SHORT REPORT

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

Antoni Colom1,2, Suzanne Mavoa3,4, Maurici Ruiz1,5, Julia Wärnberg2,6, Josep Muncunill7, Jadwiga Konieczna1,2, Guillaume Vich8, Francisco Javier Barón-López2,9, Montserrat Fitó2,10, Jordi Salas-Salvadó2,11,12, Dora Romaguera1,2

1 Research Group on Nutritional Epidemiology & Cardiovascular Physiopathology, Health Research Institute of the Balearic Islands (IdISBa), University Hospital Son Espases, 07120 Palma, Spain
2 Consorcio CIBER, M.P. Fisiopatología de la Obesidad y Nutrición (CIBEROBN), Instituto de Salud Carlos III (ISCIII), Madrid, Spain
3 Mary MacKillop Institute for Health Research, Australian Catholic University, Melbourne, Australia
4 Melbourne School of Population and Global Health, University of Melbourne, Melbourne, Australia
5 Servicio de SIG y Teledetección, Vicerectorat d’Innovació i Transferència, Universitat de les Illes Balears, Palma, Spain
6 Departamento de Enfermería, Facultad de Ciencias de la Salud, Universidad de Málaga – Instituto de Investigación en Biomedicina (IBIMA), Málaga, Spain
7 Genomics and Bioinformatics Platform, Balearic Islands Health Research Institute (IdISBa), University Hospital Son Espases, Palma, Spain
8 Geography Department, Autonomous University of Barcelona, Bellaterra, Spain
9 Departamento de Salud Pública, Facultad de Medicina, Universidad de Málaga – Instituto de Investigación en Biomedicina (IBIMA), Málaga, Spain
10 Unit of Cardiovascular Risk and Nutrition, Institut Hospital del Mar de Investigaciones Médicas Municipal d’Investigació Mèdica (IMIM), Barcelona, Spain
11 Universitat Rovira i Virgili, Departament de Bioquímica i Biotecnologia, Unitat de Nutrició Humana. Hospital Universitari San Joan de Reus, Reus, Spain
12 Institut d’Investigació Pere Virgili (IISPV), Human Nutrition Unit: Prevention and Epigenetics, Reus, Spain

Address correspondence to: Dora Romaguera. Tel: 871 205000; Fax: 871 206868. Email: mariaadoracion.romaguera@ssib.es

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 Díeta 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, ($\beta = 3.44; 95\% \text{ CI} = 0.52; 6.36 \text{ min/day}$). When analyses were stratified by intervention arm, the association was only observed in the intervention group ($\beta = 6.357; 95\% \text{ CI} = 2.07; 10.64 \text{ min/day}$) ($P$ 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 $< 40 \text{ kg/m}^2$) 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

| Study condition | All | 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             |     |               |                    |    |
| Men             | 117 (51.3%) | 60 (49.2%) | 57 (53.8%) | 0.576 |
| Women           | 111 (48.7%) | 62 (50.8%) | 49 (46.2%) |    |
| BMI (kg/m²)     | 32.7 (3.31) | 32.5 (3.55) | 33.0 (3.01) | 0.226 |
| Educational level|     |               |                    |    |
| Primary school or less | 135 (59.2%) | 70 (57.4%) | 65 (61.3%) | 0.639 |
| Secondary school or higher | 93 (40.8%) | 52 (42.6%) | 41 (38.7%) |    |
| Self-reported health |     |               |                    |    |
| Excellent/very good/good | 156 (68.4%) | 82 (67.2%) | 74 (69.8%) | 0.781 |
| Fair/poor       | 72 (31.4%) | 40 (32.5%) | 32 (30.2%) |    |
| Precipitation accelerometer wearing period |     |               |                    |    |
| No rain         | 119 (52.2%) | 65 (53.3%) | 54 (50.9%) | 0.827 |
| 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 |     |               |                    |    |
| No              | 89 (39.0%) | 55 (45.1%) | 34 (32.1%) | 0.061 |
| 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) | 0.026 |
| Engaging in ≥150 min/week self-reported leisure-time MVPA |     |               |                    |    |
| No              | 83 (36.4%) | 53 (43.4%) | 30 (28.3%) | 0.374 |
| 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 |     |               |                    |    |
| No              | 106 (46.5%) | 63 (51.6%) | 43 (40.6%) | 0.124 |
| 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.
966 per increment in 1 z-score neighbourhood walkability

When considering the overall sample, AA-MVPA increased

Associations of neighbourhood walkability on
daily walking (Table 1).

Participants did 34.1 min MVPA/day based on accelerometer

to an increase of 6.36 (95% CI = 2.07; 10.64)

Discussion

Neighbourhood walkability and physical activity

Urbanisation and inactive ageing are transformative trends

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 neighbour-
hood 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

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, partici-
pcants 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).

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  | 0.05  | 0.927  | 0.398  | 0.44  | 0.311  | 0.358  | 1.66  | 0.412  | 0.136  |
| 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  | 0.358  | 1.66  | 0.412  | 0.136  | 0.055  | 0.927  | 0.398  |
| 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  | 0.703  | 0.412  | 0.703  | 0.412  | 0.303  | 0.703  | 0.412  |
| 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  | 0.725  |
| 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;3.47  | 0.755  |
| Z-score land use mix | -3.20  | -6.32;0.99  | 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  | 0.703  | 0.412  | 0.703  | 0.412  | 0.303  | 0.703  | 0.412  |
| 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;4.66  | 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).

To date, only one previous study conducted in North
America has explored the effects of objective neighbour-
hood walkability and physical activity in a tailored
intervention to increase physical activity in older adults.
Higher walkability combined with a physical activity inter-
vention could be the most effective strategy to increase
physical activity among older adults.

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.

Supplementary appendices 2–5 (online) shows 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).
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 reflect 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: Appendix 1: 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.

**Acknowledgements:** The authors would like to acknowledge the investigators, personnel, and study participants of the PREDIMED-Plus study, as well as all affiliated primary care centres. Also, we would like to acknowledge the Institut d’Investigació Sanitària Illes Balears to support the open access publication of this work. [A.C.] thank Dr. Alain F. Zuur and Dra. Elena N. Ieno at Highland Statistics Ltd. for teaching how to deal with the great amount of misery that comes together in the statistical analysis.

**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.

**Declaration of Sources of Funding:** This work was supported by Instituto de Investigación en Salud Carlos III [grant numbers PI14/00853, PI16/00662 and PI17/00525], and Consejería de Salud de la Junta de Andalucía [grant number PS0358–2016]. Co-funded by FEDER. Institut d’Investigació Sanitària Illes Balears fellowship TalentPlus Tech Construyendo Valor Generando Salud [grant numbers ITS2018–002] to [A.C.]. AstraZeneca Foundation (Young investigator Award 2017 on obesity and type 2 diabetes to [D.R.]. Australian National Health and Medical Research Council fellowship [grant numbers #1121035] to [S.M.]. [J.S.S.], gratefully acknowledges the financial support by ICREA under the ICREA Academia programme.

**References**

1. World Health Organization. World Report on Ageing and Health. World Health Organization, Geneva, 2015.
2. United Nations Department of Economic and Social Affairs Population Division. World population ageing, 2017.
3. Guthold R, Stevens GA, Riley BM, Bull FC. Worldwide trends in insufficient physical activity from 2001 to 2016: a pooled analysis of 358 population-based surveys with 19 million participants. Lancet Glob Heal 2018; 6: e1077–86.
4. Oliveira JS, Sherrington C, Amorim AB, Dario AB, Tiedemann A. What is the effect of health coaching on physical activity participation in people aged 60 years and over? A systematic review of randomised controlled trials. Br J Sports Med 2017; 51: 1425–32.
5. Zubala A, MacGillivray S, Frost H et al. Promotion of physical activity interventions for community dwelling older adults: a systematic review of reviews. PLoS One 2017; 12: e0180902.
6. Van Cauwenberg J, Nathan A, Barnett A, Barnett DW, Cerin E. Relationships between neighbourhood physical environ-
A. Colom et al.

mental attributes and older adults’ leisure-time physical activity: a systematic review and meta-analysis. Sport Med 2018; 48: 1635–60.
7. Barnett DW, Barnett A, Nathan A, Van Cauwenberg J, Cerin E. Built environmental correlates of older adults’ total physical activity and walking: a systematic review and meta-analysis. Int J Behav Nutr Phys Act 2017; 14: 103.
8. Satariano WA, Guralnik JM, Jackson RJ, Marottoli RA, Phelan EA, Prohaska TR. Mobility and aging: new directions for public health action. Am J Public Health 2012; 102: 1508–15.
9. Forsyth A, Michael Oakes J, Lee B, Schmitz KH. The built environment, walking, and physical activity: is the environment more important to some people than others? Transp Res Part D Transp Environ 2009; 14: 42–9.
10. Frank LD, Sallis JF, Saelens BE et al. The development of a walkability index: application to the neighborhood quality of life study. Br J Sports Med 2010; 44: 924–33.
11. King AC, Sallis JF. Why and how to improve physical activity promotion: lessons from behavioral science and related fields. Prev Med (Baltim) 2009; 49: 286–8.
12. MacLean PS, Rothman AJ, Nicastro HL et al. The Accumulating Data to Optimally Predict Obesity Treatment (ADOPT) Core Measures Project: rationale and approach. Obesity 2018; 26: S6–S15.
13. Schröder H, Cárdenas-Fuentes G, Martínez-González MA et al. Effectiveness of the physical activity intervention program in the PREDIMED-plus study: a randomized controlled trial. Int J Behav Nutr Phys Act 2018; 15: 110.
14. Martínez-González MA, Buil-Cosiales P, Corella D et al. Cohort profile: design and methods of the PREDIMED-plus randomized trial. Int J Epidemiol 2019; 48: 387–388.
15. Alberti KGMM, Eckel RH, Grundy SM et al. Harmonizing the metabolic syndrome. Circulation 2009; 120: 1640–5.
16. World Health Organization. Global recommendations on physical activity for health. World Health Organization, Geneva, 2010.
17. Forsyth A, Van Riper D, Larson N, Wall M, Neumark-Sztainer D. Creating a replicable, valid cross-platform buffering technique: the sausage network buffer for measuring food and physical activity built environments. Int J Health Geogr 2012; 11: 14.
18. Jia P, Yu C, Remais JV et al. Spatial life course epidemiology reporting standards (ISLE-ReSt) statement. Heal Place 2020; 61: 102243.
19. Hildebrand M, Van Hees VT, Hansen BH, Ekelund U. Age group comparability of raw accelerometer output from wrist- and hip-worn monitors. Med Sci Sports Exerc 2014; 46: 1816–24.
20. Molina L, Sarmiento M, Peñafiel J et al. Validation of the Regicior short physical activity questionnaire for the adult population. PLoS One 2017; 12: e0168148.
21. Duque I, Domínguez-Berjón MF, Cebrecos A et al. Deprivation index by enumeration district in Spain, 2011. Gac Sanit 2020; S0213-9111: 30272–9.
22. World Health Organization. Global action plan on physical activity 2018–2030: more active people for a healthier world. World Health Organization, Geneva, 2018.
23. King AC, Salvo D, Banda JA et al. Preserving older adults’ routine outdoor activities in contrasting neighborhood environments through a physical activity intervention. Prev Med (Baltim) 2017; 96: 87–93.
24. Van Holle V, Van Cauwenberg J, Van Dyck D, Deforche B, Van de Wege N, De Bourdeaudhuij I. Relationship between neighborhood walkability and older adults’ physical activity: results from the Belgian environmental physical activity study in seniors (BEPAS seniors). Int J Behav Nutr Phys Act 2014; 11: 110.
25. Delegado-llo X, Marquet O, Vich G, Schipperij J, Temperate ZK. Rain moderate the effect of Neighborhood walkability on walking time for seniors in Barcelona. Int J Environ Res Public Health 2020; 17: 1–11.
26. Sallis JF, Cerin E, Kerr J et al. Built environment, physical activity, and obesity: findings from the international physical activity and environment network (IPEN) adult study. Annu Rev Public Health 2020; 41: 119–39.
27. Kerr J, Norman GJ, Adams MA et al. Do neighborhood environments moderate the effect of physical activity lifestyle interventions in adults? Heal Place 2010; 16: 903–8.
28. Ding D, Lawson KD, Kolbe-Alexander TL et al. The economic burden of physical inactivity: a global analysis of major non-communicable diseases. Lancet 2016; 388: 1311–24.
29. Van Cauwenberg J, De Bourdeaudhuij I, Clarys P et al. Street characteristics preferred for transportation walking among older adults: a choice-based conjoint analysis with manipulated photographs. Int J Behav Nutr Phys Act 2016; 13: 6–17.

Received 7 January 2020; editorial decision 5 September 2020
Author/s:
Colom, A; Mavoa, S; Ruiz, M; Wärnberg, J; Muncunill, J; Konieczna, J; Vich, G; Barón-López, FJ; Fitó, M; Salas-Salvadó, J; Romaguera, D

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

Date:
2021-05-05

Citation:
Colom, A., Mavoa, S., Ruiz, M., Wärnberg, J., Muncunill, J., Konieczna, J., Vich, G., Barón-López, F. J., Fitó, M., Salas-Salvadó, J. & Romaguera, D. (2021). Neighbourhood walkability and physical activity: moderating role of a physical activity intervention in overweight and obese older adults with metabolic syndrome. Age Ageing, 50 (3), pp.963-968. https://doi.org/10.1093/ageing/afaa246.

Persistent Link:
http://hdl.handle.net/11343/273845

File Description:
Published version

License:
CC BY-NC