Table1 Baseline socio-demographic and clinical characteristics of the study population based on serum cis-β-carotene quartiles.

Characteristic	cis-β-carotene				P value
	Quartiles 1	Quartiles 2	Quartiles 3	Quartiles4	
Participants, n	624	3845	2407	2405	
Age, years	33.4 ±18.8	33.6 ± 20.0	38.3± 22.6	49.0 ± 22.8	<0.001
Gender					
Man	373 (59.8%)	2063 (53.7%)	1197 (49.7%)	924(38.4%)	
Woman	251 (40.2%)	1782 (46.3%)	1210 (50.3%)	1481(61.6%)	
Body Mass Index (kg/m^2)	28.49 ± 6.84	27.86 ± 7.42	26.52 ±6.35	25.97 ±5.39	<0.001
Systolic blood pressure (mm Hg)	118.96±17.07	118.01 ± 17.74	119.33 ± 19.90	124.09± 23.20	<0.001
Diastolic blood pressure (mm Hg)	66.73± 13.80	67.40 ± 13.61	66.58 ± 13.54	67.85 ± 14.16	0.108
Ratio of Family income to poverty	2.10 ± 1.52	2.36 ± 1.57	2.46 ± 1.61	2.84 ± 1.64	<0.001
High school education or higher, n (%)	389(62.3%)	2516(65.43%)	1574(65.39%)	1735(72.14%)	<0.001
Waist circumference, cm	97.26± 17.91	94.34± 18.14	91.40 ± 16.71	90.70 ± 14.60	<0.001
Thigh circumference, cm	54.43 ± 8.13	53.61 ± 7.82	51.90 ± 7.22	50.83 ± 6.57	<0.001
Fasting Blood Glucose (mmol/L)	5.71 ± 0.44	5.64 ± 1.78	5.60 ± 1.82	5.54 ± 1.57	0.046

Fasting Insulin(pmol/L)	90.43 ± 103.70	90.76 ± 98.18	73.31 ± 75.91	59.84 ± 72.23	<0.001
C-peptide(mmol/L)	0.95±0.54	0.85±0.46	0.79±0. 45	0.72±0.37	<0.001
C-reactive protein(mg/dL)	0.55 ±1.31	0.44 ±0.80	0.38 ±0.78	0.34 ±0.84	<0.001
Triglyceride (mmol/L)	1.67 ± 2.13	1.50 ±1.29	1.46 ± 1.12	1.41 ± 1.22	<0.001
LDL-cholesterol (mmol/L)	2.57± 0.99	2.67 ± 0.85	2.86 ± 0.90	3.14 ± 0.99	<0.001
HOMA-IR	3.48 ± 4.88	3.47 ± 5.03	2.86 ± 4.65	2.28 ± 3.60	<0.001
HOMA-B	170.87 ± 742.09	138.63± 73.84	118.98±218.06	90.45 ± 245.77	<0.001
α-carotene(μmol/L)	0.02 ± 0.02	0.03 ± 0.03	0.06 ± 0.04	0.15 ± 0.17	<0.001
trans-b-carotene (μmol/L)	0.08 ± 0.04	0.14 ± 0.06	0.26 ± 0.08	0.67 ± 0.50	<0.001
Combined Lutein/zeaxanthin (μmol/L)	0.20 ± 0.08	0.22 ± 0.09	0.27 ± 0.12	0.37 ± 0.18	<0.001
trans-lycopene (μmol/L)	0.33 ± 0.18	0.40 ± 0.19	0.43 ± 0.20	0.45 ± 0.22	<0.001

Note: The HOMA-IR was calculatedusing the formula: fasting insulin (pmol/l) × FPG (mmol/l)/156.3. Insulin resistance was defined as HOMA-IR ≥2.5 [23].HOMA-B was calculated according to the formula: (2.9 × fasting insulin [pmol/l])/(FPG [mmol/l -3.5)].Values are mean ± SD or n (%)

Table 2. Correlation between cis-β-carotene in blood biochemistry

Variables	cis-β-carotene(μmol/L)		Fasting blood glucose(mmol/L)		Triglyceride (mmol/L)		Insulin(pmol/L)		SBP average		DBP average		HOMA-R	
	r value	p value	r value	p value	r value	p value	r value	p value	r value	p value	r value	p value	r value	p value
cis-β-carotene(μmol/L)	1		-0.034	<0.001	-0.041	<0.001	-0.113	<0.001	0.109	<0.001	-0.003	0.831	-0.088	<0.001
Fasting blood glucose(mmol/L)	-0.034	0.339	1		0.240	<0.001	0.220	<0.001	0.220	<0.001	0.072	<0.001	0.481	<0.001
Triglyceride (mmol/L)	-0.041	<0.001	0.240	<0.001	1		0.174	<0.001	0.145	<0.001	0.098	<0.001	0.198	<0.001
Insulin: SI(pmol/L)	-0.113	<0.001	0.220	<0.001	0.174	<0.001	1		0.045	<0.001	-0.008	<0.001	0.895	<0.001
SBP average	0.109	<0.001	0.22	<0.001	0.145	<0.001	0.045	<0.001	1		0.331	<0.001	0.094	<0.001
DBP average	-0.003	0.831	0.072	<0.001	0.098	<0.001	-0.008	0.511	0.331	<0.001	1		0.005	0.679
HOMA-R	-0.088	<0.001	0.481	<0.001	0.198	<0.001	0.895	<0.001	0.094	<0.001	0.005	0.679	1	

Notes: Pearson correlation was calculated to assess the strength of relationship between cis-β-carotene and blood biochemistry.

Table 3The associated between serum Fasting Glucose(mmol/L) and cis-β-carotene (μmol/L)

Per 1 μmol/L increased in serum cis-β-carotene	Model 1 β (95% CI) P Value	Model 2 β (95% CI) P Value	Model 3 β (95% CI) P Value
Participants	9281	8537	5742
Fasting Glucose(mmol/L)	0.10(0.009,0.011) <0.001	0.001(-0.001,0.003) 0.537	0.0130.009,0.017) <0.001
HOMA-IR	0.022(0.021,0.022) <0.001	0.005(0.003, 0.007) <0.001	0.017(0.014, 0.021) <0.001
HOMA-B	0.022(0.021,0.022) <0.001	0.004(0.002, 0.006) <0.001	0.013(0.009, 0.017) <0.001
Triglyceride(mmol)	0.010(0.009,0.011) <0.001	0.04(0.003, 0.006) <0.001	0.013(0.009, 0.017) <0.001
Insulin(pmol/L)	0.023(0.022,0.024) <0.001	0.006(0.004, 0.008) <0.001	0.009(0.006, 0.012) <0.001

Notes: Model 1 adjust for: no covariates. Model 2 adjust for: age, gender, ratio of family income to poverty. Model 3 adjust for: systolic blood pressure, diastolic blood pressure, BMI, LDL-cholesterol and C-reaction protein. In the subgroup analysis stratified by gender and educational level.

Table-4. The activity of cardiac mitochondrial electron transport chain complex(ETC)

Activity (nmol/min/mg mt prot)	complex I	complex II	complexIII	complex IV
Control	4.83±0.61	0.45±0.07	2.11±0.11	2.47±0.42
4 weeks DM	2.72±0.17*	0.46±0.04	1.2±0.07*	2.34±0.25*
4 weeks DM +β-carotene	3.43±0.37#	0.41±0.05	0.74±0.13#	1.66±0.16#
8 weeks DM	1.77±0.47*	0.43±0.03	0.71±0.11*	2.20±0.12*
8 weeks DM +β-carotene	3.94±0.44#	0.42±0.06	1.39±0.09#▽	1.93±0.14#▽

Notes:*$P<0.05$ vs. control group; # $P<0.05$ vs. 4 weeks DMp; ▽$P<0.05$ vs. 8 weeks DM. Data are shown as means ± SEM (n = 4).