Supplemental material

Natural outdoor environments and mental health: stress as a possible mechanism

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Table S1 – Participants sampling strategy

	Invited n	Willing to participate n (% from the invited ones)	Participated n	Finally included in the analyses
Barcelona	1044	379 (37%)	109	107
Stoke-on-Trent				
From the original sample	1044	164 (17%)	49	45
Further approaches	4814	107 (2.22%)	50	45
Doetinchem	861	224 (26%)	111	105
Kaunas	997	280 (28%)	112	104

CalFit data treatment

We downloaded CalFit data, including both accelerometer and location data from the smartphones and processed data in three steps.

1) Location data (including GPS and, when GPS data were not available, wireless network triangulation data) were converted into a Geographic Information Systems (GIS) data layer. We then attached the street network maps, and participant geocoded home and work addresses to the location data layer. After this, we resampled to 10 seconds to reduce the measurement error in the geolocation. We searched for any spatio-temporal clusters (i.e. points under the space and time threshold of 150m and 30 minutes) in our data and from these: (i) all the location points of each cluster identified as home or work were given the home or work value; (ii) each of the location points of each short-time cluster (i.e. points over the space and time threshold of 150m and 30 minutes) were considered part of a trip and kept as individual points; (iii) all the location points from the other clusters were considered places other than home or work, so we calculated the cluster centroid and assigned the value of the centroid to all the points of that cluster. We then added information from Urban Atlas 2006, Top10NL and Landsat 8 to develop exposure indicators for each location point. Finally, we resampled to one-minute assigning the mode of all the calculated indicators. This resampling was done because one-minute was the minimum meaningful physical activity information that our measurement instruments could provide.

2) We used the three accelerometer axis to get two g-forces (vertical and horizontal). After this, we converted the vertical force recorded in g-force into counts using a linear regression, and these counts into METs using the equation of Freedson et al (Freedson et al., 1998), as described previously (Donaire-Gonzalez et al., 2013). We then defined time not wearing the smartphone as those periods of time of at least 40 consecutive minutes below 0.34 g in the vertical axis. These periods of time were excluded from analyses.

3) We excluded those days that were non-study days (e.g. delivery and collection days). We then applied the criterion of at least 10 hours wearing the smartphone as days with enough information to validly explore the associations of our interest. Those days not fulfilling the criterion were excluded from the analyses

PHENOTYPE guidelines for NDVI

Water bodies (major blue spaces such as coastal water and large inland lakes) were identified using a standardized European layer (CORINE Land Cover 2006, CLC2006) and a local layer to represent the outside area of the coastline. We extracted these identified water cells from the NDVI surface after atmospherical corrections and created a new layer that was used to perform analyses with NDVI.

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Average week psychological wellbeing morning index

In the morning participants were asked: right now, do you feel: (i) so down in the dumps nothing could cheer you up?, (ii) downhearted and blue?, (iii) a happy person?, (iv) a very nervous person?, (v) calm and peaceful?. Each item had five possible responses: very much/a lot, moderately, somewhat, slightly, not at all. For three items (i, ii and iv) the answers were scored as very much/a lot with a 1, moderately with a 2.5, somewhat with a 4, slightly with a 5, and not at all with a 6. For two items (iii and v) the answers were inversely scored as not at all with a 1, slightly with a 2.5, somewhat with a 4, moderately with a 5, not at all with a 6. The final index was a composite measure based on the sum of scored responses to the items. For the participants that answered only three or four of the five items, the missing items were represented by the average score of the answered items to calculate the final index. For participants answering only two, one or zero items, a final index was not calculated. The final index was transformed to a 0-100 scale according to the guidelines (Ware et al. 1993):

$$\text{Transformed final index} = \frac{\text{Final items sum score} - 5}{25} * 100$$

Low scores of the transformed index indicated feelings of nervousness and depression, and higher scores indicated feeling peaceful, happy and calm. An average of all the morning transformed final indices was calculated for each participant, where higher scores reflect greater psychological wellbeing (i.e. better mental health).

Average week no somatisation morning index

In the morning participants were asked: Right now, do you suffer from: (i) dizziness/light-headed, (ii) painful muscles, (iii) back and/or shoulder pain, (iv) headache, (v) nausea, (vi) pain in the abdomen or stomach area, (vii) pain in the chest, (viii) ache in the back of the head, (ix) fatigue. The 4DSQ items were (i) to (vii). Each item had five possible responses scored as: no with a 5, a little with a 4, mild with a 3, moderate with a 2, severe with a 1. We constructed a sum score of all the items ranging between 9 and 45, with high scores indicating no perceived somatisation symptoms An average was calculated from all the morning scores of each participant. Higher scores of no somatisation indicated. better mental health.

Average week vitality morning index

In the morning participants were asked: right now, do you feel: (i) full of pep, (ii) you had a lot of energy, (iii) worn out, (iv) tired. Each item had five possible answers: very much/a lot, moderately, somewhat, slightly, not at all.

For two items (i and ii) the answers were scored as not at all with a 1, slightly with a 2.5, somewhat with a 4, moderately with a 5, not at all with a 6. For two items (iii and iv) the answers were scored inversely as very much/a lot with a 1, moderately with a 2.5, somewhat with a 3, slightly with a 5, not at all with a 6. For the participants that answered only three of the four items, the missing items were represented by the average score of the answered items to calculate the final index. For participants answering only two, one or zero items, final index was not calculated. The final index was transformed to a 0-100 scale according to the guidelines (Ware et al. 1993) as:

$$Transformed\ final\ index = \frac{Final\ items\ sum\ score - 4}{20} * 100$$

Low scores of the transformed index indicated feeling tired and worn out, and higher scores indicating feeling full of energy. An average of all the morning transformed final indices was calculated for each participant. Higher scores of average week vitality reflect higher vitality (i.e. better mental health).

Perceived stress question

Please, indicate how stressed have you felt during your day on this scale regarding:

Overall (in general terms)

none usual stress level as bad as it could be

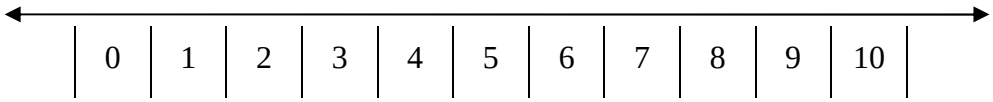

Table S2 – Intercities comparisons. Detailed chi2 values and p-values associated to chi2, kruskal-wallis, and posthoc tests.

	Overall		Barcelona vs. Stoke-on-Trent	Barcelona vs. Doetinchem	Barcelona vs. Kaunas	Stoke-on-Trent vs. Doetinchem	Stoke-on-Trent vs. Kaunas	Doetinchem vs. Kaunas
	Chi2	p-value	p-value	p-value	p-value	p-value	p-value	p-value
Sociodemographic characteristics								
Age	97.68	<0.01	0.07	<0.01	<0.01	<0.01	0.24	0.03
Education	19.59	<0.01	1.00	1.00	0.01	1.00	<0.01	<0.01
Exposure								
Presence of green and/or blue spaces	24.10	<0.01	<0.01	<0.01	0.01	0.12	0.50	<0.01
Contact with green and/or blue spaces	61.60	<0.01	0.04	<0.01	0.01	<0.01	1.00	<0.01
Mediators								
Perceived stress	109.46	0.02	<0.01	<0.01	0.94	0.99	0.01	<0.01
Social contacts indicators								
Neighbourhood attachment	49.85	<0.01	0.98	0.97	<0.01	1.00	<0.01	<0.01
Frequency of contacts with neighbours	10.57	0.01	0.91	0.12	1.00	1.00	0.43	0.03

Note: Grey cells indicate those tests that indicate differences between the cities (p-value ≤ 0.05).

Table S3 – P-values of ANOVA comparison test between model including interaction and not including it.

		Psychological wellbeing	No somatisation	Vitality	Sleep quality
gender	Contact with green and/or blue spaces	0.79	0.94	0.73	0.17
	Contact with surrounding greenness	0.03	0.30	0.21	0.20
age	Contact with green and/or blue spaces	0.58	0.60	0.62	0.04
	Contact with surrounding greenness	0.50	0.75	0.56	<0.01
education	Contact with green and/or blue spaces	0.4	0.35	0.88	0.17
	Contact with surrounding greenness	0.67	0.33	0.31	0.24
city	Contact with green and/or blue spaces	0.54	0.10	0.74	0.93
	Contact with surrounding greenness	0.47	<0.01	0.17	0.52

Note: Grey cells indicate those models where including the interaction with contact with NOE is statistically significantly improving the model (p-value ≤ 0.05).

Table S4 – Adjusted models for contact with NOE and average week morning values of mental health.

	Contact with green and/or blue spaces			Contact with surrounding greenness
	High	Medium	Low	
		coef/OR	coef/OR	coef/IRR
Psychological wellbeing (morning)	ref	-2.91 (-5.79, -0.04) *	-5.93 (-9.07, -2.78) *	3.52 (1.40, 5.64) *
No somatisation (morning)	ref	0.01 (-0.75, 0.75)	-0.92 (-1.74, -0.10) *	0.86 (0.31, 1.41) *
Vitality (morning)	ref	-3.59 (-7.78, 0.61)	-8.29 (-12.88, -3.70) *	6.35 (3.28, 9.42) *

Note: Linear regression models for all the outcomes. Models include city, neighbourhood socioeconomic status, gender, age, and education level as covariates. Grey cells indicate those models where contact with NOE is statistically significantly associated to the outcome in the expected direction.

* Statistically significant associations (p-value≤ 0.05).

NOE for Natural Outdoor Environments

Table S5 – Adjusted models for contact with NOE and week changes of mental health.

	Contact with green and/or blue spaces			Contact with surrounding greenness
	High	Medium	Low	
		Coef. (95%CI)	Coef. (95%CI)	Coef. (95%CI)
Psychological wellbeing week change	ref	0.59 (-2.28, 3.45)	-2.67 (-5.82, 0.49)	-0.28 (-2.41, 1.85)
No somatisation week change	ref	0.10 (-0.52, 0.71)	-0.02 (-0.69, 0.66)	-0.11 (-0.56, 0.35)
Vitality week change	ref	0.75 (-3.68, 5.19)	0.27 (-4.62, 5.16)	-2.61 (-5.87, 0.64)
Week sleeping quality§	ref	1.01 (0.87, 1.17)	0.87 (0.74, 1.03)	1.92 (1.72, 2.15) *

Note: Linear regression models (coefficient and 95% CI reported) for all the outcomes with the exception of week sleeping quality (§) that was modelled as a Poisson model (IRR and 95% CI reported). Linear regression models include city, neighbourhood socioeconomic status, gender, age, and education level as covariates. Poisson models include city and neighbourhood socioeconomic status as covariates. Grey cells indicate those models where contact with NOE is statistically significantly associated to the outcome in the expected direction.

* Statistically significant associations (p-value≤ 0.05).

NOE for Natural Outdoor Environments

Table S6- Adjusted models for contact with NOE and daily changes of mental health.

	Contact with main NOE			Contact with surrounding greenness
	Low	Medium	High	
		Coef. (95% CI)	Coef. (95% CI)	Coef. (95% CI)
Psychological wellbeing daily change	ref	0.07 (-0.93, 1.08)	0.25 (-0.99, 1.48)	0.05 (-0.90, 1.01)
No somatisation daily change	ref	-0.04 (-0.25, 0.17)	0.13 (-0.13, 0.40)	0.15 (-0.05, 0.36)
Vitality daily change	ref	-1.40 (-2.88, 0.08)	-2.50 (-4.42, -0.58) *	-1.07 (-2.58, 0.44)
Daily sleeping quality§	ref	1.17 (0.83, 1.66) a	0.88 (0.57, 1.35) b	1.05 (0.80, 1.39) a

Note: Linear regression models (coefficient and 95% CI reported) for all the outcomes with the exception of day sleeping quality (§) that was modelled as a binomial mixed effect model (OR and 95% CI reported). Models include subject as a random effect, and city, neighbourhood socioeconomic status, gender, age, and education level as fixed effects. Grey cells indicate those models where contact with NOE is statistically significantly associated to the outcome in the expected direction.

a indicates model adjusted for all the previously indicated variables except city.

b indicates models that include subject as a random effect and only gender as a fixed effect.

* Statistically significant associations (p-value≤ 0.05).

NOE for Natural Outdoor Environments