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P2-376

## Background

• We try to evaluate metabolic syndrome (MS) components of normal weight central obese adolescents in Korea stratified by waist to height ratio (WHR).

## Methods

• This is a cross-sectional study. Data were obtained from the Korean National Health and Nutrition Examination Survey conducted during 2008-2010.

• The subjects were grouped as normal (5th-85th percentiles) or overweight ( $\geq$  85th percentile) by BMI and central obesity was defined as those in the upper highest quartile of age and sex specific WHR.

• Body composition groups were classified into no central obesity normal weight (NW), central obesity normal weight (CONW), no central obesity overweight (OW) and central obesity overweight (COOW).

## Results

• The prevalence of NW was 72.7% (604/832), CONW was 9.6% (83/832), OW was 2.5% (20/832) and COOW was 15.1% (125/832) in females.

• The prevalence of NW was 72.3% (662/909), CONW was 7.0% (61/909), OW was 2.2% (21/909) and COOW was 18.5% (165/909) in males.

• In females, CONW showed higher levels of insulin ( $P < 0.006$ ), HOMA-IR ( $P < 0.006$ ) and ALT ( $P < 0.001$ ) than NW.

• In males, CONW had higher levels of insulin ( $P < .0001$ ), HOMA-IR ( $P < .0001$ ), and WBC count ( $P < 0.021$ ) and lower level of HDL ( $P < .0001$ ) than NW. However, there was no significant difference in MS components between CONW and OW in both females and males.

• WHR had significant positive correlations with BMI, insulin, HOMA-IR, and ALT in females. WHR also had significant positive correlations with BMI, insulin, HOMA-IR, TG/HDL ratio, and ALT, WBC and a negative correlation with HDL in males.

• In males, CONW showed 2.5 times (95% confidence interval, 1.21-5.00) more likely to having high insulin resistance than NW after adjusting for age, weight, and ALT.

**Table 1. Subject characteristics and laboratory data according to four body composition groups in female 13-18 adolescents.**

Female	Normal weight(BMI 5 <sup>th</sup> to 85 <sup>th</sup> )			Overweight(BMI over85 <sup>th</sup> )			
	NW	CONW	P value	OW	COOW	P value	P value
	604 (72.7 %)	83 (9.6 %)		20(2.53 %)	125(15.099 %)		
				NW vs. CONW	OW vs. COOW		Among Groups
Age(years)	15.4±0.1	15.4±0.2	0.879	15.6±0.4	15.3±0.2	0.579	0.945
Height(cm)	160.5±0.3	158.7±1	0.074	161.9±0.8	160.8±0.5	0.227	0.082
Weight(kg)	50.8±0.2	54.9±1.0	<.0001	65.1±1.2	68.6±1	0.022	<.0001
BMI	19.7±0.1	21.7±0.2	<.0001	24.8±0.3	26.5±0.3	<.0001	<.0001
WC(cm)	65.8±0.2	75.1±0.6	<.0001	71.3±0.6	81±0.7	<.0001	<.0001
WHR	41±0.1	47.3±0.2	<.0001	44.0±3.0	50.4±0.4	<.0001	<.0001
SBP(mmHg)	101.8±0.5	102.1±1.4	0.813	102.2±2.8	105.7±1	0.242	0.006
DBP(mmHg)	65.7±0.4	64.7±1.2	0.374	66.6±2	66.7±1	0.953	0.568
Glucose(mg/dL)	87.5±0.3	88±0.7	0.401	87.5±1.2	89.9±0.8	0.081	0.028
Insulin(μU/ml)	11.4(11-11.8)	12.9(11.9-13.9)	0.006	14.3(12.0-17.1)	16(14.5-17.7)	0.272	<.0001
HOMA-IR	2.5(2.4-2.5)	2.8(2.6-3)	0.006	3.1(2.6-3.7)	3.5(3.2-3.9)	0.201	<.0001
TG(mg/dL)	71.6(68.7-74.7)	77.5(69.5-86.6)	0.186	77.3(59.2-100.9)	89(80.0-99.1)	0.344	0.002
HDL(mg/dL)	56.4±0.5	54.6±1.5	0.284	50.8±2.1	49.4±1.2	0.563	<.0001
TG/HDL	1.3(1.2-1.4)	1.5(1.3-1.7)	0.121	1.5(1.2-2.1)	1.8(1.6-2.1)	0.285	<.0001
ALT (U/L)	10(9.7-10.3)	11.5(10.8-12.3)	<.0001	11.8(9.9-14.1)	12.9(11.6-14.3)	0.392	<.0001
AST(U/L)	16(15.7-16.3)	15.6(14.8-16.5)	0.458	15.6(13.9-17.5)	15.8(15.3-16.4)	0.839	0.861
WBC(10 <sup>9</sup> /L)	5.9(5.8-6)	6.1(5.7-6.6)	0.260	6.3(5.7-7.0)	6.7(6.4-7.0)	0.351	<.0001

Data are presented as the means ± standard error (SE), geometric mean (95% CI) or % (SE). Insulin, HOMA-IR, TG, TG/HDL, ALT, AST and WBC count were tested after logarithmic transformation.

**Table 2. Subject characteristics and laboratory data according to four body composition groups in male 13-18 adolescents.**

Male	Normal weight(BMI 5 <sup>th</sup> to 85 <sup>th</sup> )			Overweight(BMI over85 <sup>th</sup> )			
	NW	CONW	P value	OW	COOW	P value	P value
	662 (72.3 %)	61 (7.0 %)		21 (2.2 %)	165 (18.5 %)		
				NW vs. CONW	OW vs. COOW		Among Groups
Age(years)	15.5±0.1	15.3±0.3	0.464	16.3±0.4	15.5±0.1	0.044	0.107
Height(cm)	171.6±0.3	169.1±1.4	0.099	176.9±1.2	172.1±0.6	<.001	<.0001
Weight(kg)	59.9±0.4	68±1.2	<.0001	79.5±1.2	81.8±1	0.157	<.0001
BMI	20.3±0.1	23.7±0.1	<.0001	25.4±0.1	27.5±0.2	<.0001	<.0001
WC(cm)	70.1±0.3	82.2±0.6	<.0001	80.2±1	88.6±0.7	<.0001	<.0001
WHR	40.9±0.1	48.7±0.3	<.0001	45.3±0.4	51.4±0.4	<.0001	<.0001
SBP(mmHg)	108±0.5	110.4±1.3	0.075	110.6±2.4	115.8±1.1	0.050	<.0001
DBP(mmHg)	67.7±0.4	65.7±1.1	0.101	69.6±1.6	70.7±0.9	0.526	0.002
Glucose(mg/dL)	88.6±0.3	89.1±1.1	0.642	91.2±2.1	90.4±0.6	0.702	0.034
Insulin(μU/ml)	10.6(10.3-11)	13.6(12.3-15.1)	<.0001	15.1(12.3-18.5)	17.4(16.0-18.8)	0.210	<.0001
HOMA-IR	2.3(2.3-2.4)	3(2.7-3.3)	<.0001	3.4(2.7-4.3)	3.9(3.6-4.2)	0.288	<.0001
TG(mg/dL)	70.4(67.4-73.5)	76.2(64.0-90.8)	0.386	73.6(56.3-96.2)	114(101.5-127.9)	0.003	<.0001
HDL(mg/dL)	51.8±0.4	47±1.1	<.0001	52.6±2.9	45.7±0.7	0.022	<.0001
TG/HDL	1.4(1.3-1.4)	1.6(1.3-2.0)	0.101	1.4(1.0-2.0)	2.5(2.2-2.9)	0.003	<.0001
ALT (U/L)	12.8(12.3-13.4)	17(15.3-18.8)	<.0001	22.8(15.0-34.8)	24.8(22.3-27.7)	0.704	<.0001
AST(U/L)	17.9(17.5-18.4)	18.6(17.5-19.8)	0.272	20.1(16.6-24.5)	21(19.9-22.1)	0.698	<.0001
WBC(10 <sup>9</sup> /L)	6(5.9-6.1)	6.4(6.1-6.8)	0.021	6.5(6.1-6.9)	6.8(6.5-7.0)	0.257	<.0001

**Table 3. Correlations between WHR or BMI and metabolic syndrome components in 13-18 adolescents.**

	Female		Male	
	WHR	BMI	WHR	BMI
	r	P-value	r	P-value
BMI	0.84	<.0001	0.91	<.0001
WHR	.		.	
SBP(mmHg)	0.18	<.0001	0.18	<.0001
DBP(mmHg)	-0.01	0.916	0.05	0.412
Glucose(mg/dL)	0.11	0.085	0.12	0.072
Insulin(μU/ml)	0.30	<.0001	0.33	<.0001
HOMA-IR	0.30	<.0001	0.32	<.0001
TG(mg/dL)	0.17	<.0001	0.16	<.0001
HDL(mg/dL)	-0.22	<.0001	-0.23	<.0001
TG/HDL	0.22	<.0001	0.22	<.0001
ALT(U/L)	0.32	<.0001	0.33	<.0001
AST(U/L)	-0.004	0.919	-0.02	0.643
WBC(10 <sup>9</sup> /L)	0.16	<.0001	0.19	<.0001

**Table 4. Correlations between WHR and MS components of normal and overweight 13-18 adolescents.**

	FEMALE				MALE			
	Normal weight(BMI 5 <sup>th</sup> to 85 <sup>th</sup> )	Overweight(BMI over 85 <sup>th</sup> )	Normal weight(BMI 5 <sup>th</sup> to 85 <sup>th</sup> )	Overweight(BMI over 85 <sup>th</sup> )	Normal weight(BMI 5 <sup>th</sup> to 85 <sup>th</sup> )	Overweight(BMI over 85 <sup>th</sup> )	Normal weight(BMI 5 <sup>th</sup> to 85 <sup>th</sup> )	Overweight(BMI over 85 <sup>th</sup> )
	r	P-value	r	P-value	r	P-value	r	P-value
BMI	0.67	<.0001	0.75	<.0001	0.80	<.0001	0.84	<.0001
SBP(mmHg)	0.05	0.271	0.30	<.001	0.10	0.018	0.15	0.133
DBP(mmHg)	-0.08	0.063	0.06	0.516	-0.03	0.555	0.12	0.274
Glucose(mg/dL)	-0.02	0.557	0.21	0.160	0.01	0.772	-0.04	0.648
Insulin(μU/ml)	0.10	0.014	0.24	0.006	0.27	<.0001	0.26	0.001
HOMA-IR	0.08	0.025	0.26	0.002	0.29	<.0001	0.24	0.003
TG(mg/dL)	0.07	0.059	0.12	0.145	0.10	0.064	0.23	0.005
HDL(mg/dL)	-0.10	0.017	-0.10	0.229	-0.17	<.0001	-0.17	0.036
TG/HDL	0.10	0.015	0.13	0.073	0.140	0.008	0.23	0.005
ALT(U/L)	0.23	<.0001	0.19	0.034	0.32	<.0001	0.33	<.0001
AST(U/L)	-0.01	0.839	0.07	0.483	0.07	0.179	0.27	0.0007
WBC(10 <sup>9</sup> /L)	0.06	0.156	0.10	0.198	0.15	0.001	0.17	0.038

**Table 5. Multivariate analyses for the association between being in the upper highest quartile (Q4) according to age and sex specific HOMA-IR and the four body composition groups.**

Group	Model 1	Model 2	Model 3
	Female	Female	Female
NW	1	1	1
CONW	1.89 (1.04-3.42)	1.54(0.85-2.78)	1.51(0.83-2.75)
OW	3.09(1.22-7.85)	1.56(0.55-4.41)	1.55(0.54-4.44)
COOW	5.09(3.21-8.10)	2.14(1.09-4.20)	2.11(1.06-4.18)
Group	Model 1	Model 2	Model 3
	Male	Male	Male
NW	1	1	1
CONW	4.37(2.32-8.22)	2.82(1.38-5.75)	2.46(1.21-4.99)
OW	8.29(2.43-28.22)	3.29(0.90-11.98)	2.57(0.78-8.49)
COOW	10.08(6.69-15.20)	3.25(1.60-6.59)	2.38(1.20-4.70)

Model 1 adjusted for age.  
Model 2 adjusted for age and weight.  
Model 3 adjusted for age, weight and ALT.

## Conclusion

The use of WHR has discovered CONW. The CONW has higher insulin resistance than NW in male Korean adolescents.