# The effect of body shape on the development of cardiovascular disease: The KOGES study

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Background/Aims: Although obesity is a significant risk factor of metabolic disorders, some people have metabolically healthy obesity (MHO). Many studies reported inconsistent results about the development of cardiovascular disease (CVD) in individuals with MHO. This study aimed to evaluate the effect of body shape on CVD outcomes in individuals with MHO. **Methods:** We analyzed the data of 8,416 participants from the Korean Genome and Epidemiology Study, a 10-year follow-up population-based cohort study. To evaluate the participants' body shape, we calculated the Z-score of log-transformed A Body Shape Index (LBSIZ) and divided the participants into the following groups: metabolically healthy non-obesity (MHNO), MHO, metabolically unhealthy non-obesity (MUNO), and metabolically unhealthy obesity (MUO). Then, each group was classified into four subgroups based on the LBSIZ quartile. A multivariate logistic regression analysis was performed to evaluate the effect of LBSIZ for CVD events according to obesity phenotypes. The graphical relationships between LBSIZ and CVD events were also evaluated with restricted cubic spline plots **Results:** During the 10-year study period, 696 CVD events occurred in the participants. In the multivariate Cox regression model, MHO individuals did not have an increased risk of CVD compared with MHNO individuals. However, the further analysis with LBSIZ showed that the MHO participants with 3rd and 4th LBSIZ quartiles had a significantly higher hazards ratio for CVD events, whereas those with 1st and 2nd LBSIZ quartiles did not have an elevated risk of CVD compared to the MHNO participants with 1st quartile. In the restricted cubic spline regression, LBISZ showed a linear relationship with CVD events regardless of obesity phenotypes. **Conclusions:** The MHO individuals with a high quartile of LBSIZ have a significant increased risk for CVD events. MHO individuals with a high quartile of LBSIZ need to undergo interventions to reduce waist circumference

Forest plot of Hazard Ratios by groups and quartiles:

Groups	HR	95%-CI
MHNO		
Quartile 1	Reference	MHNO
Quartile 2	1.45	[0.86; 2.44]
Quartile 3	2.46	[1.53; 3.97]
Quartile 4	2.02	[1.23; 3.32]
MHO		
Quartile 1	1.42	[0.73; 2.74]
Quartile 2	1.76	[0.94; 3.32]
Quartile 3	2.11	[1.19; 3.76]
Quartile 4	3.50	[2.03; 6.03]
MUNO		
Quartile 1	2.54	[1.41; 4.56]
Quartile 2	2.08	[1.19; 3.63]
Quartile 3	3.09	[1.92; 5.00]
Quartile 4	2.09	[1.29; 3.37]
MUO		
Quartile 1	1.86	[1.02; 3.40]
Quartile 2	2.86	[1.76; 4.64]
Quartile 3	3.40	[2.15; 5.38]
Quartile 4	4.07	[2.60; 6.38]
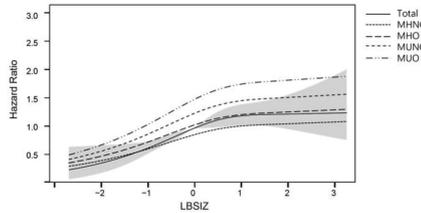
	MHNO (N=3003)	MHO (N=1287)	MUNO (N=1798)	MUO (N=2528)	P-value
Age, years	50.8 ± 8.9	50.1 ± 8.1	54.9 ± 9.1	53.3 ± 8.6	<0.001
Men, N	1546 (51.5%)	577 (44.8%)	905 (50.3%)	1061 (45.6%)	<0.001
Smoking, N					<0.001
Never smoker	1683 (56.0%)	817 (63.5%)	1005 (55.9%)	1409 (60.5%)	
Ex-smoker	451 (15.0%)	212 (16.5%)	295 (16.4%)	383 (16.5%)	
Current smoker	869 (28.9%)	258 (20.0%)	498 (27.7%)	536 (23.0%)	
Alcohol, N					<0.001
Never drinker	1302 (43.4%)	540 (42.0%)	842 (46.8%)	1161 (49.9%)	
Ex-drinker	175 (5.8%)	76 (5.9%)	126 (7.0%)	159 (6.8%)	
Current drinker	1526 (50.8%)	671 (52.1%)	830 (46.2%)	1008 (43.3%)	
Physical activity, N	1167 (38.9%)	514 (39.9%)	642 (35.7%)	788 (33.8%)	<0.001
BMI	22.2 ± 1.9	27.1 ± 1.9	22.9 ± 1.6	27.6 ± 2.1	<0.001
LBSIZ	-0.19 ± 1.03	-0.26 ± 0.91	0.31 ± 1.00	0.14 ± 0.90	<0.001
Systolic BP, mmHg	113.9 ± 15.4	115.9 ± 14.6	127.7 ± 19.1	129.8 ± 18.0	<0.001
Diastolic BP, mmHg	75.5 ± 9.9	78.1 ± 9.8	83.4 ± 11.2	85.6 ± 11.1	<0.001
Fasting glucose, mg/dl	82.2 ± 12.3	83.9 ± 10.8	90.6 ± 27.9	93.0 ± 25.1	0.000
HbA1c, %	5.5 ± 0.5	5.6 ± 0.5	6.0 ± 1.2	6.1 ± 1.1	0.188
Total cholesterol, mg/dL	184.4 ± 32.8	194.3 ± 34.5	190.7 ± 37.7	199.6 ± 35.8	<0.001
HDL-C, mg/dL	49.5 ± 10.0	47.6 ± 9.3	40.8 ± 8.7	39.5 ± 7.4	<0.001
Triglycerides, mg/dL	110.7 ± 45.1	121.6 ± 50.6	206.4 ± 119.8	219.4 ± 126.2	<0.001
LDL-C, mg/dL	112.8 ± 30.0	122.4 ± 30.9	109.4 ± 35.1	116.8 ± 34.2	0.097
Metabolic state, N					
High BP	502 (16.7%)	257 (20.0%)	1110 (61.7%)	1621 (69.6%)	<0.001
Hyperglycemia	95 (3.2%)	47 (3.7%)	501 (27.9%)	733 (31.5%)	<0.001
Low HDL-C	892 (29.7%)	454 (35.3%)	1354 (75.3%)	1874 (80.5%)	<0.001
High triglycerides	255 (8.5%)	167 (13.0%)	1330 (74.0%)	1787 (76.8%)	<0.001
CVD events, N	167 (5.6%)	83 (6.4%)	174 (9.7%)	272 (11.7%)	<0.001