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SHORT REPORT

Neighbourhood walkability and physical activity: moderating role of a physical activity intervention in overweight and obese older adults with metabolic syndrome

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Abstract

Background: While urban built environments might promote active ageing, an infrequently studied question is how the neighbourhood walkability modulates physical activity changes during a physical activity intervention programme in older adults. We assessed the influence of objectively assessed neighbourhood walkability on the change in physical activity during the intervention programme used in the ongoing PREvención con DIeta MEDiterránea (PREDIMED)-Plus trial.
Method: The present study involved 228 PREDIMED-Plus senior participants aged between 55 and 75, recruited in Palma de Mallorca (Spain). Overweight/obese older adults with metabolic syndrome were randomised to an intensive weight-loss lifestyle intervention or a control group. A walkability index (residential density, land use mix, intersections density) was calculated using geographic information systems (1 km sausage-network buffer). Physical activity was assessed using accelerometer and a validated questionnaire, at baseline and two follow-up visits (6-months and 1-year later). Generalised additive mixed models were fitted to estimate the association between the neighbourhood walkability index and changes in physical activity during follow-up.

Results: Higher neighbourhood walkability (1 z-score increment) was associated with moderate-to-vigorous accelerometer assessed physical activity duration, ($\beta = 3.44$; 95% CI = 0.52; 6.36 min/day). When analyses were stratified by intervention arm, the association was only observed in the intervention group ($\beta = 6.357$; 95% CI = 2.07;10.64 min/day) (P for interaction = 0.055).

Conclusions: The results indicate that the walkability of the neighbourhood could support a physical activity intervention, helping to maintain or increase older adults' physical activity.

Keywords: longitudinal study, physical activity intervention, walkability index, built environment, older people, PREDIMED-Plus trial

Key Points

- Living in a walkable neighbourhood plays a vital role in active ageing.
- Interrelations between physical activity interventions and environmental factors are important determinants to engage older adults in regular physical activity.
- It is crucial to consider the neighbourhood walkability when implementing physical activity programmes among older adults.

Introduction

Given the rapid increase of the older population [1,2] combined with their rising trend of insufficient physical activity [3], active ageing has become a key issue for public health. Physical activity intervention programmes among older adults have been shown to increase physical activity significantly [4,5]. However, little is known about whether the environments in which older adults are encouraged to be active play a role.

In environmental gerontology, the built environments are well known to promote active ageing at the population level [6,7]. Older adults spend more time within their immediate neighbourhood environments than younger adults [8]. This situation makes them especially sensitive to physical barriers towards health promotion efforts [9]. Multiple attributes such as residential density, intersection density and land use mix are frequently conceptualised and assessed using a walkability index, to account for built environment [10].

Additionally, socio-ecological models postulate that biological, behavioural, psychosocial and also environments factors can contribute to differential response to older adults physical activity interventions [11,12].

In this context, the PREvención con DIeta MEDiterránea (PREDIMED)-Plus study, recently published the individual-level effectiveness after 1-year of the physical activity intervention [13]. Using a sub-sample of participants from the PREDIMED-Plus, the current study aimed to (i) assess the association of neighbourhood walkability, on 1-year change in physical activity assessed by accelerometer and self-reported data and (ii) assess whether this association is strengthened with a physical activity intervention.

Methods

Study population

The present analysis was designed to measure neighbourhood walkability in a subset of participants from 1 of the 23 recruitment centres (University Hospital Son Espases (HUSE)) of the PREDIMED-Plus multicenter, parallel-group, randomised trial. Details of the trial have been published elsewhere [14]. The Committee of Research Ethics of the Balearic Islands approved this analysis, and all participants provided written informed consent.

PREDIMED-Plus participants were eligible if at enrolment they were men aged 55–75 years and women aged 60–75 years who were overweight or obese (body mass index (BMI) $\geq$27 and $<$ 40 kg/m^2) and fulfilled at least three of the metabolic syndrome criteria [15].

We included 228 participants in the analytic sample, excluding participants who reported living outside the city limits of Palma de Mallorca or had no accelerometer data.

Physical activity intervention

In the first year of the ongoing trial, participants in the intervention group received a face-to-face educational programme. Throughout the intervention, participants were encouraged to gradually increase their physical activity levels to at least 150 min/week of moderate-to-vigorous physical activity (MVPA), with the ultimate goal of walking at least 45 min/day, 6 days per week, in line World Health Organization recommendations for this age group [16].

Neighbourhood walkability index

We objectively measured neighbourhood walkability, using 1 km sausage buffer participants' residential address [17].

For each buffer, neighbourhood walkability features (residential density, intersection density and land use mix) were extracted and normalised following a z-score [10]. The walkability index was calculated by summing the z-scores of residential density, intersection density and land use mix. Details on spatial data and methods can be found in the online (Appendix 1: Methods Supporting Information) following the recent spatial lifecourse epidemiology reporting standards statement [18].

Table 1. Overall and specific study condition sample characteristics

	All	Study condition		
		Control group	Intervention group	*P*
Overall	228	122	106	
Age (years)	65.0 (4.79)	65.3 (4.69)	64.8 (4.92)	0.463
Sex				0.576
Men	117 (51.3%)	60 (49.2%)	57 (53.8%)	
Women	111 (48.7%)	62 (50.8%)	49 (46.2%)	
BMI (kg/m^2)	32.7 (3.31)	32.5 (3.55)	33.0 (3.01)	0.226
Educational level				0.639
Primary school or less	135 (59.2%)	70 (57.4%)	65 (61.3%)	
Secondary school or higher	93 (40.8%)	52 (42.6%)	41 (38.7%)	
Self-reported health				0.781
Excellent/very good/good	156 (68.4%)	82 (67.2%)	74 (69.8%)	
Fair/poor	72 (31.4%)	40 (32.5%)	32 (30.2%)	
Precipitation accelerometer wearing period				0.827
No rain	119 (52.2%)	65 (53.3%)	54 (50.9%)	
Rain	109 (47.8%)	57 (46.7%)	52 (49.1%)	
Baseline accelerometer-assessed MVPA (minutes/day)	34.1 (26.2)	32.2 (27.5)	36.3 (24.7)	0.239
Accelerometer wear time, valid days	7.82 (1.44)	7.80 (1.40)	7.85 (1.49)	0.779
Engaging in ≥150 min/week accelerometer-assessed MVPA				0.061
No	89 (39.0%)	55 (45.1%)	34 (32.1%)	
Yes	139 (61.0%)	67 (54.9%)	72 (67.9%)	
Baseline self-reported MVPA (minutes/day)	53.1 (59.5)	49.9 (60.7)	56.9 (58.1)	0.374
Engaging in ≥150 min/week self-reported leisure-time MVPA				0.026
No	83 (36.4%)	53 (43.4%)	30 (28.3%)	
Yes	145 (63.6%)	69 (56.6%)	76 (71.7%)	
Self-reported leisure-time brisk walking (minutes/day)	22.0 (29.6)	20.8 (33.2)	23.4 (24.9)	0.493
Engaging in ≥45 min/day 6 days/week self-reported leisure-time brisk walking				0.124
No	106 (46.5%)	63 (51.6%)	43 (40.6%)	
Yes	122 (53.5%)	59 (48.4%)	63 (59.4%)	
Walkability index	−0.07 (1.09)	−0.05 (1.03)	−0.10 (1.16)	0.777
Z-score residential density	−0.06 (1.02)	−0.03 (1.01)	−0.09 (1.03)	0.619
Z-score land use mix	0.05 (1.02)	0.02 (1.02)	0.09 (1.02)	0.638
Z-score intersection density	−0.07 (1.02)	−0.05 (0.97)	−0.09 (1.08)	0.780
Deprivation index	1.92 (0.99)	1.95 (1.01)	1.90 (0.96)	0.726

n, sample size; SD, standard deviation. Values shown are *n* (%) for categorical variables and mean (SD) for continuous variables. The *P*-values are computed from t-test when row-variable is continuous normal-distributed, Kruskall–Wallis test when it is continuous non-normal. When row-variable is categorical, we used chi-squared or exact Fisher test when the expected frequencies are less than 5 in some cell.

Outcome measure: physical activity

Accelerometer and self-reported assessed physical activity, at baseline, at 6 and 12 months.

Accelerometer assessed MVPA duration (minutes/day) (AA-MVPA) using GENEActiv monitors. The time spent in MVPA was determined using older adults cutoff points [19]. Self-reported leisure-time MVPA duration (minutes/day) (SRLT-MVPA) was assessed using the validated REGICOR Short Physical Activity Questionnaire [20]. Also, a domain-specific physical activity self-reported leisure-time brisk walking duration (minutes/day) (SRLT-BW) was assessed.

Data analytic plan

A generalised additive mixed models with Gaussian variance was used to evaluate the effects of neighbourhood walkability on the duration of each physical activity variable All models accounted for two nested levels of variability in the outcome, variability at the person level (i.e. between-participant multiple observations differences) nested at the area-level (i.e. clustering effects). All coefficients were adjusted for individual-level covariates: age, sex, education level, BMI and self-rated health. See Supplemental information for additional information of neighbourhood deprivation calculations [21] and rain conditions.

For each model, we examined the effect modification analysis by study condition (intensive weight-loss lifestyle intervention and unrestricted-energy Mediterranean diet control group), by adding cross-product terms between neighbourhood walkability and study condition. Additionally, stratified analyses were performed, by examining the association in intervention and control group, separately.

All analyses were conducted in R software version 3.3.3 (R Development Core Team, Vienna, Austria) using 'stats' and 'mgcv' packages and ArcGIS V10.5.1 software.

Table 2. Summary of associations between neighbourhood walkability and its components measured in the 1 Km buffer, and accelerometer-assessed moderate-to-vigorous physical activity (AA-MVPA), self-reported leisure-time moderate-to-vigorous physical activity (SRLT-MVPA) and self-reported leisure-time brisk walking (SRLT-BW) in the overall sample ($n = 228$) and after stratification according to the PREDIMED-Plus control ($n = 122$) and intervention ($n = 106$) groups

Predictor variable	Accelerometer-assessed MVPA			Self-reported Leisure-Time MVPA			Self-reported leisure-time brisk walking		
	β	95%CI	P	β	95%CI	P	β	95%CI	P
Walkability index	3.44	0.52;6.36	0.021	−4.44	−10.00;1.13	0.119	−0.05	−2.97;2.87	0.975
P for Interaction			0.055			0.927			0.485
Walkability index control group	0.10	−3.94;4.15	0.960	−4.69	−12.80;3.42	0.258	−0.94	−6.08;4.20	0.721
Walkability index intervention group	6.36	2.07;10.64	0.004	−4.78	−12.48;2.91	0.224	1.05	−2.46;4.55	0.558
Z-score of residential density	2.92	−0.19;6.03	0.067	−0.16	−6.04;5.72	0.958	−0.41	−3.47;2.65	0.794
P for Interaction			0.398			0.44			0.311
Z-score of residential density control group	1.95	−2.01;5.91	0.335	−2.14	−10.23;5.93	0.603	−1.84	−6.87;3.19	0.474
Z-score of residential density intervention group	5.07	0.11;10.03	0.046	2.76	−5.98;11.49	0.537	1.66	−2.29;5.60	0.412
Z-score intersection density	4.32	1.19;7.45	0.007	−4.18	−10.18;1.82	0.173	−0.36	−3.50;2.79	0.824
P for Interaction			0.111			0.848			0.572
Z-score intersection density control group	1.38	−2.98;5.75	0.535	−4.61	−13.38;4.15	0.303	−1.10	−6.67;4.47	0.7
Z-score intersection density intervention group	6.86	2.25;11.48	0.004	−4.18	−12.47;4.12	0.325	0.60	−3.17;4.37	0.755
Z-score land use mix	−3.20	−6.32;-0.09	0.045	−0.77	−6.65;5.11	0.798	0.70	−2.37;3.76	0.656
P for Interaction			0.683			0.365			0.421
Z-score land use mix control group	−3.03	−7.00;0.94	0.136	1.42	−6.66;9.50	0.731	1.82	−3.20;6.84	0.477
Z-score land use mix intervention group	−4.51	−9.49;0.47	0.077	−4.24	−12.94;4.46	0.340	−0.97	−4.93;2.98	0.629

n, sample size; β, non-standardised coefficient; 95%CI, confidence interval; P, P-value. β indicates change associated with physical activity duration according to minutes per day per increment in 1 z-score walkability index. All coefficients were adjusted for individual-level covariate (study condition, visit, sex, baseline age, baseline self-rated health, repeated measured BMI at each visit, baseline educational level and two-level random intercept participant nested in neighbourhood deprivation index; when the outcome was AA-MVPA, models were further adjusted for the repeated indicator of rainy conditions at each visit).

Results

Descriptive statistics

The mean age of study participants was 65.0 years (range 55; 75) and 48.7% were women. On average, at baseline, participants did 34.1 min MVPA/day based on accelerometer data, 53.1 min of SRLT-MVPA/day and 22.0 min of brisk walking/day (Table 1).

Associations of neighbourhood walkability on physical activity duration

When considering the overall sample, AA-MVPA increased per increment in 1 z-score neighbourhood walkability ($\beta = 3.44$; 95% CI = 0.52;6.36 min/day; $P = 0.021$). An interaction was detected between study condition (control group and intervention group) and neighbourhood walkability ($P = 0.05$). Stratified analyses showed that each unitary increment in 1 z-score neighbourhood walkability was associated with an increase of 6.36 (95% CI = 2.07;10.64) min/day among individuals assigned to the intervention group. No association was observed for the control group. See supplemental information for additional information of the associations of neighbourhood walkability components on physical activity.

Supplementary appendices 2–5 (online) shows additional sensitivity analyses (different buffer sizes and different operationalists of outcome variables) confirming the primary analysis (Table 2).

Discussion

This study provides new evidence on the association between neighbourhood walkability and physical activity in a tailored intervention to increase physical activity in older adults. Higher walkability combined with a physical activity intervention could be the most effective strategy to increase physical activity among older adults.

Neighbourhood walkability and physical activity

Urbanisation and inactive ageing are transformative trends that have become a crucial global issue for public health yet the influence of built environments is still unknown [22]. The most important contribution of the presented study is the examination of the interacting effect of neighbourhood walkability and individual-level intervention on physical activity changes among European older adults using a prospective design within a randomised trial.

Our findings indicate a higher walkability index was related to an increase in AA-MVPA during the PREDIMED-Plus physical activity intervention suggesting that living in highly walkable areas supports this type of intervention.

To date, only one previous study conducted in North America has explored the effects of objective neighbourhood walkability on self-reported physical activity among older adults attempting to increase their physical activity levels [23]. These findings are consistent with our results on

SRLT-MVPA, while the relationships between neighbourhood walkability and SRLT-BW, King and colleagues also found no association [23].

Among cross-sectional studies, there have been similar findings [24] and a recent study showed that older adults residing in low walkable areas in a similar Mediterranean environment were less likely to walk [25]. Even so, this hypothesis was not strongly supported, as a recent international study found that neighbourhoods designed to support transport walking also appeared to facilitate walking for leisure, as well as total MVPA [26]. In this context, our results indicate that neighbourhood walkability combined with a physical activity intervention seems to be more related to transportation behaviours than leisure-time ones.

Strengths and limitations

The present study has several strengths, including the use of a prospective design within a randomised trial with both self-reported and accelerometer measures of physical activity; while other studies have mostly used cross-sectional data [6,7] or self-report questionnaires [23,27]. Physical activity intervention programmes focused on overweight/obese senior adults reflects an essential contribution to a critical issue for public health [28]. Also, our study was conducted in the context of a European region, adding to the body of evidence that was based on other non-European areas.

Even so, our results should be interpreted with caution since the follow-up period was only one-year, which might be too short to detect major changes. Also, the smaller sample sizes used in the stratified analyses should be acknowledged as a limitation. In addition, we lacked a specific measure of active transportation, which could have provided additional insights related to this domain-specific physical activity [29].

Future studies should explore combinations of environmental features, to explain more variation in physical activity than single variables.

Conclusions

This study provides new evidence highlighting the importance of considering neighbourhood walkability and built environment when designing and implementing physical activity programmes. Results indicate that among overweight and obese senior adults with metabolic syndrome and assigned to a tailored intervention to increase physical activity, living in a walkable neighbourhood appears to be an essential factor in active ageing. This adds to increasing evidence supporting a whole system approach when designing physical activity intervention programmes and warrants further investigation.

Supplementary Data: Supplementary data mentioned in the text are available in Age and Ageing online Appendix file: Appendix1: Methods Supporting Information. Appendix 2: Results Supporting Information. Appendix 3: Supplementary Table S1. Summary of dichotomized associations measured in the 1 Km buffer. Appendix 4: Supplementary table S2. Summary of associations measured in the 0.5 Km buffer. Appendix 5: Supplementary Table S3. Summary of associations measured in the 0.5 Km buffer. Appendix 6: Availability of data and materials. Appendix 7: Abbreviations.

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Declaration of Conflicts of Interest: None.

Ethics Approval and Consent to Participate: The Committee of Research Ethics of the Balearic Islands (CEI-IB) approved the study (approval number IB-2242/14-PI). All participants provided written informed consent to participate in the study.

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