Exposure to Residential Green Space and Bone Mineral Density in Young Children

Supplementary material

Supplementary Online Content

This supplementary material has been provided by the authors to give readers additional information about their work.

eMethods 1. Multiple linear regression equation

$$Y_i = \beta_0 + \beta_1 X_{i1} + \beta_2 X_{i2} + \ldots + \beta_p X_{ip} + \varepsilon_i$$

Where Y_i is the child's bone mineral density for the i-th observation, β_0 corresponds to the intercept term, $\beta_{1..p}$ denotes the regression coefficient associated with each independent variable, $X_{i1\ldots ip}$ represents the p independent variables for the i-th observation (green space exposure, child's sex, age, weight, height, ethnicity, maternal education, child's daily screen time, vitamin supplementation, daily dairy products consumption, season, and neighborhood median annual income), and ε_i corresponds to the error term for the i-th observation.

eMethods 2. Logistic regression equation

When the bone mineral density is coded as a binary outcome, where $Y_i = 0$ when the i-th child's bone mineral density is higher or equal to the sex-specific 10th percentile of the study population, and $Y_i = 1$ when the i-th child's bone mineral density is lower than the sex-specific 10th percentile of the study population, the probability of having bone mineral density lower than the sex-specific 10th percentile of the study population is denoted as $\pi_i = P(Y_i = 1)$. This probability, π_i, is connected with the linear predictor via a logit link function:

$$\log\left(\frac{\pi_i}{1 - \pi_i}\right) = \beta_0 + \beta_1 X_{i1} + \beta_2 X_{i2} + \ldots + \beta_p X_{ip} + \varepsilon_i$$

where β_0 is the intercept term, $\beta_{1..p}$ corresponds to the regression coefficient associated with each independent variable, $X_{i1\ldots ip}$ represents the p independent variables for the i-th observation (green space exposure, child's sex, age, weight, height, ethnicity, maternal education), and ε_i denotes the error term for the i-th observation.

eTable 1. Determinants of bone mineral density presented as the difference (95% CI) in m/s

	Simple regression		Multiple regression	
	Difference (95% CI), m/s	Pvalue	Difference (95% CI), m/s	P value
Child				
Sex, girls	7.34 (-17.99 to 32.67)	0.57	2.38 (-27.53 to 32.29)	0.88
Age, +1 y	53.79 (24.63 to 82.95)	<0.001	45.69 (-2.04 to 93.42)	0.06
Weight, +1 kg	4.75 (-0.43 to 9.93)	0.07	-1.64 (-12.01 to 8.74)	0.76
Height, +1 cm	3.01 (0.47 to 5.55)	0.02	-0.01 (-5.58 to 5.55)	1.00
Ethnicity, Non-European	30.70 (-27.64 to 89.03)	0.30	18.24 (-52.93 to 89.41)	0.62
Daily screen time, h/d				
< 1	Reference		Reference	
1-2	12.87 (-17.37 to 43.11)	0.41	15.64 (-16.03 to 47.31)	0.33
> 2	15.99 (-37.48 to 69.46)	0.56	9.20 (-47.48 to 65.88)	0.75
Vitamin supplementation, Yes	-14.45 (-41.14 to 12.24)	0.29	-24.33 (-55.45 to 6.79)	0.13
Daily dairy products consumption, serving/day	5.27 (-8.52 to 19.06)	0.46	4.79 (-9.95 to 19.54)	0.52
Season				
Winter	Reference		Reference	
Spring	-1.44 (-35.35 to 32.47)	0.93	-16.37 (-57.12 to 24.38)	0.43
Summer	-11.76 (-46.69 to 23.18)	0.51	-22.81 (-63.23 to 17.61)	0.27
Autumn	-13.54 (-53.03 to 25.95)	0.50	-1.57 (-49.15 to 46.02)	0.95
Mother				
Education level				
Low	Reference		Reference	
Middle	26.48 (-37.63 to 90.59)	0.42	33.42 (-38.18 to 105.02)	0.36
High	32.45 (-28.25 to 93.15)	0.30	52.70 (-15.47 to 120.87)	0.13
Neighborhood median annual income, +1000 €	-2.13 (-6.38 to 2.12)	0.33	-3.80 (-9.29 to 1.69)	0.18

eTable 2. Association between child's bone mineral density and the percentage of residential surrounding green space within all radii (100-3000 m) for the total population (n=327), girls (n=180) and boys (n=147)

	Total population (n=327)		Girls (n=180)		Boys (n=147)		
	Difference (95% CI), m/s	P value	Difference (95% CI), m/s	P value	Difference (95% CI), m/s	P value	P value for interaction[a]
Total green							
100 m	13.88 (-5.56 to 33.32)	0.16	2.21 (-19.28 to 23.69)	0.84	33.58 (-0.91 to 68.07)	0.06	0.16
300 m	26.23 (8.66 to 43.80)	0.004	14.96 (-3.71 to 33.64)	0.12	44.89 (11.24 to 78.54)	0.009	0.25
500 m	27.38 (9.63 to 45.13)	0.003	20.42 (-0.52 to 41.36)	0.06	38.42 (7.79 to 69.05)	0.01	0.46
1000 m	26.17 (6.40 to 45.94)	0.01	19.55 (-2.67 to 41.77)	0.08	37.65 (2.52 to 72.77)	0.04	0.53
3000 m	25.32 (5.25 to 45.40)	0.01	14.77 (-10.29 to 39.82)	0.25	38.32 (6.15 to 70.48)	0.02	0.25
High green (>3 m)							
100 m	6.59 (-6.85 to 20.02)	0.34	2.33 (-14.98 to 19.65)	0.79	11.75 (-6.38 to 29.88)	0.20	0.41
300 m	18.13 (1.99 to 34.27)	0.03	11.53 (-7.36 to 30.43)	0.23	27.67 (0.4 to 54.95)	0.05	0.41
500 m	25.30 (7.93 to 42.68)	0.004	16.02 (-3.79 to 35.83)	0.11	38.24 (8.53 to 67.96)	0.01	0.33
1000 m	21.18 (1.59 to 40.78)	0.03	16.11 (-6.02 to 38.24)	0.15	33.74 (-2.28 to 69.75)	0.07	0.51
3000 m	18.91 (0.07 to 37.74)	0.05	8.11 (-14.07 to 30.3)	0.47	34.29 (2.19 to 66.39)	0.04	0.20
Low green (≤3 m)							
100 m	6.30 (-11.71 to 24.32)	0.49	-0.61 (-22.08 to 20.85)	0.96	17.35 (-14.26 to 48.95)	0.28	0.31
300 m	10.07 (-5.61 to 25.75)	0.21	6.62 (-12.62 to 25.85)	0.50	13.88 (-12.56 to 40.33)	0.30	0.60
500 m	4.27 (-12.35 to 20.89)	0.61	7.02 (-14.05 to 28.08)	0.51	0.62 (-27.62 to 28.85)	0.97	0.73
1000 m	9.25 (-4.65 to 23.15)	0.19	6.04 (-11.07 to 23.15)	0.49	12.81 (-11.45 to 37.06)	0.30	0.60
3000 m	19.16 (-0.29 to 38.61)	0.05	16.21 (-7.69 to 40.12)	0.18	22.71 (-9.18 to 54.6)	0.16	0.73

Estimates are presented as the difference (95% CI) in bone mineral density (m/s) for an interquartile range (IQR) increment in total green space (sum of high and low green), high green (> 3 m) and low green (≤ 3 m) within a 100-3000 m radius for the total population (n= 327), girls (n= 180) and boys (n= 147). The main model was adjusted for the child's sex, ethnicity, age, weight, and height at follow-up and by maternal education. [a]Represents the overall p-value for the interaction green space x child's sex.

eTable 3. Association between the risk of low mineral density and percentage of residential surrounding green space within all radii (100-3000 m) for the total population (n=327), girls (n=180), and boys (n=147)
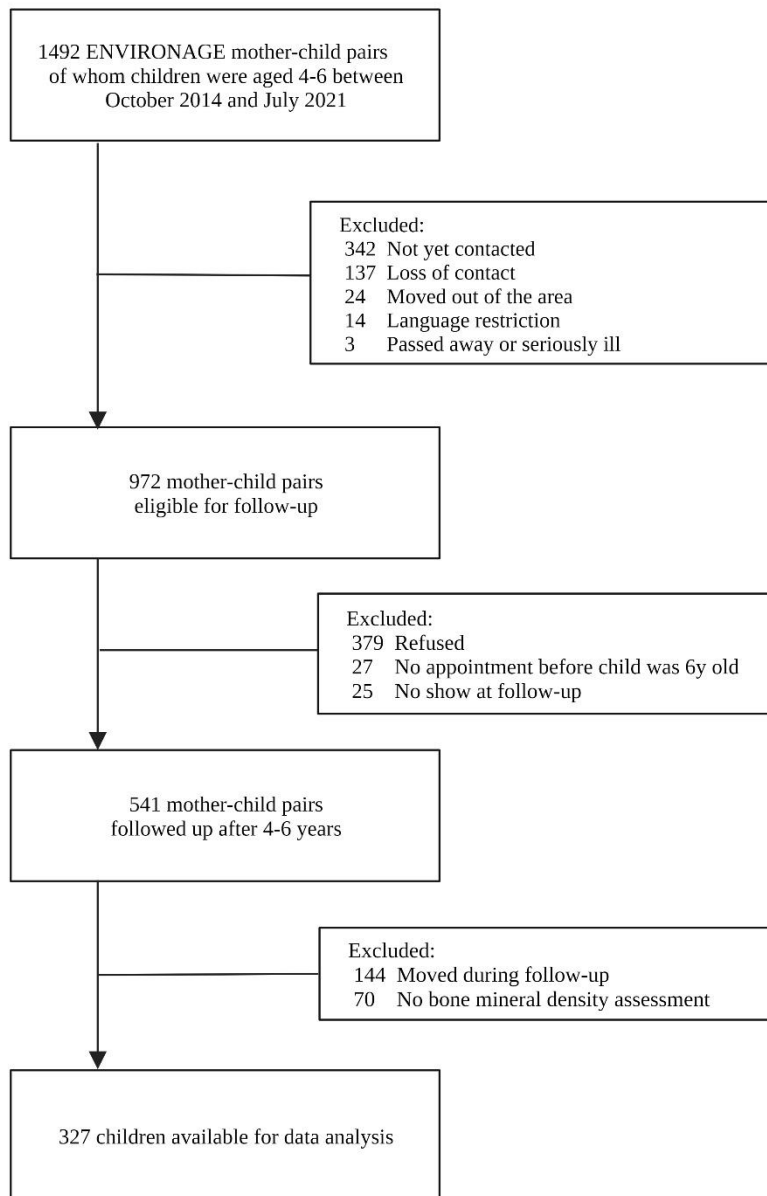
	Total population (n=327)		Girls (n=180)		Boys (n=147)		
	OR (95% CI), m/s	P value	OR (95% CI), m/s	pPvalue	OR (95% CI), m/s	Pvalue	P value for interaction[a]
Total green							
100 m	0.58 (0.32 to 1.03)	0.07	0.92 (0.40 to 2.06)	0.85	0.34 (0.13 to 0.8)	0.02	0.14
300 m	0.46 (0.26 to 0.79)	0.006	0.51 (0.25 to 1.00)	0.06	0.37 (0.13 to 0.9)	0.04	0.83
500 m	0.44 (0.25 to 0.76)	0.004	0.38 (0.17 to 0.81)	0.01	0.48 (0.20 to 1.07)	0.08	0.62
1000 m	0.33 (0.17 to 0.61)	<0.001	0.29 (0.11 to 0.64)	0.004	0.36 (0.14 to 0.88)	0.03	0.63
3000 m	0.39 (0.21 to 0.70)	0.002	0.36 (0.15 to 0.83)	0.02	0.41 (0.17 to 0.90)	0.03	0.94
High green (>3 m)							
100 m	0.79 (0.49 to 1.18)	0.28	0.85 (0.41 to 1.53)	0.61	0.67 (0.32 to 1.15)	0.21	0.46
300 m	0.57 (0.30 to 0.97)	0.06	0.52 (0.20 to 1.08)	0.12	0.57 (0.21 to 1.25)	0.21	0.84
500 m	0.45 (0.22 to 0.83)	0.02	0.35 (0.12 to 0.82)	0.03	0.55 (0.20 to 1.28)	0.20	0.44
1000 m	0.39 (0.18 to 0.75)	0.008	0.27 (0.09 to 0.68)	0.01	0.5 (0.17 to 1.27)	0.17	0.39
3000 m	0.46 (0.25 to 0.82)	0.01	0.41 (0.17 to 0.90)	0.03	0.49 (0.20 to 1.12)	0.10	0.83
Low green (≤3 m)							
100 m	0.76 (0.44 to 1.28)	0.30	1.17 (0.53 to 2.63)	0.70	0.47 (0.20 to 1.03)	0.07	0.14
300 m	0.71 (0.44 to 1.13)	0.15	0.82 (0.42 to 1.63)	0.57	0.6 (0.29 to 1.17)	0.15	0.54
500 m	0.76 (0.46 to 1.24)	0.27	0.8 (0.37 to 1.70)	0.56	0.67 (0.32 to 1.36)	0.28	0.76
1000 m	0.58 (0.37 to 0.90)	0.02	0.68 (0.34 to 1.26)	0.24	0.44 (0.21 to 0.85)	0.02	0.37
3000 m	0.48 (0.26 to 0.87)	0.02	0.57 (0.23 to 1.30)	0.19	0.37 (0.15 to 0.86)	0.03	0.36

Estimates are presented as the odds ratio (OR) (95% CI) of low bone mineral density for an interquartile range (IQR) increment in total green space (sum of high and low green) within a 100-3000 m radius for the total population (n= 327), girls (n= 180) and boys (n= 147). The model was adjusted for the child's sex, ethnicity, age, weight, and height at follow-up and by maternal education (n= 327).
[a]Represents the overall p-value for the interaction green space x child's sex.

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┌─────────────────────────────────────┐
│  1492 ENVIRONAGE mother-child pairs  │
│  of whom children were aged 4-6 between │
│      October 2014 and July 2021      │
└─────────────────────────────────────┘
              │
              │        ┌──────────────────────────────────────────┐
              │        │ Excluded:                                │
              │        │   342  Not yet contacted                 │
              ├────────│   137  Loss of contact                   │
              │        │    24  Moved out of the area             │
              │        │    14  Language restriction              │
              │        │     3  Passed away or seriously ill       │
              │        └──────────────────────────────────────────┘
              ▼
┌─────────────────────────────────────┐
│       972 mother-child pairs         │
│        eligible for follow-up        │
└─────────────────────────────────────┘
              │
              │        ┌──────────────────────────────────────────────────┐
              │        │ Excluded:                                        │
              ├────────│   379  Refused                                   │
              │        │    27  No appointment before child was 6y old    │
              │        │    25  No show at follow-up                      │
              │        └──────────────────────────────────────────────────┘
              ▼
┌─────────────────────────────────────┐
│       541 mother-child pairs         │
│      followed up after 4-6 years     │
└─────────────────────────────────────┘
              │
              │        ┌──────────────────────────────────────────┐
              │        │ Excluded:                                │
              ├────────│   144  Moved during follow-up            │
              │        │    70  No bone mineral density assessment │
              │        └──────────────────────────────────────────┘
              ▼
┌─────────────────────────────────────┐
│   327 children available for data    │
│              analysis                │
└─────────────────────────────────────┘
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eFigure 1. Flowchart describing the included ENVIRONAGE participants

Pearson Correlation

Total green

	100 m	300 m	500 m	1000 m	3000 m
100 m	1				
300 m	0.69	1			
500 m	0.58	0.94	1		
1000 m	0.48	0.8	0.9	1	
3000 m	0.42	0.68	0.77	0.9	1

High green (>3 m)

	100 m	300 m	500 m	1000 m	3000 m
100 m	1				
300 m	0.75	1			
500 m	0.64	0.93	1		
1000 m	0.51	0.74	0.87	1	
3000 m	0.38	0.58	0.68	0.85	1

Low green (≤3 m)

	100 m	300 m	500 m	1000 m	3000 m
100 m	1				
300 m	0.62	1			
500 m	0.48	0.89	1		
1000 m	0.36	0.7	0.85	1	
3000 m	0.21	0.48	0.56	0.72	1
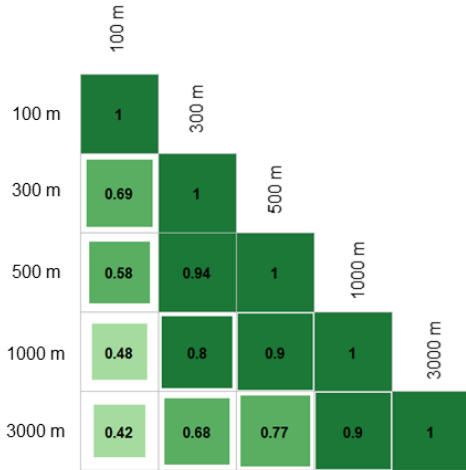
Spearman Correlation

Total green

	100 m	300 m	500 m	1000 m	3000 m
100 m	1				
300 m	0.68	1			
500 m	0.57	0.93	1		
1000 m	0.47	0.8	0.9	1	
3000 m	0.41	0.69	0.76	0.88	1

High green (>3 m)

	100 m	300 m	500 m	1000 m	3000 m
100 m	1				
300 m	0.71	1			
500 m	0.57	0.9	1		
1000 m	0.45	0.72	0.88	1	
3000 m	0.37	0.6	0.71	0.86	1

Low green (<3 m)

	100 m	300 m	500 m	1000 m	3000 m
100 m	1				
300 m	0.6	1			
500 m	0.47	0.89	1		
1000 m	0.33	0.68	0.83	1	
3000 m	0.2	0.44	0.52	0.69	1
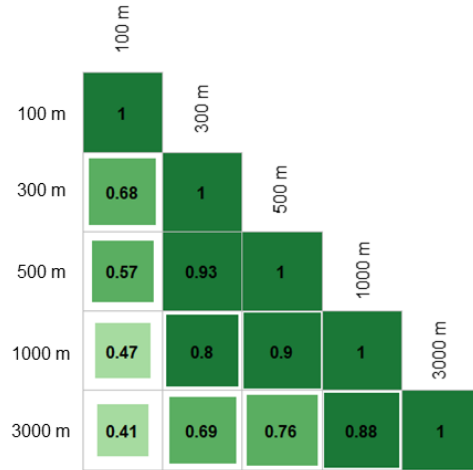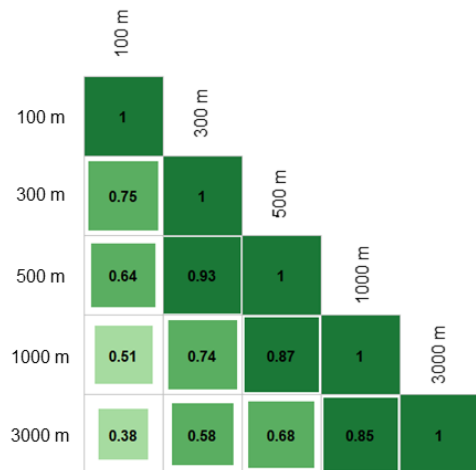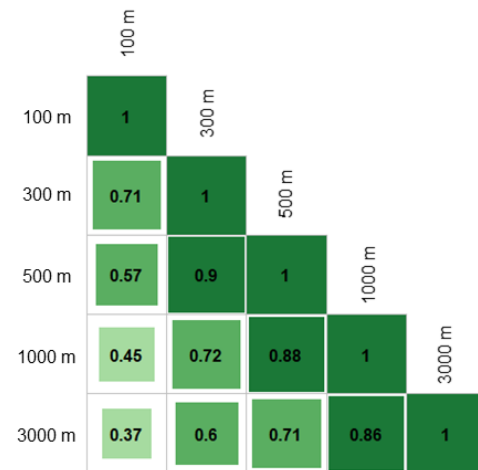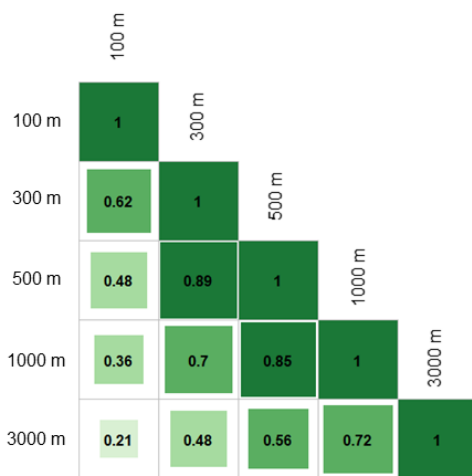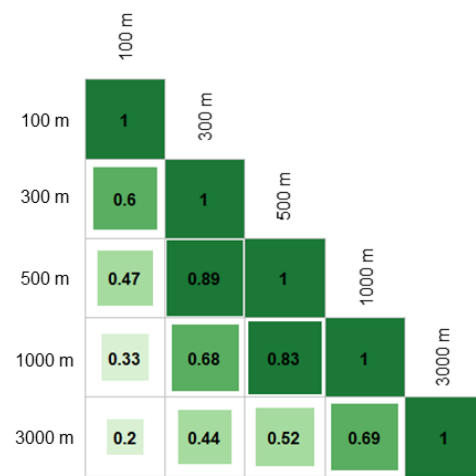
eFigure 2. Pearson (left) and Spearman (right) correlation matrix between residential green space radius (100-3000 m) for total green (sum of high and low green), high green (>3 m), and low green (≤3 m)