OW): 25~29.9 kg/m² , (obese, OB: 30
 kg/m²).
 2. 3)
 1) 10
 가 / 1
 (%) impedance (RIA kit, Daiichi, Japan) c-peptide
 (Inbody 2.0, Biospace, Korea) (IRMA kit, Dain-
 abot, Japan)
 2) 4) (coronary artery ca-
 lification, CAC)
 (insulin Electron beam computed tomography (EBT, IM-

ATRON Ultrafast CT, USA)

38)

R-R 80% EKG gate
3mm
40 CAC
CAC Agatston
(pixel: 0.5 mm²)
CT number 130~
199 HU (Hounsfield unit) 1, 200~299 HU 2,
300~399 HU 3, 400 HU 4

(total abdominal fat area)
(visceral fat
tissue), (subcutaneous fat
tissue)
/ (visceral fat area/su-
bcutaneous fat area, VSR)

SPSS for Windows, version 11.0

33)

5) (intima-media thick-
ness, IMT)
B-mode Toshiba SSA-270A
(Toshiba, Japan) 7.5 MHz (Axial resolu-
tion: 0.2 mm)

Students t-test one-way
ANOVA chi-square tests p 0.05

wall) 10 mm 가 (far
Pignoli 34,35)
(leading edge)

1.
530 (UW),
(NW), (OW), (OB) 47
(8.9%), 329 (62.1%), 133 (25.1%) 21 (3.9%)

Multicenter Isradipine Diuretic Atherosclerosis Study
(MIDAS) IMT 가 1.3 mm
plaque가
36,37)

/ 가 가
0.82±0.11, 0.91±0.20, 0.97±0.13, 0.98±0.14
가 21.2±5.2%,
25.1±5.7%, 30.9±5.6%, 35.3±5.2% 가
(Table 1).

6) - (ankle-brachial pressure
index, ABPI)
Plethysmography (MVL, Modulab, Life Science Inc.
Greenwich. CT)

(, ,)
가 (Table 1).

7)
CT Max II (General Electric
Co.)
Hounsfield number가 -150 -50

UW 135.2±21.1, NW 136.1±18.1, OW 139.9
±23.2, OB 145.2±18.2 mmHg 가
UW NW 가
가 (Table

Table 1. The Clinical and Biochemical Characteristics of Patients According to BMI

	UW	NW	OW	OB
Number	47	329	133	21
Sex (M:F)	27:20	202:127	78:55	12:9
Age (years)	53.2±11.8	57.2±12.1	57.4±11.1	57.4±10.2
BMI (kg/m ²)	17.2±1.1	22.5±1.2 ^a	26.7±1.3 ^{b,c}	30.4±1.1 ^{d,e,f}
WHR	0.82±0.11	0.91±0.25 ^a	0.97±0.13 ^{b,c}	0.98±0.14 ^{d,c}
Fat (%)	21.2±5.2	25.1±5.7 ^a	30.9±5.6 ^{b,c}	35.3±5.2 ^{d,e,f}
DM duration (years)	11.4±7.2	10.9±6.2	10.6±7.2	10.2±6.4
Anti-hypotensive medication	6/47 (12.8%)	42/329 (12.8%)	23/133 (17.3%)	4/21 (9.0%)
Smoking	10/47 (21.3%)	77/329 (23.4%)	29/133 (21.8%)	5/21 (23.8%)
Nephropathy	16/47 (34.0%)	115/329 (35.0%)	48/133 (36.1%)	8/21 (38.1%)
Neuropathy	28/47 (59.6%)	197/329 (59.9%)	84/133 (63.2%)	14/21 (66.7%)
Retinopathy	18/47 (38.3%)	121/329 (36.8%)	53/133 (39.8%)	9/21 (42.9%)
Prevalence of CHD	2/47 (4.3%)	14/329 (4.3%)	6/133 (4.5%)	1/21 (4.8%)
Systolic BP (mmHg)	135.2±21.1	136.1±18.1	139.9±23.2 ^{b,c}	145.2±18.2 ^{d,e,f}
Diastolic BP (mmHg)	81.1±10.8	86.5±10.1	88.1±11.2	93.1±10.2
T. cholesterol (mmol/L)	4.86±0.88	5.18±1.08	5.15±0.81	5.48±0.81
Triglyceride (nmol/L)	1.64±0.58	1.97±0.70 ^a	1.98±0.64 ^b	1.93±0.86 ^c
HDL-C (mmol/L)	1.28±0.27	1.11±0.29 ^a	1.10±0.30 ^b	1.08±0.34 ^c
HbA1c (%)	10.0±2.3	9.3±2.1	9.1±1.0	9.7±2.2
Free fatty acid (nmol/L)	2.55±0.93	2.27±0.84 ^a	2.69±1.14 ^b	2.35±0.80 ^{d,e,f}
Fibrinogen (g/L)	4.14±0.83	4.05±0.81 ^a	4.21±0.90 ^b	3.99±0.81 ^{d,e,f}
24-hr albumin (g)	4.04±1.89	4.42±2.32	4.62±1.93	4.68±1.84
C-peptide (µg/L)	1.45±1.02	1.51±2.01	1.77±1.70 ^b	1.99±2.02 ^{d,e,f}
ISI (%/min)	2.45±2.10	2.31±2.11 ^a	1.97±1.90 ^b	1.89±2.22 ^{d,e,f}

Values are mean±SD. UW, under weight; NW, normal weight; OW, over weight; OB, obese; BMI, body mass index; WHR, waist hip ratio; DM, diabetes mellitus; CHD, coronary heart disease; BP, blood pressure; HDL-C, high density lipoprotein-cholesterol; ISI, insulin sensitivity index. a: UW vs. NW, p<0.05; b: UW vs. OW, p<0.05; c: UW vs. OB, p<0.05; d: NW vs. OW, p<0.05; e: NW vs. OB, p<0.05; f: OW vs. OB, p<0.05.

1). UW 1.64±0.58 nmol/L (NW, 1.97±0.70; OW, 1.98±0.64; OB, 1.93±0.86 mg/dL) ±0.80 nmol/L 가 , UW 1.28±0.27 mmol/L (NW, 1.11 ±0.29; OW, 1.10±0.30; OB, 1.08±0.34 mg/dL). 가 . 24 HbA1c 가 C-peptide

Table 2. Comparison of Abdominal Fat and Thigh Muscle Areas by CT Scan Between the Insulin Resistance (IR) group and non insulin resistance (non-IR) according to insulin sensitivity index

	IR group	non-IR group	p-value
Number	39	41	
Sex (M:F)	23:16	24:17	NS
Age (years)	57.3±12.1	55.4±12.1	NS
BMI (kg/m ²)	22.2±1.1	22.3±1.3	NS
Waist/hip ratio	0.95±0.05	0.91±0.05	0.02
Fat (%)	28.1±5.5	24.2±5.2	0.01
DM duration (years)	11.1±6.3	10.8±6.5	NS
Visceral fat area (cm ²)	152.0±60.7	96.5±28.5	0.03
SQ fat area (cm ²)	184.2±84.5	126.9±59.7	0.05
Thigh muscle area (cm ²)	99.7±37.9	114.6±40.2	0.02
V/S ratio	0.94±0.52	0.72±0.17	0.01
V/M ratio	1.32±0.38	0.86±0.24	0.01

Values are mean±SD. IR; insulin resistance; BMI, body mass index; DM, diabetes mellitus; SQ, subcutaneous; V/S ratio, visceral fat area/subcutaneous fat area ratio; V/M ratio, visceral fat area/thigh muscle area

Table 3. The Comparison of Normal-Weight Patients With and Without Abdominal Obesity According to WHR ; Median Values in Men-0.95 and Women-0.91

	Men (n=115)			Women (n=100)		
	> 0.95	< 0.95	p-value	> 0.91	< 0.91	p-value
Number	75	40		61	39	
Age (years)	55.2±11.8	56.2±12.1	NS	58.3±11.1	57.4±10.2	NS
BMI (kg/m ²)	22.8±1.1	22.4±1.2	NS	22.7±1.3	22.4±1.1	NS
Fat (%)	24.2±5.2	21.1±5.7	0.01	28.2±5.6	25.3±5.2	0.02
DM duration (years)	10.3±7.2	10.9±6.2	NS	11.1±7.2	10.2±6.4	NS
Systolic BP (mmHg)	136.2±21.1	133.1±18.1	0.05	138.9±23.2	132.2±18.2	0.05
Diastolic BP (mmHg)	85.1±10.8	83.5±10.1	NS	86.1±11.2	85.1±10.2	NS
T. cholesterol (mmol/L)	4.98±0.88	4.97±1.08	NS	5.28±0.81	5.25±0.81	NS
Triglyceride (mmol/L)	2.06±0.58	1.85±0.70	0.03	2.05±0.64	1.77±0.86	0.01
HDL-C (mmol/L)	1.06±0.26	1.67±0.29	0.02	1.10±0.30	1.26±0.34	0.02
HbA1c (%)	9.0±2.3	9.1±2.1	NS	9.1±1.0	9.0±2.2	NS
Free fatty acid (nmol/L)	2.55±0.93	2.27±0.84	0.04	2.69±1.14	2.35±0.80	0.03
Fibrinogen (g/L)	4.18±0.83	3.53±0.81	0.02	4.21±0.91	3.99±0.81	0.04
ISI (%/min)	2.01±2.10	2.78±2.11	0.02	2.03±1.90	2.57±2.22	0.02

Values are mean±SD. BMI, body mass index; DM, diabetes mellitus; BP, blood pressure; T. cholesterol, total cholesterol; HDL-C, high density lipoprotein-cholesterol; ISI, insulin sensitivity index

1.45±1.20, 1.51±2.01, 1.77±1.70, 1.99 ±2.02 mg/dL 가
 UW NW (Table 1). (136.2±21.1 vs. 133.2±18.1 mmHg, p=0.05)
 ISI 2.45± (138.9±23.5 vs. 132.2±18.2 mmHg, p=0.05) 가
 2.10, 2.01±2.11, 1.97±1.90, 1.89±2.22%/min 2.5%/ ,
 min UW 28%, NW 65%, 62%
 60%, OW 68%, OB 75%가 41% 34%
 가 가 가
 (UW vs. NW, p<0.05; UW vs. OW, p<0.05; UW vs. OB, p<0.05; NW vs. OW, p<0.05; NW vs. OB, p<0.05; OW vs. OB, p<0.05). 가
 가 ISI가 2.5%/min 가 2.06
 41 2.5%/min 39 ±0.58 1.85±0.70 mmol/L (p=0.03),
 CT (computed tomography) 2.05±0.64 1.77±0.86 mg/dL (p=0.01) 1.06
 가 가 ±0.26 1.67±0.29 mg/dL (p=0.02), 1.10
 가 (152.0±60.7 vs. 96.5 ±0.30 1.26±0.34 mmol/L (p=0.02)
 ±28.5 cm², p=0.03), (184.2±84.5 vs. HbA1c 가
 126.9±59.7 cm², p=0.05) 가
 (99.7±37.9 vs. 114.6±40.2 cm², p=0.02) (2.55±0.93 vs. 2.27±0.84 mg/dL, p=0.04),
 (Table 2). 가 (2.69±1.14 vs. 2.35±0.80 nmol/L, p=0.03). fibrinogen
 / (0.94±0.52 vs. 0.72±0.17, p=0.01) / (4.18±0.83 vs. 3.53±0.81 g/L, p=0.04)
 (1.32±0.38 vs. 0.86±0.24, p=0.01)가 (4.21±0.91 vs. 3.99±0.81 mg/dl, p=0.04)
 가 (Table 3).
 - (r=0.89, p=0.001) ISI
 2. / 가 (2.01±2.10 vs. 2.78±2.11 mg/dL, p=0.02)
 (2.03±1.90 vs. 2.57±2.22 mg/dL, p=0.02)
 가 - 3.
 가 0.95
 0.91 가 NW
 (Table 3). (1.04±0.29 vs. 0.89±0.23 mm, p<0.05), OW
 (24.2±5.2% vs. 21.1±5.2%, p=0.01) (1.08±0.22 vs. 0.92±0.21 mm, p<0.05).
 (28.2±5.6% vs. 25.3±5.2%, p=0.02)

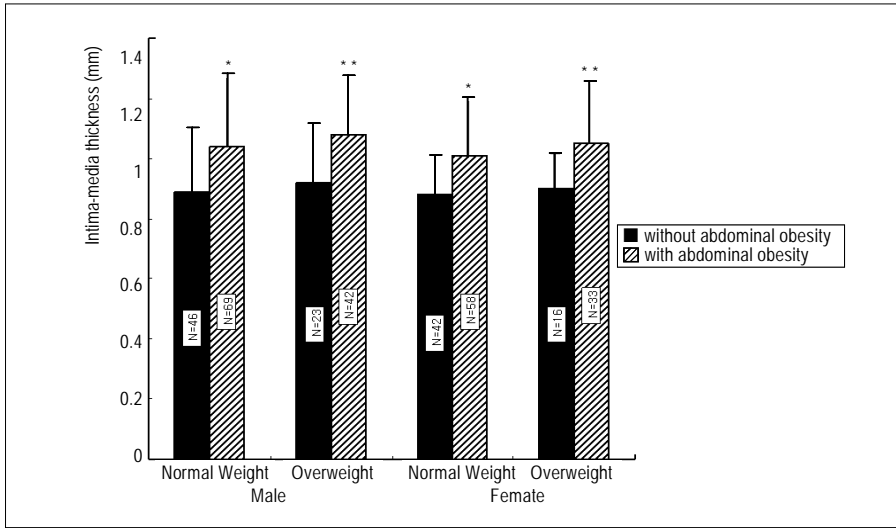


Fig. 1. The comparison of IMT in subjects between NW group and OW group with or without abdominal obesity. * : P < 0.05, compared to subjects without abdominal obesity in NW group; ** : P < 0.05, compared to subjects without abdominal obesity in OW group

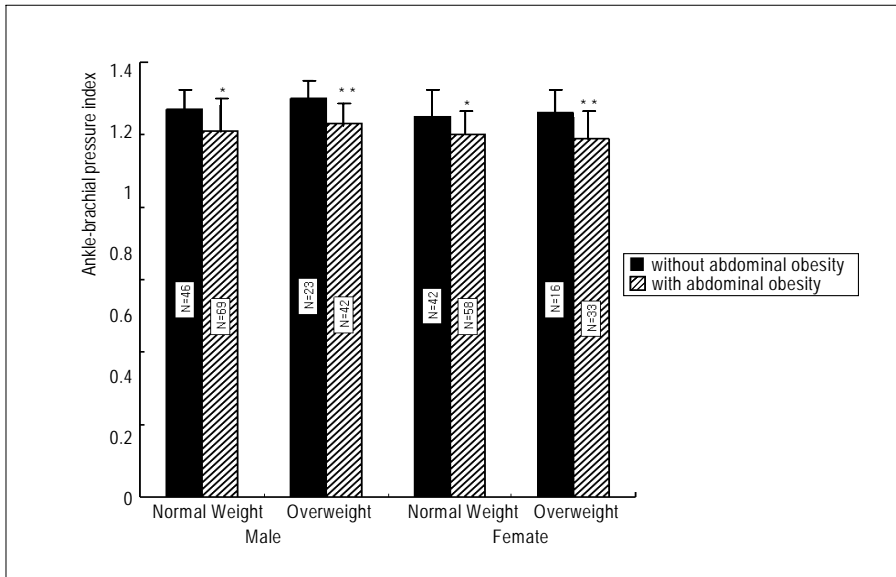


Fig. 2. The comparison of ABPI in subjects between NW group and OW group with or without abdominal obesity. * : P < 0.05, compared to subjects without abdominal obesity in NW group; ** : P < 0.05, compared to subjects without abdominal obesity in OW group

NW
가

OW
(Fig. 1).
가

NW

OW

(1.01±0.20 vs. 0.88±0.18 mm, p<0.05),

(1.05±0.22 vs.

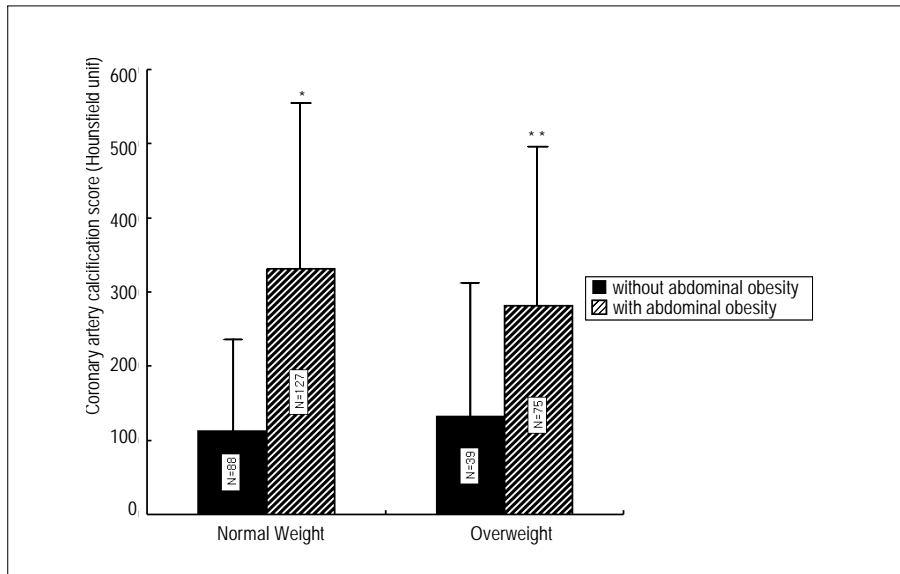


Fig. 3. The comparison of coronary artery calcification score measured by EBT between NW group and OW group with or without abdominal obesity. * : P < 0.05, compared to subjects without abdominal obesity in NW group; ** : P < 0.05, compared to subjects without abdominal obesity in OW group

0.90±0.17 mm, p<0.05). NW OW mm, p<0.05), OW (282±
가 , , 215 vs. 132±178 mm, p<0.05). NW OW
(Fig. 1). 가
- 가 NW , , (Fig. 3).
(1.01±0.09 vs. 1.07±0.06 mm, p<0.05), OW
(1.03±0.05 vs. 1.10±0.05
mm, p<0.05). NW OW (,), 2
가 (Fig. 2). 가 NW , ,
(1.00
±0.05 vs. 1.05±0.08 mm, p<0.05), OW 2) 3) 4
(0.99±0.06 vs. 1.06±0.07 mm, p<0.05).
NW OW (odds ratio)
가 , , 2-4,11,39-41)
(EBT , 2 ,
가 NW ,
(331±229 vs. 112±106

가

50%

46,47)

가

가

48)

가

60%

42)

2

32)

Hales 49)

ISI 2.5%/min

5)

2

가 (th-

rifty phenotype hypothesis)

30

가

가

43,44)

가

가 가

가

70%가

가

가 20~25 kg/m²

가

60%

가

1966 Welborn 50)

가 가

45)

80

mg/dL

200 mg/dL

가 140

mg/dL

(14 U/mL)

가,

105 mg/dL

8

51,52)

6) 314

U/mL

가

가 . 7) 62) .

가 가 .

가 , 8,9) . 16)

가 가

50% 가 17) . 2

53,54) , 가

59% 38% , 58%

35%

가 -

가 , - : 2 가 .

1,55~57) /

가 2 가 .

10,11,58) , /

2 530 (26~85 , 56)

(body mass index, BMI) 가

: 18.5 kg/m² , :

1,59) 18.5~24.9 kg/m², : 25~29.9 kg/m², : 30

kg/m² 8.9%, 62.1%, 25.1%

3.9% . 가

12~15,60) B-mode

(coronary artery calcification, CAC),

61) (intima-media thickness,

IMT) - (ankle-brachial pressure

11. , , , , , , , :
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12. , , , , , , , :
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Plethysmography
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