Published in final edited form as:
Prev Med. 2018 November ; 116: 60–67. doi:10.1016/j.ypmed.2018.08.008.

Neighborhood walkability and physical activity among older women: Tests of mediation by environmental perceptions and moderation by depressive symptoms☆

Stephanie L. Orstad[a,*], **Meghan H. McDonough**[b], **Peter James**[c], **David B. Klenosky**[d], **Francine Laden**[c,e,f], **Marifran Mattson**[g], and **Philip J. Troped**[h]

[a]Division of General Internal Medicine and Clinical Innovation, New York University School of Medicine, 462 1st Avenue, New York, NY 10016, USA

[b]Faculty of Kinesiology, University of Calgary, KNB 250, 2500 University Drive NW, Calgary, AB T2N 1N4, Canada

[c]Department of Epidemiology, Harvard T.H. Chan School of Public Health, 655 Longwood Avenue, Boston, MA 02115, USA

[d]Department of Health and Kinesiology, Purdue University, Lambert Fieldhouse, 800 West Stadium Avenue, West Lafayette, IN 47907, USA

[e]Department of Environmental Health, Harvard T.H. Chan School of Public Health, 401 Park Drive, 4th Floor West, Boston, MA 02215, USA

[f]Channing Division of Network Medicine, Brigham and Women's Hospital and Harvard Medical School, 401 Park Drive, 3rd Floor West, Boston, MA 02215, USA

[g]Brian Lamb School of Communication, Purdue University, Beering Hall of Liberal Arts and Education, 100 North University Street, West Lafayette, IN 47907, USA

[h]Department of Exercise and Health Sciences, University of Massachusetts Boston, 100 Morrissey Boulevard, Boston, MA 02125, USA

Abstract

Features that enhance neighborhood walkability (higher population density, street connectivity and access to destinations) are associated with higher levels of physical activity among older adults. The perceived neighborhood environment appears to mediate associations between the objective built environment and physical activity. The role of depressed mood in these associations is poorly understood. We examined the degree to which depressive symptoms moderated indirect associations between the objective neighborhood environment and physical activity via the perceived neighborhood environment in older women. We analyzed data on 60,133 women (mean

☆The authors of this paper report no conflicts of interest or financial disclosures.

*Corresponding author. stephanie.orstad@nyulangone.org (S.L. Orstad), meghan.mcdonough@ucalgary.ca (M.H. McDonough), pjames@hsph.harvard.edu (P. James), klenosky@purdue.edu (D.B. Klenosky), francine.laden@channing.harvard.edu (F. Laden), mmattson@purdue.edu (M. Mattson), phil.troped@umb.edu (P.J. Troped).

Appendix A. Supplementary data
Supplementary data to this article can be found online at https://doi.org/10.1016/j.ypmed.2018.08.008.

age = 73.1 ± 6.7 years) in the U.S. Nurses' Health Study cohort who completed the 2008 questionnaire. Self-reported measures included the Geriatric Depression Scale, perceived presence of recreational facilities, retail destinations, sidewalks, and crime, and participation in recreational physical activity and neighborhood walking. We created an objective walkability index by summing z-scores of intersection and facility counts within 1200-meter residential network buffers and census tract-level population density. We used multiple regression with bootstrap-generated 95% bias-corrected confidence intervals (*BC CI*s) to test for mediation and moderated mediation. Objective walkability was associated with 1.99 times greater odds of neighborhood walking (95% *BC CI* = 1.92, 2.06) and 1.38 times greater odds of meeting physical activity recommendations (95% *BC CI* = 1.34, 1.43) via the perceived neighborhood environment. These indirect associations were weaker among women with higher depressive symptom scores. Positive associations between objective neighborhood walkability and physical activities such as walking among older women may be strengthened with a reduction in their depressive symptoms.

1. Introduction

Physically active older adults have a lower risk for many chronic health conditions compared to those who are less physically active (Nelson et al., 2007; Chodzko-Zajko et al., 2009). They also live with fewer functional limitations (e.g., in walking or activities of daily living) and greater health-related quality of life (Motl and McAuley, 2010). Conceptual models and empirical evidence suggest that as adults age and their mobility worsens, the design of their neighborhood becomes particularly important in attenuating declines in physical function (Glass and Balfour, 2003; Clarke and George, 2005; Yen et al., 2009; Balfour and Kaplan, 2002; King et al., 2011; Eronen et al., 2014). Older adults who live in more walkable neighborhoods, characterized by higher population density, street connectivity, and access to destinations (Cervero and Kockelman, 1997; Frank et al., 2010), engage in more moderate-vigorous physical activity (MVPA) (King et al., 2011; Van Holle et al., 2014, 2015; Carlson et al., 2012) and walk more for leisure and transport (King et al., 2011; Van Holle et al., 2014, 2015; Carlson et al., 2012; Kerr et al., 2014; Winters et al., 2015; Berke et al., 2007; Nagel et al., 2008; Gauvin et al., 2012; Troped et al., 2014; Nathan et al., 2014) compared to those who live in less walkable neighborhoods. Also, perceived proximity to retail destinations (Shigematsu et al., 2009), access to recreation facilities (Shigematsu et al., 2009; Li et al., 2005; Adams et al., 2012), and safety from traffic and crime (Li et al., 2005) have been associated with walking among older adults.

Objective and perceived neighborhood environment measures that assess conceptually comparable features (e.g., self-reported and GIS-based park proximity) exhibit low agreement, suggesting they may capture related but distinct constructs that predict unique variance in the same physical activity outcome (Sallis, 2009; Nasar, 2008; Orstad et al., 2016). Ecological models of health behavior suggest environmental perceptions mediate associations between the objective built environment and physical activity (King et al., 2002; Sallis et al., 2008; Ewing and Handy, 2009; Ding and Gebel, 2012). However, few studies examining associations between objective walkability and physical activity among older adults have examined mediation by the perceived neighborhood environment (Carlson et al., 2012; Ding et al., 2014). The few studies conducted have demonstrated that perceived access to retail destinations and places to be physically active mediate associations between objective measures of intersection and destination density and walking for transport (Koohsari et al., 2014; Van Dyck et al., 2013).

Depression affects up to 13.5% of older U.S. adults, and older women are particularly susceptible (CDC, 2015; Barry et al., 2008). While physical activity can alleviate depressive symptoms (Rosenbaum et al., 2014; Conn, 2010; Krogh et al., 2011; Huang et al., 2015), prospective associations between physical activity and depressive symptoms appear to be bidirectional (Lindwall et al., 2011). That is, older adults with clinically diagnosed depression (Wassink-Vossen et al., 2014; Morey et al., 2003; McKee et al., 2015) or higher levels of depressive symptoms (Krämer et al., 2014a; Wilcox et al., 2003; van Gool et al., 2003; Shaw and Spokane, 2008) engage in less physical activity, which may further increase chronic disease risk. Depression may impact adults' physical activity through lower levels of motivation (e.g., behavioral intention) and volitional capacities (i.e., ability to transform their intention into behavior) (Krämer et al., 2014a,b; Scarapicchia et al., 2014). Since environmental perceptions form through cognitive, affective, and social processes (Nasar, 2008; Bandura, 1978; Davies, 2009), depressive symptoms may also influence physical activity by interacting with individuals' perceptions of their neighborhood environment. For example, individuals with more distress, hopelessness, or depressed mood report worse perceptions of their neighborhood than those with less depressed mood (Bailey et al., 2014), even when controlling for objective neighborhood features (Latkin et al., 2009; Mair et al., 2012; Kamphuis et al., 2010). As a result, depressive symptoms may dampen positive associations between neighborhood walkability and physical activity.

We examined whether objective measures of neighborhood walkability were 1) directly associated with neighborhood walking and meeting physical activity recommendations, and 2) indirectly associated with neighborhood walking and meeting physical activity recommendations via the perceived neighborhood environment, among older U.S. women. We also examined the degree to which depressive symptoms moderated these direct and indirect associations (see Fig. 1 for conceptual framework).

2. Methods

2.1. Study design and sample

For this cross-sectional analysis we examined data in 2013 from the Nurses' Health Study (NHS), a prospective cohort study of registered nurses across the United States (Belanger et al., 1978). The NHS originated in 1976 with over 121,700 women to examine risk factors for breast cancer and other chronic diseases. Participants complete a questionnaire every two years and response rates are approximately 90% over follow-up. The 2008 questionnaire included questions on the perceived neighborhood environment. We included women (N = 60,133) who completed the 2008 questionnaire and had complete data for key study variables. We excluded women who were unable to walk and/or who were in an assisted living facility or nursing home. Human research protection committees at Brigham and Women's Hospital and Purdue University approved study protocols.

2.2. Measures

2.2.1. Physical activity—We examined two physical activity outcomes. Neighborhood walking was based on the item, "I walk around my neighborhood twice a week or more for leisure or exercise (yes/no)." Meeting physical activity recommendations was derived from the question, "During the past year, what was your average time per week spent at each of the following recreational activities?" Response options ranged from 0 to ≥11 h/week. Activities included walking, jogging, running, bicycling, racquet sports, swimming, stair climbing, aerobics/dance, weight training and other vigorous activities. Consistent with prior NHS analyses, a metabolic equivalent task (MET) value was assigned to each activity (Ainsworth et al., 2000, 2011). MET values were assigned to walking based on usual walking pace outdoors (< 2 mph = 0, 2–2.9 mph = 3.0, 3–3.9 mph = 4.0, and ≥4 mph = 4.5). Activities of less-than-moderate intensity (i.e., < 3.0 METs) were excluded. We multiplied MET values by the midpoint of the range of hours reported for a given activity (e.g., 2–3 h = 2.5 h) to calculate MET hours/week. We multiplied the total MET hours/week across all activities by 60 to yield the average MET minutes/week of recreational physical activity. We then created a binary outcome (< 500 versus ≥500 MET min/ week, the latter which approximates the recommended 150 min of moderate-vigorous intensity physical activity per week) (Buchner et al., 2008). NHS physical activity items have adequate two-year reproducibility and validity compared to seven-day physical activity diaries (Wolf et al., 1994).

2.2.2. Objective neighborhood walkability—We used geographic information systems (GIS) data and software to measure neighborhood walkability. Consistent with prior NHS analyses demonstrating associations between walkability and physical activity (Troped et al., 2014), we created a 1200-meter line-based road network buffer around each geocoded home address. A line-based or "sausage" buffer refers to the resulting shape when a line is traced a set distance on either side of a street and extends a certain distance along the street network from a starting point (Oliver et al., 2007; Forsyth et al., 2012). Using a line-based buffer delimits the observations to areas accessible by walking. Highways and on-ramps were excluded from the observed road network. We used a 1200-meter buffer because the results of a sensitivity analysis suggest that it is the most relevant spatial context for physical activity in the NHSII cohort (James et al., 2014). The walkability index (James et al., 2015a) was derived by z-transforming and summing scores from three variables shown to support pedestrian behavior: intersection count, facility count, and population density (Cervero and Kockelman, 1997; Lovasi et al., 2012). Intersection count, defined as the number of three-way or greater intersections within the buffer, was derived from ArcGIS StreetMap USA™ road network data (Environmental Systems Research Institute, Inc., 2008). Higher values indicate a more connected street network. Facility count (number of facilities within the buffer) was derived from the ArcGIS 2009 InfoUSA™ public and commercial facilities database, which includes retail, food, service, cultural, recreational, and other establishments. InfoUSA™ and similar databases have shown good validity when facilities were verified on-site (James et al., 2014; Paquet et al., 2008). Higher values indicate a greater mix of residential and commercial land use, more walking destinations, and more places for active recreation. Population density was defined as the number of persons per square mile within the census tract of residence during the 2000 U.S. Census.

2.2.3. Perceived neighborhood environment—Women responded yes or no to four statements adapted from the Physical Activity Neighborhood Environment Survey (PANES) about the presence of "free or low cost recreation facilities", "shops, stores, and markets", "sidewalks on most streets", and "the crime rate makes it unsafe" (Alexander et al., 2006). The PANES has demonstrated good test-retest reliability (Alexander et al., 2006) and construct validity (Sallis et al., 2009). We reverse coded the crime item so that a "no" response indicated a favorable perception of safety. We created a composite measure of the perceived neighborhood environment by summing the number of favorable responses, with values ranging from 0 to 4; an approach utilized in previous research (Troped et al., 2011).

2.2.4. Depressive symptoms—Women responded to the 15-item Geriatric Depression Scale (GDS-15), a valid and reliable measure of depressive symptomology in the older adult population (Korner et al., 2006). Women were prompted to choose the best answer (yes/no) for how they felt during the past month regarding a list of 15 clinically relevant symptoms. A score ≥5 may suggest clinical depression (Almeida and Almeida, 1999). However, because depressive symptoms may also influence neighborhood perceptions at subclinical levels (Latkin et al., 2009), we used a continuous scale (0–15) to capture the depressive symptomology represented in non-clinical populations.

2.2.5. Covariates—We controlled for demographic and health-related covariates that may confound associations between objective and perceived neighborhood environment, depressive symptoms, and physical activity. Covariates were age, race, Hispanic ethnicity, nurse's education, husband's education, marital status, employment status, body mass index (BMI; kg/m^2), and previous chronic disease (i.e., cancer, diabetes or heart disease). Since socioeconomic status is an important factor in health status, we considered nurse's and husband's education to reflect household income and adjusted for census tract-level household income, a proxy for neighborhood socioeconomic status. To account for the potential influence of missing data, we created indicator variables for covariates with missing observations.

2.3. Statistical analysis

The data met the assumptions of multivariate analysis, including linearity and homoscedasticity, except that logarithmic (log10) transformation of the walkability index was necessary to address positive skewness and ensure that residuals were normally distributed (Tabachnick and Fidell, 2013). No multicollinearity among predictor variables was detected. We used multiple linear regression (Hayes, 2013; Preacher et al., 2007) with objective walkability as the independent variable, perceived neighborhood environment as the mediator, depressive symptoms as the moderator, and neighborhood walking and meeting physical activity recommendations as the outcomes. We also conducted a sensitivity analysis to separately examine associations between the three objective built environment variables that comprised the walkability index and each physical activity outcome.

To test for mediation we used bootstrap resampling ($k = 5000$) with 95% bias-corrected confidence intervals (*BC CIs*) of the indirect effects using PROCESS© v2.13 for SAS® 9.3 (Hayes, 2013). A *BC CI* that did not include zero indicated statistically significant mediation. To determine which mediation pathways were moderated by depressive symptoms, we examined a preliminary model in which depressive symptoms moderated all pathways in the model (see Fig. 1). If an effect was not moderated (i.e., $p \geq .05$ for the interaction term), we removed the nonsignificant interaction term from the model (Hayes, 2013). We repeated this process until only statistically significant interaction terms remained. Since the final models contained a significant interaction term, we employed a parameter estimate of the function linking the indirect effect to values of depressive symptoms called the index of moderated mediation (Hayes, 2015). A *BC CI* that did not include zero for the index of moderated mediation indicated that an indirect effect significantly varied across levels of depressive symptoms (Hayes, 2015).

We tested and plotted moderated indirect and direct effects at the $M \pm 1SD$ of depressive symptoms. Since the $M - 1SD$ was outside of the range of data, we used the minimum value (0) instead (data not shown). We employed the Johnson-Neyman technique to identify the value of depressive symptoms at which a moderated association transitioned from nonsignificant to statistically significant (Hayes, 2013). All variables in the interaction terms were mean-centered prior to analysis. We reported unstandardized regression weights for associations with perceived neighborhood environment, and the exponents of unstandardized logistic regression coefficients (i.e., odds ratios) for associations with the two dichotomous physical activity outcomes.

3. Results

As shown in Table 1, participants' average age was 73.1 ± 6.7 years. The majority of women were white, married, and not working outside of the home. About 50% did not meet physical activity recommendations, 20.1% were obese (BMI ≥ 30) and 38.5% had a history of chronic disease. Eight percent reported depressive symptom scores suggestive of mild clinical depression or higher (≥5). Supplemental Table 1 shows means and Pearson correlations among study variables.

3.1. Associations between objective neighborhood walkability and physical activity outcomes via perceived neighborhood environment

3.1.1. Neighborhood walking—The odds of a woman walking in her neighborhood was two times the odds of a woman whose neighborhood was one unit lower in objective walkability via perceptions of the neighborhood environment (95% *BC CI* = 1.92, 2.06). As shown in Fig. 2, a one unit higher objective walkability score was associated with a 1.59 (out of 4) point higher perceived neighborhood environment score (95% *CI* = 1.56,1.63). In turn, having more positive perceptions was associated with 1.54 times greater odds of neighborhood walking (95% *CI* = 1.51, 1.57). This positive indirect association between objective walkability and neighborhood walking via perceived neighborhood environment seemed to be driven largely by significant positive indirect associations between two of the three walkability components (facility count and population density) and neighborhood walking via perceived neighborhood environment, whereas intersection count was not significantly indirectly associated with neighborhood walking (Supplemental Table 2).

Depressive symptoms significantly moderated the indirect association between objective walkability and neighborhood walking via perceived neighborhood environment (index of moderated mediation = −0.02; *SE* = 0.00; 95% *BC CI* = −0.03, −0.02). The Johnson-Neyman technique, which indicated the value of depressive symptoms at which an association transitioned from nonsignificant to statistically significant, showed that this indirect association was statistically significant throughout the range of depressive symptoms. As shown in Fig. 2, women who lived in more walkable neighborhoods tended to have more positive perceptions of their neighborhood for physical activity than women who lived in less walkable neighborhoods, however, this positive association was weaker among those with higher depressive symptom scores ($\beta_{walkability \times depressive} = -0.05$, $SE = 0.01$; $p < .0001$). In turn, a woman's positive perceptions did not translate to greater odds of neighborhood walking to the same extent as other women living in the neighborhood if she reported higher depressive symptoms. In addition, among the 8.0% of women with depressive symptoms scores > 4.05 (which approach levels suggestive of mild clinical depression), intersection count was inversely associated with perceived neighborhood environment scores.

3.1.2. Meeting physical activity recommendations—

The odds of a woman meeting physical activity recommendations was 1.38 times the odds of a woman whose neighborhood was one unit lower in objective walkability via perceptions of the neighborhood environment (95% *BC CI* = 1.34, 1.43). As shown in Fig. 3, a one unit higher objective walkability score was associated with a 1.59 point higher perceived neighborhood environment score (95% *CI* = 1.56, 1.63) which, in turn, was associated with 1.23 times greater odds of meeting physical activity recommendations (95% *CI* = 1.20, 1.25).

Depressive symptoms significantly moderated the indirect association between objective walkability and meeting physical activity recommendations (index of moderated mediation = −0.01; *SE* = 0.00; 95% *BC CI* = −0.01, −0.01). This indirect association was statistically significant throughout the range of depressive symptoms. As shown in Fig. 3, women who lived in more walkable neighborhoods tended to have more positive perceptions of their neighborhood than women who lived in less walkable neighborhoods, however, this positive association was weaker among those with higher depressive symptom scores ($\beta_{walkability \times depressive} = -0.05$, $SE = 0.01$; $p < .0001$). In turn, a woman's positive perceptions did not translate to greater odds of meeting physical activity recommendations to the same extent as other women living in the neighborhood if she experienced higher depressive symptoms.

3.2. Direct associations between objective neighborhood walkability and physical activity outcomes

A one unit higher objective walkability score was associated with 16% lower odds of neighborhood walking (*OR* = 0.84; 95% *CI* = 0.78, 0.92; see Fig. 2) and 39% lower odds of meeting physical activity recommendations (*OR* = 0.61; 95% *CI* = 0.56, 0.66; see Fig. 3), controlling for perceived neighborhood environment. The aforementioned indirect associations between objective walkability and both physical activity outcomes via perceptions were positive. However, because the direct associations between objective walkability and both physical activity outcomes held the opposite sign, perceived neighborhood environment acted as a suppressor rather than a mediator of these direct associations, suggesting that including perceptions in the model enhanced rather than attenuated the predictive validity of these inverse associations (MacKinnon et al., 2000). When perceptions and the significant interaction term were not in the models, the magnitude of positive associations between objective walkability and physical activity outcomes was greater. That is, the association between objective walkability and neighborhood walking was positive (*OR* = 1.71; 95% *CI* = 1.58, 1.85), and the inverse association between objective walkability and meeting physical activity recommendations was attenuated (*OR* = 0.86; 95% *CI* = 0.80, 0.93). Thus, perceived neighborhood environment as a mediator may explain positive but did not explain inverse associations between objective walkability and these physical activity outcomes.

4. Discussion

In recent studies, greater objective destination density (Van Dyck et al., 2013; Gebel et al., 2011), population density (Gebel et al., 2011), and street connectivity (Koohsari et al., 2014; Van Dyck et al., 2013; Gebel et al., 2011) were indirectly associated with walking for transportation via the perceived neighborhood environment. In the present study, greater objective walkability, facility counts, and population density (but not intersection count) were significantly associated with neighborhood walking and physical activity for recreation via the perceived neighborhood environment. These findings are consistent with a recent review in which objective access to destinations and residential density (but not street connectivity) were associated with total walking and physical activity among older adults (D.W. Barnett et al., 2017). The nonsignificance of intersection count in this study may be because we examined physical activity for recreation purposes as opposed to active transportation, and connectivity has been consistently associated with active transportation in adults (Bauman et al., 2012). However, even in studies examining correlates of active transport, street connectivity may be a facilitator rather than an essential factor for older adults (Cerin et al., 2017). Collectively with other recent studies (Troped et al., 2016; Orstad et al., 2017; Cerin et al., 2018), these findings begin to build an evidence base for the mediating role of environmental perceptions in associations between aspects of objectively-measured walkability and physical activity for transportation and recreation.

Women with depressed mood may use public spaces differently, thus accumulate experiences of their neighborhood that are different than residents without depressed mood (Wallace et al., 2015). The weaker positive association between objective walkability and perceived neighborhood environment, and the inverse association in the case of intersection count, among women with higher depressive symptoms may be explained by heightened perceptions of traffic danger, poor aesthetics, and unsafe or insufficient sidewalk space in highly connected areas. These processes may have consequences for physical activity levels among older women, as suggested by weaker indirect associations with physical activity outcomes. The extent to which women have favorable perceptions of their neighborhood and engage in physical activity, whether they live in low- or high-walkable neighborhoods (Gebel et al., 2011; Cerin et al., 2017; Koohsari et al., 2015), may depend in part on the supports available to alleviate depressive symptoms. Further research is warranted to examine the extent to which depressive symptoms moderate these associations in older men and other groups. Such research can inform comprehensive physical activity interventions that incorporate built environment and cognitive strategies to enhance perceptions of the neighborhood environment for physical activity and reduce symptoms of depression.

In this study, a composite measure of perceived recreation facilities, retail destinations, sidewalks, and crime significantly suppressed (“enhanced”) inverse associations between objective walkability and physical activity outcomes. In one previous study of women, a seven-item perceived neighborhood environment scale (e.g., recreational facilities, ease of walking, and presence of other active people) also suppressed the association between a composite measure of objective connectivity and destination density and leisure-time walking, while perceptions of poor aesthetics, low personal safety, and low social cohesion mediated the association (Van Dyck et al., 2013). Older women who live in objectively walkable areas may perceive certain aspects of their neighborhood favorably, such as access to retail destinations (Koohsari et al., 2014; Jack and McCormack, 2014) and recreation facilities (Van Dyck et al., 2013; Jack and McCormack, 2014). Perhaps more vulnerable to safety hazards than younger woman, they may perceive other aspects of walkable areas less favorably, such as aesthetics (Van Dyck et al., 2013; Borst et al., 2008) and safety from traffic (Jack and McCormack, 2014) and crime (Van Dyck et al., 2013; Jack and McCormack, 2014). Sufficient evidence suggests perceived aesthetics and traffic and personal safety are consistently positively associated with total walking among older adults (D.W. Barnett et al., 2017). Therefore, this study’s inverse associations may be accounting for relevant perceptions (i.e., aesthetics and traffic safety) that were not examined. Future research should consider the ways in which older women interpret and perceive neighborhood aesthetics, traffic danger, disorder, and the condition of sidewalks, parks, and recreation facilities, which seem to be important for leisure walking even when objective conditions of walkability are met.

4.1. Strengths and limitations

Strengths of this study include the large national sample of older women living in communities ranging from urban to rural, the inclusion of the objective and perceived neighborhood environment in conceptual and statistical models, the focus on correlates of neighborhoodbased physical activity for specific recreational purposes, and the examination of depressive symptoms in physical activity and built environment research. The cross-sectional study design precludes us from making causal inferences or identifying the direction of associations. Not all potential pathways among the neighborhood environment, physical activity and depression were examined. For example, neighborhood attributes such as low SES and high crime rates are associated with depression in older adults (A. Barnett et al., 2017). Therefore, we controlled for neighborhood SES to account for some of the variance in depressive symptoms potentially explained by the environment. Women’s anxiety symptoms, which are co-morbid with depressive symptoms, were not accounted for in this study; thus, future examination of the moderating role of anxiety is needed. Women’s past experiences in their neighborhoods and vehicle ownership were not assessed as potential confounders. Nor was residential self-selection, though not considered a major source of bias in the NHS cohort (James et al., 2015b). Self-reported walking and physical activity measures may have overestimated physical activity behavior. The use of a perceived neighborhood environment measure that was not a close match conceptually to the walkability index may have underestimated indirect associations with physical activity. The use of a composite walkability measure limits practical application of these findings to built environmental and policy interventions to promote physical activity among older adults. Future studies are needed to identify innovative ways to measure the built environment that can be readily translated into action by urban planners and public health professionals. Low-income neighborhoods and other racial/ethnic minority groups are not well represented in this sample of women with nursing degrees, which may affect the generalizability of these findings to marginalized populations.

5. Conclusion

This study's findings indicate that older women who live in objectively more walkable neighborhoods tend to have more positive perceptions and, in turn, are more active than women who live in less walkable neighborhoods. However, even subclinical levels of depressive symptoms may dampen positive associations between objective walkability and physical activity via perceptions of their neighborhood. Therefore, depressive symptoms should be factored into conceptual models that explain older adults' physical activity and when developing physical activity interventions for older women.

Supplementary Material

Refer to Web version on PubMed Central for supplementary material.

Acknowledgments

We thank Dr. Olivia Okereke, MD, MS, for her helpful comments at early stages of this analysis.

Funding

This research was supported by the National Institutes of Health; grants R00 CA201542, R01 ES017017, and UM1 CA186107. This study was also supported by the Channing Division of Network Medicine, Department of Medicine, Brigham and Women's Hospital and Harvard Medical School and internal research funding from the University of Massachusetts Boston.

References

Adams MA, Sallis JF, Conway TL, et al., 2012 Neighborhood environment profiles for physical activity among older adults. Am. J. Health Behav 36 (6), 757–769. https://doi.org/10.5993/AJHB.36.6.4. [PubMed: 23026035]

Ainsworth BE, Haskell WL, Whitt MC, et al., 2000 Compendium of physical activities: an update of activity codes and MET intensities. Med. Sci. Sports Exerc 32 (9 Suppl), S498–S504. https://doi.org/10.1097/00005768-200009001-00009. [PubMed: 10993420]

Ainsworth BE, Haskell WL, Herrmann SD, et al., 2011 2011 Compendium of physical activities: a second update of codes and MET values. Med. Sci. Sports Exerc 43 (8), 1575–1581. https://doi.org/10.1249/MSS.0b013e31821ece12. [PubMed: 21681120]

Alexander A, Bergman P, Hagströmer M, Sjöström M, 2006 IPAQ environmental module; reliability testing. J. Public Health 14 (2), 76–80. https://doi.org/10.1007/s10389-005-0016-2.

Almeida OP, Almeida SA, 1999 Short versions of the geriatric depression scale: a study of their validity for the diagnosis of a major depressive episode according to ICD-10 and DSM-IV. Int. J.

Geriatr. Psychiatry 14 (10), 858–865. https://doi.org/10.1002/(SICI)1099-1166(199910)14:10<858::AID-GPS35>3.0.CO;2-8. [PubMed: 10521885]

Bailey EJ, Malecki KC, Engelman CD, et al., 2014 Predictors of discordance between perceived and objective neighborhood data. Ann. Epidemiol 24 (3), 214–221. https://doi.org/10.1016/j.annepidem.2013.12.007. [PubMed: 24467991]

Balfour JL, Kaplan GA, 2002 Neighborhood environment and loss of physical function in older adults: evidence from the Alameda County Study. Am. J. Epidemiol 155 (6), 507–515. https://doi.org/10.1093/aje/155.6.507. [PubMed: 11882524]

Bandura A, 1978 Self system in reciprocal determinism. Am. Psychol 33 (4), 344–358. https://doi.org/10.1037/0003-066X.33.4.344.

Barnett DW, Barnett A, Nathan A, Van Cauwenberg J, Cerin EA-OX, 2017 Built environmental correlates of older adults' total physical activity and walking: a systematic review and meta-analysis. Int. J. Behav. Nutr. Phys. Act 14 (103), 1–24. [PubMed: 28057008]

Barnett A, Zhang CJP, Johnston JM, Cerin E, 2017 Relationships between the neighborhood environment and depression in older adults: a systematic review and meta-analysis. Int. Psychogeriatr https://doi.org/10.1017/S104161021700271X.

Barry LC, Allore HG, Guo Z, Bruce ML, Gill TM, 2008 Higher burden of depression among older women: the effect of onset, persistence, and mortality over time. Arch. Gen. Psychiatry 65 (2), 172–178. https://doi.org/10.1001/archgenpsychiatry.2007.17. [PubMed: 18250255]

Bauman AE, Reis RS, Sallis JF, Wells JC, Loos RJ, Martin BW, 2012 Correlates of physical activity: why are some people physically active and others not? Lancet 380 (9838), 258–271. https://doi.org/10.1016/S0140-6736(12)60735-1. [PubMed: 22818938]

Belanger CF, Hennekens CH, Rosner B, Speizer FE, 1978 The nurses' health study. Am. J. Nurs 78 (6), 1039–1040. https://doi.org/10.2307/3462013. [PubMed: 248266]

Berke EM, Koepsell TD, Moudon AV, Hoskins RE, Larson EB, 2007 Association of the built environment with physical activity and obesity in older persons. Am. J. Public Health 97 (3), 486–492. https://doi.org/10.2105/AJPH.2006.085837. [PubMed: 17267713]

Borst HC, Miedema HME, de Vries SI, Graham JMA, van Dongen JEF, 2008 Relationships between street characteristics and perceived attractiveness for walking reported by elderly people. J. Environ. Psychol 28 (4), 353–361. https://doi.org/10.1016/j.jenvp.2008.02.010.

Buchner D, Bishop J, Brown D, et al., 2008 Physical Activity Guidelines for Americans. pp. 2008. http://health.gov/paguidelines/pdf/paguide.pdf.

Carlson JA, Sallis JF, Conway TL, et al., 2012 Interactions between psychosocial and built environment factors in explaining older adults' physical activity. Prev. Med 54 (1), 68–73. https://doi.org/10.1016/j.ypmed.2011.10.004. [PubMed: 22027402]

CDC, 2015 Depression is not a normal part of growing older. In: Healthy Aging,. https://www.cdc.gov/aging/mentalhealth/depression.htm, Accessed date: 12 November 2015.

Cerin E, Nathan A, van Cauwenberg J, Barnett DW, Barnett A, 2017 The neighbourhood physical environment and active travel in older adults: a systematic review and meta-analysis. Int. J. Behav. Nutr. Phys. Act 14 (15), 1–23. https://doi.org/10.1186/s12966-017-0471-5. [PubMed: 28057008]

Cerin E, Conway TL, Adams MA, et al., 2018 Objectively-assessed neighbourhood destination accessibility and physical activity in adults from 10 countries: an analysis of moderators and perceptions as mediators. Soc. Sci. Med 211, 282–293. https://doi.org/10.1016/j.socscimed.2018.06.034. [PubMed: 29966823]

Cervero R, Kockelman K, 1997 Travel demand and the 3Ds: density, diversity, and design. Transp. Res. Part D: Transp. Environ 2 (3), 199–219. https://doi.org/10.1016/S1361-9209(97)00009-6.

Chodzko-Zajko WJ, Proctor DN, Fiatarone Singh MA, et al., 2009 American College of Sports Medicine position stand. Exercise and physical activity for older adults. Med. Sci. Sports Exerc 41 (7), 1510–1530. https://doi.org/10.1249/MSS.0b013e3181a0c95c. [PubMed: 19516148]

Clarke P, George LK, 2005 The role of the built environment in the disablement process. Am. J. Public Health 95 (11), 1933–1939. https://doi.org/10.2105/AJPH.2004.054494. [PubMed: 16195520]

Conn VS, 2010 Depressive symptom outcomes of physical activity interventions: metaanalysis findings. Ann. Behav. Med 39 (2), 128–138. https://doi.org/10.1007/s12160-010-9172-x. [PubMed: 20422333]

Davies C, 2009 Are places concepts? Familarity and expertise effects in neighborhood cognition. In: Hornsby KS, Claramunt C, Denis M, Ligozat G (Eds.), Spatial Information Theory: 9th International Conference, COSIT 2009 Aber Wrac'h, France, September 21–25, 2009 Proceedings Springer Berlin Heidelberg, Berlin, Heidelberg, pp. 36–50. https://doi.org/10.1007/978-3-642-03832-7_3.

Ding D, Gebel K, 2012 Built environment, physical activity, and obesity: what have we learned from reviewing the literature? Health Place 18 (1), 100–105. https://doi.org/10.1016/j.healthplace.2011.08.021. [PubMed: 21983062]

Ding D, Sallis JF, Norman GJ, et al., 2014 Neighborhood environment and physical activity among older adults: do the relationships differ by driving status? J. Aging Phys. Act 22, 421–431. https://doi.org/10.1123/JAPA.2012-0332. [PubMed: 24084049]

Eronen J, von Bonsdorff M, Rantakokko M, Rantanen T, 2014 Environmental facilitators for outdoor walking and development of walking difficulty in community-dwelling older adults. Eur. J. Ageing 11 (1), 67–75. https://doi.org/10.1007/s10433013-0283-7. [PubMed: 28804315]

Ewing R, Handy S, 2009 Measuring the unmeasurable: urban design qualities related to walkability. J. Urban Des 14 (1), 65–84. https://doi.org/10.1080/13574800802451155.

Forsyth A, Van Riper D, Larson N, Wall M, Neumark-Sztainer D, 2012 Creating a replicable, valid cross-platform buffering technique: the sausage network buffer for measuring food and physical activity built environments. Int. J. Health Geogr 11 (14), 1–9. https://doi.org/10.1186/1476-072X-11-14. [PubMed: 22230476]

Frank LD, Sallis JF, Saelens BE, et al., 2010 The development of a walkability index: application to the Neighborhood Quality of Life Study. Br. J. Sports Med 44 (13), 924–933. https://doi.org/10.1136/bjsm.2009.058701. [PubMed: 19406732]

Gauvin L, Richard L, Kestens Y, et al., 2012 Living in a well-serviced urban area is associated with maintenance of frequent walking among seniors in the VoisiNuAge study. J. Gerontol. B Psychol. Sci. Soc. Sci 67 (1), 76–88. https://doi.org/10.1093/geronb/gbr134. [PubMed: 22227735]

Gebel K, Bauman AE, Sugiyama T, Owen N, 2011 Mismatch between perceived and objectively assessed neighborhood walkability attributes: prospective relationships with walking and weight gain. Health Place 17 (2), 519–524. https://doi.org/10.1016/j.healthplace.2010.12.008. [PubMed: 21233002]

Glass TA, Balfour JL, 2003 Neighborhoods, aging, and functional limitations In: Kawachi I, Bergman LF (Eds.), Neighborhoods and Health. Oxford University Press, USA https://doi.org/10.1093/acprof:oso/9780195138382.003.0014.

Hayes AF, 2013 Introduction to Mediation, Moderation, and Conditional Process Analysis: A Regression-based Approach. The Guilford Press, New York, NY.

Hayes AF, 2015 An index and test of linear moderated mediation. Multivar. Behav. Res 50 (1), 1–22. https://doi.org/10.1080/00273171.2014.962683.

Huang TT, Liu CB, Tsai YH, Chin YF, Wong CH, 2015 Physical fitness exercise versus cognitive behavior therapy on reducing the depressive symptoms among community-dwelling elderly adults: a randomized controlled trial. Int. J. Nurs. Stud 52 (10), 1542–1552. https://doi.org/10.1016/j.ijnurstu.2015.05.013. [PubMed: 26105535]

Jack E, McCormack GR, 2014 The associations between objectively-determined and self-reported urban form characteristics and neighborhood-based walking in adults. Int. J. Behav. Nutr. Phys. Act 11, 71 https://doi.org/10.1186/1479-5868-11-71. [PubMed: 24893719]

James P, Berrigan D, Hart JE, et al., 2014 Effects of buffer size and shape on associations between the built environment and energy balance. Health Place 27, 162–170. https://doi.org/10.1016/j.healthplace.2014.02.003. [PubMed: 24607875]

James P, Hart JE, Laden F, 2015a Exposures to neighborhood walkability and particulate air pollution in a nationwide cohort of women. Environ. Res 142, 703–711. https://doi.org/10.1016/j.envres.2015.09.005. [PubMed: 26397775]

James P, Hart J, Arcaya M, Feskanich D, Laden F, Subramanian SV, 2015b Neighborhood self-selection: the role of pre-move health factors on the built and socioeconomic environment. Int. J. Environ. Res. Public Health 12 (10), 12489 https://doi.org/10.3390/ijerph121012489. [PubMed: 26457712]

Kamphuis CB, Mackenbach JP, Giskes K, Huisman M, Brug J, van Lenthe FJ, 2010 Why do poor people perceive poor neighbourhoods? The role of objective neighbourhood features and psychosocial factors. Health Place 16 (4), 744–754. https://doi.org/10.1016/j.healthplace.2010.03.006. [PubMed: 20382555]

Kerr J, Norman G, Millstein R, et al., 2014 Neighborhood environment and physical activity among older women: findings from the San Diego cohort of the Women's Health Initiative. J. Phys. Act. Health 11 (6), 1070–1077. https://doi.org/10.1123/jpah.2012-0159. [PubMed: 23963780]

King AC, Stokols D, Talen E, Brassington GS, Killingsworth R, 2002 Theoretical approaches to the promotion of physical activity: forging a transdisciplinary para-digm. Am. J. Prev. Med 23 (2 Suppl), 15–25. https://doi.org/10.1016/S07493797(02)00470-1. [PubMed: 12133734]

King AC, Sallis JF, Frank LD, et al., 2011 Aging in neighborhoods differing in walkability and income: associations with physical activity and obesity in older adults. Soc. Sci. Med 73 (10), 1525–1533. https://doi.org/10.1016/j.socscimed.2011.08.032. [PubMed: 21975025]

Koohsari MJ, Sugiyama T, Lamb KE, Villanueva K, Owen N, 2014 Street connectivity and walking for transport: role of neighborhood destinations. Prev. Med 66, 118–122. https://doi.org/10.1016/j.ypmed.2014.06.019. [PubMed: 24963892]

Koohsari MJ, Badland H, Sugiyama T, Mavoa S, Christian H, Giles-Corti B, 2015 Mismatch between perceived and objectively measured land use mix and street connectivity: associations with neighborhood walking. J. Urban Health 92 (2), 242–252. https://doi.org/10.1007/s11524-014-9928-x. [PubMed: 25539783]

Korner A, Lauritzen L, Abelskov K, et al., 2006 The Geriatric Depression Scale and the Cornell Scale for Depression in Dementia. A validity study. Nord. J. Psychiatry 60 (5), 360–364. https://doi.org/10.1080/08039480600937066. [PubMed: 17050293]

Krämer LV, Helmes AW, Seelig H, Fuchs R, Bengel J, 2014a Correlates of reduced exercise behaviour in depression: the role of motivational and volitional deficits. Psychol. Health 29 (10), 1206–1226. https://doi.org/10.1080/08870446.2014.918978. [PubMed: 24785393]

Krämer LV, Helmes AW, Bengel J, 2014b Understanding activity limitations in depression: integrating the concepts of motivation and volition from health psychology into clinical psychology. Eur. Psychol 19 (4), 278–288. https://doi.org/10.1027/1016-9040/a000205.

Krogh J, Nordentoft M, Sterne JA, Lawlor DA, 2011 The effect of exercise in clinically depressed adults: systematic review and meta-analysis of randomized controlled trials. J. Clin. Psychiatry 72 (4), 529–538. https://doi.org/10.4088/JCP.08r04913blu. [PubMed: 21034688]

Latkin CA, German D, Hua W, Curry AD, 2009 Individual-level influences on perceptions of neighborhood disorder: a multilevel analysis. J. Community Psychol 37 (1), 122–133. https://doi.org/10.1002/jcop.20284. [PubMed: 20027234]

Li F, Fisher KJ, Brownson RC, Bosworth M, 2005 Multilevel modelling of built environment characteristics related to neighbourhood walking activity in older adults. J. Epidemiol. Community Health 59 (7), 558–564. https://doi.org/10.1136/jech.2004.028399. [PubMed: 15965138]

Lindwall M, Larsman P, Hagger MS, 2011 The reciprocal relationship between physical activity and depression in older European adults: a prospective cross-lagged panel design using SHARE data. Health Psychol. 30 (4), 453–462. https://doi.org/10.1037/a0023268. [PubMed: 21480713]

Lovasi GS, Grady S, Rundle A, 2012 Steps forward: review and recommendations for research on walkability, physical activity and cardiovascular health. Public Health Rev. 33 (4), 484–506. https://doi.org/10.1007/BF03391647. [PubMed: 25237210]

MacKinnon D, Krull J, Lockwood C, 2000 Equivalence of the mediation, confounding and suppression effect. Prev. Sci 1 (4), 173–181. https://doi.org/10.1023/A:1026595011371. [PubMed: 11523746]

Mair C, Kaplan GA, Everson-Rose SA, 2012 Are there hopeless neighborhoods? An exploration of environmental associations between individual-level feelings of hopelessness and neighborhood characteristics. Health Place 18 (2), 434–439. https://doi.org/10.1016/j.healthplace.2011.12.012. [PubMed: 22265206]

McKee G, Kearney PM, Kenny RA, 2015 The factors associated with self-reported physical activity in older adults living in the community. Age Ageing 44 (4), 586–592. https://doi.org/10.1093/ageing/afv042. [PubMed: 25863770]

Morey MC, Dubbert PM, Doyle ME, MacAller H, Crowley GM, Kuchibhatla M, Schenkman M, Horner RD, 2003 From supervised to unsupervised exercise: factors associated with exercise adherence. J. Aging Phys. Act 11 (3), 351–368. https://doi.org/10.1123/japa.11.3.351.

Motl RW, McAuley E, 2010 Physical activity, disability, and quality of life in older adults. Phys. Med. Rehabil. Clin. N. Am 21 (2), 299–308. https://doi.org/10.1016/j.pmr.2009.12.006. [PubMed: 20494278]

Nagel CL, Carlson NE, Bosworth M, Michael YL, 2008 The relation between neighborhood built environment and walking activity among older adults. Am. J. Epidemiol 168 (4), 461–468. https://doi.org/10.1093/aje/kwn158. [PubMed: 18567638]

Nasar JL, 2008 Assessing perceptions of environments for active living. Am. J. Prev. Med 34 (4), 357–363. https://doi.org/10.1016/j.amepre.2008.01.013. [PubMed: 18374252]

Nathan A, Wood L, Giles-Corti B, 2014 Exploring socioecological correlates of active living in retirement village residents. J. Aging Phys. Act 22 (1), 1–15. https://doi.org/10.1123/japa.2012-0189. [PubMed: 23170755]

Nelson ME, Rejeski WJ, Blair SN, et al., 2007 Physical activity and public health in older adults: Recommendation from the American College of Sports Medicine and the American Heart Association. Med. Sci. Sports Exerc 39 (8), 1435–1445. https://doi.org/10.1249/mss.0b013e3180616aa2. [PubMed: 17762378]

Oliver LN, Schuurman N, Hall AW, 2007 Comparing circular and network buffers to examine the influence of land use on walking for leisure and errands. Int. J. Health Geogr 6 (1), 41 https://doi.org/10.1186/1476-072X-6-41. [PubMed: 17883870]

Orstad SL, McDonough MH, Stapleton S, Altincekic C, Troped PJ, 2016 A systematic review of agreement between perceived and objective neighborhood environment measures and associations with physical activity outcomes. Environ. Behav 49 (8), 904–932. https://doi.org/10.1177/0013916516670982.

Orstad SL, McDonough MH, Klenosky DB, Mattson M, Troped PJ, 2017 The observed and perceived neighborhood environment and physical activity among urban-dwelling adults: the moderating role of depressive symptoms. Soc. Sci. Med 190, 57–66. https://doi.org/10.1016/j.socscimed.2017.07.026. [PubMed: 28843130]

Paquet C, Daniel M, Kestens Y, Leger K, Gauvin L, 2008 Field validation of listings of food stores and commercial physical activity establishments from secondary data. Int. J. Behav. Nutr. Phys. Act 5, 58 https://doi.org/10.1186/1479-5868-5-58. [PubMed: 19000319]

Preacher KJ, Rucker DD, Hayes AF, 2007 Addressing moderated mediation hypotheses: theory, methods, and prescriptions. Multivar. Behav. Res 42 (1), 185–227. https://doi.org/10.1080/00273170701341316.

Rosenbaum S, Tiedemann A, Sherrington C, Curtis J, Ward PB, 2014 Physical activity interventions for people with mental illness: a systematic review and metaanalysis. J. Clin. Psychiatry 75 (9), 964–974. https://doi.org/10.4088/JCP.13r08765. [PubMed: 24813261]

Sallis JF, 2009 Measuring physical activity environments: a brief history. Am. J. Prev. Med 36 (4, Suppl 1), S86–S92. https://doi.org/10.1016/j.amepre.2009.01.002. [PubMed: 19285214]

Sallis JF, Owen N, Fisher EB, 2008 Ecological models of health behavior In: Glanz K, Rimer BK, Viswanath K (Eds.), Health Behavior and Health Education: Theory, Research, and Practice, 4 ed. Jossey-Bass, San Francisco, CA, pp. 465–485.

Sallis JF, Bowles HR, Bauman AE, et al., 2009 Neighborhood environments and physical activity among adults in 11 countries. Am. J. Prev. Med 36 (6), 484–490. https://doi.org/10.1016/j.amepre.2009.01.031. [PubMed: 19460656]

Scarapicchia TMF, Sabiston CM, O'Loughlin E, Brunet J, Chaiton M, O'Loughlin JL, 2014 Physical activity motivation mediates the association between depression symptoms and moderate-to-vigorous physical activity. Prev. Med 66, 45–48. https://doi.org/10.1016/j.ypmed.2014.05.017. [PubMed: 24879889]

Shaw BA, Spokane LS, 2008 Examining the association between education level and physical activity changes during early old age. J. Aging Health 20 (7), 767–787. https://doi.org/10.1177/0898264308321081. [PubMed: 18559963]

Shigematsu R, Sallis JF, Conway TL, et al., 2009 Age differences in the relation of perceived neighborhood environment to walking. Med. Sci. Sports Exerc 41 (2), 314–321. https://doi.org/10.1249/MSS.0b013e318185496c. [PubMed: 19127195]

Tabachnick BG, Fidell LS, 2013 Using Multivariate Statistics, sixth ed. Pearson.

Troped PJ, Tamura K, Whitcomb HA, Laden F, 2011 Perceived built environment and physical activity in U.S. women by sprawl and region. Am. J. Prev. Med 41 (5), 473–479. https://doi.org/10.1016/j.amepre.2011.07.023. [PubMed: 22011417]

Troped PJ, Starnes HA, Puett RC, et al., 2014 Relationships between the built environment and walking and weight status among older women in three U.S. States. J. Aging Phys. Act 22 (1), 114–125. https://doi.org/10.1123/japa.2012-0137. [PubMed: 23538637]

Troped PJ, Tamura K, McDonough MH, et al., 2016 Direct and indirect associations between the built environment and leisure and utilitarian walking in older women. Ann. Behav. Med 51 (2), 282–291. https://doi.org/10.1007/s12160-016-9852-2.

Van Dyck D, Veitch J, De Bourdeaudhuij I, Thornton L, Ball K, 2013 Environmental perceptions as mediators of the relationship between the objective built environment and walking among socio-economically disadvantaged women. Int. J. Behav. Nutr. Phys. Act 10 (108), 1–9. https://doi.org/10.1186/1479-5868-10-108. [PubMed: 23281722]

van Gool CH, Kempen GI, Penninx BW, Deeg DJ, Beekman AT, van Eijk JT, 2003 Relationship between changes in depressive symptoms and unhealthy lifestyles in late middle aged and older persons: results from the Longitudinal Aging Study Amsterdam. Age Ageing 32 (1), 81–87. https://doi.org/10.1093/ageing/32.1.81. [PubMed: 12540353]

Van Holle V, Van Cauwenberg J, Van Dyck D, Deforche B, Van de Weghe N, De Bourdeaudhuij I, 2014 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 11, 110 https://doi.org/10.1186/s12966-014-0110-3. [PubMed: 25148845]

Van Holle V, Van Cauwenberg J, Deforche B, Van de Weghe N, De Bourdeaudhuij I, Van Dyck D, 2015 Do psychosocial factors moderate the association between objective neighborhood walkability and older adults' physical activity? Health Place 34, 118–125. https://doi.org/10.1016/j.healthplace.2015.05.004. [PubMed: 26022772]

Wallace D, Louton B, Fornango R, 2015 Do you see what I see? Perceptual variation in reporting the presence of disorder cues. Soc. Sci. Res 51 (0), 247–261. https://doi.org/10.1016/j.ssresearch.2014.10.004. [PubMed: 25769865]

Wassink-Vossen S, Collard RM, Oude Voshaar RC, Comijs HC, de Vocht HM, Naarding P, 2014 Physical (in)activity and depression in older people. J. Affect. Disord 161, 65–72. https://doi.org/10.1016/j.jad.2014.03.001. [PubMed: 24751309]

Wilcox S, Bopp M, Oberrecht L, Kammermann SK, McElmurray CT, 2003 Psychosocial and perceived environmental correlates of physical activity in rural and older African American and white women. J. Gerontol. B Psychol. Sci. Soc. Sci 58 (6), 329–337. https://doi.org/10.1093/geronb/58.6.P329.

Winters M, Barnes R, Venners S, et al., 2015 Older adults' outdoor walking and the built environment: does income matter? BMC Public Health 15 (1), 876 https://doi.org/10.1186/s12889-015-2224-1. [PubMed: 26359159]

Wolf AM, Hunter DJ, Colditz GA, et al., 1994 Reproducibility and validity of a selfadministered physical activity questionnaire. Int. J. Epidemiol 23 (5), 991–999. https://doi.org/10.1093/ije/23.5.991. [PubMed: 7860180]

Yen IH, Michael YL, Perdue L, 2009 Neighborhood environment in studies of health of older adults: a systematic review. Am. J. Prev. Med 37 (5), 455–463. https://doi.org/10.1016/j.amepre.2009.06.022. [PubMed: 19840702]

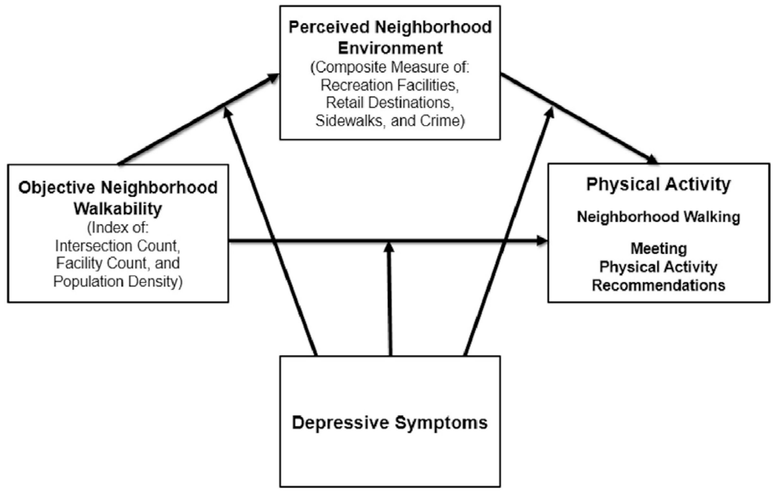

Fig. 1.

Conceptual model of indirect and direct associations between objective neighborhood walkability and physical activity outcomes moderated by depressive symptoms among U.S. women nurses in 2008.

Note: Model depicts perceived neighborhood environment as a potential mediator of the association between objective neighborhood walkability and physical activity.

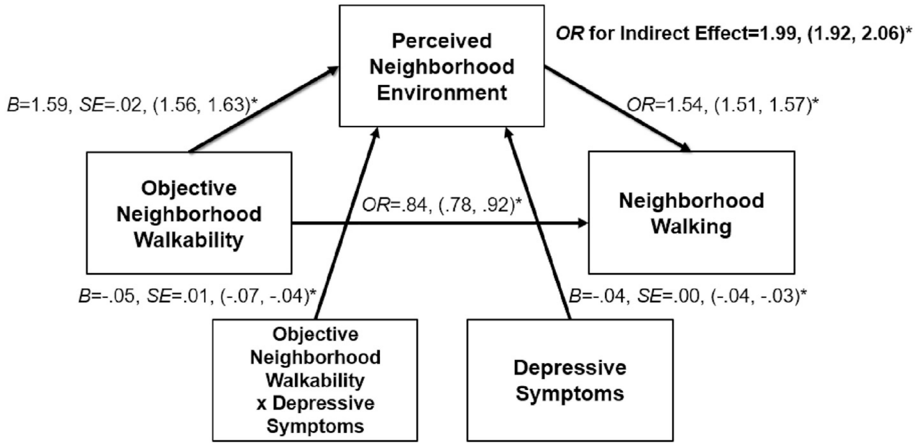

Fig. 2.
Direct associations between objective neighborhood walkability, perceived neighborhood environment, and neighborhood walking among U.S. women nurses in 2008.
Notes: Unstandardized regression weights (*B*) and the exponents of unstandardized logistic regression coefficients or odds ratios (*OR*) reported. Neighborhood walking defined as < 2 times or ≥2 times per week. Model adjusted for age, race, Hispanic ethnicity, nurse's education, husband's education, marital status, employment status, body mass index, previous chronic disease, and census tract-level household income.
*Significant direct effect, tested using 95% confidence intervals (95% CIs) or significant indirect effect, tested using 95% bias-corrected confidence intervals (95% *BC CI*s).

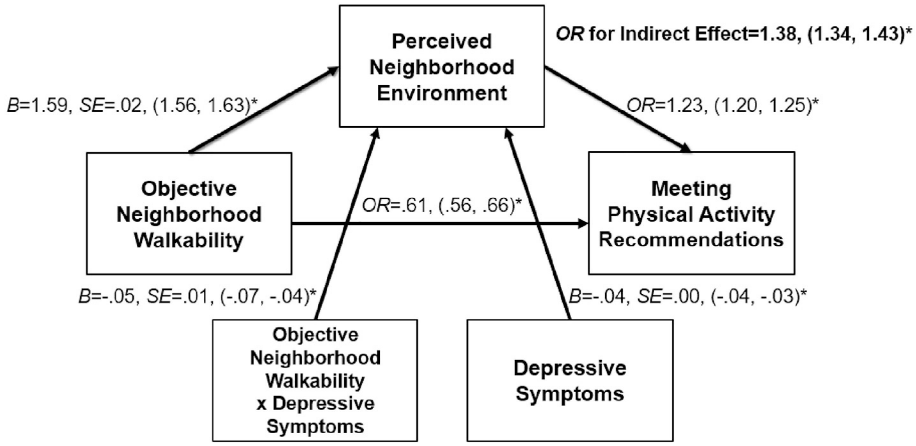

Fig. 3.
Direct associations between objective neighborhood walkability, perceived neighborhood environment, and meeting physical activity recommendations among U.S. women nurses in 2008. Notes: Unstandardized regression weights (*B*) and the exponents of unstandardized logistic regression coefficients or odds ratios (*OR*) reported. Meeting physical activity recommendations defined as weekly average of < 500 or ≥500 MET minutes. Model adjusted for age, race, Hispanic ethnicity, nurse's education, husband's education, marital status, employment status, body mass index, previous chronic disease, and census tract-level household income.
*Significant direct effect, tested using 95% confidence intervals (95% CIs) or significant indirect effect, tested using 95% bias-corrected confidence intervals (95% *BC CI*s).

Table 1.

Demographic and health-related characteristics of 60,133 U.S. women nurses in 2008.

Variables	Number (proportion) All participants	Number (proportion) Walkers < 2 times/week	Number (proportion) Walkers ≥ 2 times/week
N	60,133	33,211	26,922
Age (years) (*M* ± *SD*; range)	*M* = 73.1 ± 6.7; Range = 61.5–88.8	*M* = 73.6 ± 6.8; Range = 61.5–88.8	*M* = 72.5 ± 6.5; Range = 61.5–88.5
Race/ethnicity			
White	58,675 (97.6)	32,346 (97.4)	26,329 (97.8)
Black	792 (1.3)	518 (1.6)	274 (1.0)
Asian	489 (0.8)	242 (0.7)	247 (0.9)
Other[a]	177 (0.3)	105 (0.3)	72 (0.3)
Hispanic/Latino			
Yes	528 (0.9)	299 (0.9)	229 (0.9)
Education			
Registered nurse	36,842 (61.3)	21,150 (63.7)	15,692 (58.3)
Bachelors	11,498 (19.1)	5900 (17.8)	5598 (20.8)
Masters	5205 (8.7)	2566 (7.7)	2639 (9.8)
Doctorate	597 (1.0)	274 (0.8)	323 (1.2)
Not reported	5991 (10.0)	3321 (10.0)	2670 (9.9)
Husband’s education			
High school graduate or less	20,048 (33.3)	12,139 (36.6)	7909 (29.4)
College graduate	13,799 (23.0)	7330 (22.1)	6469 (24.0)
Graduate school	11,877 (19.8)	5855 (17.6)	6022 (22.4)
Not reported or not married	14,409 (24.0)	7887 (23.8)	6522 (24.2)
Marital status			
Married or domestic partner	39,054 (65.0)	21,016 (63.3)	18,038 (67.0)
Divorced or separated	4765 (7.9)	2548 (7.7)	2217 (8.2)
Widowed	16,162 (26.9)	9561 (28.8)	6601 (24.5)
Not reported or never married	152 (0.3)	86 (0.3)	66 (0.2)
Employment status			
Retired or homemaker	49,169 (81.8)	27,131 (81.7)	22,038 (81.9)
Working full- or part-time	10,566 (17.6)	5806 (17.5)	4760 (17.7)
Not reported	398 (0.7)	274 (0.8)	124 (0.5)
Census tract-level median household income (*M* ± *SD*; range)	*M* = $63,504 ± 23,725; Range = $0–200,001	*M* = $62,339 ± 22,972; Range = $0–200,001	*M* = $64,942 ± 24,548; Range = $0–200,001
Body mass index (BMI)			
< 30	43,198 (71.8)	22,032 (66.3)	21,166 (78.6)
≥30	12,074 (20.1)	8456 (25.5)	3618 (13.4)
Not reported	4861 (8.1)	2723 (8.2)	2138 (7.9)
Previous chronic disease[b]			
Yes	23,124 (38.5)	13,738 (41.4)	9386 (34.9)
Depressive symptoms[c]			

Variables	Number (proportion) All participants	Number (proportion) Walkers < 2 times/week	Number (proportion) Walkers ≥ 2 times/week
< 5	55,312 (92.0)	29,785 (89.7)	25,527 (94.8)
≥5	4821 (8.0)	3426 (10.3)	1395 (5.2)
Recreational physical activity			
Meeting recommendations[d]	29,784 (49.5)	11,922 (35.9)	9060 (33.7)
Not meeting recommendations	30,349 (50.5)	21,289 (64.1)	17,862 (66.4)
Neighborhood walking			
< 2 times/week	33,211 (55.2)	33,211 (100.0)	0 (0.0)
≥2 times/week	26,922 (44.8)	0 (0.0)	26,922 (100.0)

Notes: Proportions may not total 100.0 due to rounding to the nearest tenth of a percentage.

[a]Other category includes American Indian and Hawaiian.

[b]Includes self-reported prior incidence of clinician-diagnosed cancer, diabetes and/or heart disease.

[c]A Geriatric Depression Scale (GDS-15) score ≥5 may suggest clinical depression.

[d]Based on an average of ≥500 MET min/week, which approximates the recommended 150 min of moderate-vigorous intensity physical activity per week.