**Supplemental Materials**

**Community greenness, blood pressure, and hypertension in urban dwellers: the 33 Communities Chinese Health Study**

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**Fig. S1**. Directed acyclic graph for the association between greenness and blood pressure, showing all potential confounders and mediators. Pink lines indicate potential confounders and green lines indicate potential mediators.

**Fig. S2**. Directed acyclic graph for the association between greenness and blood pressure, showing only confounders and mediators retained in the final models. Pink lines indicate potential confounders and green lines indicate potential mediators.

**Table S1** Summary of prior studies of green space and blood pressure and hypertension

|  |  |  |  |  |
| --- | --- | --- | --- | --- |
| Authors, publication year [reference] | Study design | Country | Population | Main findings |
| Dzhambov et al. 2018 [1] | Cross-sectional study | Austria | 555 adults with a mean age of 46.59 years | Higher overall greenness was associated with lower odds of hyper/hypotension and lower SBP levels. |
| Groenewegen et al. 2018 [2] | Cross-sectional study | Netherlands | 1,159,529 people of all ages | Higher percentage of green space was associated with lower risk of hypertension. |
| Jia et al. 2018 [3] | Cross-sectional study | China | 1944 residents (40 years or older | Compared to the group with low NDVI levels, people living in moderate-to-high NDVI exposures had a significant reduction in risk of hypertension (55-84% reduction). |
| Jendrossek et al. 2017 [4] | Cross-sectional study | Germany | Women (47.6 years on average in Munich and 45.7 years in Wesel) (n = 3063) | No significant association was observed between NDVI500m and hypertension prevalence. |
| Vienneau et al. 2017 [5] | Cohort study | Switzerland | 4.2 million adults (≥30 years) | Higher greenspace exposure was associated with lower hypertension related deaths. |
| Bijnens et al. 2017 [6] | Cross-sectional study | Belgium | 278 twins with a mean age of 20.9 years | Higher greenness in the early-life environment was independently associated with both SBP and DBP levels. |
| Lane et al. 2017 [7] | Cross-sectional study | India | 3150 adults >20 years | A 0.17-unit decrease in NDVI was associated with 4.3mmHg, 1.2 mmHg, and 3.1mmHg increase in SBP, DBP, and cPP, respectively. |
| Brown et al. 2016 [8] | Cross-sectional study | United States | 249,405 medicare beneficiaries (≥65 years) | Each 0.1-unit increase in NDVI was associated with a significant 7% decrease of hypertension. |
| Markevych et al. 2014 [9] | Cross-sectional study | Germany | Children (10 years on average) (n = 2078) | Children living in low and moderate greenness (NDVI500m) areas had significantly higher SBP and DBP levels than those living in high greenness areas. |
| Grazuleviciene et al. 2014 [10] | Cross-sectional study | Lithuania | 3416 female residents (20-45 years) | Higher distance to city parks was associated with higher odds ratios for high-normal blood pressure and normal blood pressure categories. |
| Tamosiunas et al. 2014 [11] | Cohort study | Lithuania | 5112 men and women with a mean age of 60.4 years | Park use was not significantly associated with arterial hypertension. |
| Morita et al. 2011 [12] | Cross-sectional study | Japan | 5040 individuals aged 35-69 years | No association between either blood pressure levels and hypertension prevalence and the frequency of forest walking was observed. |
| Grazuleviciene et al. 2015 [13] | RCT | Lithuania | 20 stable CAD patients randomly allocated to 7 days controlled walking in a city part or street. | Decreases in SBP and DBP were observed for those walking in green environments. |
| Ochiai et al. 2015 [14] | Pre-post study | Japan | 9 Japanese males with high-normal blood pressure (aged 40-72 years) | Both SBP and DBP were significantly lower than baseline following forest therapy. |
| Calogiuri et al. 2015 [15] | RCT | Norway | 14 municipality employee (mean age: 49 years) | Compared people doing exercising indoor, those who exercising in the green spaces had statistically significant reduced DBP, but not SBP. |
| Lee et al. 2014a [16] | RCT | Japan | 48 young Japanese adult males (mean age: 21.2 years) | No significant change in SBP and DBP was observed between forest walking group and urban walking group. |
| Lee et al. 2014b [17] | RCT | Korean | 62 Korean women aged >60 years | Walking in the forest significantly decreased SBP and DBP. In the city-walking group, no significant changes in blood pressure was observed. |
| Toda et al. 2013 [18] | Pre-post study | Japan | 20 healthy males with a mean age of 67.6 years | Immediately and at 30 min after the walk, SBP was significantly lower in the walking (forest) protocol than in the control (office) protocol. |
| Tsunetsugu et al. 2013 [19] | Controlled trial | Japan | 12 university students with a mean age of 21.1 years | Compared with viewing urban area group, viewing forest group has significantly lower DBP but not SBP. |
| Sung et al. 2012 [20] | Controlled trial | Japan | 56 adults (mean age in control and forest group was 63 and 66, respectively) | The BP change at week 1 and week 8 did not differ between the control and forest group. Significant change was only observed at 3 days for SBP. |
| Li et al. 2011 [21] | Panel study | Japan | 16 healthy male subjects (aged 57.4 ± 11.6 years)  | Habitual walking in forest environments may lower both SBP and DBP by reducing sympathetic nerve activity. |
| Hartig et al. 2011 [22] | Field experiment | United States | 112 students of the university of California | After conducting tasks, sitting in a room with views of trees induced significant reduction in DBP (but not SBP) than sitting in a room with no view. |
| Park et al. 2010 [23] | Review and randomized crossover study | Japan | 280 male adult Japanese (aged 21.7 ± 1.5 years) | Forest environments promote lower concentrations of cortisol, lower pulse rate, lower blood pressure (both SBP and DBP), greater parasympathetic nerve activity, and lower sympathetic nerve activity than do city environments. |
| Tsunetsugu et al. 2007 [24] | RCT | Japan | 12 male university students aged 21-23 years | Both SBP and DBP were significantly lower in the forest walking group than in the city area walking group. |
| Parsons et al. 1998 [25] | Field experiment | United States | 160 college-age participants (mean age: 20.2 years) | The SBP of participants who watched a videotape of natural environments after being exposed to a stressor decreased faster than those of participants watched a videotape of urban environments. |

Abbreviations: DBP, diastolic blood pressure; NDVI, normalized difference vegetation index; PP, pulse pressure; RCT, randomized control trial; SBP, systolic blood pressure.

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**Table S2** Maincharacteristics of study participants

|  |  |  |
| --- | --- | --- |
|  | Hypertension  | Non-hypertension  |
| Characteristics | (n = 8657) | (n =16,188) |
| Age (n, %)a |  |  |
|  <65 years | 7315 (84.5) | 15,296 (94.5) |
|  ≥65 years | 1342 (15.5) | 892 (5.5) |
| Sex (n, %)a |  |  |
| Men | 5144 (59.4) | 7517 (46.4) |
| Women | 3513 (40.6) | 8671 (53.6) |
| Nationality (n, %)a |  |  |
| Han | 8291 (95.8) | 15,179 (93.8) |
| Others | 366 (4.2) | 1009 (6.2) |
| Education level (n, %)a |  |  |
|  Low (<9 years) | 1941 (22.4) | 2496 (15.4) |
|  High (≥9 years) | 6716 (77.6) | 13,692 (84.6) |
| Household income levels per year (n, %)a |  |  |
|  <10,000 Yuan | 2156 (24.9) | 3605 (22.3) |
|  ≥10,000 Yuan | 6501 (75.1) | 12,583 (77.7) |
| Regular exercise (n, %)a |  |  |
|  No | 5486 (63.4) | 11,712 (72.3) |
|  Yes | 3171 (36.6) | 4476 (27.7) |
| BMI, kg/m2 (mean ± SD)a | 26.07 ± 3.69 | 23.51 ± 3.39 |
| SBP, mmHg (mean ± SD)a | 148.24 ± 18.01 | 116.05 ± 11.39 |
| DBP, mmHg (mean ± SD)a | 92.62 ± 10.70 | 75.41 ± 7.48 |

Abbreviations: BMI, body mass index; DBP, diastolic blood pressure; SBP, systolic blood pressure; SD, standard deviation.

aDifferencewas significant between hypertension and non-hypertension groups (*P* < 0.05).

**Table S3** Distribution for NDVI and SAVI in 33 communities

|  |  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- | --- |
| **Exposures** | **Mean** ± SD |  | **Median**  | **25th percentile** | **75th percentile** | **IQR** | **Min** | **Max** |
| NDVI500-m | 0.33 ± 0.13 |  | 0.29  | 0.23 | 0.40 | 0.17 | 0.18 | 0.80 |
| NDVI1000-m | 0.34 ± 0.12 |  | 0.31  | 0.25 | 0.40 | 0.15 | 0.20 | 0.75 |
| SAVI500-m | 0.19 ± 0.08 |  | 0.16 | 0.13 | 0.24 | 0.11 | 0.10 | 0.48 |
| SAVI1000-m | 0.19 ± 0.08 |  | 0.17 | 0.14 | 0.24 | 0.10 | 0.11 | 0.45 |

Abbreviations: IQR, interquartile range (computed by subtracting the 1st quartile from the 3rd quartile); Max, maximum; Min, minimum; NDVI, normalized difference vegetation index; SAVI, soil adjusted vegetation index; SD, standard deviation

**Table S4** Correlations between NDVI, SAVI, and air pollutants in 33 communities

|  |  |
| --- | --- |
|  | **Correlation coefficient** |
|  | **NDVI500-m** | **NDVI1000-m** | **SAVI500-m** | **SAVI1000 -m** | **PM2.5** | **NO2** |
| NDVI500-m | 1 | 0.90a | 0.98a | 0.89a | -0.32 | -0.05 |
| NDVI1000-m |  | 1 | 0.89a | 0.97a | -0.39a | -0.08 |
| SAVI500-m |  |  | 1 | 0.90a | -0.32 | -0.06 |
| SAVI1000-m |  |  |  | 1 | -0.43a | -0.07 |
| PM2.5, μg/m3 |  |  |  |  | 1 | 0.61a |
| NO2, μg/m3 |  |  |  |  |  | 1 |

Abbreviations: NO2, nitrogen dioxide; NDVI, normalized difference vegetation index; PM2.5, particle with aerodynamic diameter ≤2.5 µm; SAVI, soil adjusted vegetation index.

aStatistically significant correlation (p<0.05).

**Table S5** Associations between per IQR increase in SAVIaand blood pressure metrics (n = 24,845)

|  |  |  |  |
| --- | --- | --- | --- |
|  | **β (95% CI)b** |  | **OR (95% CI)b** |
| **Model** | **SBP** | **DBP** |  | **Hypertension** |
| SAVI500-m | -0.89 (-1.21, -0.57) | -0.14 (-0.33, 0.06) |  | 0.95 (0.91, 0.99) |
| SAVI1000-m | -0.85 (-1.17, -0.54) | -0.21 (-0.40, -0.02) |  | 0.94 (0.90, 0.98) |

Abbreviations: β, unstandardized regression coefficient; CI, confidence interval; DBP, diastolic blood pressure; IQR, interquartile range; OR, odds ratio; SAVI, soil adjusted vegetation index; SBP, systolic blood pressure.

aIQR was 0.11 for SAVI500-m and 0.10 for SAVI1000-m

bAdjusted for age, sex, ethnicity, household income level, and district GDP level.

**Table S6** Associations between NDVI500-m and blood pressures in sensitivity analyses

|  |  |
| --- | --- |
|  | β **(95% CI)a** |
|  | **SBP** | **DBP** |
| Excluding participants taking anti-hypertensive medicines (n =22,201 ) | -0.76 (-1.05, -0.46) | -0.13 (-0.31, 0.05) |
| Excluding participants with cardiovascular diseases (n = 23,839 ) | -0.78 (-1.09, -0.47) | -0.11 (-0.30, 0.07) |
| Excluding participants with hypotension(n = 24,568) | -0.86 (-1.16, -0.55) | -0.14 (-0.33, 0.05) |

Abbreviations: CI, confidence interval; DBP, diastolic blood pressure; NDVI, normalized difference vegetation index; SBP, systolic blood pressure.

aAdjusted for age, sex, ethnicity, household income level, and district GDP level.

**Table S7** Associations between per IQRa increase in NDVI and blood pressure metrics before and after additional adjustment for physical activity (n = 24,845)

|  |  |  |  |
| --- | --- | --- | --- |
|  | β **(95% CI)** |  | **OR (95% CI)** |
| **Model** | **SBP** | **DBP** |  | **Hypertension** |
| NDVI500-m |  |  |  |  |
| Adjusted modelb | -0.82 (-1.13, -0.51) | -0.12 (-0.31, 0.07) |  | 0.95 (0.92, 0.99) |
| Additionally adjusted modelc | -0.83 (-1.14, -0.52) | -0.12 (-0.31, 0.06) |  | 0.95 (0.92, 0.99) |
| NDVI1000-m |  |  |  |  |
| Adjusted modelb | -0.78 (-1.08, -0.48) | -0.20 (-0.38, -0.02) |  | 0.94 (0.91, 0.98) |
| Additionally adjusted modelc | -0.79 (-1.09, -0.50) | -0.20 (-0.38, -0.02) |  | 0.94 (0.91, 0.98) |

Abbreviations: β, unstandardized regression coefficient; CI, confidence interval; DBP, diastolic blood pressure; IQR, interquartile range; NDVI, normalized difference vegetation index; OR, odds ratio; SAVI, soil adjusted vegetation index; SBP, systolic blood pressure.

aIQR 0.17-unit for NDVI500-m and 0.15-unit for NDVI1000-m.

bAdjusted for age, sex, ethnicity, household income level , and district GDP level.

cAdjusted for age, sex, ethnicity, household income level, district GDP level, and physical activity.



**Fig. S1**. Directed acyclic graph for the association between greenness and blood pressure, showing all potential confounders and mediators. Pink lines indicate potential confounders and green lines indicate potential mediators.



**Fig. S2**. Directed acyclic graph for the association between greenness and blood pressure, showing only confounders and mediators retained in the final models. Pink lines indicate potential confounders and green lines indicate potential mediators.