Supplemental Material

Contents

Variable[a]	Normal (47.4%)	Osteopenia (44.4%)	Osteoporosis (8.17%)	P value[b]
Age	60.52 (0.22)	63.79 (0.29)	69.26 (0.56)	<0.001
Sex				<0.001
Female	37%	62%	82%	
Male	63%	38%	18%	
Ethnicity				<0.001
Non-Hispanic White	72%	79%	85%	
Mexican American	5.4%	4.8%	3.2%	
Non-Hispanic Asian	1.8%	3.0%	4.1%	
Non-Hispanic Black	13%	4.8%	2.6%	
Other Hispanic	3.9%	4.2%	3.0%	
Other Race	3.6%	3.7%	2.5%	
BMI	30.74 (0.16)	27.63 (0.14)	25.25 (0.29)	<0.001
Marital status				<0.001
Coupled	73%	67%	49%	
Single	27%	33%	51%	
PIR				<0.001
[0,1.3]	14%	15%	20%	
(1.3,1.85]	8.6%	11%	16%	
(1.85,3.5]	23%	25%	31%	
>3.5	54%	49%	34%	
PA miniutes per week	616.43 (25.08)	520.75 (27.74)	381.05 (70.99)	<0.001
Femur neck BMD	0.88 (0.00)	0.68 (0.00)	0.54 (0.00)	<0.001
LE8 score	64.62 (0.49)	68.11 (0.48)	66.63 (1.08)	<0.001
CVH				<0.001
Low	14%	9.2%	11%	
High	15%	22%	22%	
Moderate	71%	69%	67%	
Health behavior score	68.98 (0.65)	69.91 (0.60)	65.25 (1.35)	0.004
Diet score	45.46 (1.12)	49.51 (1.14)	46.66 (2.17)	0.012
Physical activity score	71.96 (1.26)	68.24 (1.22)	56.30 (3.19)	<0.001
Nicotine exposure score	75.31 (1.00)	77.04 (1.17)	76.14 (1.88)	0.030
Sleep health score	83.18 (0.70)	84.85 (0.77)	81.91 (1.72)	0.084
Health factor score	60.25 (0.56)	66.31 (0.57)	68.00 (1.23)	<0.001
BMI score	50.25 (0.96)	66.17 (0.79)	79.37 (1.75)	<0.001
Blood lipids score	58.18 (0.84)	59.76 (0.84)	60.21 (1.92)	0.2
Blood glucose score	73.64 (0.96)	79.57 (0.85)	79.54 (1.68)	<0.001
Blood pressure score	58.93 (0.96)	59.72 (0.90)	52.89 (2.25)	0.033
Osteoporosis family history				<0.001
No	88%	81%	76%	
Yes	12%	19%	24%	

[a] Mean (SE)

[b] Design-based Kruskal-Wallis test for continuous variables; Pearson's X^2 with Rao & Scott adjustment for categorical variables

Table S1: Weighted descriptive statistics by osteoporosis status

	Multivariate Model 1[a]				Multivariate Model 2[b]			
	Binary Logistic		Modified Poisson		Binary Logistic		Modified Poisson	
	aOR(95% CI)	P value	aOR(95% CI)	P value	aOR(95% CI)	P value	aOR(95% CI)	P value
LE8 score								
Low(0-49)	1[Reference]	-	1[Reference]	-	1[Reference]	-	1[Reference]	-
Moderate(50-79)	0.56(0.42-0.76)	0.0003	0.66(0.53-0.82)	0.0003	0.62(0.46-0.83)	0.0018	0.7(0.56-0.86)	0.0009
Hight(80-100)	0.4(0.24-0.66)	0.0006	0.51(0.35-0.74)	0.0006	0.53(0.31-0.89)	0.0182	0.62(0.42-0.92)	0.0173
P_{trend}	0.0004		0.0003		0.0062		0.003	
Each 10-points increment	0.78(0.69-0.88)	0.0001	0.83(0.76-0.91)	0.0001	0.82(0.72-0.94)	0.0054	0.87(0.78-0.96)	0.0006
Health behavior								
Diet[c]								
1st–24th (least ideal)	1[Reference]	-	1[Reference]	-	1[Reference]	-	1[Reference]	-
25th–49th	0.77(0.48-1.25)	0.2834	0.83(0.58-1.19)	0.2980	0.8(0.5-1.3)	0.3659	0.85(0.6-1.2)	0.3561
50th–74th	0.57(0.35-0.94)	0.0297	0.66(0.45-0.96)	0.0322	0.62(0.37-1.02)	0.0613	0.7(0.48-1.02)	0.0605
75th–94th	0.49(0.28-0.85)	0.0113	0.58(0.39-0.88)	0.0322	0.55(0.33-0.91)	0.0202	0.64(0.44-0.94)	0.0250
$\geq$95th (ideal)	0.39(0.21-0.75)	0.0050	0.48(0.3-0.79)	0.0045	0.45(0.24-0.84)	0.0123	0.54(0.34-0.86)	0.0096
P_{trend}	0.0367		0.0311		0.0753		0.0677	
Each 10-points increment	0.91(0.86-0.97)	0.0026	0.93(0.89-0.97)	0.0022	0.93(0.88-0.98)	0.0059	0.94(0.91-0.98)	0.0062
Physical activity(min/per week)								
0	1[Reference]	-	1[Reference]	-	1[Reference]	-	1[Reference]	-
1–29	0.41(0.12-1.44)	0.1610	0.51(0.18-1.45)	0.2042	0.46(0.13-1.63)	0.2243	0.56(0.19-1.6)	0.2709
30–59	1.47(0.87-2.48)	0.1458	1.33(0.93-1.9)	0.1189	1.56(0.92-2.64)	0.0979	1.35(0.94-1.93)	0.1036
60–89	0.65(0.33-1.3)	0.2198	0.72(0.42-1.22)	0.2159	0.68(0.33-1.41)	0.2967	0.74(0.43-1.28)	0.2730
90–119	0.66(0.32-1.33)	0.2382	0.72(0.42-1.24)	0.2317	0.71(0.33-1.51)	0.3694	0.77(0.43-1.37)	0.3694
120–149	0.64(0.3-1.36)	0.2426	0.71(0.39-1.28)	0.2508	0.74(0.34-1.6)	0.4366	0.79(0.44-1.43)	0.4285
$\geq$150	0.55(0.39-0.76)	0.0006	0.63(0.49-0.82)	0.0007	0.59(0.41-0.83)	0.0036	0.67(0.51-0.88)	0.0040
P_{trend}	0.0139		0.0192		0.0226		0.039	
Each 10-points increment	0.94(0.91-0.97)	0.0004	0.96(0.93-0.98)	0.0005	0.95(0.92-0.98)	0.0028	0.96(0.94-0.99)	0.0031
Nicotine exposure score								
Low(0-49)	1[Reference]	-	1[Reference]	-	1[Reference]	-	1[Reference]	-
Moderate(50-79)	0.51(0.32-0.81)	0.0047	0.58(0.41-0.84)	0.0046	0.61(0.39-0.97)	0.0358	0.67(0.47-0.95)	0.0272
Hight(80-100)	0.62(0.42-0.91)	0.0158	0.69(0.51-0.93)	0.0153	0.8(0.53-1.21)	0.2893	0.83(0.6-1.14)	0.2460
P_{trend}	0.0115		0.0104		0.1073		0.0856	
Each 10-points increment	0.97(0.92-1.01))	0.1645	0.97(0.94-1.01)	0.1692	1(0.95-1.05)	0.9472	1(0.96-1.04)	0.8733
Sleep health (hours)								
<4	1[Reference]	-	1[Reference]	-	1[Reference]	-	1[Reference]	-
4-<5	0.21(0.07-0.68)	0.0102	0.32(0.14-0.7)	0.0056	0.22(0.07-0.71)	0.0124	0.31(0.14-0.68)	0.0039
5-<6 or $\geq$10	0.23(0.09-0.59)	0.0030	0.33(0.17-0.63)	0.0011	0.26(0.1-0.63)	0.0039	0.36(0.2-0.65)	0.0011
6-<7	0.18(0.07-0.44)	0.0004	0.28(0.15-0.52)	0.0001	0.21(0.09-0.51)	0.0008	0.31(0.17-0.55)	0.0001
9-<10	0.21(0.08-0.56)	0.0021	0.32(0.17-0.61)	0.0007	0.27(0.11-0.66)	0.0047	0.38(0.21-0.67)	0.0012
7-<9	0.14(0.06-0.32)	<0.0001	0.22(0.13-0.39)	<0.0001	0.18(0.08-0.39)	0.0001	0.27(0.16-0.44)	<0.0001
P_{trend}	0.0004		<0.0001		0.0022		0.0001	
Each 10-points increment	0.91(0.86-0.97)	0.0057	0.93(0.89-0.98)	0.0045	0.94(0.88-1)	0.0409	0.95(0.91-1)	0.0371
Health factor								
BMI (kg/m^2)								
$\geq$40	1[Reference]	-	1[Reference]	-	1[Reference]	-	1[Reference]	-
35.0-39.9	0.63(0.16-2.52)	0.5092	0.77(0.21-2.91)	0.7003	0.68(0.17-2.82)	0.5948	0.82(0.21-3.14)	0.7638
30.0-34.9	0.82(0.21-3.19)	0.7664	1.14(0.34-3.84)	0.8271	0.92(0.24-3.53)	0.9008	1.22(0.37-4.05)	0.7432
25.0-29.9	0.74(0.14-3.89)	0.7216	1.16(0.29-4.6)	0.8315	0.9(0.17-4.64)	0.8980	1.28(0.32-5.06)	0.7197
<25	0.91(0.13-6.46)	0.9237	1.39(0.29-6.72)	0.6775	1.18(0.17-8.17)	0.8658	1.58(0.33-7.52)	0.5602
P_{trend}	0.6464		0.7232		0.6196		0.6441	
Each 10-points increment	1.01(0.88-1.16)	0.8507	1.03(0.92-1.15)	0.6069	1.03(0.9-1.19)	0.6489	1.04(0.93-1.16)	0.498
Blood lipids score								
Low(0-49)	1[Reference]	-	1[Reference]	-	1[Reference]	-	1[Reference]	-
Moderate(50-79)	1.2(0.84-1.73)	0.3136	1.16(0.88-1.55)	0.2904	1.28(0.88-1.85)	0.1914	1.2(0.91-1.59)	0.1884
Hight(80-100)	1.04(0.75-1.45)	0.7924	1.04(0.81-1.35)	0.7390	1.06(0.75-1.49)	0.7390	1.06(0.82-1.37)	0.6687
P_{trend}	0.5756		0.5524		0.3949		0.4014	
Each 10-points increment	1(0.94-1.05)	0.8983	1(0.96-1.04)	0.9148	1(0.94-1.06)	0.9584	1(0.96-1.04)	0.988
Blood glucose (HbA1c%)								
HbA1c $\geq$10	1[Reference]	-	1[Reference]	-	1[Reference]	-	1[Reference]	-
HbA1c 8.0-8.9	0.17(0.03-1.08)	0.0601	0.24(0.05-1.1)	0.0661	0.16(0.03-0.99)	0.0483	0.23(0.05-1.03)	0.0540
HbA1c 7.0-7.9	0.08(0.02-0.39)	0.0022	0.12(0.03-0.44)	0.0017	0.08(0.02-0.37)	0.0017	0.12(0.04-0.43)	0.0014
HbA1c <7.0	0.17(0.05-0.63)	0.0088	0.24(0.09-0.64)	0.0050	0.18(0.05-0.62)	0.0071	0.25(0.1-0.63)	0.0043
HbA1c 5.7-6.4	0.31(0.08-1.15)	0.0781	0.39(0.14-1.04)	0.0597	0.31(0.09-1.11)	0.0721	0.39(0.15-1.01)	0.0522
HbA1c <5.7	0.24(0.06-0.9)	0.0346	0.31(0.11-0.84)	0.0228	0.25(0.07-0.92)	0.0373	0.33(0.12-0.86)	0.0245
No diabetes	0.25(0.08-0.82)	0.0223	0.33(0.14-0.79)	0.0142	0.29(0.09-0.89)	0.0304	0.36(0.16-0.84)	0.0181
P_{trend}	0.0244		0.0213		0.0174		0.0166	
Each 10-points increment	1(0.94-1.05)	0.8929	1(0.96-1.05)	0.9773	1.01(0.95-1.07)	0.6938	1.01(0.96-1.06)	0.7014
Blood pressure score								
Low(0-49)	1[Reference]	-	1[Reference]	-	1[Reference]	-	1[Reference]	-
Moderate(50-79)	0.98(0.67-1.42)	0.9060	1(0.74-1.34)	0.9795	1.02(0.69-1.5)	0.9336	1.03(0.77-1.39)	0.8280
Hight(80-100)	0.87(0.6-1.25)	0.4442	0.89(0.67-1.2)	0.4455	0.97(0.67-1.4)	0.8759	0.98(0.74-1.3)	0.8882
P_{trend}	0.7348		0.729		0.9776		0.9558	
Each 10-points increment	0.98(0.93-1.03)	0.3608	0.99(0.95-1.02)	0.3983	0.99(0.95-1.04)	0.7105	0.99(0.96-1.03)	0.7631

[a] Model 1: Adjusted for age, sex, BMI and ethnicity.

[b] Model 2: Model 1 + education level, marital status, poverty-income ratio(PIR) and osteoporosis family history.

[c] Diet measured as the Healthy Eating Index 2015(HEI-2015) quantile.

Table S2: Association of the Life's Essential 8 scores with osteoporosis from logistic regression and modified poisson regression modeling

Domain	CVH metric	Method of measurement	Quantification of CVH metric
Health behaviors	Diet	13 daily dietary components using HEI-2015 (population)	Points / Level 100 / >95th percentile 80 / 75th-94th percentile 50 / 50th-74th percentile 25 / 25th-49th percentile 0 / 1st-24th percentile
	Physical activity	Minutes of moderate or vigorous physical activity per week (Questionnaire PAQ)	Points / Level 100 / ≥150 minutes 80 / 90-119 minutes 60 / 60-89 minutes 40 / 30-59 minutes 20 / 1-29 minutes 0 / 0 minutes
	Nicotine exposure	Use of cigarettes (Questionnaire SMQ)	Points / Level 100 / Never smoker 75 / Former smoker, quit ≥5 yrs 50 / Former smoker, quit 1-<5 yrs 25 / Former smoker, quit <1 yrs 0 / Current smoker (Subtract 20 points if living with an active indoor smoker)
	Sleep health	Average hours of sleep per night (Questionnaire SLQ)	Points / Level 100 / 7-9 90 / 6-<7 or ≥9-<10 40 / 5-<6 or ≥10 20 / 4-<5 0 / <4
Health factors	BMI	Body mass index (Examination BMX)	Points / Level 100 / <25 70 / 25.0-29.9 30 / 30.0-34.9 15 / 35.0-39.9 0 / ≥40.0
	Blood lipids	Non-HDL cholesterol (mg/dL, Laboratory BMX)	Points / Level 100 / <130 60 / 130-159 40 / 160-189 20 / 190-219 0 / ≥220 (Subtract 20 points if treated with drugs)
	Blood glucose	Fasting blood glucose (mg/dL, Laboratory GLU) or casual hemoglobin A1c (%, Laboratory GHB)	Points / Level 100 / No diabetes & FBG <100 or HbA1c <5.7 60 / No diabetes & FBG 100–125 or HbA1c 5.7–6.4 (Prediabetes) 40 / Diabetes with HbA1c <7.0 30 / Diabetes with HbA1c 7.0-7.9 20 / Diabetes with HbA1c 8.0-8.9 10 / Diabetes with HbA1c 9.0-9.9 0 / Diabetes with HbA1c ≥10.0

Domain	CVH metric	Method of measurement	Quantification of CVH metric
	Blood pressure	Appropriately measured systolic and diastolic blood pressure (mmHg, Laboratory GHB)	Points / Level 100 / <120/80 75 / 120-129/<80 50 / 130-139 or 80-89 25 / 140-159 or 90-99 0 / ≥160 or ≥100 (Subtract 20 points if treated with drugs)

Table S3: Life's Essential 8 metrics for measurement and quantitative assessment of CVH.

Component	Maximum points	Standard for maximum score	Standard for minimum score of zero
Adequacy			
Total Fruits	5	≥0.8 c equivalents/1,000 kcal	No fruit
Whole Fruits	5	≥0.4 c equivalents/1,000 kcal	No whole fruit
Total Vegetables	5	≥1.1 c equivalents/1,000 kcal	No vegetables
Greens and Beans	5	0.2 c equivalents/1,000 kcal	No dark green vegetables or beans and peas
Whole Grains	10	≥1.5 oz equivalents/1,000 kcal	No whole grains
Dairy	10	≥1.3 c equivalents/1,000 kcal	No dairy
Total Protein Foods	5	≥2.5 oz equivalents/1,000 kcal	No protein foods
Seafood and Plant Proteins	5	≥0.8 c equivalents/1,000 kcal	No seafood or plant proteins
Fatty Acids	10	(PUFAs[a]+MUFAs[b])/SFAs[c]≥2.5	(PUFAs+MUFAs)/SFAs≤1.2
Moderation			
Refined Grains	10	≤1.8 oz equivalents/1,000 kcal	≥4.3 oz equivalents/1,000 kcal
Sodium	10	≤1.1 g/1,000 kcal	≥2.0 g/1,000 kcal
Added Sugars	10	≤6.5% of energy	≥26% of energy
Saturated Fats	10	≤8% of energy	≥16% of energy

[a] PUFAs=polyunsaturated fatty acids.
[b] MUFAs=monounsaturated fatty acids.
[c] SFAs=saturated fatty acids.

Table S4: Healthy Eating Index-2015 components, point values, and standards for scoring.

Model	Type	VIF[a]			AIC[b]		
		Term	GVIF	Df	$GVIF^{\frac{1}{2\cdot Df}}$	Eff.p	AIC	Deltabar
Model 1	Binary Logistic	CVH[c]	1.33	2.00	1.07	14.0	3048	1.40
		Age	1.75	1.00	1.32			
		Sex	1.13	1.00	1.06			
		BMI	1.59	1.00	1.26			
		Ethnicity	1.56	5.00	1.05			
	Binary Logistic	LE810[d]	1.22	1.00	1.10	13.2	3028	1.46
		Age	1.66	1.00	1.29			
		Sex	1.12	1.00	1.06			
		BMI	1.64	1.00	1.28			
		Ethnicity	1.50	5.00	1.04			
	Modified Poisson	CVH	1.29	2.00	1.07	11.6	2090	1.16
		Age	2.22	1.00	1.49			
		Sex	1.07	1.00	1.04			
		BMI	1.95	1.00	1.40			
		Ethnicity	1.73	5.00	1.06			
	Modified Poisson	LE810	1.12	1.00	1.06	10.8	2076	1.20
		Age	2.11	1.00	1.45			
		Sex	1.06	1.00	1.03			
		BMI	1.96	1.00	1.40			
		Ethnicity	1.62	5.00	1.05			
Model 2	Binary Logistic	CVH	2.67	2.00	1.28	29.4	3018	1.73
		Age	2.18	1.00	1.48			
		Sex	1.43	1.00	1.20			
		BMI	1.84	1.00	1.35			
		Ethnicity	6.67	5.00	1.21			
		Education level	3.74	2.00	1.39			
		Marital status	2.53	1.00	1.59			
		PIR	5.47	3.00	1.33			
		Osteoporosis family history	1.88	1.00	1.37			
	Binary Logistic	LE810	2.32	1.00	1.52	28.7	3006	1.79
		Age	2.19	1.00	1.48			
		Sex	1.45	1.00	1.21			
		BMI	2.01	1.00	1.42			
		Ethnicity	5.57	5.00	1.19			
		Education level	4.11	2.00	1.42			
		Marital status	2.53	1.00	1.59			
		PIR	5.22	3.00	1.32			
		Osteoporosis family history	1.98	1.00	1.41			
	Modified Poisson	CVH	2.64	2.00	1.27	23.2	2066	1.36
		Age	2.74	1.00	1.65			
		Sex	1.43	1.00	1.19			
		BMI	2.27	1.00	1.51			
		Ethnicity	5.79	5.00	1.19			
		Education level	4.26	2.00	1.44			
		Marital status	2.68	1.00	1.64			
		PIR	5.49	3.00	1.33			
		Osteoporosis family history	1.89	1.00	1.37			

Model	Type	VIF[a]			AIC[b]		
		Term	GVIF	Df	$GVIF^{\frac{1}{2 \cdot Df}}$	Eff.p	AIC	Deltabar
	Modified Poisson	LE810	2.11	1.00	1.45	22.6	2058	1.41
		Age	2.75	1.00	1.66			
		Sex	1.39	1.00	1.18			
		BMI	2.46	1.00	1.57			
		Ethnicity	4.87	5.00	1.17			
		Education level	4.54	2.00	1.46			
		Marital status	2.72	1.00	1.65			
		PIR	5.00	3.00	1.31			
		Osteoporosis family history	1.99	1.00	1.41			

[a] VIF (Variance Inflation Factor): Assesses multicollinearity; higher values indicate stronger correlation among predictors. VIF < 5: Generally considered to indicate no significant multicollinearity. VIF < 10: Commonly used threshold, where multicollinearity is still considered acceptable.

[b] AIC (Akaike Information Criterion): A measure of model fit quality; lower values indicate a better balance of fit and complexity.

[c] CVH (Cardiovascular Health): Categorized as Low (poor health), Moderate (moderate health), and High (optimal health).

[d] Each 10-points increment of LE8, a continuous variable ranging from 0 to 10.

Table S5: Generalized variance-inflation factors (VIF) and Akaike Information Criterion (AIC) for models.

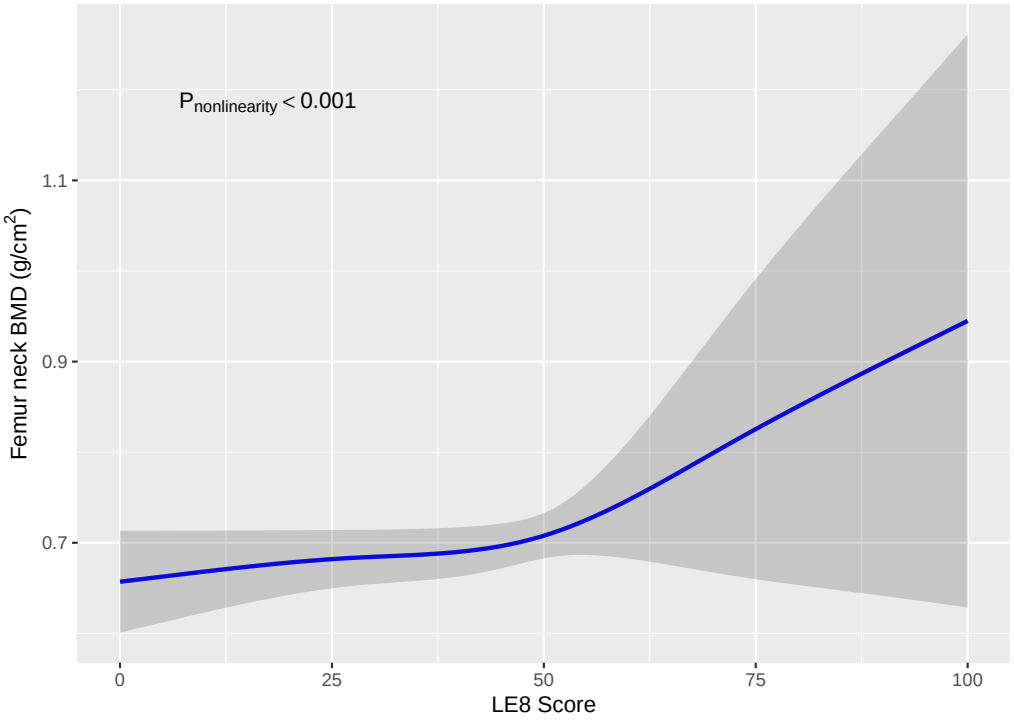

Figure S1: Restricted cubic spline curves for association between LE8 and Femur BMD.

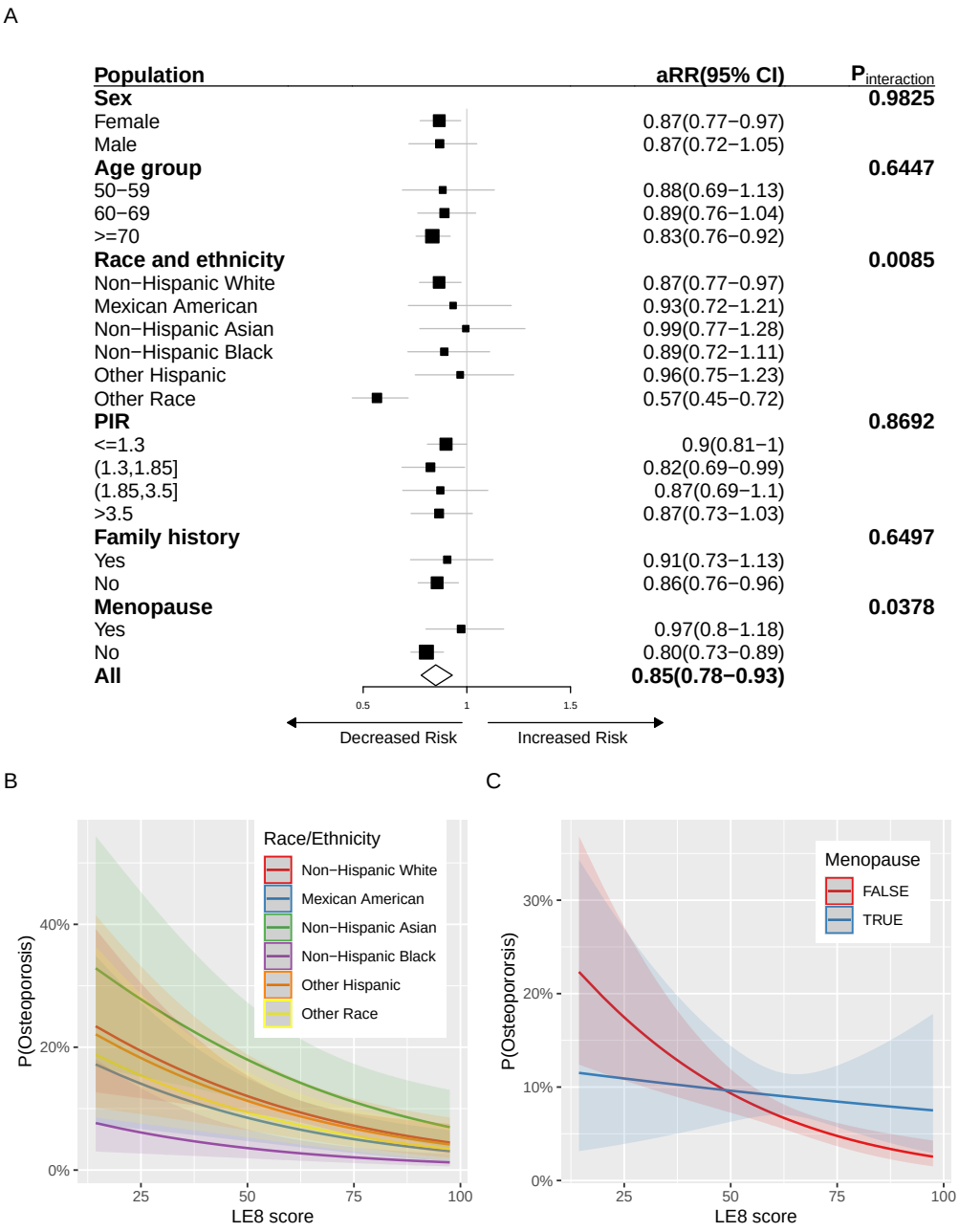

Figure S2: Subgroup analyses of relative risk for osteoporosis by each 10-points increment on LE8 scores.