

Blood Lead is associated with Impaired Fasting Glucose in Middle-aged population: The 2008-2011 Korean National Health and Nutrition Examination Survey

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BACKGROUND

Environmental exposure to heavy metals have affected human health. Several studies have suggested that lead increase oxidative stress and induce mitochondrial dysfunction. The objective was to determine whether there was an association between blood lead level and impaired fasting glucose(IFG) in middle-aged population.

METHODS

This study was based on the data from the Korean National Health and Nutrition Examination Survey (KNHANES), conducted by the Korean Ministry of Health and Welfare in 2008-2011. Of 37,753 participants, data for 2,366 adults ≥40 years of age without diabetes were included in the analysis. Subjects were subdivided according to quartile of blood lead level. Multivariate logistic regression analyses were used to identify whether there was an independent association between blood lead level and IFG by adjusting for confounding factors.

Table 1. The characteristics of the study population

	Total	NGT	IFG	<i>P</i> value
N (%)	2,366	1,727(73)	639(27.0)	
Sex, male (%)	1060(46.2)	707(42.7)	353(55.8)	< 0.001
Age (years)	54.28 ± 0.31	53.75 ± 0.38	55.70 ± 0.63	0.012
BMI (kg/m ²)	23.97 ± 0.10	23.61 ± 0.10	24.91 ± 0.18	< 0.001
SBP (mmHg)	122.69 ± 0.47	120.85 ± 0.54	127.57 ± 0.92	< 0.001
DBP(mmHg)	78.65 ± 0.32	77.90 ± 0.34	80.63 ± 0.67	< 0.001
FPG (mg/dL)	94.79 ± 0.28	90.25 ± 0.17	106.82 ± 0.32	< 0.001
Smoking (%)				0.002
Never	56.1	58.8	49.1	
Past	22.3	20.5	27.0	
Current	21.6	20.7	23.9	
Alcohol drinking (%)				0.904
No	26.8	26.9	26.5	
Yes	73.2	73.1	73.5	
Family income ^a (%)				0.906
< 100	15.3	15.2	15.7	
100-199	17.0	16.5	18.1	
200-299	16.8	17.0	16.2	
≥ 300	50.9	51.3	50.0	
Less than high school education (%)	42.6	41.1	46.6	0.088
Residence in urban area (%)	67.6	67.5	67.9	0.910
Regular exercise ^b , yes (%)	7.9	8.3	6.7	0.356
Total energy intake (kcal)	2049.73 ± 23.39	2022.62 ± 26.58	2121.59 ± 49.90	0.083
F/Hx of DM ^c , yes (%)	16.1	14.3	20.8	0.003
Known HTN (%)	23.0	20.1	30.9	< 0.001
Known dyslipidemia (%)	9.8	8.6	13.0	0.021
Lead (µg /dL)	2.577 ± 0.331	2.522 ± 0.384	2.723 ± 0.565	0.002
Lead grade (%)				0.001
Quartile 1(≤1.845)	25.1	27.4	20.6	
Quartile 2(1.846-2.434)	25.1	26.3	21.6	
Quartile 3(2.435-3.091)	24.9	24.6	26.7	
Ouartila 1(>2 001)	24.0	21.7	21.1	

Table 2. The characteristics of the study population according to serum lead level

N (%) S93(25.1) S94(25.1) S90(24.9) Sex, male (%) 105(17.1) 222(41.4) 307(54.2) 426(73.7) <0.001 Age (years) 53.67±0.73 52.48±0.50 55.90±0.70 55.12±0.59 <0.001 BMI (kg/m²) 23.93±0.17 24.06±0.17 23.95±0.15 0.934 SBP (mmHg) 120.09±0.85 119.80±0.95 123.99±0.96 127.07±0.94 <0.001 DBP (mmHg) 75.95±0.51 77.66±0.64 79.07±0.69 82.07±0.59 <0.001 Smoking (%) Never 80.2 61.3 50.4 31.4 Past 14.4 18.5 24.3 32.3 Current 5.4 20.2 25.3 36.3 Alcohol drinking (%) No 40.0 25.4 25.8 15.3 Yes 60.0 74.6 74.2 84.7 Family income³ (%) 15.3 10.0 19.2 16.8 100-199 17.0 17.3 15.3 18.3 200-299 18.1 15.4 14.8 18.8 ≥ 300 49.6 57.3 50.7 46.1 Less than high school education (%) Residence in urban area (%) Regular exercise ^b , yes (%) Regular exercise ^b , yes (%) 7.3 8.1 8.3 7.8 0.957 Total energy intake (kcal) 1854.33 2003.72 2054.56 2297.91 <0.001 Known dyslipidemia (%) 10.8 12.5 7.8 7.9 0.099 Known dyslipidemia (%) 10.8 12.5 7.8 7.9 0.099		Lead(µg /dL)				
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Never 80.2 61.3 50.4 31.4 Past 14.4 18.5 24.3 32.3 Current 5.4 20.2 25.3 36.3 Alcohol drinking (%)	`	93.12 ± 0.53	94.48 ± 0.49	95.40 ± 0.52	96.24 ± 0.52	
Past Current 5.4 20.2 25.3 36.3 Alcohol drinking (%)		0.0.4				< 0.001
Current 5.4 20.2 25.3 36.3 Alcohol drinking (%) No 40.0 25.4 25.8 15.3 Yes 60.0 74.6 74.2 84.7 Family income ^a (%) 40.0 25.4 25.8 15.3 Yes 60.0 74.6 74.2 84.7 Family income ^a (%) 0.070 < 100 15.3 10.0 19.2 16.8 100-199 17.0 17.3 15.3 18.3 200-299 18.1 15.4 14.8 18.8 ≥ 300 49.6 57.3 50.7 46.1 Less than high school education (%) 39.2 36.3 46.6 48.4 0.003 Residence in urban area (%) 70.2 66.6 70.7 2.9 0.128 (%) Regular exercise ^b , yes (%) 7.3 8.1 8.3 7.8 0.957 Total energy intake (kcal) 1854.33 2003.72 2054.56 2297.91 <0.001 F/Hx of DMc, yes (%) 21.8 12.5 14.6 15.4 0.007 Known HTN(%) 23.9 19.3 25.5 23.5 0.295						
Alcohol drinking (%) No 40.0 25.4 25.8 15.3 Yes 60.0 74.6 74.2 84.7 Family income ^a (%) < 100 15.3 10.0 17.0 17.3 15.3 18.3 200-299 18.1 15.4 14.8 18.8 ≥ 300 49.6 57.3 50.7 46.1 Less than high school education (%) Residence in urban area 70.2 66.6 70.7 2.9 0.070 0.070 0.070 0.070 0.070 18.1 15.4 14.8 18.8 200-299 18.1 15.4 14.8 18.8 200-299 18.1 15.4 14.8 18.8 200-299 18.1 18.1 15.4 14.8 18.8 200-299 18.1 18.8 200-299 18.1 18.1 15.4 14.8 18.8 2003-72 29 0.128 (%) Total energy intake (kcal) 1854.33 2003.72 2054.56 2297.91 20001 ±42.68 F/Hx of DMc, yes (%) 21.8 12.5 14.6 15.4 0.007 Known HTN(%) 23.9 19.3 25.5 23.5 0.295						
No 40.0 25.4 25.8 15.3 Yes 60.0 74.6 74.2 84.7 Family income ^a (%) 0.070 < 100 15.3 10.0 19.2 16.8 100-199 17.0 17.3 15.3 18.3 200-299 18.1 15.4 14.8 18.8 ≥ 300 49.6 57.3 50.7 46.1 Less than high school education (%) Residence in urban area (%) Regular exercise ^b , yes (%) 7.3 8.1 8.3 7.8 0.957 (%) Total energy intake (kcal) 1854.33 2003.72 2054.56 2297.91 <0.001 ± 42.60 ± 45.77 ± 49.92 ± 42.68 F/Hx of DMc, yes (%) 21.8 12.5 14.6 15.4 0.007 Known HTN(%) 23.9 19.3 25.5 23.5 0.295		5.4	20.2	25.3	36.3	
Yes 60.0 74.6 74.2 84.7 Family income³ (%) 0.070 < 100	Alcohol drinking (%)					< 0.001
Family income ^a (%)	No	40.0	25.4			
< 100	Yes	60.0	74.6	74.2	84.7	
100-199 17.0 17.3 15.3 18.3 200-299 18.1 15.4 14.8 18.8 ≥ 300 49.6 57.3 50.7 46.1 Less than high school education (%) 39.2 36.3 46.6 48.4 0.003 Residence in urban area (%) 70.2 66.6 70.7 2.9 0.128 (%) Regular exercise ^b , yes (%) 8.1 8.3 7.8 0.957 (%) 1854.33 2003.72 2054.56 2297.91 <0.001	Family income ^a (%)					0.070
200-299 18.1 15.4 14.8 18.8 ≥ 300 49.6 57.3 50.7 46.1 Less than high school education (%) 39.2 36.3 46.6 48.4 0.003 Residence in urban area (%) 70.2 66.6 70.7 2.9 0.128 (%) Regular exercise ^b , yes (%) 8.1 8.3 7.8 0.957 (%) 1854.33 2003.72 2054.56 2297.91 <0.001	< 100	15.3	10.0	19.2	16.8	
≥ 300 49.6 57.3 50.7 46.1 Less than high school education (%) Residence in urban area (%) Regular exercise ^b , yes (%) Total energy intake (kcal) F/Hx of DM ^c , yes (%) Known HTN(%) 49.6 57.3 50.7 46.1 46.1 48.4 0.003 66.6 70.7 2.9 0.128 8.1 8.3 7.8 0.957 2054.56 2297.91 <0.001 ±42.60 ±45.77 ±49.92 ±42.68 1854.33 12.5 14.6 15.4 0.007 Known HTN(%) 23.9 19.3 25.5 23.5 0.295	100-199	17.0	17.3	15.3	18.3	
Less than high school education (%) 39.2 36.3 46.6 48.4 0.003 Residence in urban area (%) 70.2 66.6 70.7 2.9 0.128 (%) Regular exerciseb, yes (%) 8.1 8.3 7.8 0.957 (%) 1854.33 2003.72 2054.56 2297.91 <0.001	200-299	18.1	15.4	14.8	18.8	
education (%) Residence in urban area (%) Regular exercise ^b , yes 7.3 8.1 8.3 7.8 0.957 (%) Total energy intake (kcal) 1854.33 ±42.60 ±45.77 ±49.92 ±42.68 F/Hx of DM ^c , yes (%) 21.8 12.5 14.6 15.4 0.007 Known HTN(%) 23.9 19.3 25.5 23.5 0.295	≥ 300	49.6	57.3	50.7	46.1	
(%) Regular exerciseb, yes 7.3 8.1 8.3 7.8 0.957 (%) Total energy intake (kcal) 1854.33	_	39.2	36.3	46.6	48.4	0.003
(%) Total energy intake (kcal) F/Hx of DM ^c , yes (%) Known HTN(%) 1854.33 2003.72 2054.56 2297.91 40.001 ±45.77 ±49.92 ±42.68 12.5 14.6 15.4 0.007 19.3 25.5 23.5 0.295		70.2	66.6	70.7	2.9	0.128
Total energy intake (kcal) ±42.60 ±45.77 ±49.92 ±42.68 F/Hx of DM ^c , yes (%) 21.8 12.5 14.6 15.4 0.007 Known HTN(%) 23.9 19.3 25.5 23.5 0.295		7.3	8.1	8.3	7.8	0.957
Known HTN(%) 23.9 19.3 25.5 23.5 0.295	Total energy intake (kcal)					< 0.001
	F/Hx of DMc, yes (%)	21.8	12.5	14.6	15.4	0.007
Known dyslipidemia (%) 10.8 12.5 7.8 7.9 0.099	Known HTN(%)	23.9	19.3	25.5	23.5	0.295
	Known dyslipidemia (%)	10.8	12.5	7.8	7.9	0.099
IFG (%) 20.6 21.6 26.7 31.1 0.001	IFG (%)	20.6	21.6	26.7	31.1	0.001

Data are expressed as the mean \pm SD for continuous variables and as weighted percentages for categorical variables. NGT, normal glucose tolerance; IFG, impaired fasting glucose; BMI, body mass index; SBP, systolic blood pressure; DBP, diastolic blood pressure; FPG, fasting plasma glucose.

a Unit is thousand Korean wons/month. b Regular exercise was indicated as 'yes' when the subject did moderate exercise on a regular basis (for more than 30).

Table 3. Odds ratio (95% CI) for impaired fasting glucose according to quartiles of lead

min at a time and more than 5 times a week). ^cFamily history of diabetes limited 1st degree relatives.

31.1

21.7

	Quartile 1	Quartile 2	Quartile 3	Quartile 4
Model 1	1	1.093(0.751-1.589)	1.439(1.005-2.060)*	1.906(1.369-2.654)*
Model 2	1	1.073(0.728-1.583)	1.202(0.826-1.751)	1.484(1.010-2.180)*
Model 3	1	1.077(0.729-1.591)	1.209(0.833-1.754)	1.491(1.004-2.214)*

Model 1: unadjusted.

Quartile 4(>3.091)

Model 2: adjusted for age, sex, and diabetes risk factors (known HTN, known dyslipidemia, F/Hx of DM, SBP, DBP, and BMI)

Model 3: model 2 plus lifestyle behaviors (smoking status, alcohol drinking, regular exercise, and total energy intake) and sociodemographic factors (residential area, family income, and education).

**P* < 0.05

CONCLUSION

Blood lead level was independently associated with IFG in Korean middle-aged population. We propose that the lead may contribute to increasing glucose level and risk of prediabetes.









24.9