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Associations of serum cystatin C with obesity phenotypes in Korean adults

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Background/Aims: Serum cystatin C is associated with cardiovascular diseases and metabolic syndrome including obesity. Obesity is a heterogeneous condition and classified into subgroups recently. The purpose of this study was to evaluate the association of serum cystatin C with obesity phenotypes. **Methods:** This cross-sectional study evaluated 3,422 (men, 2,021; women, 1,401) subjects who were 20-70 years old, and classified as metabolically healthy and normal weight (MHNW), metabolically unhealthy but normal weight (MUNW), metabolically healthy but obese (MHO) or metabolically unhealthy and obese (MUO). **Results:** Cystatin C was significantly increased in MHO compared with MUNW in men and highest in MUO in both genders. With the increase of cystiatin C quartile, the percentages of MHO were significantly increased, and those of MUO were significantly increased in both genders. eGFRcys was significantly lowered in MHO compared with MUNW in men, and lowest in MUO in both genders. **Conclusions:** Among obesity phenotypes, serum cystatin C may be more related with MHO rather than MUNW, and higher cystatin C level was significantly related with MUO in both genders.

Table 1. Differences in the parameter values among obesity phenotypes

Parameters	Obesity phenotype				*P*-Value
	MHNW	MUNW	MHO	MUO	
Men					
Number (2,021)	720	341	464	496	
Age, Years	52.5 ± 10.0[a]	54.7 ± 7.8[b]	53.1 ± 10.0[a]	52.8 ± 9.5[a]	0.003
BMI, kg/m^2	22.7 ± 1.6[a]	23.1 ± 1.5[b]	27.0 ± 1.8[c]	27.3 ± 2.0[d]	< 0.001
WC, cm	80.3 ± 5.6[a]	82.9 ± 5.0[b]	90.2 ± 5.6[c]	91.4 ± 5.7[d]	< 0.001
SBP, mmHg	116.4 ± 10.0[a]	124.0 ± 10.8[b]	1117.6±10.3[c]	125.4 ± 11.7[c]	< 0.001
DBP, mmHg	76.9 ± 8.2[a]	82.4 ± 8.2[b]	76.6 ± 8.4[a]	82.6 ± 8.9[b]	< 0.001
AST, IU/L	30.4 ± 11.6[a]	32.1 ± 14.8[a]	31.7 ± 10.7[a]	35.4 ± 14.2[b]	< 0.001
ALT, IU/L	27.4 ± 14.0[a]	31.3 ± 17.0[b]	33.7 ± 18.9[c]	40.5 ± 22.4[d]	< 0.001
TC, mg/dL	197.1 ± 36.6	197.5 ± 40.7	198.1 ± 38.7	194.5 ± 44.1	0.517
TG, mg/dL	100.0 ± 45.7[a]	170.8 ± 73.5[c]	117.9 ± 49.6[b]	185.7 ± 72.8[d]	< 0.001
HDL, mg/dL	53.2 ± 10.8[a]	47.4 ± 10.6[b]	49.3 ± 9.0[b]	44.5 ± 9.7[c]	< 0.001
LDL, mg/dL	131.8 ± 33.1[a]	133.9 ± 33.6[b]	1333.9 ± 35.1[b]	131.4 ± 37.4[a]	0.566
FBG, mg/dL	95.4 ± 20.5[a]	114.2 ± 27.6[b]	97.8 ± 16.6[a]	113.5 ± 25.7[b]	< 0.001
Insulin, μU/mL	3.84 ± 2.61[a]	5.18 ± 4.47[b]	5.97 ± 4.85[c]	7.39 ± 3.71[d]	< 0.001
HOMA-IR	0.93 ± 0.89[a]	1.47 ± 1.48[b]	1.50 ± 1.84[b]	2.10 ± 1.27[c]	< 0.001
25(OH)D_3, ng/mL	20.9 ± 8.5[c]	19.2 ± 8.4[a,b]	20.1 ± 8.1[b,c]	18.5 ± 7.4[a]	< 0.001
CRP, mg/dL	0.17 ± 0.55	0.12 ± 0.17	0.17 ± 0.28	0.19 ± 0.45	0.053
Creatinine, mg/dL	0.91 ± 0.14[a]	0.91 ± 0.14[a]	0.94 ± 0.13[b]	0.94 ± 0.14[b]	< 0.001
Cystatin C, mg/L	0.83 ± 0.20[a]	0.83 ± 0.21[a]	0.87 ± 0.19[b]	0.88 ± 0.20[b]	< 0.001
eGFRcre	93.94 ± 13.19[b]	92.53 ± 12.08[a,b]	91.60 ± 12.74[a]	91.40 ± 13.40[a]	0.002
eGFRcys	111.15 ± 35.86[a]	110.85 ± 34.83[a]	103.55 ± 30.46[b]	103.00 ± 33.89[b]	< 0.001
eGFRcr-cys	99.20 ± 16.76[b]	98.31 ± 16.21[b]	95.50 ± 15.85[a]	94.75 ± 16.85[a]	< 0.001
Women					
Number (1,401)	897	196	169	139	
Age, Years	50.0 ± 9.9[a]	56.2 ± 8.0[b]	54.8 ± 8.5[b]	57.5 ± 7.0[c]	< 0.001
BMI, kg/m^2	21.6 ± 2.0[a]	22.4 ± 1.7[b]	26.6 ± 1.5[c]	27.6 ± 2.6[d]	< 0.001
WC, cm	73.4 ± 6.3[a]	76.9 ± 5.8[b]	84.5 ± 5.5[c]	88.1 ± 6.9[d]	< 0.001
SBP, mmHg	113.2 ± 11.2[a]	122.6 ± 13.0[b]	119.2 ± 12.5[b]	127.8 ± 13.4[c]	< 0.001
DBP, mmHg	73.0 ± 8.3[a]	78.2 ± 9.6[c]	76.2 ± 8.7[b]	80.4 ± 8.8[d]	< 0.001
AST, IU/L	25.4 ± 8.9[a]	28.9 ± 15.0[b]	28.6 ± 12.5[b]	29.2 ± 10.4[b]	< 0.001
ALT, IU/L	18.9 ± 9.8[a]	24.8 ± 17.6[b]	27.2 ± 19.1[c]	28.1 ± 15.9[c]	< 0.001
TC, mg/dL	200.3 ± 35.2	205.4 ± 40.6	206.7 ± 40.6	204.8 ± 41.9	0.082
TG, mg/dL	83.5 ± 32.5[a]	150.2 ± 68.9[c]	96.3 ± 34.3[b]	146.4 ± 55.7[c]	< 0.001
HDL, mg/dL	61.5 ± 11.6[c]	49.3 ± 10.6[a]	58.3 ± 11.6[b]	49.1 ± 10.8[a]	< 0.001
LDL, mg/dL	127.9 ± 32.0[a]	139.6 ± 33.0[b]	135.2 ± 35.8[b]	140.1 ± 35.4[b]	< 0.001
FBG, mg/dL	90.7 ± 13.0[a]	107.7 ± 30.4[c]	93.8 ± 10.1[a]	114.4 ± 31.4[c]	< 0.001
Insulin, μU/mL	3.96 ± 1.84[a]	5.97 ± 4.63[b]	5.73 ± 2.56[b]	7.58 ± 3.96[c]	< 0.001
HOMA-IR	0.91 ± 0.48[a]	1.61 ± 1.42[c]	1.34 ± 0.63[b]	2.18 ± 1.58[d]	< 0.001
25(OH)D_3, ng/mL	19.8 ± 10.3	19.4 ± 10.0	18.6 ± 9.7	17.3 ± 8.4	0.032
CRP, mg/dL	0.98 ± 0.39[a]	0.11 ± 0.19[a]	0.14 ± 0.25[a,b]	0.20 ± 0.33[b]	0.009
Creatinine, mg/dL	0.66 ± 0.10	0.66 ± 0.12	0.66 ± 0.09	0.66 ± 0.11	0.989
Cystatin C, mg/L	0.72 ± 0.17[a]	0.75 ± 0.19[a,b]	0.76 ± 0.16[b]	0.79 ± 0.21[b]	< 0.001
eGFRcre	101.89 ± 11.94[b]	97.54 ± 11.57[a]	98.41 ± 9.9[a]	95.96 ± 10.23[a]	< 0.001
eGFRcys	109.67 ± 14.68[b]	104.89 ± 14.08[a]	103.74 ± 12.63[a]	101.67 ± 13.25[a]	< 0.001
eGFRcr-cys	107.37 ± 16.10[b]	102.24± 16.19[a]	101.42 ± 14.35[a]	98.59 ± 15.55[a]	< 0.001

Table 2. Differences in the parameter values among serum cystatin C groups

Parameters	Cystatin C level				*P*-Value
	First	Second	Third	Fourth	
Men					
Number (2,021)	633	449	666	273	
Age, Years	51.5 ± 9.8[a]	52.6 ± 9.0[a]	53.8 ± 9.5[b]	55.6 ± 9.3[c]	< 0.001
BMI, kg/m^2	24.5 ± 2.8[a]	24.8 ± 2.7[a,b]	25.1 ± 2.7[b]	25.5 ± 2.5[c]	< 0.001
WC, cm	85.1 ± 7.6[a]	85.2 ± 7.5[a]	86.1 ± 7.1[a]	87.5 ± 7.4[b]	< 0.001
SBP, mmHg	120.9 ± 11.3	120.2 ± 11.5	119.4 ± 11.2	120.1 ± 11.5	0.107
DBP, mmHg	79.4 ± 9.0[a]	79.9 ± 8.8[a]	78.5 ± 8.6[a]	78.7 ± 9.2[a]	0.045
AST, IU/L	31.8 ± 12.5[a]	31.5 ± 11.2[a]	32.2 ± 12.2[a]	34.3 ± 16.7[b]	0.029
ALT, IU/L	32.2 ± 17.9[a]	32.1 ± 17.7[a]	32.5 ± 17.6[a]	35.4 ± 23.9[b]	0.079
TC, mg/dL	197.0 ± 38.9	198.1 ± 39.1	197.2 ± 39.9	193.0 ± 42.0	0.390
TG, mg/dL	132.0 ± 69.6[a]	134.1 ± 70.6[a]	140.4 ± 70.3[a,b]	145.7 ± 66.4[b]	0.020
HDL, mg/dL	51.5 ± 11.4[c]	49.5 ± 10.0[b]	48.3 ± 10.4[b]	45.5 ± 9.5[a]	< 0.001
LDL, mg/dL	13.40 ± 33.1	134.0 ± 34.3	131.4 ± 35.4	130.0 ± 37.3	0.195
FBG, mg/dL	104.5± 23.1	104.4 ± 27.3	102.2 ± 21.6	103.3 ± 25.8	0.283
Insulin, μU/mL	5.27 ± 3.36	5.24 ± 5.36	5.49 ± 3.81	5.91 ± 3.61	0.108
HOMA-IR	1.41 ± 1.17	1.41 ± 1.94	1.44 ± 1.31	1.56 ± 1.19	0.506
25(OH)D_3, ng/mL	19.2 ± 7.4	20.1 ± 8.3	20.0 ± 8.5	20.4 ± 9.0	0.122
CRP, mg/dL	0.14 ± 0.34[a]	0.17 ± 0.38[a,b]	0.16 ± 0.42[a,b]	0.23 ± 0.63[b]	0.041
Creatinine, mg/dL	0.87 ± 0.12[a]	0.91 ± 0.11[b]	0.95 ± 0.12[c]	1.04 ± 0.18[d]	< 0.001
Cystatin C, mg/L	0.64 ± 0.71[a]	0.80 ± 0.00[b]	0.94 ± 0.49[c]	1.21 ± 0.15[d]	< 0.001
eGFRcre	98.17 ± 10.72[d]	94.30 ± 10.92[c]	90.28 ± 12.00[b]	82.12 ± 15.44[a]	< 0.001
eGFRcys	147.61 ± 27.03[d]	107.79 ± 3.93[c]	87.14 ± 6.87[b]	107.35 ± 34.23[a]	< 0.001
eGFRcr-cys	113.44 ± 9.56[d]	101.92 ± 6.74[c]	89.01 ± 7.86[b]	71.06 ± 10.23[a]	< 0.001
Obesity phenotype					< 0.001
MHNW	251(39.7%)	166(37.0%)	220(33.0%)	83(30.4%)	
MUNW	127(20.1%)	81(18.0%)	94(14.1%)	39(14.3%)	
MHO	126(19.9%)	108(24.1%)	164(24.6%)	66(24.2%)	
MUO	129(20.4%)	94(20.9%)	188(28.2%)	85(31.1%)	
Women					
Number (1,401)	465	348	296	292	
Age, Years	49.4 ± 9.7[a]	51.9 ± 9.3[b]	52.8 ± 10.1[b]	56.4 ± 8.1[c]	< 0.001
BMI, kg/m^2	22.4 ± 3.0[a]	22.7 ± 2.6[a]	23.2 ± 3.0[b]	23.7 ± 3.1[c]	< 0.001
WC, cm	75.3 ± 8.4[a]	75.6 ± 7.4[a]	77.7 ± 8.0[b]	79.2 ± 7.7[c]	< 0.001
SBP, mmHg	116.9 ± 12.8	117.1 ± 12.4	115.8 ± 13.0	116.8 ± 13.6	0.618
DBP, mmHg	74.9 ± 8.9	75.7 ± 8.6	74.5 ± 9.3	74.3 ± 9.1	0.186
AST, IU/L	25.3 ± 9.5[a]	25.6 ± 8.7[a]	27.8 ± 12.3[b]	29.0 ± 12.2[b]	< 0.001
ALT, IU/L	20.0 ± 12.4[a]	20.6 ± 11.1[a]	22.9 ± 15.4[b]	24.1 ± 15.9[b]	< 0.001
TC, mg/dL	200.5 ± 38.2	203.5 ± 35.6	201.7 ± 34.4	204.1 ± 41.0	0.545
TG, mg/dL	96.4 ± 48.7[a]	96.4 ± 47.4[a]	100.3 ± 48.9[a]	112.6 ± 55.6[b]	< 0.001
HDL, mg/dL	59.3 ± 12.2[b]	58.8 ± 12.2[a,b]	57.2 ± 12.0[a,b]	56.7 ± 13.4[a]	0.013
LDL, mg/dL	132.5 ± 32.8	132.8 ± 32.0	130.2 ± 31.9	130.5 ± 37.3	0.662
FBG, mg/dL	97.2 ± 26.5	94.5 ± 14.1	94.1 ± 14.9	96.8 ± 20.4	0.098
Insulin, μU/mL	4.67 ± 2.56	4.72 ± 3.66	4.89 ± 2.88	5.07 ± 2.90	0.294
HOMA-IR	1.17 ± 0.94	1.14 ± 1.06	1.18 ± 0.81	1.26 ± 0.94	0.427
25(OH)D_3, ng/mL	17.8 ± 8.9[a]	19.2 ± 9.9[a,b]	20.0 ± 10.7[b]	21.4 ± 10.8[c]	< 0.001
CRP, mg/dL	0.13 ± 0.52[a]	0.09 ± 0.20	0.12 ± 0.26	0.11 ± 0.18	0.383
Creatinine, mg/dL	0.63 ± 0.09[a]	0.65 ± 0.09[a]	0.67 ± 0.10[b]	0.70 ± 0.13[c]	< 0.001
Cystatin C, mg/L	0.55 ± 0.06[a]	0.70 ± 0.00[b]	0.80 ± 0.00[c]	0.99 ± 0.15[d]	< 0.001
eGFRcre	104.51 ± 10.67[c]	101.55 ± 10.03[c]	99.07 ± 11.31[b]	93.24 ± 12.13[a]	< 0.001
eGFRcys	123.22 ± 10.01[d]	107.69 ± 4.06[c]	100.40 ± 4.14[b]	89.40 ± 6.58[a]	< 0.001
eGFRcr-cys	119.94 ± 10.98[d]	107.12± 6.89[c]	100.23 ± 7.27[b]	83.82 ± 10.92[a]	< 0.001
Obesity phenotype					< 0.001
MHNW	324(69.7%)	232(66.7%)	188(63.5%)	153(52.4%)	
MUNW	63(13.5%)	44(12.6%)	43(14.5%)	46(15.8%)	
MHO	40(8.6%)	46(13.2%)	36(12.2%)	47(16.1%)	
MUO	38(8.2%)	26(7.5%)	29(9.8%)	46(15.8%)	

Data are presented as mean ± SD.

p-values were calculated by one-way analysis of variance followed by the post hoc Student-Newman-Keuls test. Within rows, values with different superscript letters (a-d) are statistically different (*P* <0.05).

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A Rare Case of Diabetic Hand Ulcer – Tropical Diabetic Hand Syndrome

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Hand complications of diabetes mellitus are rare compared to foot complications. Tropical diabetic hand syndrome (TDHS) describes an acute complex hand complication affecting patients with diabetes in the tropical or costal areas usually following a minor injury to the hand. TDHS is poorly understood both by the patients as well as the clinicians. However, the condition may have severe consequences including permanent disability and even death without prompt and aggressive treatment. We here present a case of diabetic ulceration of thumb that has missed the proper time of treatment and lead to amputation. A 49-year-old man was referred to our emergency department (ED) because of suppurating ulcer and swelling of the left thumb of one week duration. One month prior to this visit, he had pain in his left thumb but thought nothing of it at the time. When he saw a doctor of local health care center, he was brought to our ED for operation. He has a 20 year history of type 2 diabetes mellitus and hypertension. 3 years prior to the ED visit, transtibial amputation was done on his left leg, and he was begun hemodialysis at cause of diabetic nephropathy. On arrival, physical examination revealed febrile (body temperature 38.5˚C) and his left thumb was swollen, warm and ulcerated with abscess formation. Laboratory test revealed leukocytosis (WBC 18.57 × 109/L), anemia (Hb 6.9 g/dl), erythrocyte sedimentation rate (86 mm/hr), elevated C-reactive protein (205.37 mg/L), elevated procalcitonin (1.69 ng/ml), elevated HbA1c (7.9 %) and elevated creatinine (6.04 mg/dL). Empirical antibiotics therapies were started and immediate surgical debridement was performed. Amputation of thumb was inevitable because the tissue was necrotic and abscess formed due to extensive inflammation. Cultures of this ulcer yielded growth of Enterobacter aerogenes that was susceptible to piperacillin/tazobactam, and intravenous therapy with these agents was started. During the hospital stay, four time surgical debridement and daily dressings were performed. A healthy granulation tissue started to grow on the affected finger but a permanent disability caused by amputation remained.