Transitions in frailty status in older adults: Associations with neighbourhood parks over the lifecourse

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Summary

Parks provide opportunities for physical activity, stress reduction and social interaction and have been shown, in cross-sectional studies, to reduce the likelihood of transition to frailty in older age. We employed a longitudinal design to examine what pattern of residential-based park availability throughout life was associated with frailty transition in later life. Greater childhood distance to neighbourhood parks had consistent associations with declining frailty status in later life (odd ratio per 100 m increase: 1.18, 1.03-1.36). We found that these associations were moderated by socioeconomic factors and the size of the park. Increasing the number and size of child-friendly parks in cities could be an appropriate approach to reduce the burden of frailty in older age.

KEYWORDS: Longitudinal, life course, frailty, ageing, green space

1. Background

Frailty is a state of heightened vulnerability to stressors which causes a reduction in mobility and inability to perform everyday tasks (Clegg, Young et al. 2013). Parks provide opportunities for physical activity, stress reduction and social interaction (Hartig, Mitchell et al. 2014). A previous study found that green space availability (600 m buffer around residence) was associated with frailty transition (Wang, Lau et al. 2017). Our objectives are to: (i) determine the most appropriate metric of parks for the mechanism of physical activity; (ii) determine what pattern of park exposure throughout life is associated with frailty transition in later life.

2. Methods

2.1. Study setting and population

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The Lothian Birth Cohort 1936 (LBC 1936) is a cohort based in and around Edinburgh, UK. A full cohort profile is available (Deary, Gow et al. 2012). Briefly, children who had taken the Scottish Mental Health Survey in 1947, were re-contacted and recruited to the LBC 1936 at mean age 70 (N = 1,091). Examinations have occurred every three years at mean ages: 70 (wave 1: 2006), 73 (wave2: 2009) and 76 (wave 3: 2012). In 2016, the participants were asked to fill out a life-grid questionnaire, which was designed to collect information on their residence for each decade of life (n=592). Participants were eligible for the Edinburgh life course analysis if they had at least one Edinburgh-based (1961 city boundary) address during childhood (1936-1958), adulthood (1959-1978) and later adulthood (1979-2015), and complete information on frailty transition status (n=253). Lifecourse periods were centered by the year that public parks information was collected.

2.2. Predictor Variable – Historical Parks

Historical information on public parks was collected for 1949, 1969 and 2009 from open space surveys. Further information on the process of building this longitudinal dataset for Edinburgh is presented elsewhere (Pearce, Shortt et al. 2016).

2.3. Outcome variable – Frailty transition status

Frailty status was determined at wave 1 and wave 3 using Fried's phenotype (Fried, Tangen et al. 2001), which is composed of five components: weakness, self-reported exhaustion, slow walking speed, low physical activity and unintentional weight loss. Frailty is defined as the presence of three or more of these components and pre-frailty as the presence of one or two components. We followed the operationalisation of the LBC1936 variables for each component outlined previously (Gale, Ritchie et al. 2017). Three categories of change based on the data from the two time points were calculated (improved, stable, and worsened).

2.4. Covariates

Covariates included age, sex, number people per room in childhood home (as a marker of childhood socioeconomic status), father's Occupational Social Class (OSC) and the participant's OSC. OSC was defined as "Professional-managerial (I/II)" and "Skilled, partly skilled, unskilled (III/IV/V)" based on the Office of Population Censuses and Surveys 1980 coding. Socioeconomic status (Jones, Hillsdon et al. 2009) and park size (Jansen, Ettema et al. 2017) were identified as effect modifiers.

2.5. Park Metric Selection

Several metrics of green space (availability/distance/size) have been used in the past, with the relationship with physical activity sensitive to the metric used (Schipperijn, Cerin et al. 2017).

We constructed park availability buffers (percentage of buffer that contained parks) around each residence at 50 m intervals from 50 to 3,000 m, Euclidean distance to nearest park and the size of the nearest park. The mean percentage, distance and size of the park was taken for residences within the childhood, adulthood and later adulthood periods. We then determined the most appropriate park metric for wave 1 physical activity (higher/lower status cut by median number (7 days) of active days per month) by including all of the green space metrics (n=62) as predictors in an Elastic-Net Regularized Generalized Linear Model (Friedman, Hastie et al. 2010). Cross-validation of lambda values was used to select the most appropriate park metric.

2.6. Life course model selection

We adapted a lifecourse model selection procedure to determine the most appropriate combination of exposure (parks) for the outcome of interest (frailty) (Mishra, Nitsch et al. 2009). We used an ordered logistic model with the park metric as the independent variable and frailty transition status as the ordered dependent variable. Briefly, several life course models were encoded: critical periods (childhood, adulthood and later adulthood), accumulation (strict and relaxed), effect modification (interaction between childhood and adulthood; adulthood and later adulthood) and no effect (no terms). Each life course model was compared to a saturated model (all terms) using likelihood ratio tests. If the no effect model was insignificant ($p>0.05$) then parks were assumed to have no effect on frailty transition. If the no effects model was significant then the lifecourse model with the highest p-value would be selected as the most appropriate model.

2.7. Multivariable and stratified analyses

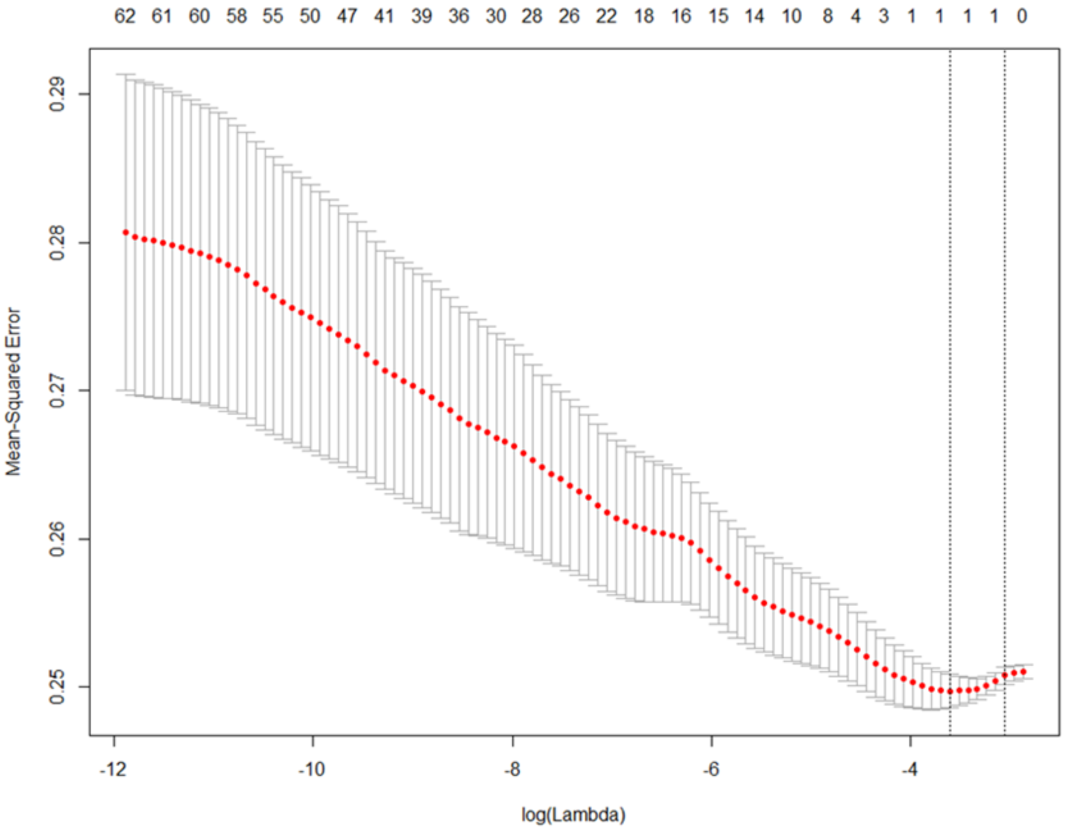
Using the most appropriate lifecourse model we developed a multivariable analyses with adjustment for age, sex, childhood OSC, childhood people per room and adulthood OSC. Missing data was imputed using multiple imputation via chained equations, 20 datasets were created and results were presented as the pooled estimates (Stef van Buuren 2011). We tested for interactions between our green space metric and childhood OSC, adulthood OSC and childhood park size, with significance level set as $p<0.10$. Statistically significant effect modifiers were then used in stratified models. For the stratified analyses closest park size was dichotomised into smaller parks and larger, split by the median. All statistical analysis and geoprocessing was undertaken using Rstudio Version 1.1.383 and R 3.3

3. Results

3.1. Park Metric Selection

Figure 1 shows the cross-validation procedure for the park metric selection. The weight given to the regularization term is lambda. The cross validation curve (red dotted line) for the relationship between multiple lambda values (x axis) and the mean squared error of the model is presented. The top row of numbers along the x axis is the number of predictors. The dotted line is the minimum lambda (lowest MSE), the second line is the most regularized model such that error is within one standard error of the minimum. This indicated that distance to nearest park was most appropriate due to having the lowest mean squared error. This variable was taken on to the lifecourse analysis.

Figure 1: Cross validation of lambda values



3.2. Life Course Model Selection

In Table 1 the demographic, socioeconomic and environmental characteristics of the participants by frailty transition status are presented. The results of the lifecourse model selection are presented in Table 2. The 'no effect' model had a significant likelihood ratio test (p=0.02), which indicated that distance to parks were associated with frailty transition status. The 'relaxed accumulation" model had the best model fit (AIC: 475; LRT: 0.54), and indicated that this was the most appropriate model to explain frailty transition in later adulthood. Greater distance from a public park in childhood was associated with greater likelihood of being in a worse frailty trajectory, which remained statistically significant after adjustment for covariates (aOR 1.19; 95%CI 1.02-1.38). The interaction between distance to nearest park and childhood OSC, adulthood OSC and childhood nearest park size were significant (p=0.07, p=0.07 and p<0.01 respectively). In the stratified analysis the effect of distance to parks was modified by childhood OSC, whereby those in the lower socioeconomic group had a stronger association with frailty transition (aOR 1.22, 95%CI 1.04-1.42) (Table 3). Results were similar when distance to parks was stratified by adulthood OSC (aOR 1.28; 95CI 1.02-1.60) (Table 3).

Table 1: Participant characteristics by frailty transition status

Characteristic		Frailty Transition Status (age 70 to 76)		
	Total (n=254)	Improved (n=36)	Stable (n=148)	Worsened (n=69)
Demographic/socioeconomic at wave 1 (age 70)				
Age (years)	69.32 ± 0.70	69.56 ± 0.65	69.31 ± 0.76	69.23 ± 0.68
Sex				
Female	120 (47)	20 (56)	65 (44)	35 (51)
Father's Occupational Social Class				
Professional-managerial (I/II)	55 (22)	9 (25)	36 (24)	10 (14)
Skilled, partly skilled, unskilled (III/IV/V)	196 (77)	27 (75)	112 (76)	57 (83)
NA	2 ()	-	-	2 (3)
Participant's Occupational Social Class				
Professional-managerial (I/II)	122 (48)	15 (42)	76 (51)	31 (45)
Skilled, partly skilled, unskilled (III/IV/V)	129 (51)	21 (58)	71 (48)	37 (54)
NA	2 (0)	-	1 (0)	1 (0)
Green space metric				
Childhood				
Distance to nearest park (m)	274 ± 179	261 ± 157	253 ± 175	327 ± 190
Size of nearest park (km2)	1.7 ± 0.4	1.1 ± 0.2	1.5 ± 0.4	2.2 ± 0.5
Adulthood				
Distance to nearest park (km)	281 ± 164	274 ± 1.46	278 ± 169	290 ± 163
Size of nearest park (km2)	1.7 ± 0.4	2.8 ± 0.6	1.5 ± 0.3	1.6 ± 0.4
Later Adulthood				
Distance to nearest park (km)	269 ± 172	290 ± 172	282 ± 187	231 ± 123
Size of nearest park (km2)	1.4 ± 0.3	1.2 ± 0.2	1.4 ± 0.2	1.6 ± 0.4

Table 2: Frailty transition status and distance to parks throughout life

Distance to nearest park lifecourse model	Frailty Transition Status (N=253)				
	AIC	P α	OR	95%CI LL	95%CI UL
a) Accumulation					
- Strict	484	0.02	1.01	0.95	1.08
- Relaxed	475	0.54	1.18*	1.03	1.36
			1.16	0.97	1.39
			0.79*	0.66	0.93
b) Critical Time Period					
- Childhood	479	0.10	1.18*	1.03	1.36
- Adulthood	484	0.02	1.04	0.90	1.21
- Later adulthood	480	0.06	0.87*	0.76	1.00
c) Effect modification					
- Early	482	0.05	0.97	0.89	1.05
- Later	480	0.09	0.99	0.94	1.04
No effect	482	0.02	-	-	-

* $p<0.05$

Table 3: Frailty transition status and childhood distance to parks in multi-variable ordinal logistic regression models

Model	Childhood Distance to Parks (per 100 m)		
	OR	CI (95%CI)	P-value
Full adjusted $^{\beta}$	1.19 *	1.02-1.38	0.02
Stratified by Father's OSC			
Professional/Managerial (I/II)	0.96	0.67-1.37	0.80
Skilled, partly skilled, unskilled (III/IV/V)	1.22 *	1.04-1.42	0.02
Stratified by Adulthood OSC			
Professional/Managerial (I/II)	1.10	0.92-1.34	0.28
Skilled, partly skilled, unskilled (III/IV/V)	1.28 *	1.02-1.60	0.03
Stratified by Childhood Park size (m^2)			
Small (260 - $3.61^{e+}04$)	1.11	0.89-1.37	0.35
Large ($3.61^{e+}04$ - $2.65^{e+}06$)	1.30 *	1.06-1.59	0.01

$^{\beta}$ Adjusted for sex, age, father's occupational social class, people per room in childhood home, participant's occupational social class
* $P<0.05$

4. Discussion

Greater childhood distance to neighbourhood parks had consistent associations with declining frailty status in later life, through the proposed mechanism of lower physical activity. This does not rule out the other mechanisms as distance to parks will be correlated with multiple mechanisms, however it may provide a degree of focus for policy recommendations. We also found that these associations were moderated by socioeconomic factors in childhood and adulthood. This meant that individuals the lower socioeconomic group (Skilled. Partly skilled, unskilled) were more likely to display an effect between park distance and frailty outcomes. Likewise, the results indicated that the size of the park, which might be a proxy for quality of park, had an effect on the relationship, whereby greater distance from larger parks was associated with greater difference in frailty status change, than distance to smaller parks.

Increasing the number and size of child-friendly parks in cities could be an appropriate approach to reduce the burden of frailty in older age.

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7. Biography

Dr. Mark Cherrie – Postdoctoral Researcher (Environment and Health)
Mark is an early career researcher whose research is focused on human interactions with the built and natural environment and how this affects behaviour and health both on the short and long term (e.g. adolescent smoking behaviour, adult asthma hospitalisations, lifetime cognitive ageing).

Prof. Jamie Pearce - Professor of Health Geography and co-director of the Centre for Environment, Society and Health (CRESH)
Jamie's work considers social, political and environmental processes affecting social and spatial inequalities in health. His work has focused on the role of place in understanding health outcomes and health-related behaviours, including smoking status, physical activity and obesity.

Dr. Niamh Shortt- Reader in Human Geography, Dean of Diversity and Inclusion and co-director of the Centre for Environment, Society and Health (CRESH)

Niamh is a Reader in Health Geography and co-director of the Centre for Environment, Society and Health (CRESH). Her research considers how the environment shapes our health, health behaviours and resulting health inequalities. She focuses on the effect of place and in particular the idea of the locale in which various aspects of the social and natural environment converge to influence health outcomes.

Prof. Ian Deary - He is Professor of Differential Psychology at the University of Edinburgh, director of Centre for Cognitive Ageing and Cognitive Epidemiology and director of the Lothian Birth Cohort studies of healthy ageing
Ian’s principal research interests are: human mental abilities, the effects of ageing and medical conditions on mental skills, and the impact of cognitive ability on people's lives.

Prof. Catharine Ward Thompson - Professor of Landscape Architecture at the Edinburgh School of Architecture and Landscape Architecture (ESALA) and Director of the OPENspace research centre.
Her research focuses on inclusive access to outdoor environments, environment-behaviour interactions, landscape design for older people, children and teenagers, and salutogenic environments.